Functional use of large stone tool from the Upper Paleolithic site of Kamennaya Balka II (the Northern Azov Sea region, Russia)

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Abstract:

The assemblages of many Paleolithic sites on the Russian Plain contain large pebbles of various types of stone, which, due to the natural and unmodified forms, rarely become objects of special study. Some of them retain their natural shape, others are slightly artificially modified. In the course of our research, artifacts from several Paleolithic sites in Russia and the Republic of Moldova were subjected to a comprehensive study. Technical-morphological and experimental-traceological studies made it possible to characterize the methods of their manufacture and use. Among the items studied, there is a trapezoidal slab retrieved in the lower layer of the Late Paleolithic stratified site Kamennaya Balka II (the Northern Azov Sea region, Russia). On its surface, use-wear traces were found, which are characteristic of wear traces on tools used to grind plant materials. To verify the results of the traceological analysis, a series of experiments was performed. The wear traces on the working part of the experimental tool turned out to be similar to those found on the original one. The functional identification of the slab from Kamennaya Balka II as a tool for processing plants was also confirmed by the discovery on the working surface of mineralized starch grains.

This comprehensive study of an unmodified stone artifact from the Kamennaya Balka II site and its identification as the lower grinding stone indicates the presence of complex foraging strategies among the economic activities of the inhabitants of the site and their successful adaptation to the natural environment in this region.

Keywords: Upper Paleolithic; Russia; stone slab; technological analysis; traceological analysis; experimental analysis; biogenic residues

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1. Introduction

Within the archaeological flaked industries of many Paleolithic sites of the Russian Plain and other territories of the Eurasian steppe there are large non-modified tools of various types of stone: sandstone, quartzite, granite, and less often, slate. Many of them retain their natural shape and do not have traces of any artificial processing, which complicates their typological systematization, while others have minimal processing by percussion, pecking, and grinding (Kuchugura 2003; Stepanova 2015: 6-7, 12-28; 2020). Traceological studies show that many of them were used as abrasives, anvils, polishers, palettes. Use-wear traces on these tools were already observed by S.A. Semenov since the 1950s, who in his works repeatedly noted that among the Paleolithic stone implements, in addition to the flaked tools listed above, there are also sandstone slabs bearing traces not only of grinding mineral pigments, but also of plants, which treatment might accompany the collection and consumption of this resource (Semenov 1974: 276-277). The excavators of the Paleolithic sites Chulatovo 2 (Russia, Voevodsky 1952) and Molodovo 5 (Chernysh 1961: 42-43, 69-70) referred about the possibility of such a use for several large slabs. In the 1970s, the outstanding Russian archaeologist A.N. Rogachev identified some unmodified stone tools from the archaeological sites of the Kostenkovsko-Borshchevskaya group as grinding stones for processing vegetation (Rogachev 1973). Since these tools represent the main evidence of the processing and use of plants in the Upper Paleolithic, their study requires an integrated approach, including archaeological methods, natural science analysis and replicative experiments (Skakun & Terekhina 2017; Skakun *et al.* 2020a; 2020b). Studies of the biogenic residues from working parts of tools are especially important for verifying traceological analysis and attribution (Adams *et al.* 2009; Longo 2016; Longo & Skakun 2017; Longo *et al.* 2019; Skakun *et al.* 2020a; 2020b; Torrence & Barton 2006: 5-200).

2. Materials and methods

In our research, a comprehensive study was conducted on a stone object from the multilayered Upper Paleolithic site Kamennaya Balka II (^{14}C dates on bone ash: SPb-1085: 15,360 ± 200 uncal. BP, 18,825 or 19,031 cal. BP, Leonova *et al.* 2015). This site belongs to a complex of sites located in the lower reaches of the Don River, in the Rostov region of Russia (Figure 1).

Currently, this site is one of the few open-type multi-layer localities. About 2000 m^2 have been excavated. It was possible to identify residential areas, specialized economic zones, hearths, among other features (Leonova *et al.* 2006; Vinogradova & Leonova 2016). The researchers noted analogies between the flint inventory of the site and the coeval Caucasian materials from Imereti in Georgia (Gvozdover 1967). The richest archaeological assemblage has been comprehensively studied using various archaeological and scientific methods, including geology, geomorphology, paleopedology, paleozoology and paleobotany. All the finds were mapped, hence a detailed planographic analysis of various remains made it possible to reveal the presence of specific activities areas in each of its three cultural horizons (Leonova 2015; Leonova *et al.* 2006). The investigated fine-grained sandstone slab was found in square c9´, in the western part of the lowest, most ancient cultural layer, in a relatively empty space, where no tools were found nearby (Figures 2 and 3).

The object was studied using technological, traceological and experimental methods (Skakun *et al.* 2018), including the study of high-fidelity molds that reproduce the nature of the surface of the tool, which allowed us to obtain microphotographs of the working surfaces for subsequent traceological analysis by using high resolution microscopy. A devoted replicative experiment was designed and carried out to reproduce the function of the grinding stone. In addition, an important part of the study was the analysis of the biogenic residues collected from the surface of the tool and from the cultural layer (Pantyukhina 2020; Skakun *et al*. 2019).

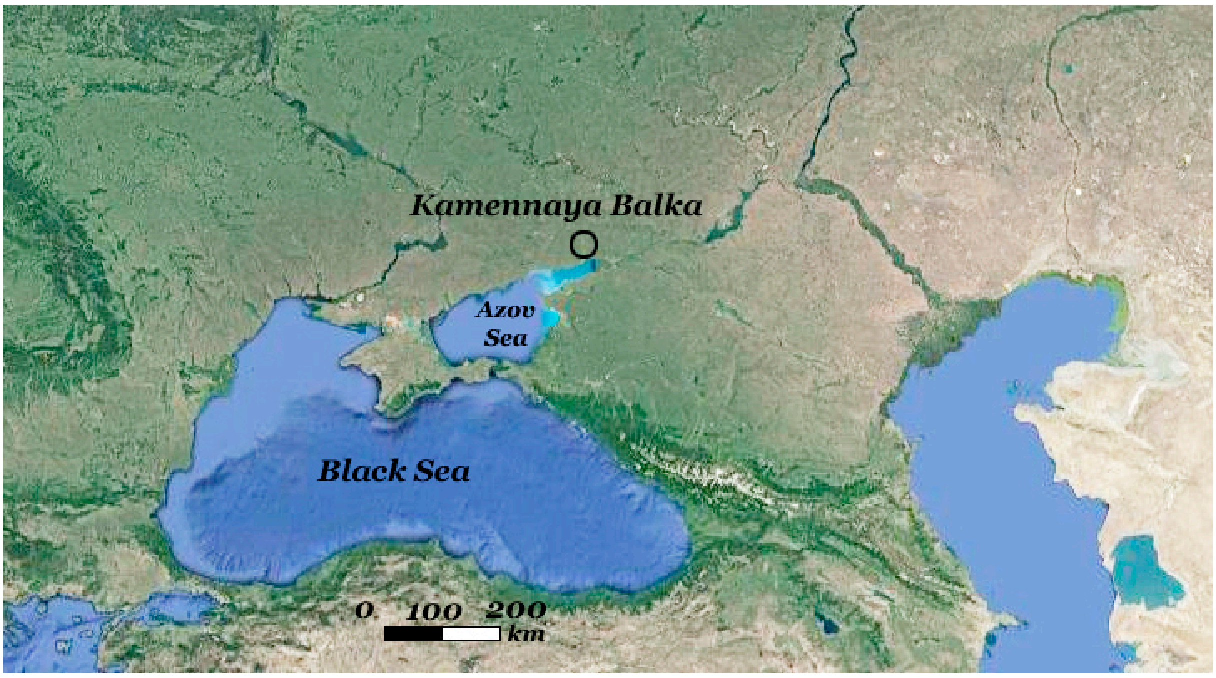

Figure 1. Location of the Kamennaya Balka Paleolithic sites complex.


