


## Research Article

# The unique Late Paleolithic artifactual bone assemblage from the Volchia Griva site, Western Siberia

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### Abstract

In 2020, a unique bone assemblage was found at the Late Paleolithic site Volchia Griva. Its base is made of a distal mammoth femur minus epiphysis, in which a cavity has been hollowed out. Impact notches along the edges of the cavity and holes in the metaphysis prove the human-made nature of this specimen. A portion of a polar fox cranium, half of a fox hemimandible, a fox tooth, and a large mammal rib fragment were enclosed in the cavity. The mammoth femur was previously used as a retoucher, as evinced by the impressions and cut marks. Incisions were detected on the polar fox cranium, indicating skinning. According to two <sup>14</sup>C dates, the age of the remains is 19.3–19.1 ka BP. Palynological analysis of the cavity fill shows a forb-grass steppe at that time. The assemblage, which has no known analogues, is a reflection of prehistoric culture. This extraordinary find most likely is evidence of the ritual behavior of people who lived in the south of Western Siberia during the last glacial maximum. The assemblage was accompanied by a large number of fox remains, and lithic artifacts identical to bladelet-based Late Paleolithic industries of Siberia and the Middle Urals.

**Keywords:** Late Pleistocene, Western Siberia, Mammoth fauna, Paleoecology, Taphonomy, Late Paleolithic, Ritual behavior

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### INTRODUCTION

In September 2020, during excavations at the Volchia Griva (VG) site in Western Siberia, Russia, in the lower bone-bearing level dated to ca. 20–18 <sup>14</sup>C ka BP, the broken-off distal end of a mammoth femur was found containing bone fragments and teeth of foxes. All these remains form an artifactual bone assemblage (ABA). There are no analogues for such a find either for the period of the last glacial maximum (LGM) or for the entire Paleolithic of Siberia. This confirms the uniqueness of VG, which was discovered in 1957 (Polunin, 1961) and studied in the 1960s through early 1990s (Alexeeva and Vereshchagin, 1970; Okladnikov et al., 1971; Maschenko and Leshchinskiy, 2001; Zenin, 2002; Leshchinskiy et al., 2008), as a paleontological, geological, and archaeological site in Northern Eurasia.

This publication follows a series of articles based on a new stage of research at VG since 2015 (Leshchinskiy et al., 2015). The results of seven fieldwork seasons indicate that VG today is the largest woolly mammoth locality in Asia, which also contains many Late Paleolithic artifacts. Excavations on an area >550 m<sup>2</sup> since the 1950s, numerous test pits, manual exploratory drilling, inspection of house cellars and water pipe trenches, and data from local residents allowed us to determine a total of

several hectares of space where mammoth faunal remains were found.

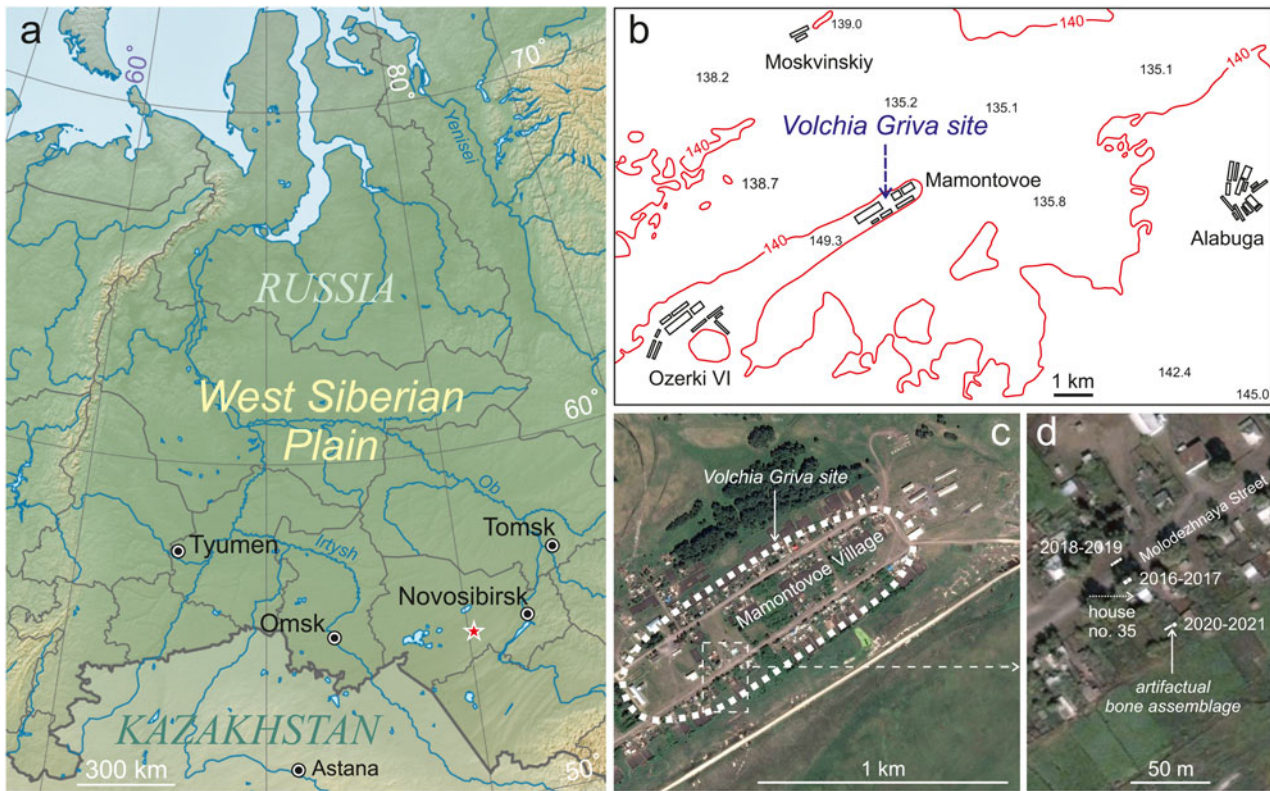
The bone-bearing horizon of VG, which is represented by a series of large lens-like strata that forms three levels in some places, contains tens of thousands of bones and teeth belonging to woolly mammoth, horse, bison, wolf, fox, rodents, and other mammals. The maximum concentration of only mammoth remains in some places exceeds 130 items/m<sup>2</sup> (Leshchinskiy and Burkanova, 2022). Lithic artifacts are found throughout the site, but their concentration is usually low (<1 specimen/m<sup>2</sup>; Leshchinskiy et al., 2021). Nevertheless, the 2020–2021 excavation pits exposed a marginal activity area of the Paleolithic site with a thick ash lens. In some parts of these new excavation pits the highest concentration of cultural materials (>1400 items/m<sup>2</sup>) known at VG was detected. Artifacts are usually small (>50% up to 1 cm in size). There is also a large amount of faunal remains (average concentration >200 items/m<sup>2</sup>), mainly in the form of fragments and whole bones, and teeth of the polar fox. In this paper, we present these data for the first time, including ABA.

### REGIONAL SETTING AND GEOLOGICAL CONTEXT

The VG site is situated in the eastern part of the Baraba Lowland, 220 km north of the border of Russia and Kazakhstan. The mammal remains are found in the northeastern part of the eponymous (Volchia Griva) sloping mound, elongated along an azimuth of ~50–55°. This mound is ~11 km long and ~0.5–1 km wide, with a maximum altitude of ~149 m asl and a relative elevation of 10–15 m above the surrounding grounds. The spatial

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**Figure 1.** Location of the Volchia Griva. (a) Administrative map of the West Siberian Plain (the star indicates the site); (b) county map with local altitudes in meters; (c) the Volchia Griva site within Mamontovoe Village (satellite image); (d) location of 2016–2021 excavation pits with the position of the ABA.

distribution of the currently known faunal and cultural materials is located within Mamontovoe Village, Kargat County, Novosibirsk Province (Fig. 1).

Currently, the Baraba Lowland is located in the forest-steppe zone of the Ob-Irtysh interfluvium. Open landscapes, unchanged by human activities, are covered with steppe halophytic-grass meadows. In forest outliers, birch dominates; willow and aspen are also found. The modern climate is markedly continental. According to observations from the middle of the twentieth century, the average air temperatures are: for July +18.3–19.7°C, and for January –19.1°C to –18.2 °C. The average annual temperature is +0.5–1.2°C, with a difference between minimum and maximum annual temperatures of ~80–95°C. The annual precipitation is 315–450 mm (Arhiv Klimaticheskikh Danykh, 2012; Pogoda i Klimat, 2020).

The Baraba Lowland is a large depression covering an area of ~117,000 km<sup>2</sup>. It is filled with predominantly loose sandy–clayey sediments, with a thickness of 500–2800 m or more. Sediment age is continuously traced from Jurassic to Quaternary (Babin et al., 2015). The geological structure of the VG site and the territory adjacent to it shows a complete absence of lithic raw material sources. The nearest accessible bedrock outcrops and alluvial pebble deposits that potentially would have been suitable for lithic toolmaking are located 90 km to the southeast of VG, in the valley of the Ob River. Thus, all lithic artifacts found at VG were brought to the site by humans, but their exact sources are currently unknown (Leshchinskiy et al., 2021).

## SITE STRATIGRAPHY

Excavations in 2020 were carried out in an area of 6 × 2 m, on the periphery of the VG central faunal accumulation discovered in

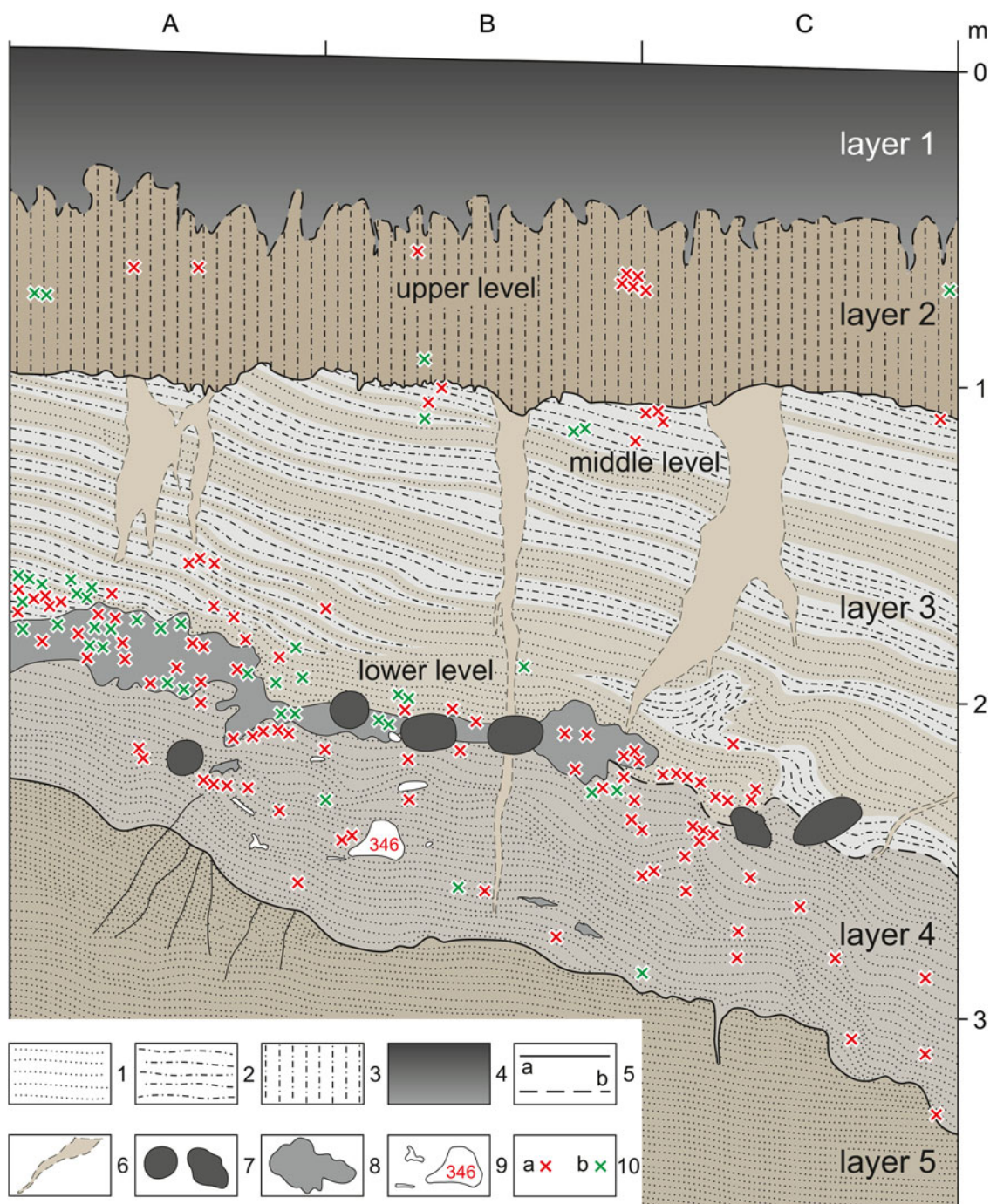
2016. The ABA was located on the mound slope, ~38 m southeast of the 2016–2017 excavation pits (Fig. 1c, d). This area was identified as promising based on the results of exploratory drilling in 2017 (Leshchinskiy and Burkanova, 2022). In 2021, the excavations continued in an area of 3 × 3 m next to the 2020 pit. The spatial position of the ABA is shown on the stratigraphic section (Fig. 2), and in part of the 2020–2021 excavation plans, with the main paleontological and archaeological finds at a depth of 225–330 cm below the ground surface (Fig. 3). The presence of nearby outbuildings and a vegetable garden is reflected in anthropogenic disturbance of soil of the research area. A summary description of the section is given below.

Layer 1 is a black massive sandy loam soil of the chernozem type. It has a thickness of up to 0.5 m (the top was cut off).

Layer 2 is a light-brown, massive loess-like sandy loam that is 0.5–0.7 m thick. Rare lithic artifacts are found throughout the layer, mainly in the middle part. In the lower half of the layer, there are a few fragments of poorly preserved large-mammal bones; they all represent the upper level of finds.

Layer 3 is a gray-brown, thinly laminated clayey sand (whitish if dry due to precipitation of Ca and Na salts from pore waters). The sediments dip along a magnetic azimuth of 120–130° (down the mound slope); sediments at the top dip at an angle of ≤5–10°, and from the middle to the bottom at an angle of 10–15° to 35°. In the upper part of the layer, there are rare lithic artifacts and fragments of mammal bones (the middle level of finds). In the lower part of the layer, sediment deformation and erosion benches up to 0.3–0.4 m high are recorded. An ash lens (thickness up to 0.35 m) is clearly visible on the declining bottom unit. The entire base of the layer (especially the ash lens) includes concentrations of lithic artifacts and faunal remains (the lower level of finds).





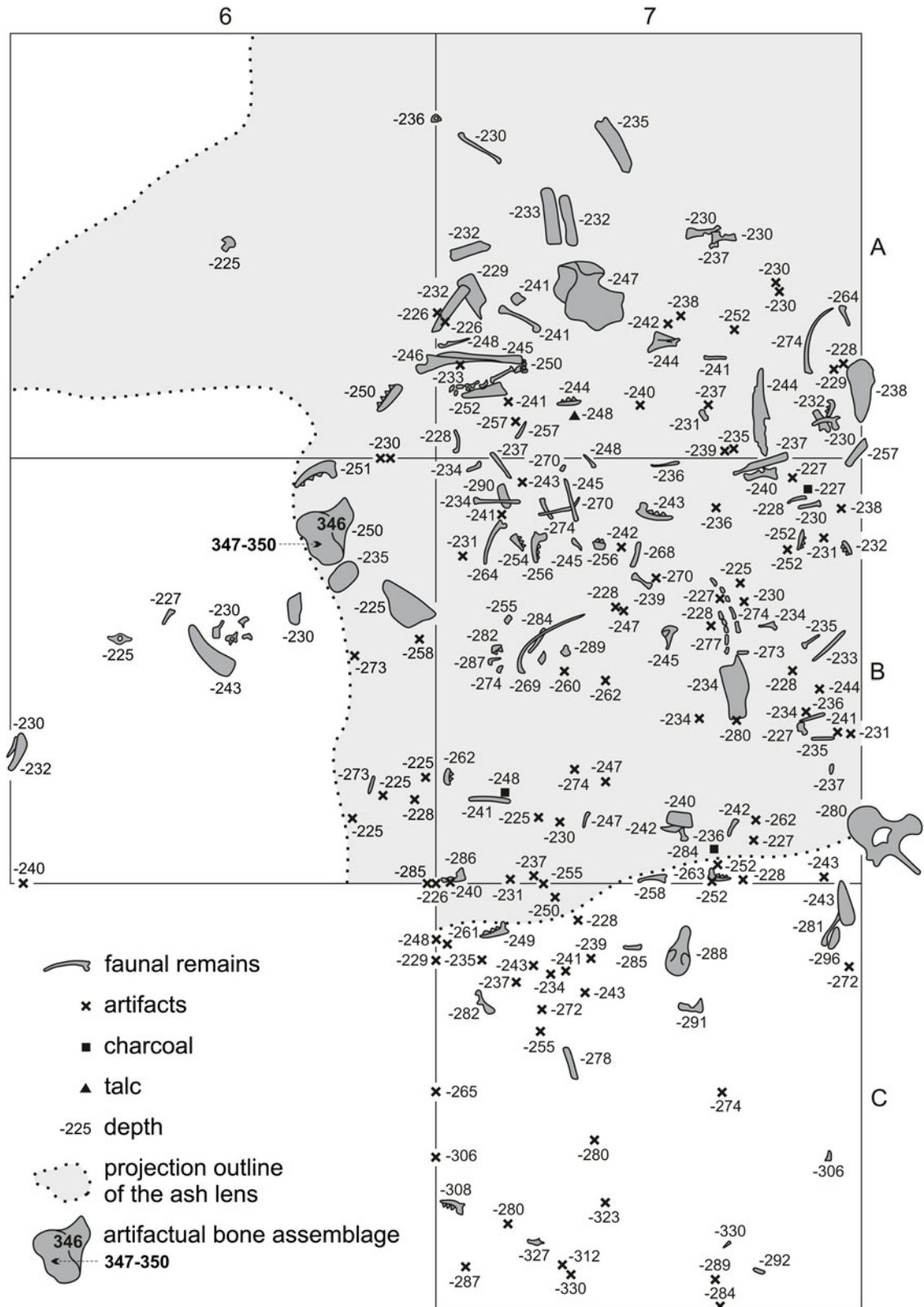
**Figure 2.** Cross-section of the Volchia Griva southeastern slope along the line A-B-C/6-7 of 2020–2021 excavation pits (see Fig. 3 for map view). 1 = sand; 2 = silt; 3 = loess-like loam; 4 = soil; 5 = boundaries (a = certain, b = assumed); 6 = desiccation cracks; 7 = holes of burrowing animals; 8 = sedimentary ash cloud; 9 = faunal remains (No. 346 = ABA); 10 = artifacts (green crosses = from 2020 fieldwork, red crosses = from 2021 fieldwork). Not all artifacts and faunal remains found near the line A-B-C/6-7 are shown.

