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The Origin of *H. s. denisovan* and Their Dispersal Across Iran

Before the early 2000s, anthropologists spoke of two taxa existing in the Late Middle and Early Upper Pleistocene: anatomically modern humans in Africa and Neanderthals associated with the Mousterian industry in Eurasia. Therefore, all Eurasian Paleolithic sites dating to that period were believed to be Mousterian and were associated with Neanderthals. In 2010, owing to the sequencing of mtDNA from a fragment of the distal phalanx of the hand found in Denisova Cave, a third species was introduced, genetically different from both anatomically modern humans and Neanderthals. This new taxon was termed H. s. denisovan—or simply Denisovan. Further studies showed that this population dispersed in the Late Middle and Early Upper Pleistocene across vast territories of Central and Southeast Asia. A question arose as to where Denisovans had originated and which routes they had taken to get to the Altai. A series of articles forthcoming in this journal will address these questions. The first of them focuses on the origin of Denisovans on the basis of H. heidelbergensis and on their migration via Iran to Central Asia.

Keywords: *H. heidelbergensis, H. s. neanderthalensis, H. s. denisovan, Early and Middle Paleolithic industries.*

Introduction

Since 1983, archaeological studies of nine cave and eleven open-air sites with long historical and cultural stratigraphic sequences have been carried out by researchers from the Institute of Archaeology and Ethnography of the Siberian Branch of the Russian Academy of Sciences, with the involvement of scientists from various other disciplines. These long-lasting and large-scale annual works resulted in accumulation of extensive material on the archaeology, geology, chronostratigraphy, paleontology, and paleogeography of the Altai. The most significant diagnostic material was collected during excavations in Denisova Cave; in its lowermost cultural layer 22.2, dated to the range of 282–256 ka BP (RTL-548), a biface reminiscent of the Acheulean handaxe was discovered. In 2001, in the course of analyzing the collected material, I came to a number of ideas that were subsequently reviewed, some of them got additional confirmation and served as a basis for further inferences (Derevianko, 2001).

1. Since the lowermost cultural layer yielded bifacially worked artifacts, the lithic industry of Denisova Cave was attributed to the Acheulean, Middle Paleolithic.

2. The closest parallels not only to the Middle, but also to the Upper Paleolithic industry of the Altai Mountains can be traced in the Levant. A striking similarity in the evolution of the industries can be explained only by a common more ancient basis. The absence of indigenous population in the Altai Mountains during the migration of hominins from the Levant to the region allowed them to preserve more primary features in the industry than in the transit territories of the Central Asian-Kazakhstan region inhabited at that time by man.

3. This industry provides the sufficient grounds to trace its development from the early to the terminal stage and the transition from the Middle to the Early Upper Paleolithic. In the initial Upper Paleolithic, two development trends have been distinguished—the Ust-Karakol and Kara-Bom, which were formed on the basis of terminal Middle Paleolithic industries.

4. The Altai lithic industry developed on the basis of the Acheulo-Yabrudian complex of the Levant. The migration route of hominins from the Levant to the Altai passed through Central Asia; this is supported by Mongolian lithic industries sharing many features with the Denisova industry. In Uzbekistan, westwards from the Altai, the Obi-Rakhmat culture was identified at the Obi-Rakhmat site; its industry, same as the Denisova, showed the parallel flaking strategy dominating in core utilization, with elongated blade blanks and microblades being the target products.

5. Judging by the sparse anthropological finds in the late 1990s, it was concluded that the second wave of hominin migration from the Near East was conducted by the early humans, archaic *H. sapiens*, or the evolutionary lineage that gave rise to the anatomically modern human (Ibid.: 97).

In 2010, the sequencing of mitochondrial and nuclear DNA from Denisova 3 has revealed that a tiny nail-bone fragment belonged to a new taxon that was genetically distinct from both modern humans and Neanderthals (Krause et al., 2010; Reich et al., 2010). Thanks to the genetic studies, it has been established that the Denisova industry belonged to a newly identified taxon named Denisovan, after the place of its discovery.

The question of the origin of the Denisovans has arisen. I am sure that this population with the Acheulo-Yabrudian industry migrated from the Levant through the Iranian Plateau and Central Asia to the Altai, therefore, the homeland of this taxon must be sought in the Near East.