Figure 2. Kamennaya Balka II site. Location of the studied slab in the lower layer (scale bar = 10 cm).

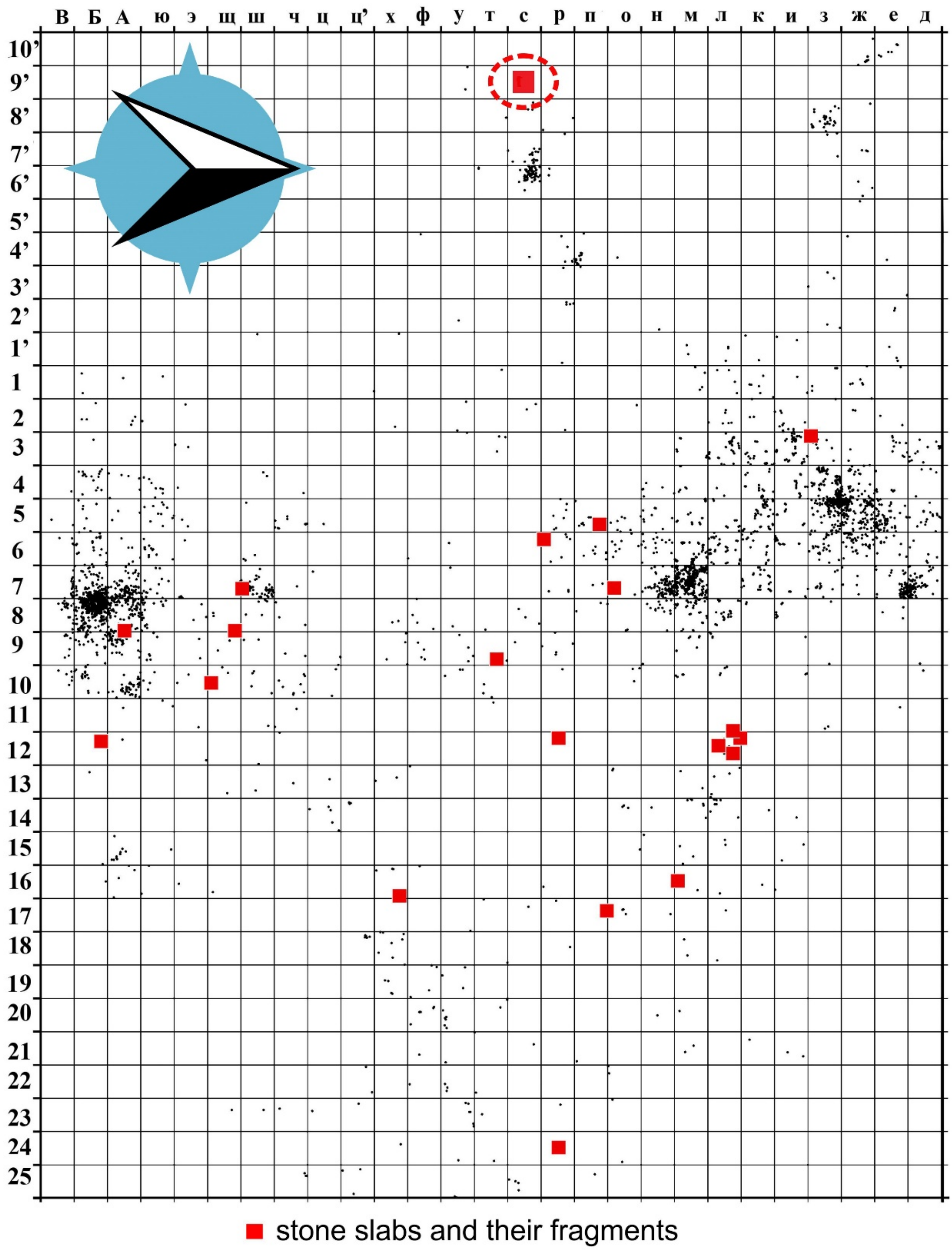

Figure 3. Kamennaya Balka II site: bottom layer. Plan of finds with stones and slabs. The studied slab is located in grid c9´. A red square was enlarged to show the right place.

Technological and traceological analyses were carried out using an MBS-10 stereomicroscope with magnification from 8.4× to 98× and an Olympus BHMJ metallographic microscope with magnification from 50× to 500×.

Microphotographs were taken with a Canon EOS 400D digital camera mounted on a metallographic microscope with a DIC (Differential Interference Contrast) module; photo fixation was performed with built-in illumination passing through the lens. The resulting pictures were post-processed by means of the Helicon Focus software into a fully focused image.

Biogenic residues were examined by optical microscopy. Micro-residues were removed from the surface of the tool using an ultrasound bath Jeken PS-20 (frequency 40KHz, power 120W) (see Figure 4) and taken from the water sample according to the published method (Pearsall *et al.* 2004). The bath was pre-washed with running water and alcohol, distilled water was used for sampling; sampling time - 30 min at 20ºC.

Figure 4. Solubilization of the adhering biogenic residues from a slab found on the Kamennaya Balka II site using an ultrasonic bath.

Residue samples were processed for starch extraction using the heavy liquid CsCl (in a specific gravity of 1.8). Extractions were mounted in 50% vol. glycerol and 50% vol. distilled water on glass slides for microscopic examination. A transmitted light AxioScope A1 microscope equipped with polarization and DIC modules was used to search and photograph starch granules. Working magnifications - 200× and 400-600×.

The routine search for starch was carried out in polarized light at 200× magnification. After detecting objects with a "Maltese cross", they were examined at 400-600× magnification. Each starch granule was photographed in polarization mode, DIC and bright field.

The description of the detected starch was carried out according to standard parameters corresponding to ICSN 2011 (ICSN 2011). Photo processing and measurements were carried out using the Zen2012 Carl Zeiss software. The discovered starch was divided into types according to a complex of morphometric features (Pantyukhina 2020; Pantyukhina *et al.* 2018; Torrence *et al.* 2004). Type identification was carried out by comparison with reference starch samples from a collection of 135 plant species and published references of different plants (Reichert 1913: 5-300).