Among them, fragments and whole bones and teeth of foxes predominate; less common are wolves, mammoths, horses, and other mammals. Thickness is 0.8–1.3 m.

The sediments of Layer 3 are disturbed by chaotic cracks that are filled with loess-like sandy loam, beginning on the bedding surface of Layer 2. The cracks are from  $\leq 3$  cm to  $\geq 20$  cm wide at the mouth, and 0.4–1.3 m long (mean values are 0.7–0.8 m). One crack that is  $\geq 1.7$  m long penetrates deep into Layer 4. Near the boundary with Layer 4, including the ash lens, there are numerous

holes of burrowing animals 10–14 cm in diameter, mostly filled with motley black-brown sandy loam. Some segments of the holes remain unfilled, and sometimes they cross the cracks.

Layer 4 is a light-brown thinly laminated clayey sand. Lithic artifacts and mammal bones and teeth are distributed throughout the layer; small ash spots  $\leq 20 \times 20$  cm in size are also found. All of this is a continuation of the lower level of finds. Often there are washout signs (including erosion benches up to 0.5 m), sliding, and deformation of sediments. The bedding surface with Layer



**Figure 3.** Sketch map of A-B/6-7 - C/7 grids of the Volchia Griva excavation pits in 2020–2021 (squares 1 × 1 m). The artifacts and selected faunal remains are shown from a depth below the zero mark of –225 cm.

5 dips along a magnetic azimuth of 100–130° at an angle of 10–35° (lines A and B) to 70–80° (line C). Thickness of Layer 4 is 0.1–0.6 m (down the slope, >1 m).

Layer 5 is a light-brown thinly laminated sand with many deformations (breaks in lamination, subsidence of microblocks, and other kinds of distortion). The top is broken by small cracks



(length up to 0.3 m, width up to 2–6 cm) that are filled with sand from the overlying Layer 4. The sediments dip along a magnetic azimuth 120–150° at an angle of 5–10° to 20–30°. The visible thickness is >1.3 m.

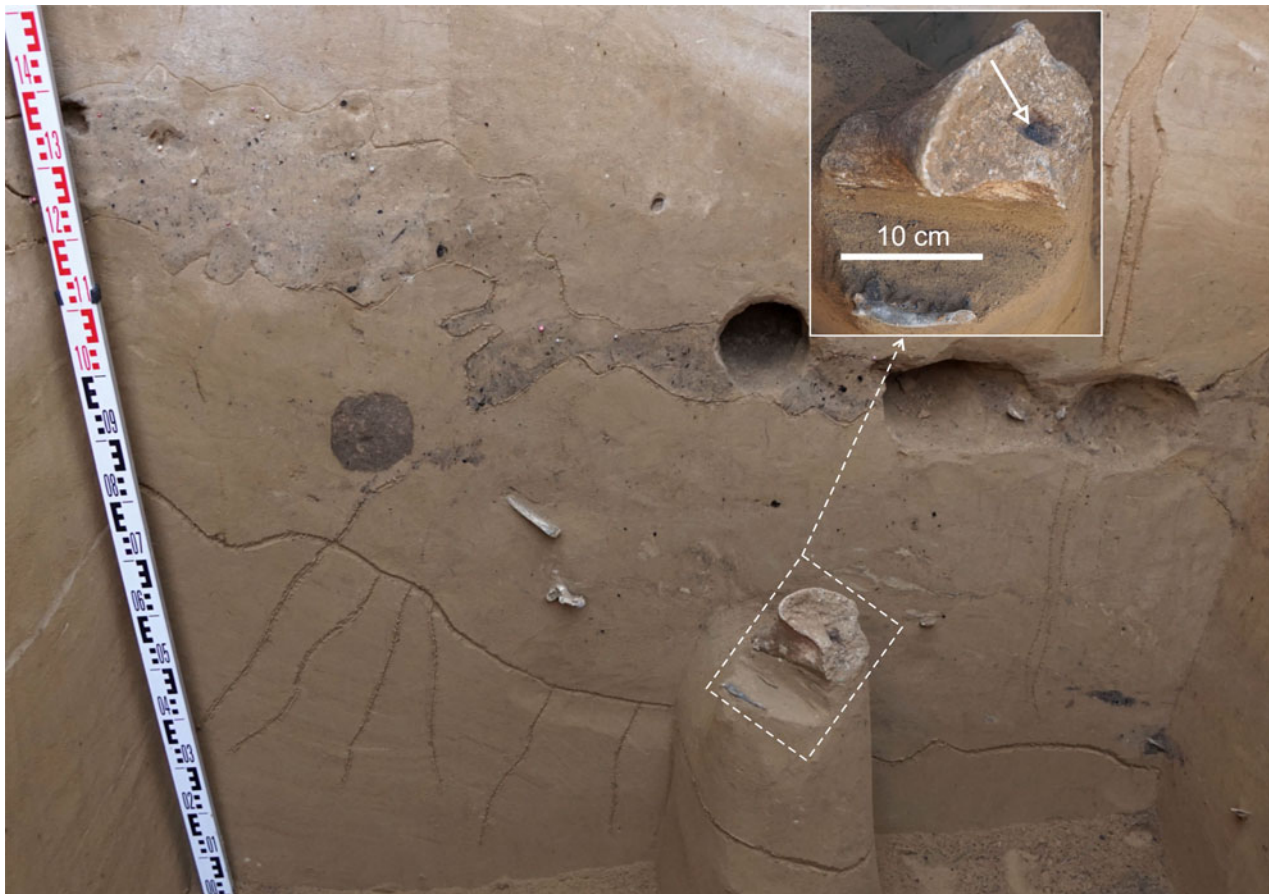
The described section can be divided into two members: member 1, which is subaerial, consisting of Layers 1–2; and member 2, which is subaerial-subaqueous, consisting of Layers 3–5. The eluvial-aeolian genesis of Layers 1–2 is beyond doubt. The stratigraphic hiatus between the members is obvious and is marked by cracks that probably formed during the drying of sandy-clayey sediments. Similar cracks also were recorded in other VG areas (Leshchinskiy et al., 2015, 2021; Leshchinskiy and Burkanova, 2022). Layers 3–5 reflect the transition from shore to lacustrine shallow water. Signs of shore slope erosion and surf activity on the beach area were accompanied by migration of the shoreline, which is marked by erosion benches. Moreover, the presence of cracks and deformations at the top of Layer 5 may indicate another sedimentation hiatus, preceding the appearance of large mammals, including humans, at the VG site. Member 2 displays a very complex relationship of sediments. It is possible that in this part of the section a larger number of layers with well-founded boundaries will be identified in the future. The holes of burrowing animals described above are of Holocene age, as indicated by their filling with a sedimentary mixture from Member 1, partial hollowness, and intersection of desiccation cracks.

The stratigraphic position of archaeological and paleontological materials found during the 2020–2021 excavations generally

corresponds to the previously identified three levels of the VG bone-bearing horizon (Leshchinskiy et al., 2008; Leshchinskiy and Burkanova, 2022, fig. 7). It is important to emphasize that the lithic artifacts and faunal remains at the base of Layer 3 and in Layer 4 represent a single lower level. Figure 2 shows that most of these finds were locally redeposited by temporary streams or were washed away by rain and meltwater down the paleoslope. As a result, many of the finds, including the ABA, are buried in the shallow lake inshore zone. In addition to geological data, this is exemplified by the different degree of preservation of mammalian bones found along the excavation lines of squares A (weathering stages of 3–5 dominate) and B–C (weathering stages of 0–2 prevail).

## MATERIALS AND METHODS

The artificial modification of the mammoth femur became apparent immediately upon its discovery (Fig. 4). Preliminary cleaning of the bone revealed a human-made cavity filled with brownish-gray sandy loam that differed sharply from the light brown sand of the enclosing sediments. This fact suggested a high value of the find, so the femur was placed in a sealed plastic bag to prevent contamination. Subsequent processing of the sample was carried out at the Laboratory of Mesozoic and Cenozoic Continental Ecosystems, Tomsk State University (LMCCE TSU). During careful preparation, the remains of a medium-sized carnivore that were found in the



**Figure 4.** The Volchia Griva section base along the line A-B/6-7 in 2020 (frame: polar fox hemimandible and the ABA in situ, arrow indicates an artificial hole in the mammoth femur metaphysis).

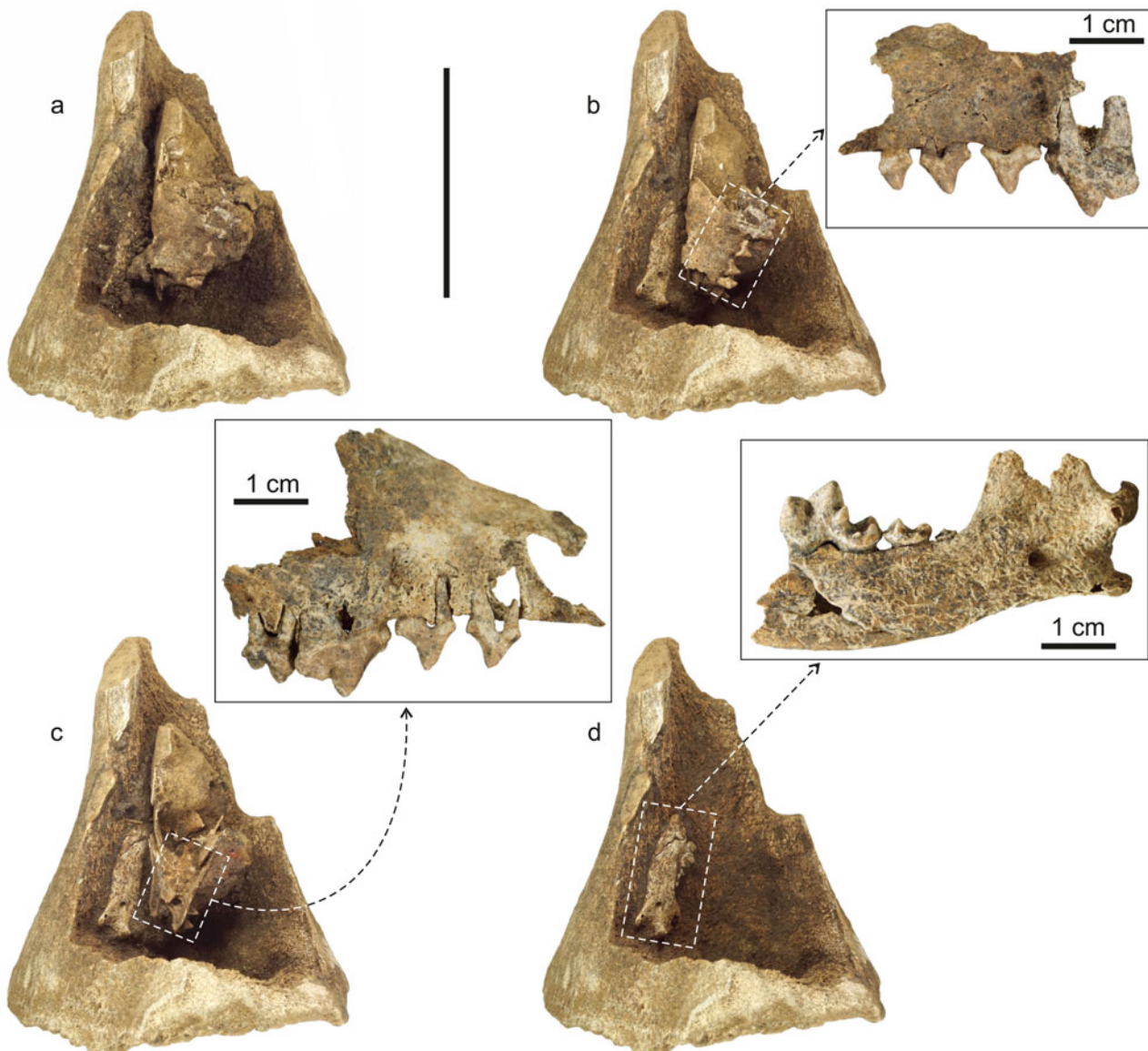
bone cavity were documented in detail by sequential digital photography (Fig. 5).

Thus, the primary materials for this paper are faunal remains representing the described assemblage: (1) a human-modified fragment of a mammoth femur; (2) portions of the cranium and hemimandible, and an isolated tooth of a medium-sized carnivore; and (3) a fragment of rib of a large mammal placed in the cavity. Secondary material was obtained during preparation (cleaning) of the ABA. This is a sandy loam with a high ash content (visible with the naked eye) that filled the rest of the cavity space. Additional material include data for the geological section of the enclosing sediments, and the associated paleontological remains and lithic artifacts.

Taphonomic analysis of the fossil remains began in the field, and was completed at the LMCCE TSU. Examination was

performed visually using a 10× magnifying glass, and a stereomicroscope Leica M 205 C (with digital camera FLEXACAM C1) with magnification up to 200×. The preservation of bone surfaces was assessed according to the weathering stages established by Behrensmeyer (1978). The taxonomy and individual ages of the animals were determined by comparison with the collections stored at the LMCCE TSU, and with published data on modern and Pleistocene mammals of the families Elephantidae and Canidae (Baryshnikov *et al.*, 1977; Kuzmina and Sablin, 1993; Sablin, 1994; Lister, 1999; Maschenko, 2002; Baryshnikov, 2006; Gimranov *et al.*, 2015; Gasilin *et al.*, 2017; Gimranov, 2021).

Palynological analysis of the sandy loam material that filled the cavity in the femur was performed at the LMCCE TSU. Chemical preparation was carried out according to the standard procedure for this type of sediment: the sample was successively treated with



**Figure 5.** Preparation stages of the ABA (scale = 10 cm). (a) The cavity was opened and the main part of the sandy loam fill was removed; (b) left side of the polar fox partial cranium and the fox hemimandible fragment are partially exposed (frame = left maxilla fragment cleaned, lateral view); (c) polar fox cranial cavities are opened (frame = right maxilla fragment cleaned, lateral view); (d) all sandy loam fill is removed and the hemimandible fragment is completely exposed (frame = right hemimandible fragment is cleaned, lingual view; note full coverage of bone surface by root marks). Some maxillary teeth are not shown because they fell out of the destroyed alveoli.



Na<sub>4</sub>P<sub>2</sub>O<sub>7</sub>, and then with 10% HCl (Zaklinskaya and Panova, 1986). Demineralization was carried out by fractionation in a heavy liquid (density of 2.2 g/cm<sup>3</sup>) based on a K-Cd mixture.

The prepared cover-glass samples were viewed under a Leica DM 1000 microscope with magnifications of 400, 630, and 1000×. Atlases, published articles, and the LMCCE TSU comparative collections were used to determine pollen and spores. The pollen spectrum (PS) documents the composition and ratio of individual seed plant taxa. The main percentage sum of PS includes the pollen of trees and shrubs (arboreal pollen “AP”), and herbs and dwarf shrubs (non-arboreal pollen “NAP”). Reconstruction of the environment corresponding to the time of the ABA burial was carried out, taking into account the contextual geological data and results of taphonomic studies.