3. Results

3.1. Technical and morphological analysis

The investigated slab has a trapezoidal shape and does not bear traces of roundness. Single percussion facets can be seen on the lateral sides. The length of its lower base is 26 cm, the upper one is 16 cm, one of the lateral sides is 20 cm and the other is 17.5 cm. Its thickness is 4 cm and it weighs 3880 g (Figure 5A).

On both surfaces and on the sides of the slab, areas of artificial processing by pecking made with a sharp tool are clearly visible. In the central part of the upper surface a shallow (0.8 cm) rounded depression (17 cm in diameter) with indistinct boundaries was created by pecking) (Figure 5A, shown encircled). On the surface of the depression there are spots with a partially destroyed natural top layer of stone. On the lower surface, one of the corners of the object is deformed by natural layering (Figure 5A, shown by arrow; Figure 5B).

3.2. Traceological analysis

When examining the slab under a low-magnification stereomicroscope, the areas with pecking were outlined and several compacted areas were identified in the central parts of the upper and lower surfaces. The most revealing use-wear traces, determining the function of the tool, were found during careful study of the micro-relief using 100× and 200× magnification on the deepened part of the upper surface on the rock grains lying in one plane (Figure 6).

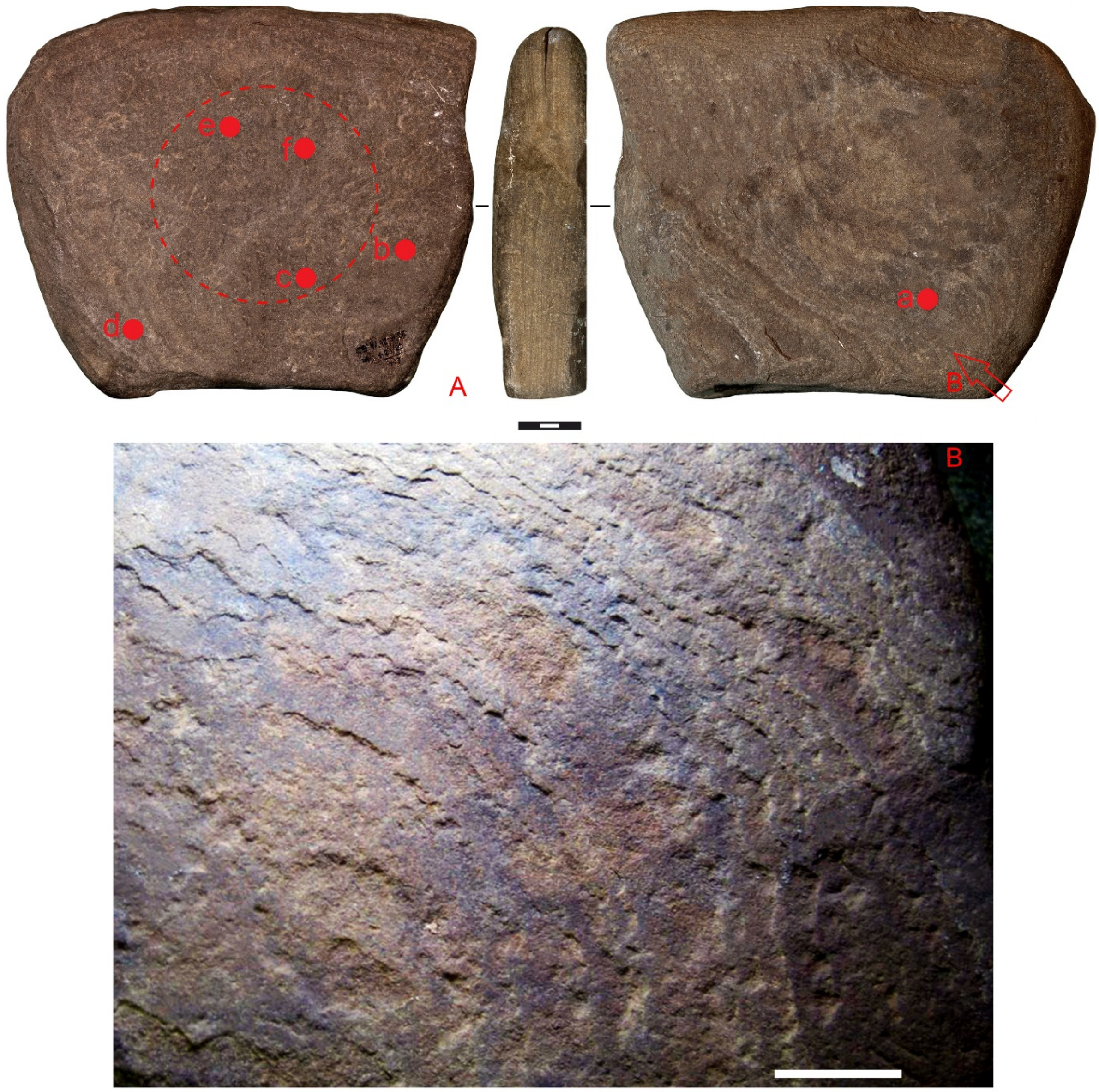

Figure 5. Slab from Kamennaya Balka II site (A): a to f spots where microphoto have been taken (see figure 6). The whole area of the slab was involved in the solubilization in the ultrasonic bath to extract use-related biogenic residues. B: spot and macrophoto of it of the lower deformade surface (scale bar = 1 cm).

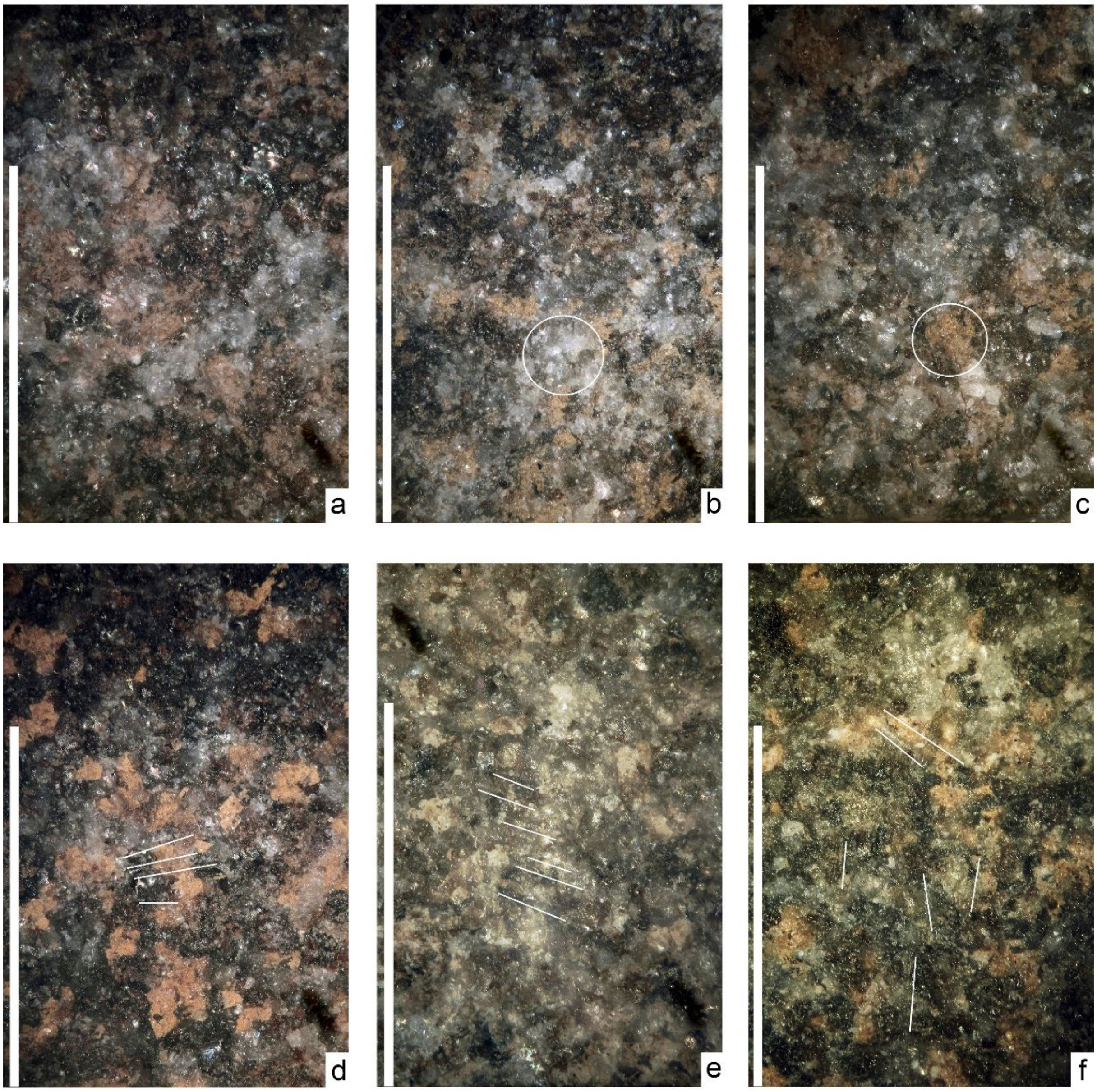

Figure 6. Microphoto of the surface of the lower grinding stone from the Kamennaya Balka II site (100×, scale bar = 1 mm): a - natural surface; b - surface with traces of technique of tool-making by pecking; c - surface with traces of percussion; d-f - working surface with linear use-wear traces.

They differ from the unused areas of the tool in the soft roundness of their boundaries; sometimes, short, shallow microcracks can be seen on them. The edges of the dimples and protrusions left by pecking were also rounded and worn out as a result of use of the tool. These places, with intensive leveling of the microrelief, capturing all its high points and giving them a denser, worn look, are concentrated in the central part of the depression and in some areas of the periphery of the working surface. In addition, spots of micropolishing, dense, smooth, fragmentarily located can be recognized. The smallest linear traces, short and superficial, are randomly located on the polish spots in the flat-lying grains of the rock. Their smoothness indicates friction contact with a soft material, and their orientation shows that the movement was performed both reciprocally and in different directions.

It is important to note that the described use-wear traces differ significantly from those on tools used as abrasives for stone, bone or antler, palettes and also grinding stones of later periods used for processing cereals (Adams *et al.* 2009; de Beaune 2003; Del Bene 1979;

Semenov 1957: 164-174; 1974: 276-281; Shchelinsky 1994; Skakun *et al.* 2018; 2020a, b; Stepanova 2015: 16, 26-27; 2020). The former are characterized by the presence of specific traces of friction between two stones - the working part of the abrasive and the surface of the stone tool being ground. This action leads to more intense abrasion and appearance of areas with uniform smoothing on the working surface of the abrasive, the formation of linear traces in the form of grooves, streaks, scratches, visible with the naked eye or under a microscope. The working parts of abrasives for bone are distinguished by specific changes in the microrelief of the stone surface: stepped scarred damage of the stone grains and slight rounding of their edges; a light shine does not spread fragmentarily, but throughout the working part. For palettes, a weak smoothness of the working areas is characteristic, but as a rule there is no polish on them, while grains of ochre often remain in the pores of the stone. Grinders for processing grains of cultivated cereals have a working part specially prepared by notches, which significantly influenced the nature of wear of its microrelief.

The complex of use-wear traces found on the upper surface of the studied item from Kamennaya Balka II makes it possible to attribute it to the tools used for kneading, shredding and grinding plant materials. The location of the wear traces indicates that it was the steady lower stone, grinding on which was carried out with a small stone or *mano*. It should be emphasized once again that neither on the working part of the investigated tool, nor on its periphery, were there any distinct traces of stone-on-stone friction, which indicates that there was an interlayer of processed plant material between the lower grinding stone and the mano. The lower surface of the investigated slab bears weakly pronounced traces of utilization in the form of slight wear, which makes it impossible to unambiguously determine the specificity of its use.

3.2.1. Experimental data

Replicative experiments were designed to study the peculiarities of the use of Upper Paleolithic grinding stones involved literary review; the selection of stone raw materials for the manos (mobile) and lower grinding stones (steady, passive base) with their preliminary preparation with rough pecking and percussion; collection and preparation of plant materials; their processing by grinding, kneading and crushing. Tools from the sites of Kamennaya Balka II, Suren I, Brînzeni 1, Cosăuți, and Kostenki 14 and 16 (Skakun *et al.* 2019; 2020a; 2020b) served as examples for the replicative experimental artifacts. Large stone slabs corresponding to archaeological specimens in terms of raw material, shape and size were selected for the lower grinding stones, and small elongated or rounded river pebbles were selected for manos (Figures 7 and 8). The experiments were described and recorded in accordance with the protocol developed in the Experimental-Traceological Laboratory of the Leningrad Regional Institute of the Academy of Sciences of the USSR (Institute for the History of Material Culture RAS (Korobkowa 1999: 15; Skakun & Terekhina 2017).

In the course of experimental work, a reference data set was obtained, which made it possible to compare the wear-traces on both the original and experimental tools.

Its working part, as occurred with the original implement, was processed with light pecking for better adhesion to the material being processed. Cattail rhizomes were used as plant raw materials. This plant was chosen for experiments due to its presence in the pollen diagrams of Kamennaya Balka II, and besides some experts assume that this plant, which is readily available and rich in starch, could well be a subject of gathering (Kozlovskaya 2002). Ethnographic observations show that cattail rhizomes in some rural regions of Europe (especially the modern territories of Moldova, Ukraine and the Caucasus) served as food until the present day (Zamyatina 2013: 199-201).