Typological analysis of the associated lithic artifacts was carried out at the Institute of Archaeology and Ethnography (IAET), the Siberian Branch of the Russian Academy of Sciences (Novosibirsk, Russia). A standard methodology was used to describe the Paleolithic materials based on the morphology and metric characteristics of each specimen (Derevianko et al., 1994, 2003). For this, we used a 10× magnification glass, and optionally a stereomicroscope with magnification up to 300×.

Radiocarbon dating and measurements of stable isotope ratios ( $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ ) for the bone samples were conducted at the Center for Collective Use “Laboratory of Radiocarbon Dating and Electron Microscopy,” Institute of Geography, Russian Academy of Sciences (Moscow, Russia; laboratory code IGAN<sub>AMS</sub>), and at the Center for Applied Isotope Studies, University of Georgia (Athens, GA, USA). First, the bone was cleaned with a wire brush, and washed using an ultrasonic bath. After physical cleaning, the dried bone was gently crushed into small fragments. The crushed bone was treated with 1N HCl at 4°C for 24 hours. The residue was filtered, treated with 0.1N NaOH on filter to remove humic acid contamination, rinsed with deionized water, and under slightly acid conditions (pH = 3) heated at 80°C for six hours to dissolve collagen and leave humic substances in the precipitate. The collagen solution was then filtered to isolate pure collagen and freeze-dried. The dried collagen was combusted at 575°C in an evacuated/sealed Pyrex ampoule in the presence of CuO. The resulting carbon dioxide was cryogenically purified from the other reaction products and catalytically converted to graphite using the method of Vogel et al. (1984). Graphite <sup>14</sup>C/<sup>13</sup>C ratios were measured with the CAIS 0.5 MeV Accelerator Mass Spectrometer (AMS). Sample ratios were compared to the ratio measured from the Oxalic Acid I (NBS SRM 4990). The quoted uncalibrated <sup>14</sup>C dates have been given in radiocarbon years before 1950 (years BP), applying the <sup>14</sup>C half-life of 5568 years. The error is quoted as one standard deviation and reflects both statistical and experimental errors. The <sup>14</sup>C dates have been corrected for isotope fractionation. Calibration of radiocarbon dates was performed using the Calib 8.1.0 program (<http://calib.org/calib/>), based on the IntCal20 dataset (Reimer et al., 2020), with ±2σ rounding calibrated dates to the next 10 years, and combining all calibrated intervals if necessary. The collagen <sup>13</sup>C/<sup>12</sup>C and <sup>15</sup>N/<sup>14</sup>N ratios were measured separately using a stable isotope ratio mass spectrometer and expressed as  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  with respect to standards (PD belemnite and AIR, respectively), with an error of less than ± 0.1‰.

## LOCATION AND ACCESSION OF MATERIALS

The described paleontological and archaeological materials are stored at the LMCCE TSU. Fieldwork was carried out based on

licenses NOV 02895 PD and NOV 02902 PD, issued by the Department for Subsurface Use, Siberian Federal District of the Russian Federation for TSU.

## RESULTS

### The ABA structure

The basis of the described assemblage is the distal portion of the left femur belonging to a young mammoth (field No. 346), ~180 mm long, without the epiphysis, which had not been fused. The maximum lateral and anteroposterior diameters are ~150 mm and >110 mm, respectively (the anterior portion of the metaphysis is locally destroyed). On the anterior side of the femur, a cavity close to rectangular in shape, ~165 × 100 mm in size, is hollowed out up to 80 mm deep (Fig. 6). The edges of the cavity were shaped by at least seven large impact-made notches ~1–2.5 cm wide. It should be noted that radial and ring cracks up to 40 mm long diverge from the transverse impact marks, penetrating deeply into the compact tissue (Fig. 6a, b). The main part of the cancellous tissue was removed during cavity construction, and the metaphysis was perforated with two holes ~44 × 20 mm and ~8 × 5 mm maximum sizes (Fig. 7b). On the opposite side of the femur (posterior surface), there are several deep longitudinal cracks (maximum length ~55 mm) running from the broken edge of the diaphysis towards the metaphysis. These cracks indicate at least five strong blows to the midshaft end (Fig. 7c, d).

Other remains of the described assemblage were found in the cavity (Fig. 5). These are portions of a cranium and mandible, and an isolated tooth, all belonging to foxes, and a fragment of a large rib. A portion of the fox cranium (field No. 347) is represented by nasalia, frontalia, maxillaria, palatinum, and mesethmoideum bones, and the vomer. Most of them are not complete. In the left maxilla, five teeth (all premolars and M<sup>1</sup>), and in the right maxilla, six teeth (all premolars and molars) remain. There is no visible tooth wear (Fig. 5b, c). The morphology and sizes of the bones and teeth point to species identification as the polar fox (*Vulpes lagopus* L.).

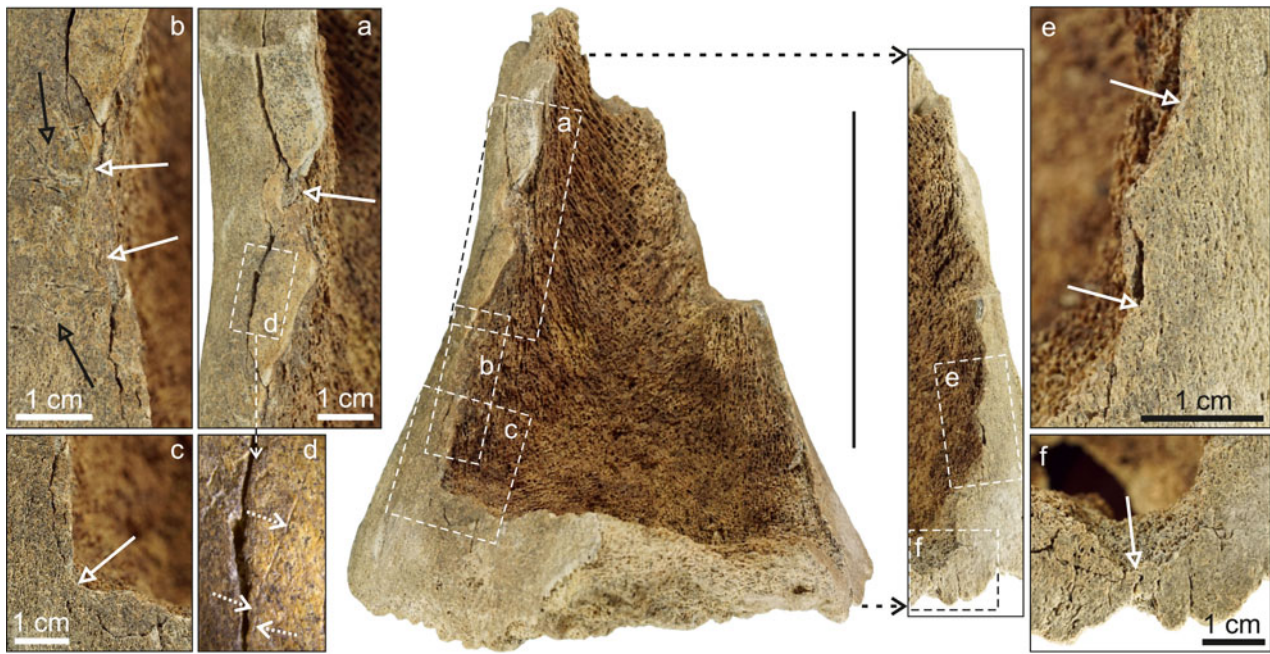
A fragment of a gracile mandible (field No. 348) is represented by the posterior portion of the right hemimandible with three molars; there is no visible tooth wear (Fig. 5d). Taxonomy due to incomplete bone size and similar morphology of teeth for Eurasian foxes can be tentatively determined as *Vulpes* cf. *V. lagopus* L.

An isolated tooth (field No. 350) found in the sandy loam fill is a left M<sup>1</sup> of *Vulpes* sp. The similarity in morphology and size of this tooth for Eurasian foxes does not allow us to give an exact species determination. There is no visible tooth wear.

A fragment of a rib (field No. 349) was also found in the sandy loam fill; it has a length of 14 mm and a cross-section of >17 × 9 mm. These parameters do not allow us to assign it to a species, but it clearly belongs to a large mammal (e.g., mammoth, horse, bison, etc.).

### Taphonomic analysis

The femur fragment with the artificial cavity is generally well preserved. Weathering of bone surfaces is at the zero stage. There are no signs that the bone was burned. At the same time, slight chemical etching of the outer compact layer is recorded (edges of fractures and cracks are rounded), including rare marks of plant roots



**Figure 6.** Completely prepared cavity in the anterior side of a mammoth femur with signs of artificial modeling (scale = 10 cm). Solid white arrows indicate impact marks, solid black arrows indicate root marks, dotted white arrows indicate cut marks. (a) Impact-made notch >2 cm wide with impact mark, one small ring, and two large radial cracks; (b) impact-made notch >2 cm wide with two impact marks and small radial cracks; (c) impact-made notch <1 cm wide with impact mark, around several ring cracks; (d) cut marks; (e) two impact-made notches, each >1 cm wide, with two impact marks and several ring cracks; (f) impact-made notch >1 cm wide with impact mark, small ring, and semi-radial cracks. Note the almost right angles of the cavity base (c, f).

(Figs. 6b, 7d). This made it difficult to diagnose other possible use traces. Nevertheless, they were identified on the lateral inner surface of the femur as a string of impressions of different depths over an area of  $\sim 62 \times 10$  mm (Fig. 7d, e). Some impressions have linear, cut-like edges. There are also several tens of linear discontinuous cut marks (usually <10 mm long, but some are >25 mm), regularly going in two directions relative to each other, at angles from  $\sim 40^\circ$  to  $\sim 90^\circ$ . Cut marks are barely noticeable, and sometimes they lie on top of the impressions (Fig. 7e). A separate clear and straight cut mark  $\sim 15$  mm long (one end bifurcates) is located on the bone surface near the edge of the cavity (Fig. 6d).

The cranial bones of the fox are small and thin. They are not very well preserved; therefore, determining the weathering stage of such remains is problematic. The bone surfaces, both outside (to a greater extent) and inside the cranium, are covered with marks of plant roots, which are also present on the teeth. On the right maxilla, in a localized area above  $P^3$  and  $P^4$  ( $\sim 0.5$  cm<sup>2</sup>), at least 10 short linear incisions with a length of up to 10 mm were identified. These linear incisions can be divided into two distinct groups: 0.01–0.02 mm wide, and 0.07–0.15 mm wide (Fig. 8). Similar marks, up to 10 mm long and <0.09–0.2 mm wide, were also recorded on the right frontale (Fig. 9). Signs of true cut marks on green bone for the ABA in general include a mostly V-shaped transverse profile, linear sharp edges, discontinuous and non-parallel marks of most incisions (Figs. 6d, 7e, 8, 9), and the presence of rare double (Fig. 8) and triple (Fig. 9) marks. There are no signs that the cranium was burned.

The hemimandible portion, together with its teeth, is completely covered with root marks. This does not allow us to determine the weathering stage or possible use indicators (cut marks, bone perhaps used as a retoucher, etc.). The same can be said about the isolated  $M^1$  tooth, which also has root marks. The fragment of the large mammal rib is poorly preserved. Its

weathering cannot be assessed because almost all of the compact tissue has been destroyed. There are no signs that any of these remains were burned.

#### Associated paleontological material

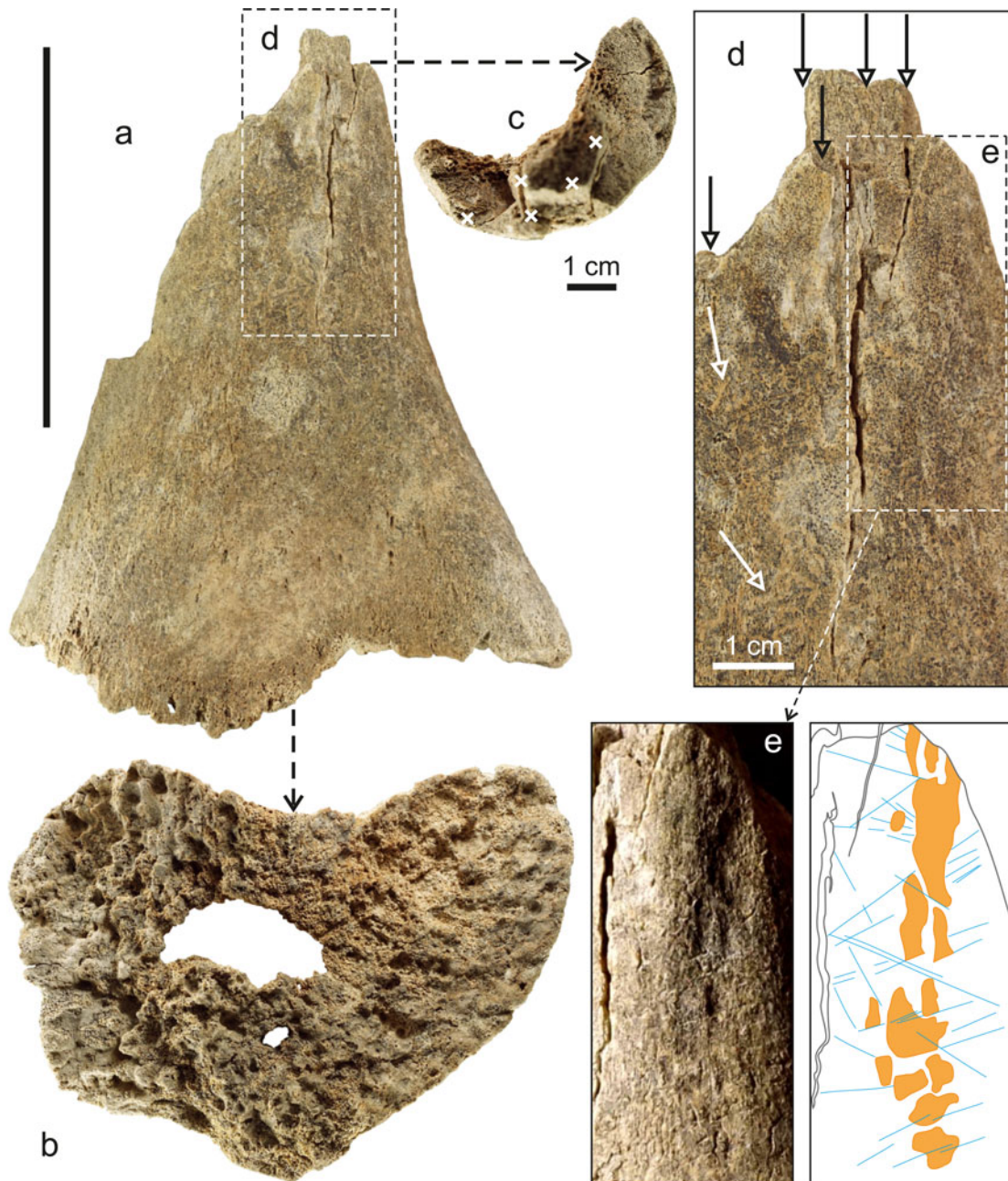
More than 1000 faunal remains were found in proximity to the ABA (Figs. 2, 3). Most of them are represented by small fragments (up to 10 mm) of bones and teeth recovered during the screen washing of bone-bearing sediments. Only a few dozen large fragments of ribs, vertebrae, limb bones, and tusks belong to woolly mammoth. The fully preserved forelimb of a wolf in anatomical position (excavation squares A6–7) coincides with the ABA level (245–250 cm below the ground surface). Almost all other remains belong to foxes (including the cranium articulated with the mandible in square C7, and isolated portions of the maxillaria and mandibles), of which >90% belong to the polar fox. Cut marks, which indicate skinning, are found on some well-preserved fox bones.

The described deposit differs sharply from most of the VG central faunal accumulation, where there is a record high concentration of large-mammal remains, the vast majority of which belongs to woolly mammoth (Leshchinskiy and Burkanova, 2022). Thus, the taphonomic picture of human activity in the area of the Paleolithic site clearly defines its functional significance and fundamental difference from the natural paleontological burial of megafauna, although there are only a few tens of meters between them.

#### Associated archaeological material

More than 750 artifacts were found in the immediate vicinity of the ABA, of which 99 lithics and one bone flake were precisely recorded in space and indicated on the excavation plan. The rest of the





**Figure 7.** Posterior side of mammoth femur with signs of artificial processing and utilization (scale = 10 cm). (a) General view; (b) perforated metaphysis; (c) transverse midshaft fracture (crosses indicate impact points); (d) area with deep longitudinal cracks (black arrows indicate impact points, white arrows indicate root marks); (e) planoconvex bone portion used as a passive retoucher, drawing shows impressions (orange spots) and straight cuts (blue lines).

specimens were found during screen washing of sediments, and these are mainly small waste products. The main concentration of artifacts is observed within the ash lens (Figs. 2, 3). The petrographic diversity of the lithic industry is limited to two large rock groups: (1) flint-jasperoid and (2) rock crystal-smoky quartz (Table 1). The collection includes products of primary splitting (cores, flakes, chunks, chips, blades, and bladelets and their fragments), and items with secondary treatment defined as tools (Fig. 10).