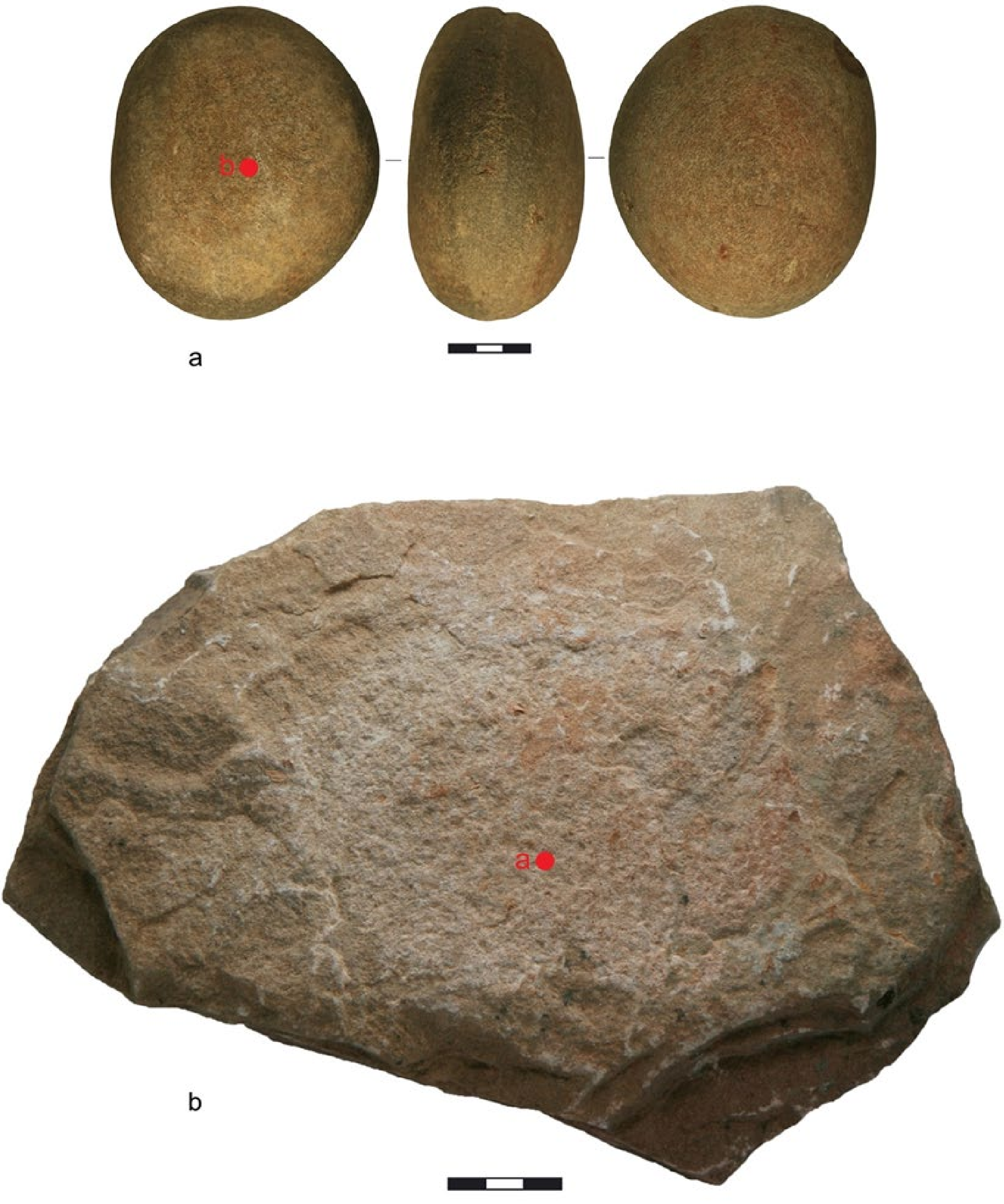

Figure 7. Experimental tools for grinding dried cattail roots after the end of an experiment: a - mano; b - grinding stone (scale bar = 1 cm). The red spot indicates the location from which the micro-photo was taken (see Figure 10).

Figure 8. Grinding dried cattail roots on an experimental grinding stone.

In the replicative experiments, the peeled and slightly dried cattail rhizomes were kneaded and ground with reciprocating (back and forth) or circular motions. The wear traces that formed on the experimental tool after five hours of work were similar to those on the original stone. As a result of the experiments, a light, thin substance was obtained (Figure 9); after mixing it with water, a pasty mass was formed, suitable for forming small pancakes.

Figure 9. "Flour" from dried cattail rhizomes obtained during the experiment.

During the replicative experiments, the types of polishing and linear traces, the time of their appearance and the nature of their location on the working surface were recorded and described (Figure 10).

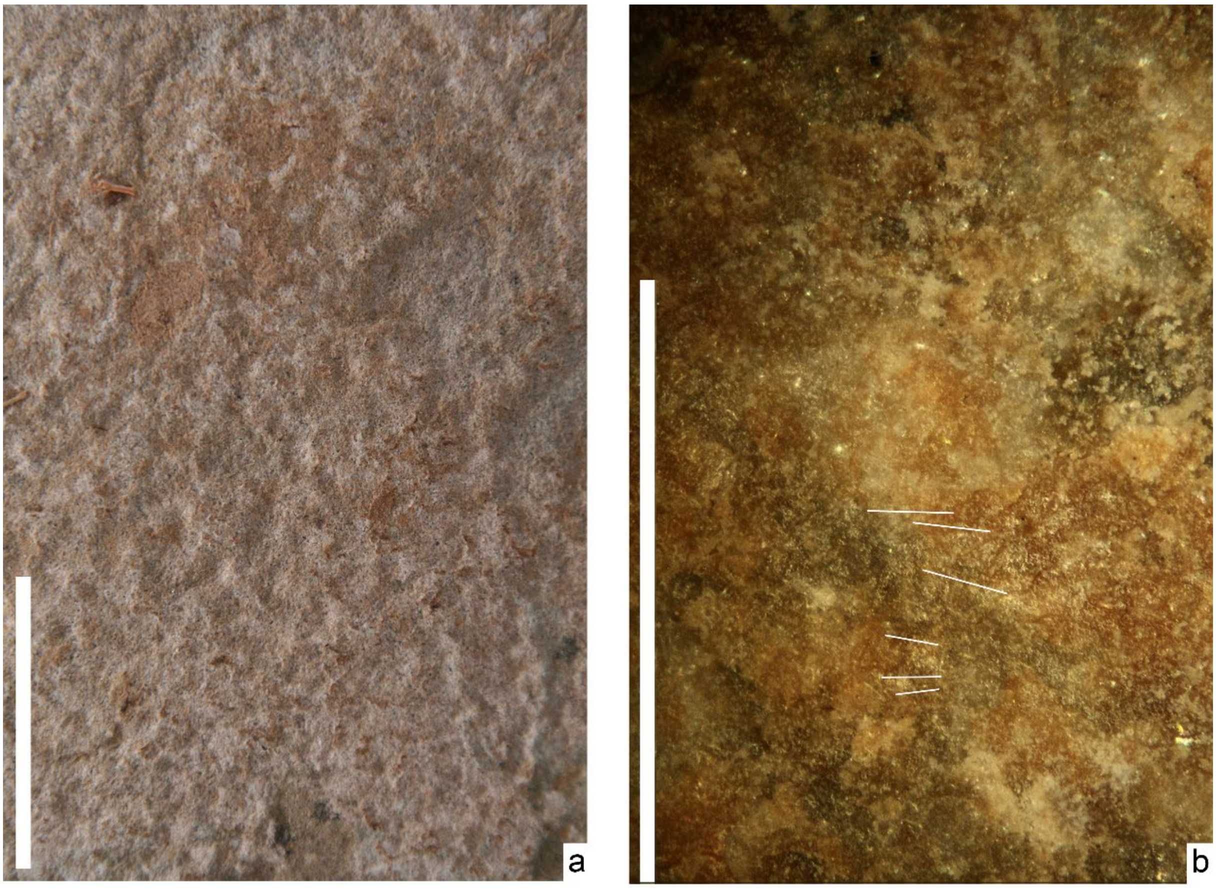

Figure 10. Micro-photo of the working surfaces of the experimental lower grinding stone (a - 50×, scale bar = 1 mm) and mano (b - 100×, scale bar = 1 mm). White lines in the micro-photo emphasize thin thread-like linear traces.