Cores are maximally residual and represent two reduction types: (1) edge-faceted (Fig. 10.1) and (2) flat (Fig. 10.3). Both types were aimed to obtain blade-like debitage. This is confirmed by the high proportion of blades and bladelets among both the waste products and tools (Fig. 10.4, 10.6, 10.9, 10.11–10.14).

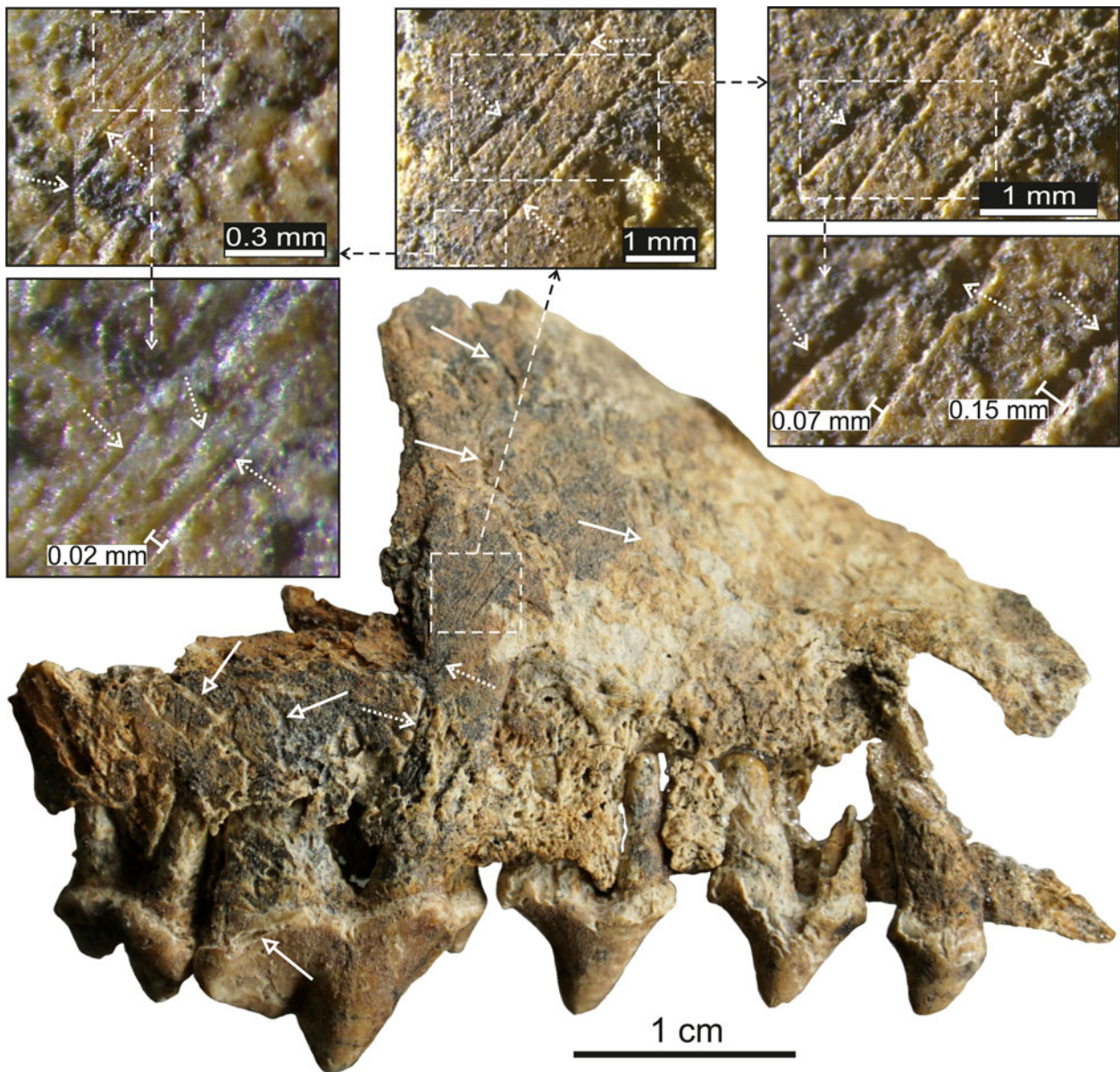
Flakes and their fragments are usually <2 cm long, but sometimes reach a length of  $\geq 3$  cm (Fig. 10.8).

The ratio of tools in the lithic collection is very high (>10%). They (in total, 12 items) are represented by burins (Fig. 10.4–10.7), blades with continuous retouch on one or two edges (Fig. 10.9, 10.12), a retouched flake, backed bladelets (with a fine marginal lateral retouch; Fig. 10.11, 10.13, 10.14), a chisel (Fig. 10.2), and a double-end scraper (Fig. 10.10).

#### *Radiocarbon dating and stable isotope analysis*

Direct  $^{14}\text{C}$  dating of the mammoth femur and polar fox cranium (vomer, mesethmoideum, and palatinum bones) was performed.





**Figure 8.** Skinning signs on the polar fox maxilla, lateral view ( $P^1$  glued into place,  $M^2$  not shown). Solid and dotted arrows indicate root and cut marks, respectively.

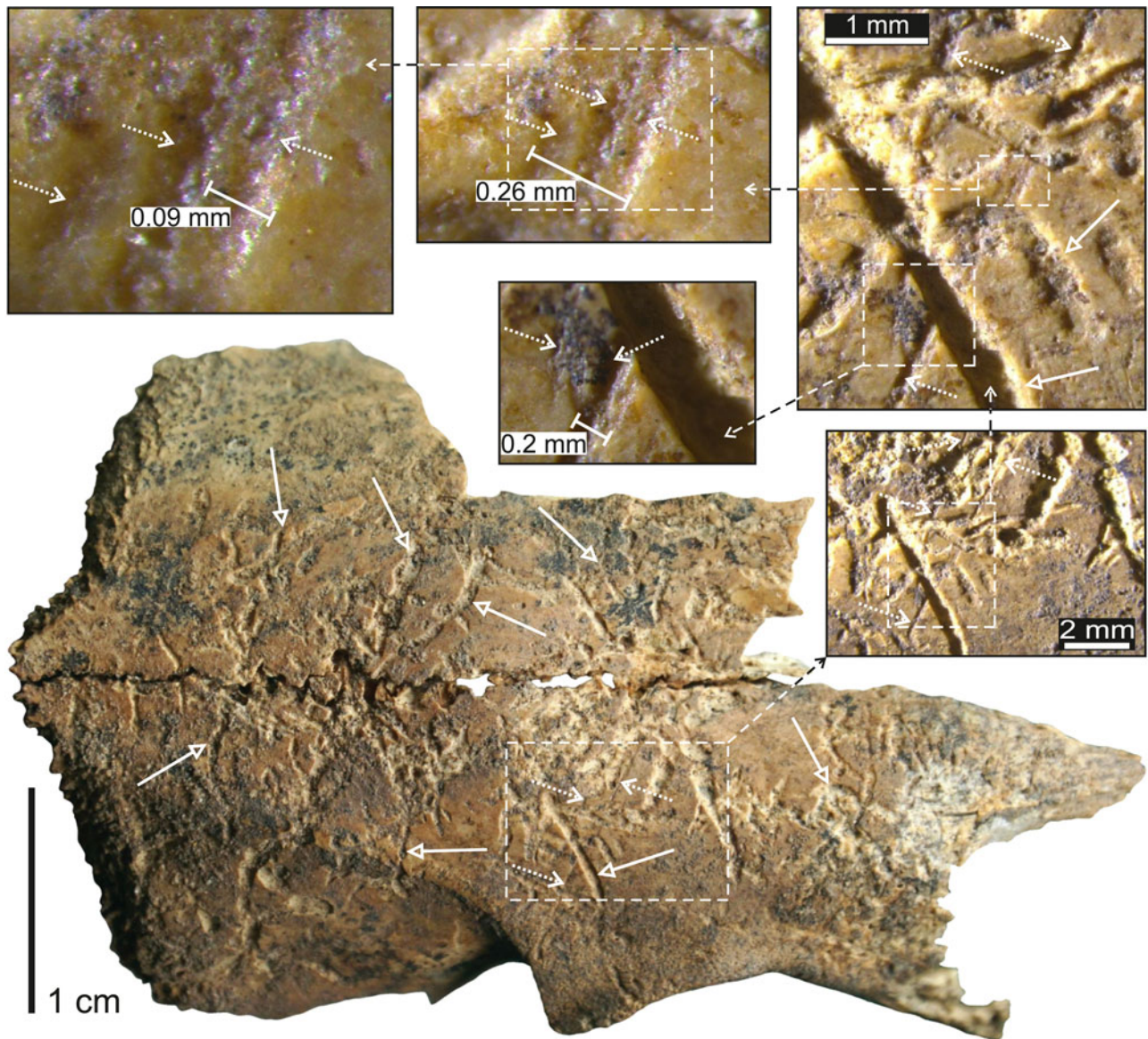
The collagen content of these samples is 17.00% and 15.05%, respectively, which is in the range for high reliability of the analysis. The results are (probability 95.4%,  $\pm 2\sigma$ ): femur—19,125  $\pm$  40 yr BP (IGAN<sub>AMS</sub>-8477); cranium—19,245  $\pm$  45 yr BP (IGAN<sub>AMS</sub>-8478). Calibrated ages for these  $^{14}\text{C}$  values are 22,930–23,120 cal yr BP and 22,980–23,660 cal yr BP, respectively. The atomic C/N ratio of the collagen for both samples is 3.14, within the range of 2.9–3.6, which is recommended for reliable data (Ambrose, 1990; Guiry and Szpak, 2021). Stable isotope data for bone collagen samples from the ABA are as follows: woolly mammoth,  $\delta^{13}\text{C} = -20.02\text{‰}$ ,  $\delta^{15}\text{N} = 12.50\text{‰}$ ; polar fox,  $\delta^{13}\text{C} = -13.13\text{‰}$ ;  $\delta^{15}\text{N} = 16.81\text{‰}$ .

#### Palynological analysis

A sample from the sandy loam fill of the ABA yielded a sufficient amount of pollen for reliable palynological analysis, the results of

which are shown on Figure 11. PS consists of 315 grains belonging to AP and NAP. The amount of AP is only 7%; among which *Pinus* s/g *Dyploxylon* dominates. Pollen of other trees (*Piceae* sp., *Betula* sp.) and shrubs (*Alnus* sp., *Salix* sp.) is very rare. Thus, NAP strongly dominates in the PS; Tricolpopollenites (tricolpate pollen with an unclear exine ornamentation) has the largest share, 31.4%. A large amount of pollen belongs to the families Brassicaceae (18.4%), Asteraceae (14.2%, including 7.9% of *Artemisia* sp.), and Rosaceae (10.2%). The pollen of Chenopodiaceae constitutes 2.9% of total NAP. Pollen of Fabaceae, Cichoriaceae, Polygonaceae, and Scrophulariaceae is grouped into “other herbs”; the share for each of these taxa is <2%. One pollen grain of *Potamogeton* sp., a typical representative of aquatic plants, is identified. No spores were found. Non-pollen palynomorphs are represented by rare *Pediastrum* sp., fungal fruiting bodies of *Glomus* sp., and hyphae and fungal spores of





**Figure 9.** Skinning signs on the polar fox frontalial, dorsal view. Solid and dotted arrows indicate root and cut marks, respectively.

indeterminate taxa. Fragments of sponge spicules and phytoliths of dicotyledonous plants are also found.

A large amount of finely dispersed charcoal/ash, visually recorded in the ABA fill, was confirmed in the palynological cover-glass preparations. Especially indicative is the contrast with the sediments of the lower bone-bearing level in the 2016 excavation pit (Leshchinskiy and Burkanova, 2022), in the samples of which there are almost no charcoal particles (Fig. 12).

## DISCUSSION

The presence of humans in the West Siberian Plain during the LGM has been considered debatable (e.g., Goebel, 2002; Graf, 2009; Chlachula, 2017; Kuzmin and Keates, 2018). By modeling the process of human colonization of Eurasia in the Late Pleistocene, it was clearly demonstrated that at ca. 20 ka BP, only in the extreme south of the region, a small population with a density of  $\leq 2$  persons per 100 km<sup>2</sup> can be assumed. As

for the rest of the West Siberia Plain, a density of  $\leq 1$  person per 100 km<sup>2</sup> or completely uninhabited has been suggested (Timmermann and Friedrich, 2016). This conclusion is generally supported by the limited reliable traces of human presence in most of the West Siberian Plain at that time. The short-term sites of Tomsk and Shikaevka, with a few <sup>14</sup>C dates of ca. 18.3–18 ka BP, were recorded in the southeastern and southwestern parts of the region, respectively (Zenin, 2002). These sites are clearly associated with mammoth remains, which implies a direct dependence of ancient humans on these animals. The same connection is obvious for the largest sites of this period (Shestakovo and Volchia Griva) associated with a natural mass accumulation of mammoth remains in the southeastern and southern peripheries of the region. The large Achinsk site and a promising mammoth site with Paleolithic artifacts called Krasnoyarskaya Kurya are in relative proximity to these sites. Verification of the geological age for all of these sites is represented by  $>40$  <sup>14</sup>C dates tightly bunched within the interval of 25.7–17 ka BP (Derevianko et al.,

**Table 1.** The petrographic composition and categories of the Volchia Griva lithic artifacts around the ABA.

Artifact categories	flint-jasperoid	rock crystal-smoky quartz	all rocks
core	1	1	2
flake	15	14	29
chunk	12	16	28
chip	2	2	4
blade	1		1
blade fragment		1	1
bladelet	7	1	8
bladelet fragment	8	6	14
retouched flake		1	1
retouched blade	2		2
double-end scraper	1		1
burin	3	1	4
backed bladelet	2	1	3
chisel	1		1
<b>Total</b>	<b>55</b>	<b>44</b>	<b>99</b>

2000, 2003; Seuru et al., 2017; Leshchinskiy et al., 2021; Leshchinskiy and Burkanova, 2022). A similar range can be seen using  $^{14}\text{C}$  dates of the mammoth fauna and the Late Paleolithic sites in the Gari area, situated in the western part of the West Siberian Plain (Chlachula and Serikov, 2010). Thus, there is no doubt that human populations existed in the south-eastern, southern, southwestern, and western parts of the region during the first half of MIS 2. The absence of LGM sites in the central, northern, and eastern parts of the West Siberian Plain is commonly assumed to be the result of various geographical barriers (e.g., severe climate, ice sheets, ice-dammed lakes, etc.). However, this absence also can be explained by the relatively poor degree of survey of this vast territory.

### *Taphonomy and paleoenvironmental conditions*

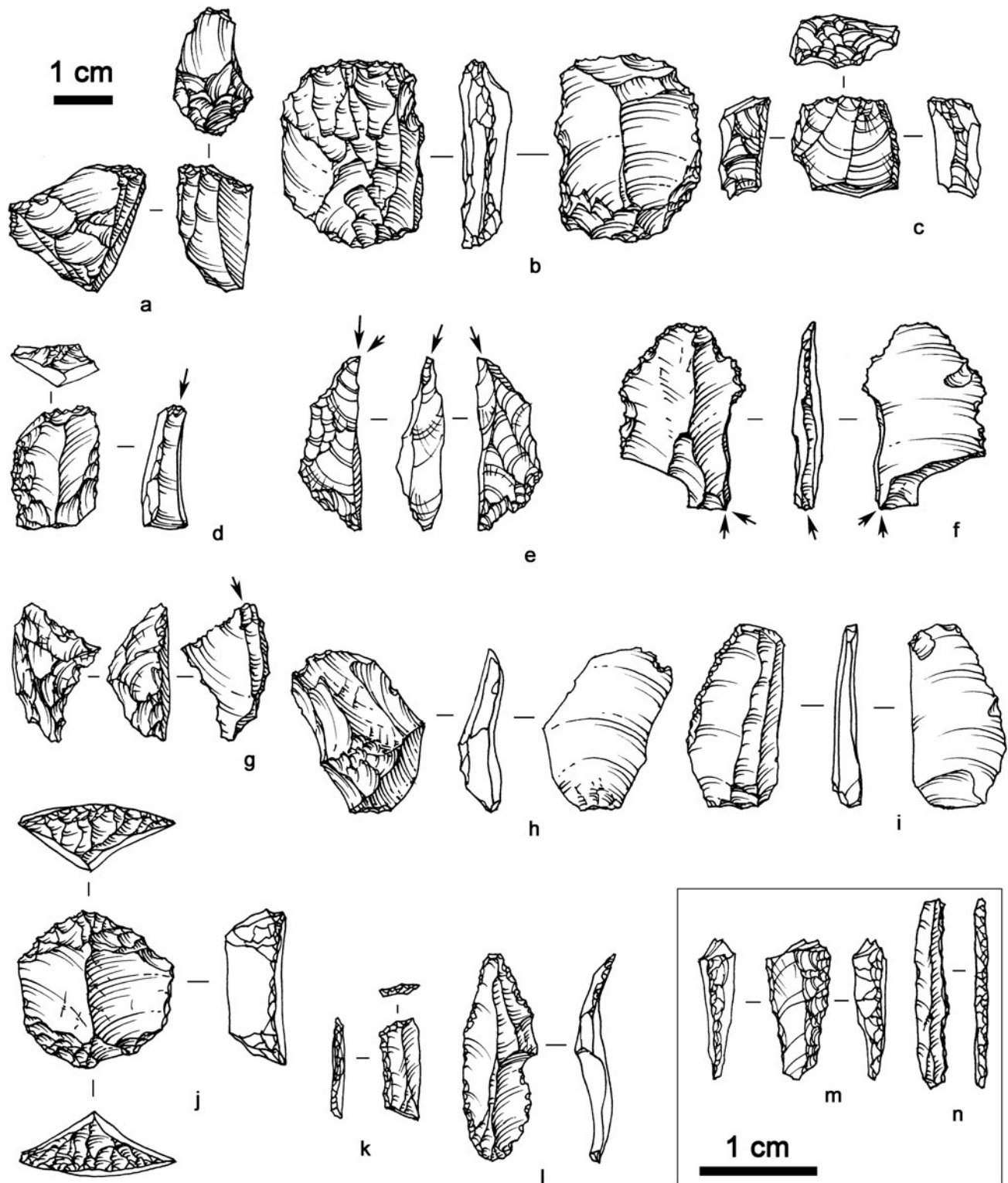
The ABA from the VG site has no current analogues either in the Paleolithic of Siberia or, possibly, the entire Northern Hemisphere. The base of the ABA from the VG site is made from a mammoth femur shaft; a medium-sized bone with an unfused epiphysis that indicates a young adult animal, with an age estimate of 12–20 years (Baryshnikov et al., 1977; Lister, 1999; Maschenko, 2002). The zero stage of weathering of the bone surfaces indicates a relatively rapid burial. In the arid African savanna, with extreme temperature fluctuations due to high ultraviolet radiation, this corresponds to a period of up to one year (Behrensmeyer, 1978; Haynes and Wojtal, 2022). In the tropical rainforest, with very little direct light and high humidity, weathering stage zero can sometimes last >15 years; and in temperate and subarctic climatic conditions, weathering stage zero probably can last >7 years, but mostly no more than three years (Tappen, 1994; Haynes, 1999).