The data obtained will serve as a reliable source for identifying tools with a similar function among stones from Upper Paleolithic collections. Our observations are also consistent with traces on ethnographic stones (Figure 11).

3.3. Analysis of plant residues

In the process of studying the biogenic residues found on the working part of the grinding stone, 83 well-preserved individual starch granules and one clump were obtained. The latter is an amyloplast - a cell where starch granules form and accumulate. Among the granules, there are specimens demonstrating mechanical deformation (Figure 13A) and signs of the enzyme attack on granules during taphonomic process (Figure 13B) (Pantyukhina 2020; Sujka & Jamroz 2007; Sun & Henson 1990). The quantitative results are presented in Table 1. In the course of research, starches of five types of plant species were identified.

Figure 11. Ethnographic tool (lower stone and mano) for grinding berries and grains (MAE RAS No. 958-6 / a-b). Cheyenne, Wyoming, USA, Late 19th century (scale bar = 1 cm). The white spot indicates the location from which the micro-photo was taken (see Figure 12).

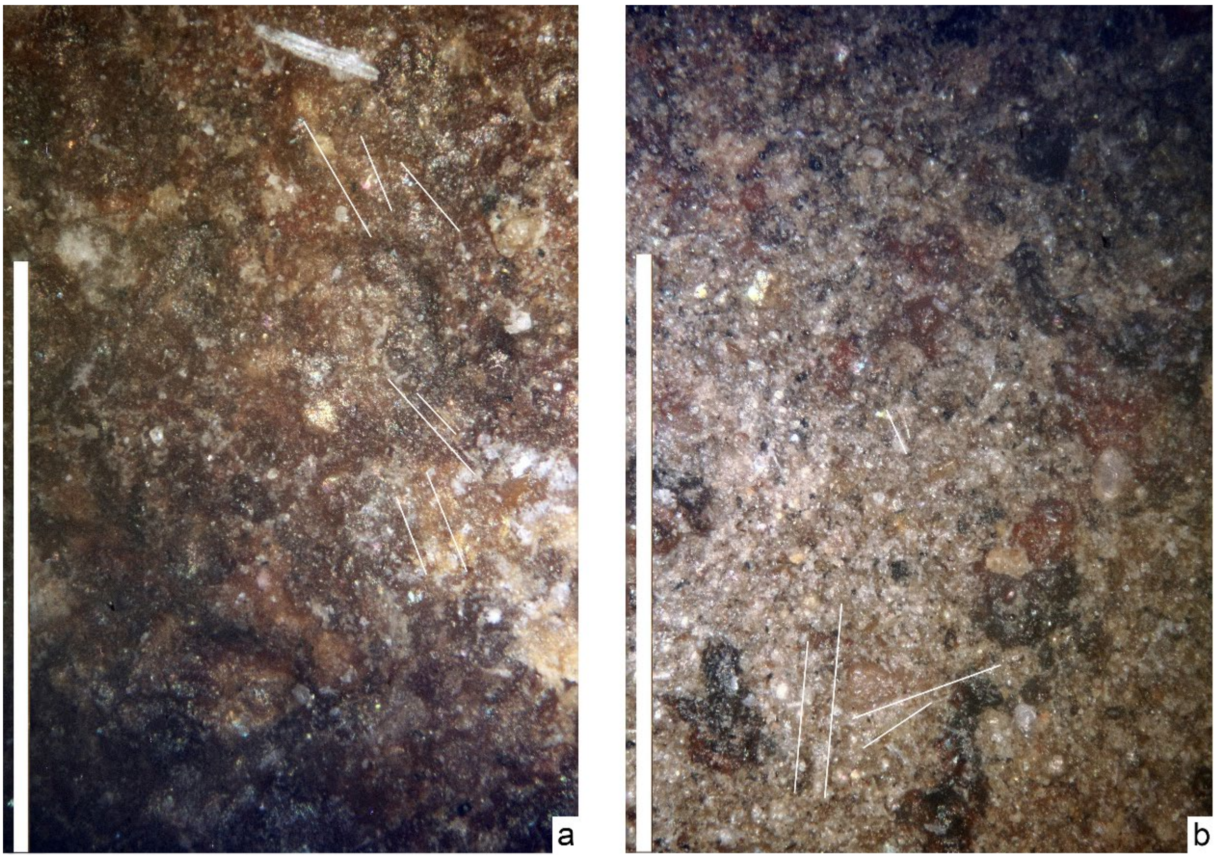

Figure 12. Micro-photo of the working surfaces of the ethnographical lower grinding stone (a - 100×, scale bar = 1 mm) and mano (b - 100×, scale bar = 1 mm). White lines in the micro-photo emphasize thin thread-like linear traces.