What were the environmental conditions in the southern part of the West Siberian Plain around the LGM? This topic has been discussed for over 50 years. Many paleogeographic reconstructions suggest radically opposite environments: from swampy tundra or forest tundra flooded by the waters of the giant ice-dammed Lake Mansi to loess- and sand-covered cold desert with regosolic gleysols, extremely low winter air temperatures, and deep ground freeze (Arkhipov, 1971; Arkhipov et al., 1980; Arkhipov and Volkova, 1994; Chlachula, 2003; Hubberten et al., 2004; Astakhov, 2006; Zykin and Zykina, 2009; Chlachula and Little, 2011; Velichko et al., 2011). Based on the most recent data, for the last 10,000 years of the Pleistocene, this region, including the Baraba Lowland, was characterized by widespread development of forb-grass steppes (Leshchinskiy and Burkanova, 2022), which indicates a dry climate and high summer insolation. Consequently, the weathering stages of large-mammal bones, described in modern thanatocenoses, indicate that burial of the mammoth femur's fragment at VG should have occurred within 1–3 years after death of the animal. This is consistent with the contemporary environmental conditions of northwestern Mongolia, which are the closest to those at the LGM in the southern part of the West Siberian Plain (Leshchinskiy, 2015). However, the described specimen could have remained on the ground surface longer under favorable conditions (e.g., the shore zone of a lake with high humidity, and shade, etc., including the factor of human influence). Root marks on the femur's surface could have formed both in subaerial and subaqueous environments, since the ABA was finally covered with sediments in lacustrine shallow water.

The special conditions at the periphery of the Paleolithic site may reflect the PS of sandy loam fill of the ABA. The ratio of AP and NAP shows that it generally corresponds to the PSs from the coeval sediments of the lower bone-bearing level, which was excavated in 2016 (Fig. 1d). Those PSs reflect the widespread steppes, as well as the presence of a lake with developed coastal and aquatic vegetation at the foot of the VG mound. In general, this situation persisted until the beginning of loess-like sandy loam accumulation (Leshchinskiy and Burkanova, 2022). However, the PS of the ABA shows a more than threefold increase in the pollen content of the cabbage family (Brassicaceae)—18.4% of AP+NAP. At the same time, its share among all detected herbs is unusually high, and amounts to almost 20%.

For comparison, published PSs from Late Pleistocene deposits in the central and southern parts of the West Siberian Plain, including mammoth fauna and Paleolithic sites, have a share of Brassicaceae of  $\leq 10\%$  of the herb composition, and even less of AP+NAP (Volkova et al., 1970; Arkhipov et al., 1973, 1976; Levina, 1979; Volkova and Volkov, 1980; Krivonogov et al., 1993; Volkova and Mikhailova, 2001; Mikhailova, 2004; Burkanova, 2006). The proportion of Brassicaceae pollen as  $\leq 10\%$  of AP+NAP also has been reported for Late Paleolithic sites in Siberia and Eastern Europe (Gladilin and Pashkevich, 1977; Gubonina, 1977; Pashkevich, 1977; Praslov et al., 1977; Mochanov et al., 1983; Tseytlin, 1985; Lbova et al., 2005; Spiridonova, 2006; Velichko et al., 2009; Tashak et al., 2017, 2019). Based on contemporary data, 58 species of this economically important family grow in the territory of Novosibirsk Province, 12 of which are found in steppe and alkali meadows, 10 species along the river and lake shores, and one species is an aquatic plant (Krasnoborov et al., 2000). Our studies of various surface PSs at VG showed that Brassicaceae pollen is rare in recent samples (Leshchinskiy and Burkanova, 2022).

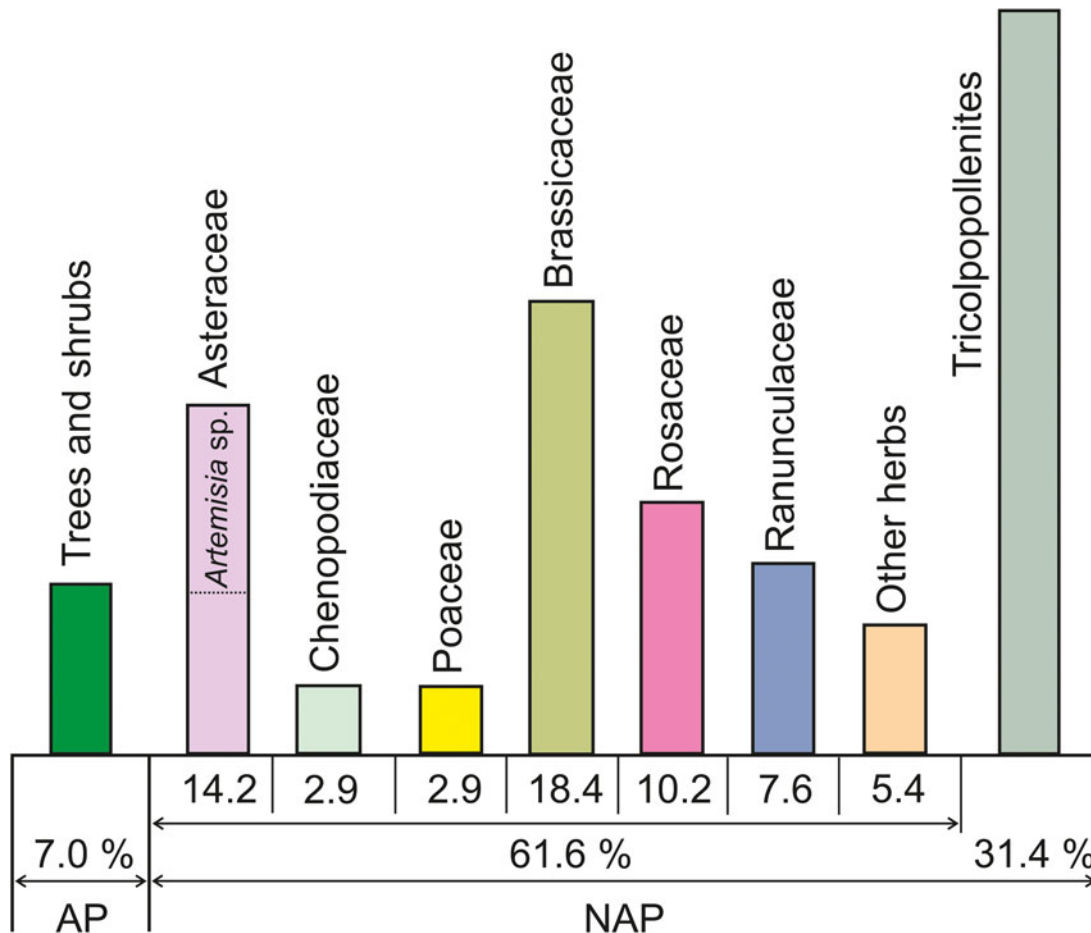




**Figure 10.** The Volchia Griva lithic artifacts (2020 and 2021 excavations). (a, c) Cores; (b) chisel; (d–g) burins (arrows indicate directions and quantity of burin blows); (h) flake; (i, l) retouched blades; (j) double-end scraper; (k, m, n) backed bladelets. Petrographic composition: smoky quartz (c), rock crystal (e, m), flint (g–i), jasperoid (a, b, d, f, j–l, n).

Thus, the available data indicate that the natural background of Brassicaceae pollen in the Late Pleistocene of Siberia and Eastern Europe probably amounted to  $\leq 10\%$  of AP+NAP. The anomalously high content of this pollen in the ABA fill, in our opinion,

could be due to two factors: (1) the specific plant composition of the area (dry sandy loam slope and proximity to the lake) and (2) human activity (collection of certain plants or their parts off site for bedding, nutrition, use as a medicine, or other purposes,



**Figure 11.** Pollen diagram for the ABA fill (AP = arboreal pollen; NAP = non-arboreal pollen; AP and NAP of the main percentage sum).

including aesthetic and ritual ones). Moreover, both factors could have acted either separately or simultaneously.

The mammoth femur and the polar fox cranium from the ABA were studied for  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  stable isotopic composition of bone collagen. The results are almost identical to the data on the mammoth and canine bones from the 2016 excavation pit, which revealed an abnormal biogeochemical composition of the VG mammalian diet (Leshchinskiy and Burkanova, 2022). Thus, the elevated  $\delta^{15}\text{N}$  value (12.50‰) for the mammoth femur is close to the range of 12.86–14.67‰ previously determined for mammoths from the VG lower bone-bearing level. In other parts of Eurasia and Eastern Beringia, the average  $\delta^{15}\text{N}$  values for mammoths dated to 20–10  $^{14}\text{C}$  ka BP are <10‰ (Bocherens et al., 1996; Szpak et al., 2010; Seuru et al., 2017; Drucker et al., 2018; Kuzmin et al., 2021). The  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  values for the polar fox cranium are also unusual: –13.13‰ and 16.81‰, respectively. They go far beyond the general range for Eurasian and Eastern Beringian populations:  $\delta^{13}\text{C}$  from approximately –23‰ to –17‰; and  $\delta^{15}\text{N}$  from ~4–10‰ (Angerbjörn et al., 1994; Dalerum et al., 2012). The new data obtained on  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  for mammalian bone collagen at VG confirm the trophic enrichment of the carnivores (Bocherens, 2015), and indicate that carrion of large herbivores could have been the basis of the polar fox diet. In turn, an elevated  $\delta^{15}\text{N}$  value for mammoth bone collagen is expected for the ecosystem of fertile forb-grass steppe under conditions of a favorable geochemical

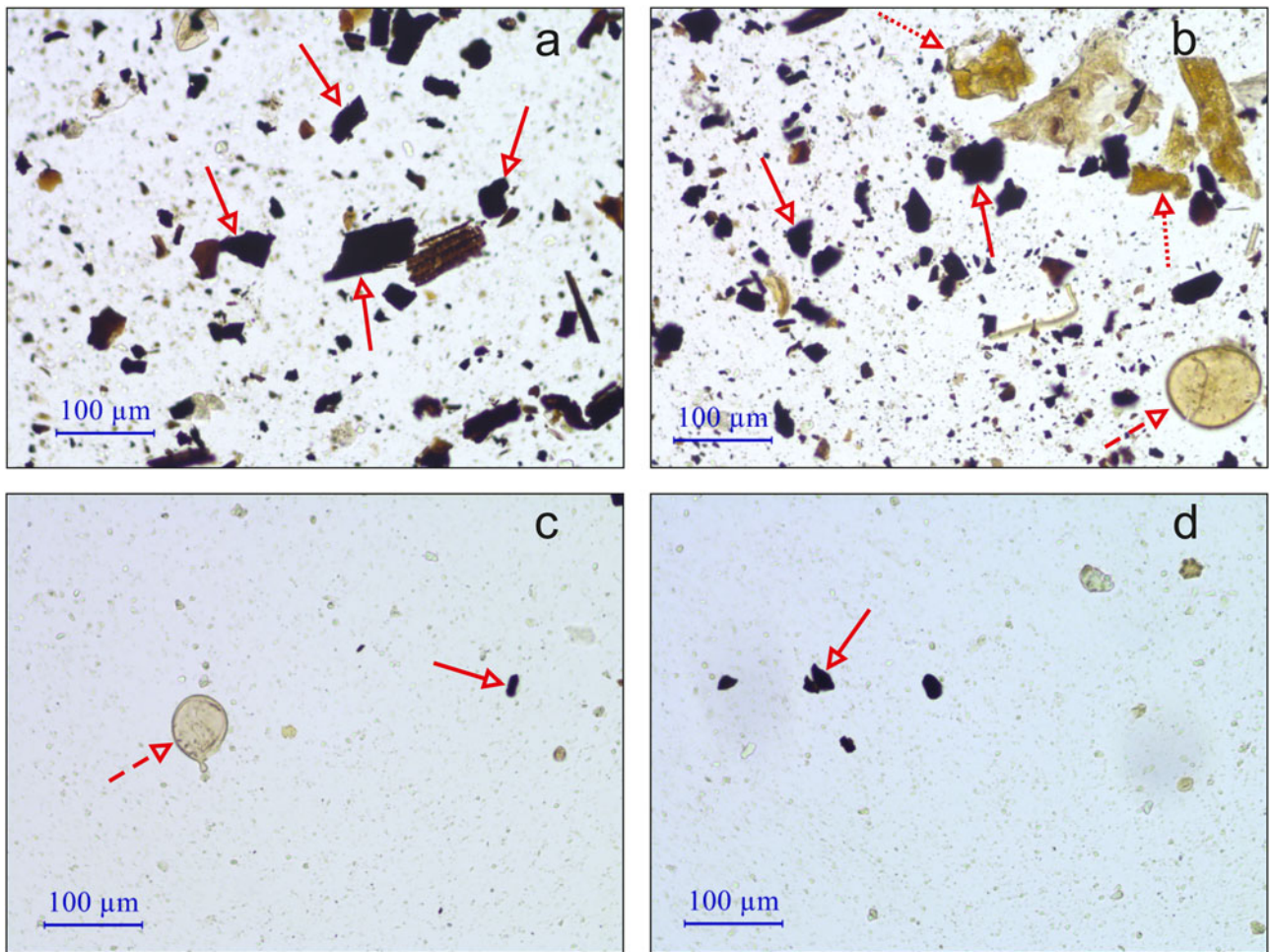
landscape formed on the VG mineral oasis (Leshchinskiy and Burkanova, 2022).

Some or even all of the components of the ABA could have been obtained from the VG thanatocenosis that already existed by that time. This is perhaps reflected in the varying coverage of the bone surfaces with root marks, which is why it has not yet been established if the cranium and hemimandible belong to one or two individuals. However, the presence of an isolated left  $M^1$  tooth and another  $M^1$  in the preserved portion of the cranium indicate that the remains of at least two foxes were buried in the bone cavity. Dates of  $19,245 \pm 45$   $^{14}\text{C}$  yr BP and  $19,125 \pm 40$   $^{14}\text{C}$  yr BP for the polar fox cranium and mammoth femur, respectively, are in good agreement with previous results for the main period of formation of the VG lower bone-bearing level at ca. 19.6–19.0  $^{14}\text{C}$  ka BP (Leshchinskiy and Burkanova, 2022).

#### Late Paleolithic activity

Considering the ABA in context, it can be argued that it is clearly human made. The regular impact notches on the edges of the femur's cavity indicate the purposeful use of a heavy hammerstone, with a working part width probably  $\geq 25$  mm. In this case, the work was carried out on green bone, as can be seen from the pattern of the accompanying cracks. Experimental study on the splitting of elephant long bones fully supports this conclusion (Haynes et al., 2021). At the same time, the almost





**Figure 12.** Palynological cover-glass preparations of the ABA fill (a, b) and sediments of the lower bone-bearing level in the 2016 excavation pit (c, d). Solid, dashed, and dotted arrows indicate charcoal/ash particles, fruit bodies of *Glomus* sp. fungi, and plant tissue remains, respectively.

right angles of the external base of the cavity (Fig. 6c, f) may indicate use of a thin tusk, bone, or antler as an intermediate tool with a width of the working part of  $\leq 10$  mm. The mechanism of formation and significance of the large hole in the metaphysis are unclear, but it is obvious that the large hole was made intentionally, and the small hole may have appeared accidentally during formation of the cavity. All these damages do not compare with the gnawing marks of bones by large carnivores: "...Gnawing animals may lick and grind fracture edges smooth, or abrade fracture edges against paws or ground surfaces while gnawing opposite ends. After long bones have been broken apart by carnivores, parts of bones unmarked by teeth will have step-fractures on edges that might also be rounded..." (Haynes and Stanford, 1984, p. 225).

The mammoth femur was used previously as a heavy passive retoucher for relatively large lithic tools. This is evinced by typical widespread chipping from pressure retouching in the form of impressions, which mark a planoconvex zone of active use with a great length ( $>6$  cm). The mammoth femur is not completely preserved, and part of it apparently was broken off during or before formation of the cavity (Fig. 7e). At the same time, discontinuous linear cut marks, sometimes overlying impressions, may reflect the beveling process. A combination of similar marks is often found on Paleolithic bone retouchers in Northern Eurasia (Moigne et al., 2016; Costamagno et al., 2018; Mozota, 2018;

Martellotta et al., 2020; Bello et al., 2021). In this aspect, the functional significance of blows to the midshaft butt, which led to the appearance of longitudinal cracks, becomes clear. The blows probably were produced by a heavy ( $\geq 2$  kg) hammerstone for the purpose of chipping long and thick cortical blanks for retouchers with a regular convex surface. According to some researchers (Mozota, 2013; Kolobova et al., 2022), the diaphyses of large mammal long bones are the best material for this purpose. Impressions and linear cut marks caused by using the mammoth femur as a retoucher are fundamentally different from the gnawing marks made by predators and scavengers, as well as from marks made by trampling. In this case, the scratches occur singly or as sets of parallel marks, whose outer edges are generally rounded (Haynes, 1982; Behrensmeier et al., 1986; Haynes et al., 2020). The impressions noted on the mammoth femur are not anatomical features. Diagnosis of mammoth femurs from natural Siberian sites, stored in the LMCCE TSU collections, did not reveal similar patterns of bone topography.

The short linear incisions in the frontal region of the polar fox cranium from the ABA were certainly made with a lithic tool during the skinning process. The tendons were cut in the skull region, near the eye sockets and on the frontal bones. Thus, the typical parameters of incisions and their clear localization on certain skeletal elements are characteristic features of Paleolithic complexes (Charles 1997; Landeck and Garriga, 2017; Konidaris

et al., 2018; Wojtal et al., 2018, 2020). In addition, the fragility of the bones does not support the option of trampling, in which case the skull would have been crushed.

Careful preparation of the polar fox remains as part of the ABA showed that the premaxillae, with incisors and the anterior portions of the maxillae together with the canines, previously were separated from the cranium, which is why they are not in the structure of the assemblage. This can be seen from the position of the preserved cranial portion at the base of the cavity, opposite the large hole (Fig. 5). The absence of parietale, jugale, squamosum, auditory bulla, occipital, and other bones of the braincase and palate may also indicate their deliberate removal by humans. However, some of them (especially the occipital bone) could have been partially destroyed during the burial process due to microbial and chemical degradation (Leshchinskiy, 2012; Calábková et al., 2022). Only the posterior portion of the hemimandible, broken between the premolars and molars, was also inserted into the cavity. The position of an isolated tooth and a large rib fragment were not clearly recorded. Nevertheless, we are inclined to think that in the final stage of the creation of the assemblage all remains were sealed by humans in the cavity in a compound made of a mixture of sand, clay, and ash. The artistic reconstruction of the ABA (without the infill, isolated tooth, and rib fragment) is shown in Figure 13.

One question about the ABA burial remains open: was it carried into the lake by natural agents such as temporary streams, colluvial processes, or wave activity, or was it deliberately placed by humans in shallow water? Movement down the slope and farther into the lacustrine shallow zone for most of the paleontological and archaeological materials recovered during the 2020–2021



**Figure 13.** Artistic reconstruction of the ABA (illustration by Anastasiia S. Leshchinskaya, idea by Sergey V. Leshchinskiy).

excavations is beyond doubt. Although this does not necessarily mean a significant redeposition of paleontological remains and artifacts, it is currently not possible to identify regularities in the distribution of the cultural layer in the studied area from a geological point of view. Therefore, we consider these finds as a single complex of the lower bone-bearing level and associate the chaotic arrangement of artifacts with the destruction of the cultural layer on the VG slope.

The VG lithic collection (Fig. 10) represents a combination of exhausted cores and blades with curved profiles, including items converted into tools. The scar pattern of the blades and flakes determines variants of cores with longitudinal and counter knapping. Backed bladelets and bladelets with a truncated transverse edge, as well as micropoints with a straight profile, are the most numerous among the tools. The lateral and transverse burins are illustrative. Scrapers, chisel-like tools, and borers are rare. Notched tools are typical, including items with a notch on the striking platform. Tools with fine dorsal retouch predominate (counter and opposite kinds of retouch are very rare). Thus, the typological composition and a large percentage of tools (Table 1), within a background of the thick cultural layer saturated with ash and burnt bone fragments, suggest a long-term occupation of the site with the active use of fire. Intensive activity at the working area was aimed mainly at toolmaking, along with butchering of animals and processing of their skins, bones, and teeth. In this case, inset tools were used widely. These data significantly supplement the previous geoarchaeological studies (Leshchinskiy et al., 2021).

The described lithic industry belongs to the bladelet-based complexes of Siberia and the Middle Urals that existed during the LGM. They are characterized by the production of bladelets (2–5 cm long), modified by marginal one-sided retouch. Micropoints, bladelets with a backed longitudinal edge, carinated scrapers, borers, burins, and chisel-like tools are common. Cores, as a rule, are represented by edge-faceted and flat varieties. Wedge-shaped cores are absent, as well as large scrapers. Overall, the VG lithic inventory has the closest analogues in the materials from the West Siberian sites of Shestakovo (geological layers V–VII) and Achinsk, probably reflecting a common cultural tradition (Anikovitch, 1976; Derevianko et al., 2000, 2003). In Eastern Siberia, similar technologies have been observed at the Volchikha (Akimova et al., 1997) and Mal'ta sites (layers 8, 9) (Medvedev et al., 2001); and in the Altai region, at the Ushlep 6 site (layer 3) (Kungurov, 1996). West of the VG site, they are known at the Talitski site in the Middle Urals (Shcherbakova, 1994).

The commonalities of LGM industries in Siberia are clearly seen in the knapping technique and the main tool categories. Differences are expressed in the details of the secondary treatment of tools and typological diversity. At the same time, there are artifacts that have a striking similarity but belong to sites situated very far apart, including micropoints, short carinated scrapers, bladelets with a notch on the striking platform, backed bladelets, and blades with retouched notches. In addition to VG, these artifacts are found at the Mal'ta, Shestakovo, and Talitski sites. Thus, in a space of almost 3000 km (from Lake Baikal to the Urals and farther to the west) in the interval of 24–17 <sup>14</sup>C ka BP, Paleolithic technocomplexes with a representative and similar microinventory can be traced.

Despite this similarity, in the Late Paleolithic sites of Siberia, no bone assemblages similar to the ABA from VG have been found so far. The presence of the polar fox cranium without nasal, orbital, and ear regions in a human-made bone cavity

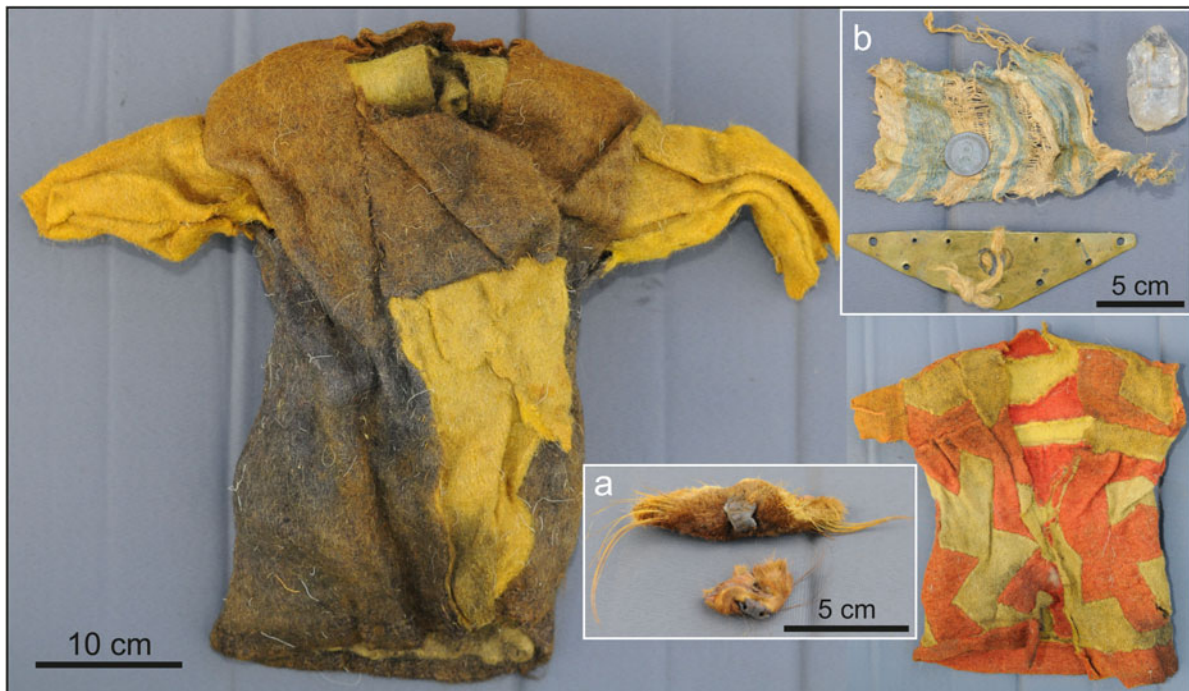


may indicate a funeral rite (a mammoth femur could serve as a coffin), or a ritual associated with depriving the head of the sense organs: smell, sight, and hearing. Similar examples are known among the native people of Western Siberia. For example, at the bear festival, the Khanty and Mansi nations perform a ritual ceremony: a hat is put on the head of a killed male bear (a scarf is tied to a female bear), and birch bark circles are placed on the eyes and nose; quite often, coins or metal plates are used instead of the circles. These actions are designed to close all the skull openings in order to interrupt any connection with the real world. At the end of the ceremony, the rhinarium together with the upper and lower lips are cut off from the bear muzzle (Markov and Lukina, 1987; Gemuev and Baulo, 1999; Kulemzin and Lukina, 2006; Sokolova, 2009).

It is important to note that modern aboriginal hunters consider as a sacred animal not only the bear, but also the fox, and some other carnivores. Their skulls, noses, teeth, paws, claws, and other remains may be kept as parts of a totem animal. An example is the cult assemblages of the guardian spirit among the indigenous peoples of Siberia, which include the nose portions of the “sacred” animal heads in association with minerals and metal artifacts (Fig. 14). Similar symbolism is well known in ancient societies of various regions of Eurasia since the Neolithic (Kulemzin et al., 1994; Baulo, 2002; Kulemzin, 2004; Sokolova, 2009). Information about the possible ritual behavior of Paleolithic people associated with carnivores is rare and contradictory. Such examples include the practice of deliberate burial of bear remains (primarily skulls and long bones) in niche-caches of caves of the Middle–Late Paleolithic in Central Europe (Bednarik, 2020), and debatable finds of “chopped off” bear craniums with

cut marks in the Acheulian cache of the Azykh Cave in the Caucasus (Guseynov, 1973).

Were any rituals performed in Western Siberia at 20–19 <sup>14</sup>C ka BP, and how complex were the relationships between humans and carnivores at that time? We have yet to receive detailed answers to these questions, but one of the key areas for investigating this problem now is the Baraba Lowland and adjacent regions. New excavations of the VG site demonstrate the great importance of the polar fox in the Late Paleolithic economy of this territory. Comparison with the main LGM sites in Eastern Siberia, Eastern Europe, and Central Europe clearly indicates that the mass procurement of these fur-bearing animals was a paleoecological trend for the human population of Northern Eurasia. Moreover, the polar fox, like other foxes, was hunted not only for its fur, but also for food, and its bones and teeth were used to make household items, tools, and personal ornaments (Sukachev et al., 1966; Gvozdover and Grigoryev, 1977; Velichko et al., 1977; Verestchagin and Kuzmina, 1977; Ermolova, 1978; Kuzmina and Sablin, 1993; Sablin, 1994; Charles 1997; Germonpre et al., 2008; Camarós et al., 2016; Baumann et al., 2020; Pryor et al., 2020; Wojtal et al., 2020; Demay et al., 2021). However, despite the abundant fox remains at these sites, there is no evidence of their ritual use. The only case that can be considered as a potential ritual use is recorded at the Předmostí site. During excavations at the end of the nineteenth century, many polar fox bones were found here inside and around human burials, including the authentic “... association of a fox skull that lay across a human skeleton... but given the frequency of fox remains over the whole area it loses any kind of exceptionality...” (Svoboda, 2008, p. 31).



**Figure 14.** Portions of the assemblage of the family guardian spirit (Mansi People, Yasunt Village, Berezovo District, Khanty-Mansi Autonomous Okrug; field materials of Prof. A.V. Baulo, 2009). The assemblage was made in the middle of the eighteenth century AD and represents two “robes” put on each other (the external one is yellow-brown); between “robes” the following items were found: (a) the mummified noses of an otter (top) and a wolverine (bottom); (b) rock crystal, triangular brass plate with holes, and a 20 kopeck coin belonging to the reign of Empress Elizabeth, wrapped in textile.

## CONCLUSIONS

The material aspects of human paleoecology in the form of lithic tools, bones, and teeth provide evidence that is useful for solving some problems of physiological adaptation to the LGM environment. At the same time, the spiritual sphere of prehistoric culture is the least tangible and most difficult part of human history to reconstruct. Nevertheless, attempts are made to isolate such sophisticated elements as magic, shamanism, totemism, fetishism, or art in its structure (Braun, 2015; Chlachula and Serikov, 2022).

The subtlety and inconsistency of reasoning regarding ritual behavior or aesthetic perceptions in the world of the Late Pleistocene people is obvious. An example is Franco-Cantabrian cave art, much of which can be interpreted as being made by children or adolescents (Bednarik, 2008). Thus, the ABA from the VG site could well be either a totem doll (imitation) of a guardian spirit or an ordinary or unusual toy for children. In any case, the main features of the ABA include (1) a series of impact notches forming a rectangular cavity in the mammoth femur; (2) removed cancellous tissue from the human-made cavity; (3) the perforated femur metaphysis; (4) the polar fox cranium with cut marks and the anterior portion removed; (5) the fox hemimandible with the anterior portion removed; and (6) longitudinally oriented position of fox remains in a bone cavity. The combination of these features denies the accidental burial of fox remains in the mammoth femur shaft. This creates confidence that the described assemblage is not a product of nature. The choice of mammoth and polar fox bones for its creation was deliberate, since the role of both species in the life of Late Paleolithic humans was extremely great.

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## REFERENCES

Akimova, E.V., Stasiuk, I.V., Tomilova, E.A., Tihomirov, M. Yu., 1997. Kompleks pozdnepaleoliticheskikh mestonahozhdeniy v logu Volchiha. In: Derevianko, A.P., Molodin, V.I. (Eds.), *Problemy Arheologii, Etnografii i Antropologii Sibiri i Sopredel'nykh Territoriy*, Vol. 3. IAET SO RAN, Novosibirsk, pp. 14–18. [in Russian]

Alexeeva, E.V., Vereshchagin, N.K., 1970. Mammoth hunters in the Baraba steppe. *Priroda* 1, 71–74. [in Russian]

Ambrose, S.H., 1990. Preparation and characterization of bone and tooth collagen for isotopic analysis. *Journal of Archaeological Science* 17, 431–451.

Angerbjörn, A., Hersteinsson, P., Lidén, K., Nelson, E., 1994. Dietary variation in Arctic foxes (*Alopex lagopus*)—an analysis of stable carbon isotopes. *Oecologia* 99, 226–232.

Anikov, M.V., 1976. Nekotorye itogi raskopok Achinskoy paleoliticheskoy stoyanki. In: Larichev, V.E. (Ed.), *Sibir', Centralnaya i Vostochnaya Aziya v drevnosti (epoha paleolita)*. Nauka, Novosibirsk, pp. 155–169. [in Russian]

Arhiv Klimaticheskikh Danykh, 2012. <http://climatebase.ru/> (accessed 21 November 2022).