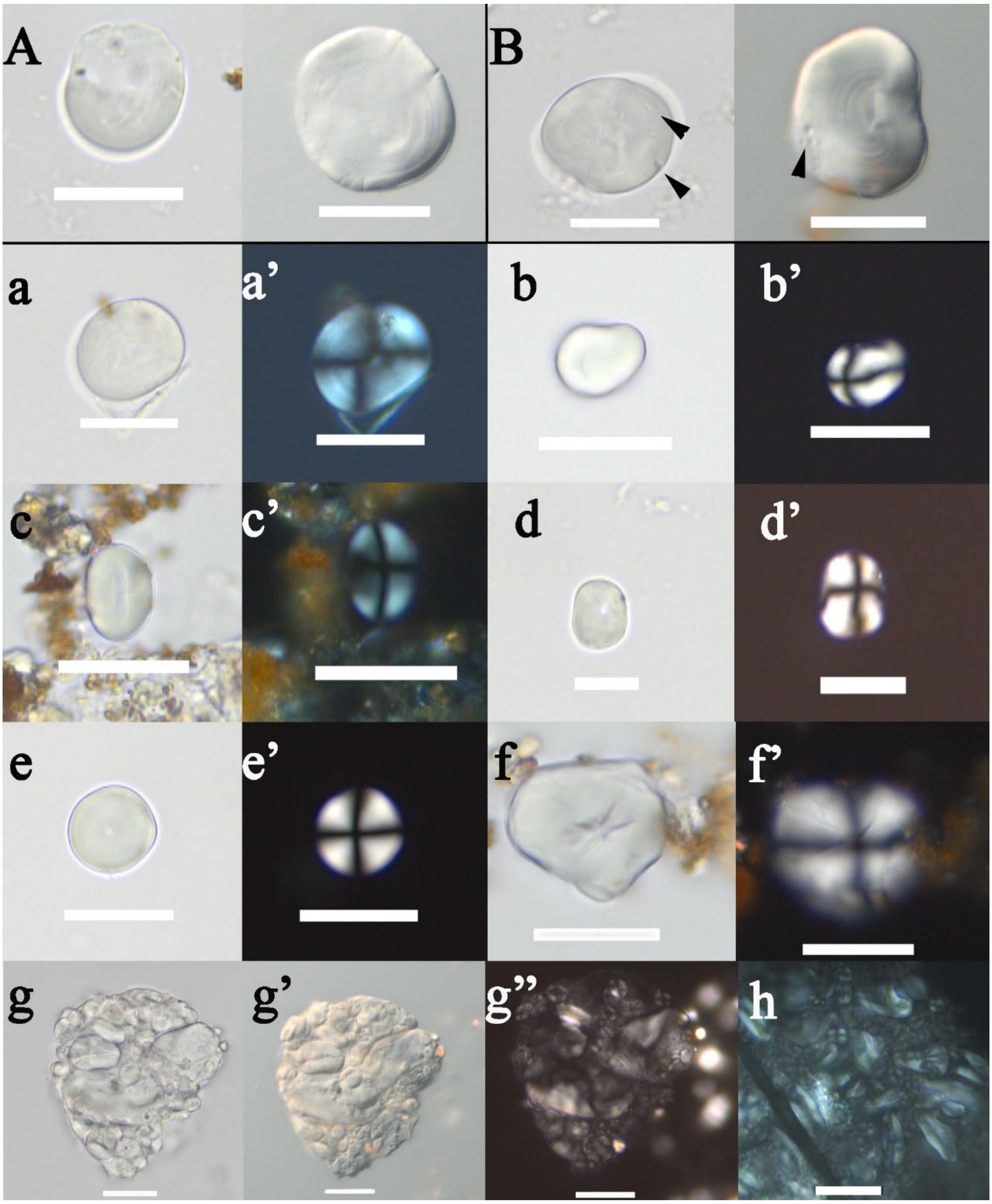

Figure 13. Ancient starch retrieved from the slab from the lower layer of the Kamennaya Balka II site. A - mechanically damaged starch granules. B - traces of enzymatic action on the shell. Arrows point to craters. A & B - granules of type 1. a - type 1; b - type 2; c - type 3; d - type 4; e - type 5; f - type 6; g - starch clamp, type 1; h - a clamp of modern starch (Elymus sp.), type 1. A on left, B on left, a, b, c, d, e, f, g - bright field; a', b', c', d', e', f ', g'', h - polarization mode; A on right, B on right, g' - DIC contrast mode. Scale bar: 20 µm, d - 10 µm.

Table 1. Distribution of starch by type. (Percentages are not provided. The quantitative contribution of each type in this study cannot reflect the significance of any taxon in the life support system)

	Type 1 Triticeae	Type 2 Typha	Type 3 Fabaceae	Type 4 Polypodiales	Type 5 USO	Type 6 Unidentified	Total
Amount	7	11	7	18	15	25	83
Clump	1	-	-	-	-	-	1

Type 1. Triticeae tribe. Separate large granules and a clump of starch with a full set of starch grains typical for this type of cereals. The shape of the granules is round, oval or lenticular in cross section. Hilum is usually in the center or displaced to one of the longitudinal sides, lamellas are visible. The surface is smooth. Extinction cross "X" or "+" shaped, the arms are straight or curved. Sizes range from 18 to 30 microns.

The starch of many Triticeae tribe cereals demonstrates bimodality - 2 groups of granules with certain morphometric characteristics: large and small. Large granules possess the identification potential, while small ones are practically impossible to diagnose separately, since similar morphometric types are present in various tissues of many plants. However, in the case of detection of starch clumps from seeds of Triticeae tribe cereals, both groups of granules will be presented (Figure 13a and g).

Type 2. Cattail (Typha). Its shape is round, oval, sub-triangular or drop-shaped. Depending on the projection and shape of the granule, the cross is located either in the center or slightly displaced. Lamellas are rarely seen. The surface is smooth, with sparse facets at one of the ends. On the surface of the granules, there are frequent small cracks, longitudinally or radially directed or smoothly enveloping the center. The extinction cross is "X" or "+" shaped, the arms are straight or arched. Size is about 7-15 microns (Figure 13b).

Type 3. Fabaceae. The shape of the granules in various projections is oval, bean-shaped or sub-triangular. Hilum is centered or offset. Lamellas are rare. In the lateral projection of the granules there is a longitudinal blurred crack. The surface is smooth. The extinction cross is "X" or "+" shaped, the arms are straight or arched. Size is about 9-16 microns (Figure 13c).

Type 4. Fern (Polypodiales). The shape is round, ovoid or oval. Hilum is in the center or offset; and looks like a small depression (this is an optical effect, since the physical center of the starch granule is located inside it. We can see different forms of this growth point because starch is more or less translucent to the light microscope (depending on the taxon and state)). The lamellas are not visible. Cracks are found in single granules and are longitudinal. For ferns in our collection, cracks are not typical, but they can be correlated with the conditions of plant processing and the preservation of ancient starch. Some granules, including round ones, have a bumpy surface. This surface condition is not typical for spherical starch forms in many plant species, but occurs in ferns, both in our reference collection and in published works (Revedin *et al.* 2010: fig. 3J). The extinction cross is "X" or "+" shaped, the arms are straight, arcuate, or have curvatures at the ends. Sizes lay in the range 4-15 microns (Figure 13d).

Type 5. Plants with underground starch storage organs (USO). In this group, we attributed single granules that show similar signs characteristic of some unrelated species: irises, lilies, aroids, water lilies and many other USO plants. It is impossible to single out any separate morphotype in this group in order to correlate with a specific taxon.

The shape is round or bell-shaped. Hilum is located in the center or offset to one of the ends, and is pointed or rounded. Sometimes lamellas are visible. Rare cracks are star-shaped. The surface is flat or there are several facets at one of the ends. The extinction cross is "+" or "X" shaped, the arms are straight, rarely with curves at the ends. Sizes are between 6 and 22 microns (Figure 13e).

Type 6. Unidentified plants. Despite the fact that this group included those starches for which no analogues were found among our reference dataset, they demonstrated uniformity of characteristics, as if they belonged to the same plant species. The shape is polyhedral. Depending on the projection of the granule, the hilum is centered or offset. It looks like a point, or bridged by "Y" or "X" shaped or transverse short cracks. The surface of the granules is smooth, with numerous edges, or bumpy. The extinction cross is "+" or "X" shaped, the arms are mostly curved. Sizes are between 13 and 26 microns (Figure 13f).