Arkhipov, S.A., 1971. *Quaternary Period of Western Siberia*. Nauka, Siberian branch, Novosibirsk. [in Russian]

Arkhipov, S.A., Astakhov, V.I., Volkov, I.A., Volkova, V.S., Panychev, V.A., 1980. Paleogeography of West-Siberian plain at the Late Zyryanka glaciation maximum. *Transactions of the Institute of Geology and Geophysics* 470, Nauka, Siberian branch, Novosibirsk. [in Russian]

Arkhipov, S.A., Dovgal', L.A., Levina, T.P., Lipagina, V.Y., Suhorukova S.S., 1976. Litologicheskaya, palinologicheskaya harakteristika, diatomovaya flora i ostrakody iz razreza tret'ey nadpoimennoy terrasy reki Ob' (Surgutskoe Priobie). In: Hlonova A.F. (Ed.), *Etyudy po paleofitologii Sibiri*. K IV Mezhdunarodnoy Palinologicheskoy Konferencii (Lakna, Indiya, 1976), Nauka, Moskva, pp. 83–102.

Arkhipov, S.A., Volkova, V.S., 1994. *Geological History, Pleistocene Landscapes and Climate in West Siberia*. NIC OIGGM SO RAN, Novosibirsk. [in Russian]

Arkhipov, S.A., Votah, M.P., Levina, T.P., 1973. Palinologicheskaya harakteristika riss-vyurmских (kazancevских) i nizhne-srednevyurmских otlozheniy doliny Sredney Obi. In: Saks, V.N., Arkhipov, S.A., Volkov, I.A., Volkova, V.S., Troitskiy, S.L. (Eds.), *Pleistocen Sibiri i Smeznykh Oblastey*. K IX kongressu INQUA (Novaya Zelandiya 1973), Nauka, Moskva, pp. 143–151.

Astakhov, V.I., 2006. Evidence of Late Pleistocene ice-dammed lakes in West Siberia. *Boreas* 35, 607–621.

Babin, G.A., Chernykh, A.I., Golovina, A.G., Zhigalov, S.V., Dolgushin, S.S., Vetrov, E.V., Korableva, T.V., et al., 2015. *Gosudarstvennaya geologicheskaya karta Rossiyskoy Federacii. Masshtab 1:1000000 (tret'ye pookolniye)*. Seriya Altaye-Sayanskaya. List N-44–Novosibirsk. Kartograficheskaya fabrika VSEGEI, St. Petersburg. [in Russian]

Baryshnikov, G.F., 2006. Late Pleistocene Arctic fox (*Alopex lagopus*) from Crimea, Ukraine. *Quaternary International* 142–143, 208–217.

Baryshnikov, G.F., Kuzmina I.T., Hrabrii V.M., 1977. Rezultaty izmereniy trubchatykh kostey mamontov Berelyokhskogo “kladbishcha”. In: Starobogatov, Ja.I. (Ed.), *Mamontovaya fauna Russkoy ravniny i Vostochnoy Sibiri*. Proceedings of the Zoological Institute 72, Academy of Sciences of the USSR, Leningrad, pp. 58–67. [in Russian]

Baulo, A.V., 2002. *Kul'tovaya Atributika Berezovskikh Hantov*. Institut arheologii i etnografii SO RAN, Novosibirsk. [in Russian]

Baumann, Ch., Wong, G.L., Starkovich, B.M., Münzel, S.C., Conard, N.J., 2020. The role of foxes in the Paleolithic economies of the Swabian Jura (Germany). *Archaeological and Anthropological Sciences* 12, 208. <https://doi.org/10.1007/s12520-020-01173-4>.

Bednarik, R.G., 2008. Children as Pleistocene artists. *Rock Art Research* 25, 173–182.

Bednarik, R.G., 2020. First Pleistocene rock art found in central Europe. *L'anthropologie* 124, 102778. <https://doi.org/10.1016/j.anthro.2020.102778>.

Behrensmeyer, A.K., 1978. Taphonomic and ecologic information from bone weathering. *Paleobiology* 4, 150–162.

Behrensmeyer, A.K., Gordon, K.D., Yanagi, G.T., 1986. Trampling as a cause of bone surface damage and pseudo-cutmarks. *Nature* 319, 768–771.

Bello, S.M., Crété, L., Galway-Witham, J., Parfitt, S.A., 2021. Knapping tools in Magdalenian contexts: new evidence from Gough's Cave (Somerset, UK). *PLoS ONE* 16, e0261031. <https://doi.org/10.1371/journal.pone.0261031>.

Bocherens, H., 2015. Isotopic tracking of large carnivore palaeoecology in the mammoth steppe. *Quaternary Science Reviews* 117, 42–71.

Bocherens, H., Pacaud, G., Lazarev, P., Mariotti, A., 1996. Stable isotope abundances (<sup>13</sup>C, <sup>15</sup>N) in collagen and soft tissues from Pleistocene mammals from Yakutia. Implications for the paleobiology of the mammoth steppe. *Palaeogeography, Palaeoclimatology, Palaeoecology* 126, 31–44.

Braun, I.M., 2015. Thoughts on Ice Age art. In: Putová, B., Soukup, V. (Eds.), *The Genesis of Creativity and the Origin of the Human Mind*. Edition: Karolinum Press, Charles University Prague The University of Chicago Press Books, pp. 130–138.

Burkanova, E.M., 2006. Results of the spore-and-pollen analysis of deposits of the Paleolithic locality Aryshevskoye 2 (southeast of West Siberian Plain). In: Rozanov, A.Yu., Lopatin, A.V., Parkhaev, P.Yu. (Eds.), *Modern Paleontology: Classical and New Methods*. PIN RAS, Moscow, pp. 121–127. [in Russian]

Calábková, G., Chlachula, J., Ivanov, M., Hložková, M., Czerniawska, J., Vašínová-Galiová, M., Prokeš, L., Gadas, P., 2022. Microbial degradation of Pleistocene permafrost-sealed fossil mammal remains. *Quaternary Research* 1–23. <https://doi.org/10.1017/qua.2022.28>.



- Camarós, E., Münzel, S.C., Cueto, M., Rivals, F., Conard, N.J.**, 2016. The evolution of Paleolithic hominin-carnivore interaction written in teeth: stories from the Swabian Jura (Germany). *Journal of Archaeological Science: Reports* **6**, 798–809.
- Charles, R.**, 1997. The exploitation of carnivores and other fur-bearing mammals during the north-western European late Upper Palaeolithic and Mesolithic. *Oxford Journal of Archaeology* **16**, 253–277.
- Chlachula, J.**, 2003. The Siberian loess record and its significance for reconstruction of Pleistocene climate change in north-central Asia. *Quaternary Science Reviews* **22**, 1879–1906.
- Chlachula, J.**, 2017. Chronology and environments of the Pleistocene peopling of North Asia. *Archaeological Research in Asia* **12**, 33–53.
- Chlachula, J., Little, E.**, 2011. A high-resolution Late Quaternary climatostratigraphic record from Iskitim, Priobie Loess Plateau, SW Siberia. *Quaternary International* **240**, 139–149.
- Chlachula, J., Serikov, Yu.B.**, 2010. Last glacial ecology and geoarchaeology of the Central Trans-Ural area: the Sosva River Upper Palaeolithic Complex, western Siberia. *Boreas* **40**, 146–160.
- Chlachula, J., Serikov, Yu.B.**, 2022. Utilitarian art and art-related objects in the Urals' Palaeolithic. *L'anthropologie*, 103049. <https://doi.org/10.1016/j.anthro.2022.103049>
- Costamagno, S., Bourguignon, L., Soulier, M.-C., Meignen, L., Beauval, C., Rendu, W., Mussini, C., Mann, A., Maureille, B.**, 2018. Bone retouchers and site function in the Quina Mousterian: the case of Les Pradelles (Marillac-le-Franc, France). In: Hutson, J., García-Moreno, A., Noack, E.S., Turner, E., Villaluenga, A., Gaudzinski-Windheuser, S. (Eds.), *The Origins of Bone Tool Technologies*. Romisch Germanisches Zentral Museum (RGZM), Mainz, pp. 165–195.
- Dalerum, F., Perbro, A., Magnusdottir, R., Hersteinsson, P., Angerbjörn, A.**, 2012. The influence of coastal access on isotope variation in Icelandic arctic foxes. *PLoS ONE* **7**, e32071. <https://doi.org/10.1371/journal.pone.0032071>.
- Demay, L., Julien, M.A., Anghelinu, M., Shydlovskiy, P.S., Koulakovska, L.V., Péan, S., Stupak, D.V., et al.**, 2021. Study of human behaviors during the late pleniglacial in the East European Plain through their relation to the animal world. *Quaternary International* **581–582**, 258–289.
- Derevianko, A.P., Markin, S.V., Vasil'ev S.A.**, 1994. *Paleolitovedenie: Vvedenie i Osnovy*. VO "Nauka", Sibirskaya izdatel'skaya firma, Novosibirsk. [in Russian]
- Derevianko, A.P., Molodin, V.I., Zenin, V.N., Leshchinskiy, S.V., Mashchenko, E.N.**, 2003. *Pozdnepleisticheskoe Mestonakhozhdenie Shestakovo*. Institute of Archeology and Ethnography, Siberian Branch of the Russian Academy of Sciences, Novosibirsk. [in Russian]
- Derevianko, A.P., Zenin, V.N., Leshchinskiy, S.V., Mashchenko, E.N.**, 2000. Peculiarities of mammoth accumulation at Shestakovo site in West Siberia. *Archaeology, Ethnology & Anthropology of Eurasia* **3** (3), 42–55.
- Drucker, D.G., Stevens, R.E., Germonpré, M., Sablin, M.V., Péan, S., Bocherens, H.**, 2018. Collagen stable isotopes provide insights into the end of the mammoth steppe in the central East European plains during the Epigravettian. *Quaternary Research* **90**, 457–469.
- Ermolova, N.M.**, 1978. Teriofauna Doliny Angary v Pozdnem Antropogene. Nauka, Sibirskoe Otdelenie, Novosibirsk. [in Russian]
- Gasilin, V.V., Nanova, O.G., Kosintsev, P.A., Gimranov, D.O.**, 2017. Identification of the Arctic fox (*Vulpes lagopus*), red fox (*Vulpes vulpes*) and corsac fox (*Vulpes corsac*, Carnivora, Mustelidae) of Northern Eurasia based on metric characteristics of the mandible. *Zoologicheskii Zhurnal* **96**, 698–710. [in Russian with English summary]
- Gemuev, I.N., Baulo, A.V.**, 1999. *Syatilishcha Mansi Verhoviev Severnoy Sos'vy*. Institut arheologii i etnografii SO RAN, Novosibirsk. [in Russian]
- Germonpre, M., Sablin, M., Khlopachev, G.A., Grigorieva, G.V.**, 2008. Possible evidence of mammoth hunting during the Epigravettian at Yudinovo, Russian Plain. *Journal of Anthropological Archaeology* **27**, 475–492.
- Gimranov, D.O.**, 2021. Structure of the upper teeth of the red fox (*Vulpes vulpes*) and Arctic fox (*Vulpes lagopus*) and analysis of dental variability in insular forms. *Russian Journal of Theriology* **20**, 96–110.
- Gimranov, D.O., Kosintsev, P.A., Gasilin, V.V.**, 2015. Species diagnostics of corsac (*Vulpes corsac*), fox (*Vulpes vulpes*), and Arctic fox (*Vulpes lagopus*) according to ontological characteristics of mandible teeth. *Zoologicheskii Zhurnal* **94**, 1338–1350. [in Russian with English summary]
- Gladilin, V.N., Pashkevich, G.A.**, 1977. Paleogeography of the middle- and Late Würmian of the Transcarpathians according to the date obtained from the studies of the Molochny Kamen' cave. In: Ivanova, I.K., Praslov, N.D. (Eds.), *Paleoecology of Early Man*. X<sup>th</sup> Congress of INQUA (U.K., 1977). Moscow Publishing House, Nauka, pp. 106–112. [in Russian with English summary]
- Goebel, T.**, 2002. The "microblade adaptation" and recolonization of Siberia during the late Upper Pleistocene. In: Elston, R.G., Kuhn, S.L. (Eds.). *Thinking Small: Global Perspectives on Microlithization*. *Archeological Papers of the American Anthropological Association* **12**, 117–131.
- Graf, K.E.**, 2009. Modern human colonization of the Siberian mammoth steppe: a view from South-Central Siberia. In: Camps, M., Chauhan, P. (Eds.). *Sourcebook of Paleolithic Transitions*. Springer Science+Business Media, LLC, Heidelberg, New York, Paris, pp. 479–501.
- Gubonina, Z.P.**, 1977. Palynological study of Late Paleolithic site Avdeyev. In: Ivanova, I.K., Praslov, N.D. (Eds.), *Paleoecology of Early Man*. X<sup>th</sup> Congress of INQUA (U.K., 1977). Moscow Publishing House, Nauka, Moscow, pp. 57–66. [in Russian with English summary]
- Guiry, E.J., Szpak, P.**, 2021. Improved quality control criteria for stable carbon and nitrogen isotope measurements of ancient bone collagen. *Journal of Archaeological Science* **132**, 105416. <https://doi.org/10.1016/j.jas.2021.105416>.
- Guseynov, M.M.**, 1973. O taynike azyhantropov v ashele. *Uchenye Zapiski Azerbaydzhanskogo Gosudarstvennogo Universiteta* **8**, 12–18. [in Russian]
- Gvozdover, M.D., Grigoryev, G.P.**, 1977. The Avdevo Paleolithic site in the Seim River basin. In: Ivanova, I.K., Praslov, N.D. (Eds.), *Paleoecology of Early Man*. X<sup>th</sup> Congress of INQUA (U.K., 1977). Moscow Publishing House, Nauka, Moscow, pp. 50–56. [in Russian with English summary]
- Haynes, G.**, 1982. Utilization and skeletal disturbances of North American prey carcasses. *Arctic* **35**, 266–281.
- Haynes, G.**, 1999. The role of mammoths in rapid Clovis dispersal. *Deinsea* **6**, 9–38.
- Haynes, G., Krasinski, K., Wojtal, P.**, 2020. Elephant bone breakage and surface marks made by trampling elephants: implications for interpretations of marked and broken *Mammuthus* spp. bones. *Journal of Archaeological Science: Reports* **33**, 102491. <https://doi.org/10.1016/j.jasrep.2020.102491>.
- Haynes, G., Krasinski, K., Wojtal, P.**, 2021. A study of fractured proboscidean bones in recent and fossil assemblages. *Journal of Archaeological Method and Theory* **28**, 956–1025.
- Haynes, G., Stanford, D.**, 1984. On the possible utilization of *Camelops* by early man in North America. *Quaternary Research* **22**, 216–230.
- Haynes, G., Wojtal, P.**, 2022. Weathering stages of Proboscidean bones: relevance for zooarchaeological analysis. *Journal of Archaeological Method and Theory*. <https://doi.org/10.1007/s10816-022-09569-3>.
- Hubberten, H.W., Andreev, A., Astakhov, V.I., Demidov, I., Dowdeswell, J.A., Henriksen, M., Hjort, C., et al.**, 2004. The periglacial climate and environment in northern Eurasia during the Last Glaciation. *Quaternary Science Reviews* **23**, 1333–1357.
- Kolobova, K., Kharevich, V., Chistyakov, P., Kolyasnikova, A., Kharevich, A., Baumann, M., Markin, S., Olsen, J.W., Krivoshapkin, A.**, 2022. How Neanderthals gripped retouchers: experimental reconstruction of the manipulation of bone retouchers by Neanderthal stone knappers. *Archaeological and Anthropological Sciences* **14**, 26. <https://doi.org/10.1007/s12520-021-01495-x>.
- Konidaris, G.E., Athanassiou, A., Tourloukis, V., Thompson, N., Giusti, D., Panagopoulou, E., Harvati, K.**, 2018. The skeleton of a straight-tusked elephant (*Palaeoloxodon antiquus*) and other large mammals from the Middle Pleistocene butchering locality Marathousa 1 (Megalopolis Basin, Greece): preliminary results. *Quaternary International* **497**, 65–84.
- Krasnoborov, I.M., Lomonosova, M.N., Shaulo, D.N., Vibe, E.I., Zhirova, O.S., Korolyuk, E.A., Krasnikov, A.A., Snytko, O.N., Tupitsyna, N.N.**, 2000. *Opredelitel' Rasteniy Novosibirskoy Oblasti*. Nauka, Sibirskoe Predpriyatie RAN, Novosibirsk. [in Russian]
- Krivonogov, S.K., Bakhareva, V.A., Kim, Yu.V., Orlova, L.A., Skabichevskaya, N.A.**, 1993. New data on stratigraphy and paleogeography of the Late Pleistocene in the Surgut Ob region. *Geologiya i Geofizika* **34** (3), 24–37. [in Russian with English summary]

- Kulemzin, V.M., 2004. *O Hantyskih Shamanah*. Estonskiy Literaturniy Muzei, Tartu. [in Russian]
- Kulemzin, V.M., Lukina, N.V., 2006. *Vasyugansko-vahovskye Hanty v Kontse XIX–Nachale XX vv.*: Etnograficheskie Ocherki. Mandr i Ka, Tyumen. [in Russian]
- Kulemzin, V.M., Matyushchenko, V.I., Bobrova, A.I. (Eds.), 1994. *Ocherki Kulturogeneza Narodov Zapadnoy Sibiri. Tom 2. Mir Realnyi i Potustoronniy*. Izdatelstvo Tomskogo Universiteta, Tomsk. [in Russian]
- Kungurov, A.L., 1996. Mal'tinskiy kul'turniy sloy poseleniya Ushliop 6. In: Kiryushin, Yu.F. (Ed.). *Sohranenie i Izuchenie Kul'turnogo Naslediya Altayskogo Kraya*. Altayskiy Universitet, Barnaul, pp. 45–50. [in Russian]
- Kuzmina, I.E., Sablin, M.V., 1993. Arctic foxes of the Late Pleistocene from the Upper Desna. In: Baryshnikov, G.F., Kuzmina, I.E. (Eds.), *Materials of Mesozoic and Cenozoic History of Terrestrial Vertebrates. Proceedings of the Zoological Institute RAS, St. Petersburg* **249**, 93–104. [in Russian with English summary]
- Kuzmin, Y.V., Bondarev, A.A., Kosintsev, P.A., Zazovskaya, E.P., 2021. The Paleolithic diet of Siberia and Eastern Europe: evidence based on stable isotopes ( $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ ) in hominin and animal bone collagen. *Archaeological and Anthropological Sciences* **13**, 179. <https://doi.org/10.1007/s12520-021-01439-5>.
- Kuzmin, Y.V., Keates, S.G., 2018. Siberia and neighboring regions in the last glacial maximum: did people occupy northern Eurasia at that time? *Archaeological and Anthropological Sciences* **10**, 111–124.
- Landeck, G., Garriga, J.G., 2017. New taphonomic data of the 1 Myr hominin butchery at Untermaassfeld (Thuringia, Germany). *Quaternary International* **436**, 138–161.
- Lbova, L.V., Kolomietc, V.L., Dergacheva, M.I., Fedenyova, I.N., Klementyev, A.M., 2005. Environment and climate during the late Upper Pleistocene in the western Trans-Baikal region (based on data from geoarchaeological sites). *Archaeology, Ethnology & Anthropology of Eurasia* **2** (22), 2–17.
- Leshchinskiy, S., 2015. Enzootic diseases and extinction of mammoths as a reflection of deep geochemical changes in ecosystems of Northern Eurasia. *Archaeological and Anthropological Sciences* **7**, 297–317.
- Leshchinskiy, S.V., 2012. Paleoeological investigation of mammoth remains from the Kraków Spadzista Street (B) site. *Quaternary International* **276–277**, 155–169.
- Leshchinskiy, S.V., Burkanova, E.M., 2022. The Volchia Griva mineral oasis as unique locus for research of the mammoth fauna and the late Pleistocene environment in Northern Eurasia. *Quaternary Research* **109**, 157–182.
- Leshchinskiy, S.V., Kuzmin, Y.V., Zenin, V.N., Jull, A.J.T., 2008. Radiocarbon chronology of the “Mammoth Cemetery” and Paleolithic site of Volchia Griva (Western Siberia). *Current Research in the Pleistocene* **25**, 53–56.
- Leshchinskiy, S.V., Zenin, V.N., Bukharova, O.V., 2021. The Volchia Griva mammoth site as a key area for geoarchaeological research of human movements in the Late Paleolithic of the West Siberian Plain. *Quaternary International* **587–588**, 368–383.
- Leshchinskiy, S.V., Zenin, V.N., Burkanova, E.M., Dudko, A.A., Gulina, A.V., Fedyayev, N.Ya., Semiryakov, A.S., Kanishcheva, E.V., 2015. Multidisciplinary studies of the Baraba mammoth refugium in 2015. *Tomsk State University Journal* **400**, 354–365. [in Russian with English summary]
- Levina, T.P., 1979. Palinologicheskaya karakteristika otlozheniy pozdnechetvertichnoy lednikovoy epohi v doline Obi. In: Volkova, V.S. (Ed.), *Stratigafiya i Palinologiya Mezozoya i Kainozoya Sibiri*. Nauka, Sibirskoe Otdelenie, Novosibirsk, pp. 62–74. [in Russian]
- Lister, A.M., 1999. Epiphyseal fusion and postcranial age determination in the woolly mammoth *Mammuthus primigenius*. *Deinsea* **6**, 79–87.
- Markov, G.E., Lukina, N.V. (Eds.), 1987. *Istochniki po Etnografii Zapadnoy Sibiri*. Izdatelstvo Tomskogo Universiteta, Tomsk. [in Russian]
- Martellotta, E.F., Delpiano, D., Govoni, M., Nannini, N., Duches, R., Peresani, M., 2020. The use of bone retouchers in a Mousterian context of Discoid lithic technology. *Archaeological and Anthropological Sciences* **12**, 228. <https://doi.org/10.1007/s12520-020-01155-6>.
- Maschenko, E.N., 2002. Individual development, biology and evolution of the woolly mammoth. *Cranium* **19**, 4–120.
- Maschenko, E.N., Leshchinskiy, S.V., 2001. Composition and morphology of mammoth remains from the Volchia Griva site. In: Podobina, V.M. (Ed.), *Evolution of Life on the Earth: Proceedings of the II International Symposium*. Tomsk State University, Tomsk, pp. 507–511. [in Russian]
- Medvedev, G.I., Slagoda, E.A., Lipnina, T.A., Berdnikova, N.E., Generalov, A.G., Rogovskoy, E.O., Oshchepkova, E.B., Vorobieva, G.A., Shmygun, P.E., 2001. *Kamennyi vek Yuzhnogo Priangariya. Bel'skiy Geoarheologicheskiy Rayon. Vol. 2*. Irkutskiy Universitet, Irkutsk. [in Russian]
- Mikhailova, I.V., 2004. Istoriya razvitiya rastitelnosti i klimata Srednego Priobia v Pozdnem Pleistocene (po dannym palinologicheskikh issledovaniy). *Novosti paleontologii i stratigrafii. Prilozhenie k zhurnalul Geologiya i Geofizika* **6–7**, 209–216. [in Russian]
- Mochanov, Yu.A., Fedoseeva, S.A., Alekseev, A.N., Kozlov, V.I., Kochmar', N.N., Shcherbakova, N.M., 1983. *Arheologicheskie Pamyatniki Yakutii. Basseyny Aldana i Oliokmy*. Nauka, Novosibirsk. [in Russian]
- Moigne, A.-M., Valensi, P., Auguste, P., García-Solano, J., Tuffreau, A., Lamotte, A., Barroso, C., Moncel, M.-H., 2016. Bone retouchers from Lower Palaeolithic sites: Terra Amata, Orgnac 3, Cagny-l'Épinette and Cueva del Angel. *Quaternary International* **409**, 195–212.
- Mozota, M., 2013. An experimental programme for the collection and use of retouching tools made on diaphyseal bone splinters. *EXARC Journal* **2013/2**. <https://exarc.net/ark:/88735/10113>.
- Mozota, M., 2018. Experimental programmes with retouchers: where do we stand and where do we go now? In: Hutson, J., García-Moreno, A., Noack, E.S., Turner, E., Villaluenga, A., Gaudzinski-Windheuser, S. (Eds.), *The Origins of Bone Tool Technologies*. Romisch Germanisches Zentral Museum (RGZM), Mainz, pp. 15–32.
- Okladnikov, A.P., Grigorenko, B.G., Alexeeva, E.V., Volkov, I.A. 1971. Stoyanka verhnepaleoliticheskogo cheloveka Volchia Griva (raskopki 1968 goda). *Materialy polevykh issledovaniy Dal'nevostochnoi arheologicheskoy ekspeditsii 2*. NII IFF SO AN SSSR, Novosibirsk, pp. 87–131. [in Russian]
- Pashkevich, G.A., 1977. Palynological study of the section of the site Korman IV. In: Goretskiy, G.I., Tseytlin, S.M. (Eds.), *The Multilayer Paleolithic Site Korman IV on the Middle Dniestr*. X<sup>th</sup> Congress of INQUA (U.K., 1977). Moscow Publishing House, Nauka, Moscow, pp. 105–111. [in Russian]
- Pogoda i Klimat, 2020. *Spravochno-Informatsionnyi Portal*. <http://www.pogodaiklimat.ru/>. [accessed 21 November 2022]
- Polunin, G.V., 1961. O krupnom zahoronenii mamontov v Barabinskoy stepi. *Trudy SNIIGGiMS* **14**, 46–48. [in Russian]
- Praslov, N.D., Levkovskaya, G.M., Kulkova, T.F., 1977. The conditions of the cultural layer bedding in the Gmelin Late Paleolithic site in the Kostenki region. In: Ivanova, I.K., Praslov, N.D. (Eds.), *Paleoecology of Early Man*, for the X<sup>th</sup> Congress of INQUA (U.K., 1977). Moscow Publishing House, Nauka, Moscow, pp. 84–95. [in Russian with English summary]
- Pryor, A.J.E., Pospuła, S., Nesnídalová T., Kowalik N., Wojtal P., Wilczyński J., 2020. Mobility and season of death of the Arctic foxes killed by Gravettian hunters at Kraków Spadzista, Poland. *Journal of Archaeological Science: Reports* **33**, 102520. <https://doi.org/10.1016/j.jasrep.2020.102520>.
- Reimer, P.J., Austin, W.E.N., Bard, E., Bayliss, A., Blackwell, P.G., Ramsey, C.B., Butzin, M., et al., 2020. The IntCal20 Northern Hemisphere radiocarbon age calibration curve (0–55 cal kBP). *Radiocarbon* **62**, 725–757.
- Sablin, M.V., 1994. Late Pleistocene Arctic fox (*Alopes lagopus rossicus*) from Kostenki of the Voronezh Region. In: Kuzmina, I.E., Baryshnikov, G.F. (Eds.), *Quaternary Fauna of Northern Eurasia*. Proceedings of the Zoological Institute RAS, St. Petersburg, 256, pp. 59–68. [in Russian with English summary]
- Seuru, S., Leshchinskiy, S., Auguste, P., Fedyayev, N., 2017. Woolly mammoth and man at Krasnoyarskaya Kurya site, West Siberian Plain, Russia (excavation results of 2014). *Bulletin de la Société Géologique de France* **188**, 4. <https://doi.org/10.1051/bsgf/2017005>.
- Shcherbakova, T.I., 1994. *Materialy Verhnepaleoliticheskoy Stoyanki Talitskogo (Ostrovskoy)*. UrO RAN, Ekaterinburg. [in Russian]
- Sokolova, Z.P., 2009. *Hanty i Mansi: Vzglyad iz XXI v.* Nauka, Moskva. [in Russian]
- Spiridonova, E.A., 2006. The sporo-pollen data. In: Voeykov, O.A. (Ed.), *Chapter 3, The Paleoecology of the Plains Paleolithic (the Kamennaja Balka Upper Paleolithic Sites North of Sea of Azov)*. Scientific World, Moscow, pp. 101–120. [in Russian]



- Sukachev, V.N., Gromov, V.I., Bader, O.N. (Eds.), 1966. *Verhnepaleoliticheskaya Soyanka Sungir [The Upper Paleolithic Site Sungir]*. Trudy Geologicheskogo Instituta AN SSSR 162, Nauka, Moskva. [in Russian]
- Svoboda, J.A., 2008. The Upper Paleolithic burial area at Předmostí: ritual and taphonomy. *Journal of Human Evolution* 54, 15–33.
- Szpak, P., Gröcke, D.R., Debruyne, R., MacPhee, R.D.E., Guthrie, R.D., Froese, D., Zazula, G.D., Patterson, W.P., Poinar, H.N., 2010. Regional differences in bone collagen  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  of Pleistocene mammoths: implications for paleoecology of the mammoth steppe. *Palaeogeography, Palaeoclimatology, Palaeoecology* 286, 88–96.
- Tappen, M., 1994. Bone weathering in the tropical rain forest. *Journal of Archaeological Science* 21, 667–673.
- Tashak, V.I., Antonova, Yu.E., Reshetova, S.A., 2019. Novye dannye po rekonstrukcii paleosredy v doline r. Tamir (Zapadnoe Zabaykalie). *Vestnik BNC SO RAN, Seria Istoricheskie Issledovaniya i Arheologia* 4 (36), 30–38. [in Russian]
- Tashak, V.I., Reshetova, S.A., Antonova, Yu.E., 2017. Rekonstrukciya sredy obitaniya cheloveka v basseine r. Udy v pozdnem Pleistocene—golocene po materialam arheologicheskogo mestonahozhdeniya Baryn-Alan 1 (Zapadnoe Zabaykalie). *Izvestiya Irkutskogo Gosudarstvennogo Universiteta, Geomorfologiya i Evolyucionnaya Geografiya, Seria "Geoarheologia. Etnologia. Antropologia."* 20, 3–25. [in Russian]
- Timmermann, A., Friedrich, T., 2016. Late Pleistocene climate drivers of early human migration. *Nature* 538, 92–95.
- Tseytlin, S.M., 1985. Geologiya verhnepaleoliticheskoy stoyanki Chernoozerie II. In: Molodin V.I. (Ed.), *Pozdnepaleoliticheskaya Epoha na Yuge Zapadnoy Sibiri*. Nauka, Sibirskoe Otdelenie, Novosibirsk, pp. 67–71. [in Russian]
- Velichko, A.A., Gribchenko, Yu.N., Markova, A.K., Udartsev, V.P., 1977. Age and habitation conditions of the site Khotylevo II at the Desna River. In: Ivanova, I.K., Praslov, N.D. (Eds.), *Paleoecology of Early Man*. X<sup>th</sup> Congress of INQUA (U.K., 1977). Moscow Publishing House, Nauka, Moscow, pp. 40–50. [in Russian with English summary]
- Velichko, A.A., Pisareva, V.V., Sedov, S.N., Sinitsyn, A.A., Timireva, S.N., 2009. Paleogeography of Kostenki-14 (Markina Gora). *Archaeology, Ethnology & Anthropology of Eurasia* 37 (4), 35–50.
- Velichko, A.A., Timireva, S.N., Kremenetski, K.V., MacDonald, G.M., Smith, L.C., 2011. West Siberian Plain as a late glacial desert. *Quaternary International* 237, 45–53.
- Verestchagin, N.K., Kuzmina, I.E., 1977. Remains of mammals from Paleolithic site on the Don and Desna rivers. In: Skarlato, O.A. (Ed.), *Mammoth Fauna of Russian Plain and Eastern Siberia*. Proceedings of the Zoological Institute, Vol. 72, Leningrad, pp. 77–110. [in Russian]
- Vogel, J.S., Southon, J.R., Nelson, D.E., Brown, T.A., 1984. Performance of catalytically condensed carbon for use in accelerator mass spectrometry. *Nuclear Instruments and Methods in Physics Research B* 5, 289–293.
- Volkova, V.S., Bukreeva, G.F., Poleshchuk, V.P., Grichuk, M.P., 1970. Sporovo-pyl'cevaya charakteristika osnovnykh razrezov pozdnepleistocenovyykh i chetvertichnykh otlozheniy. Vnelednikovaya oblast'. In: Saks, V.N. (Ed.), *Istoriya Razvitiya Rastitel'nosti Vnelednikovoy Zony Zapadno-Sibirskoy Ravniny v Pozdnepleistocenovoe i Chetvertichnoe Vremya*. Nauka, Moskva, pp. 119–195. [in Russian]
- Volkova, V.S., Mikhailova, I.V., 2001. Environment and climate in the last (Sartan) glaciation in West Siberia (according to palynological evidence). *Geologiya i Geofizika* 42, 678–689. [in Russian]
- Volkova, V.S., Volkov, I.A., 1980. Otlozheniya i landshafty sartanskoy stadii oledneniya v nizoviykh Chulyma. In: Saks, V.N., Volkova, V.S., Hlonova, A.F. (Eds.), *Paleopalinologiya Sibiri. Statii Sovetskikh Palinologov k V Mezhdunarodnoy Palinologicheskoy Konferencii (Kembrizh, Angliya, 1980)*. Nauka, Moskva, pp. 93–96. [in Russian]
- Wojtal P., Svoboda, J., Roblíčková, M., Wilczyński, J., 2020. Carnivores in the everyday life of Gravettian hunters-gatherers in Central Europe. *Journal of Anthropological Archaeology* 59, 101171. <https://doi.org/10.1016/j.jaa.2020.101171>.
- Wojtal P., Wilczyński J., Wertz K., Svoboda J.A., 2018. The scene of a spectacular feast (part II): animal remains from Dolní Věstonice II, the Czech Republic. *Quaternary International* 466, 194–211.
- Zaklinskaya, E.D., Panova, L.A. (Eds.), 1986. *Metodicheskiye Rekomendacii k Tehnike Obrabotki Osadochnykh Porod Pri Sporovo-Pyl'cevom Analize*. Ministerstvo Geologii SSSR, VSEGEI, Leningrad. [in Russian]
- Zenin, V.N., 2002. Major stages in the human occupation of the West Siberian Plain during the Paleolithic. *Archaeology, Ethnology & Anthropology of Eurasia* 4 (12), 22–44.
- Zykin, V.S., Zykina, V.S., 2009. Problems of subdivision and correlation of the Quaternary deposits in the southern West Siberian plain. *Bulletin of Commission for Study of the Quaternary* 69, 71–84. [in Russian]