4. Discussion and conclusion

Use-wear traces in the form of changes in microrelief, micropolishing or linear traces, observed on the working part of a slab from Kamennaya Balka II site during traceological studies indicate its use as a lower grinding stone for processing plant materials. This type of traces is in general agreement with those observed on grinding stones with a similar purpose from other Upper Paleolithic sites such like Suren 1, Brînzeni 1, Cosăuți and sites of the Kostenki group, but differs in intensity of their development, probably related to the duration of use and the type of processed plant materials (Longo & Skakun 2017; Revedin *et al.* 2010; Skakun *et al.* 2018; 2019; 2020a; 2020b; Stepanova 2020). Experimental work carried out in order to obtain standards with consistently expressed signs of wear confirmed the results of the traceological studies (Skakun *et al.* 2020a; 2020b).

The set of plants, determined by analyzing biogenic residues on the working part of the tool, represents various landscape components: meadows, shores along the fresh water ponds, creeks or humid lowlands, swamps and forests. These results are fully consistent with the data of palynological and pedological studies in the site, which indicate the existence of coniferous and broad-leaf forests, plant complexes characteristic of wet meadows and temporary reservoirs (Leonova 2015). The identification of starch grains allows us to suggest several possible ways of using plants by the inhabitants of Kamennaya Balka II site within the framework of a general life support system - both for food and possibly for household and medical purposes. For instance, Fabaceae, Typha and bulbs of some plants taste quite good when fresh and do not require the use of any culinary techniques (although heat treatment increases bioaccessibility), which are not reflected in the artifacts, but can be confirmed through the presence of starch, for example, in dental calculus (Buckley *et al.* 2014; Cristiani *et al.* 2016; Hardy *et al.* 2017; Henry *et al.* 2010). In addition, while cattail, corms, and ferns are available throughout the growing season, legumes and cereal species have a very limited harvest period, when the maximum amount of starch is formed in mature (ripe) plants. The grinding stone was used for pounding (grinding), kneading, pressing both raw and dry parts of starchy plants for direct consumption, making pancakes, as well as for subsequent drying, stockpiling and storage. Thus, the find of the grinding stone suggests that the inhabitants of the Kamennaya Balka II site provided themselves not only with seasonal consumption of vegetable carbohydrates, but also made reserves to maintain their stable use in their diet throughout the year.

Finds of special tools dedicated to processing useful plants at Kamennaya Balka II and other sites of the Russian Plain (Longo 2016; Longo & Skakun 2017; Longo *et al.* 2019; Skakun *et al.* 2018; 2019; 2020a; 2020b; Stepanova 2020) indicate the existence of complex foraging strategies including gathering plants and their processing as part of the economy of the Upper Paleolithic hunters, proving a deep knowledge of their habitat' resources, the acknowledgment of the dietary value of carbohydrates and the capacity to transform them into staple food.

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Data accessibility statement

The data use here are from the ownership of the authors, and the others are cited. The authors confirm that the data supporting the findings of this study are available within the article.

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Функциональное использование крупного каменного орудия из верхнепалеолитической стоянки Каменная балка II (Северное Приазовье, Россия)

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Резюме:

В археологических коллекциях многих палеолитических стоянок Русской равнины и других территорий Евразии встречаются крупные немодифицированные орудия из различных пород камня: песчаника, кварцита, гранита, реже сланца. Одни из них сохраняют свою естественную форму и не имеют следов какой-либо искусственной обработки, что затрудняет их типологическую классификацию, другие имеют минимальную обработку ударной техникой, пикетажем или пришлифовкой. Трасологические исследования показывают, что подобные артефакты использовались как отбойники, абразивы, наковальни, краскотерки, лощила, а некоторые являлись терочниками для обработки растительного сырья. Поскольку последние представляют собой основные свидетельства обработки и использования растений в верхнем палеолите, то их изучение требует комплексного подхода, включающего кроме археологических методов изучения еще и анализ органических остатков.

Наше исследование посвящено всестороннему анализу крупного каменного предмета из многослойной верхнепалеолитической стоянки Каменная Балка II (даты 14С по костному пеплу: СПб-1085: 15 360 ± 200 н. кал. л.н., 18 825 или 19 031 кал. л.н.). Эта стоянка относится к комплексу памятников, расположенных в низовьях реки Дон, в Ростовской области России. Предмет изучался технологическим и трасологическим методами, также была сделана серия специальных экспериментов, посвященных реконструкции процессов обработки растительных материалов с помощью реплик палеолитических каменных орудий. Важной частью исследования являлся анализ биогенных остатков, полученных с поверхности оригинального орудия из культурного слоя стоянки Каменная Балка II.

Исследованная плитка имеет трапециевидную форму, на ее обеих поверхностях и по боковым сторонам отчетливо видны участки с искусственной обработкой пикетажем, выполненным острым инструментом. В центральной части верхней поверхности с помощью пикетажа было образовано неглубокое (0,8 см) округлое углубление (диаметром 17 см) с нечеткими границами. В его центральной части обнаружены следующие следы утилизации: микрорельеф приподнятых зон поверхности интенсивно выровнен, границы ямок пикетажа

снивелированы, мельчайшие линейные признаки - короткие, поверхностные линии - беспорядочно располагаются на пятнах заполировки в плоско расположенных зернах породы. Данный комплекс изношенности позволяет считать, что орудие из Каменной Балки II, использовалось как нижний камень терочника, служившего для обработки растительного сырья. Для изучения особенностей использования подобных орудий были проведены экспериментальные работы, включавшие подбор каменного сырья для верхних подвижных и нижних неподвижных терочных камней, их обработку оббивкой и пикетажем, сбор и подготовку растительного сырья; его переработку с помощью измельчения и дробления. Для нижних терочных камней были выбраны крупные каменные плиты, соответствующие археологическим образцам по сырью, форме и размерам, а для верхних камней – мелкая речная галька удлиненной или округлой формы. В опытах очищенные и подсушенные корневища рогоза разминались и растирались возвратно-поступательными или круговыми движениями. Следы износа, образовавшиеся на экспериментальном орудии после пяти часов работы, были аналогичны следам на орудии из Каменной Балки, что подтвердило правильность трасологического анализа. В результате растирания рогоза была получена мелкодисперсная мучнистая субстанция, после ее замеса с водой образовывалась пастообразная масса, пригодная для формирования небольших лепешек. В ходе повторных экспериментов были зафиксированы и детально описаны виды заполировок и линейных следов, время их появления и характер расположения на рабочей поверхности. Набор растений, определенный при анализе биогенных остатков с рабочей части орудия, представляет различные виды луговой и прибрежно-водной растительности, что хорошо согласуются с данными палинологических и почвоведческих исследований Каменной Балки II. Их идентификация позволяет предполагать возможность использования этих растений обитателями Каменная Балка II как в качестве пищи, так в медицинских и хозяйственных целях.

Находки в материалах Каменной Балки II и других памятников Русской равнины специальных орудий, предназначенных для обработки полезных растений, свидетельствуют о существовании в хозяйстве эпохи палеолита сложных стратегий пищедобычи, включающих сбор растений и их переработку, что доказывает глубокое знание верхнепалеолитическими охотниками ресурсов их среды обитания, признание диетической ценности углеводов и способности превращать их в основные продукты питания.

Ключевые слова: верхний палеолит; Россия; каменная плитка; технологический анализ; трасологический анализ; экспериментальный анализ; биогенные остатки