Origin of *H. s. denisovan*

I have addressed the issues of the origin of *H. s. denisovan* in various publications (Derevianko, 2019, 2020, 2022; Derevianko, Shunkov, Kozlikin, 2020; and others); therefore, I will briefly dwell on it. J. Rightmire put forward a hypothesis as to the process of speciation of a new taxon *H. heidelbergensis*, which took place in Africa ca 800 ka BP or somewhat earlier (1996, 1998b). Many experts in physical anthropology supported his hypothesis, but designated the new taxon differently: *H. heidelbergensis*, *H. rhodesiensis*, *H. sapiens* (Rightmire, 1996, 1998a, b; 2008, 2009a, b; 2013; Tattersall, Schwarz, 2000; Bräuer, 2001a, b; Hublin, 2001; Stringer, 2002; Foley, Lahr, 2003; and others). Discussions about the role and place of this taxon in the evolution of the genus *Homo* continue to this day (Athreya, Hopkins, 2021; Roksandic et al., 2022).

H. rhodesiensis and H. heidelbergensis belonged to the same biological species evolved from the ancestral base of *H. erectus,* but they had different phylogenetic histories: *H. rhodesiensis* settled in Africa, and 200–150 ka BP provided the ancestral base for the formation of early modern humans; *H. heidelbergensis*, with the Acheulean industry, migrated to Eurasia ca 800 ka BP, and became ancestral for *H. s. denisovan* and *H. s. neanderthalensis*. Moreover, the available DNA sequences showed that these three taxa retained an open genetic system—they were able to interbreed and produce fertile offspring (Derevianko, 2019).

The split of *H. erectus* into two lineages (*H. rhodesiensis/heidelbergensis*) was the most important event in the evolution of the genus *Homo*; it marked the beginning of the formation of modern humans in Africa, and Neanderthals and Denisovans in Eurasia. Genetic studies show that this split occurred in the range of 812–793 ka BP (Reich et al., 2010; Meyer et al., 2012)*. The migration of *H. heidelbergensis* with the Acheulean industry to Eurasia is confirmed by the lithic industry from the site of Gesher Benot Ya'aqov, which has been studied for many years in Israel (Goren-Inbar et al., 2018).

The genetic and morphological evolution of modern humans in Africa took a long period of time, about 600 thousand years. For Neanderthals and Denisovans, in Eurasia this was long, too. Moreover, both branches continued to retain some features of their common ancestral genetic heritage (Derevianko, 2024).

Around 700 ka BP, tribes of *H. heidelbergensis* with the Acheulean industry from the Near East (Levant) started their dispersal across Europe and South Asia. In Europe, as a result of assimilation with late *H. erectus* (*H. antecessor*), the process of evolution of the Neanderthal taxon began, since representatives of these taxa belonged to an open genetic system (Derevianko, 2019, 2022), as well as owing to natural selection and adaptation to changing environmental conditions. The second split of the late *H. heidelbergensis* lineage occurred around 400 ka BP. At that time, part of *H. heidelbergensis* practicing the Levallois primary reduction technique settled in Europe, where they underwent further evolution to the Neanderthal taxon with the Mousterian industry, which genetically and morphologically evolved ca 200–150 ka BP (Derevianko, 2024). The other part of *H. heidelbergensis* dispersed in the east of Asia 400–

*There is no general consensus on the time of divergence of modern humans from Neanderthals and Denisovans, as well on the divergence between Neanderthals and Denisovans. This is explained by differences in the determination of the time of split of great apes and Australopithecus, and in the assessment of frequency of mutations per year, and other reasons.

350 ka BP; they met the indigenous population—late forms of *H. erectus* with a pebble-flake industry. Both taxa belonged to a genetically open system and could interbreed; hence, fertile offspring were born, and a diffusion of lithic industries occurred. The occupation of the vast territory of eastern Iran and Central Asia continued over 100–150 thousand years. In the course of dispersal, several crucial processes took place: assimilation between the migrants and the indigenous population, natural selection, adaptation to changing environmental settings, and genetic and morphological evolution of a new taxon—Denisovans and their lithic industry. About 300 ka BP, this evolving taxon began to settle in the Altai. In the lowermost culture-bearing layer 22.2 at Denisova Cave, along with the Early Middle Paleolithic industry, a deciduous molar tooth was found. The DNA sequencing of the molar showed that it belonged to a Denisovan child. This find indicates that Denisovans were the first settlers in the cave.

Thus, three stages can be distinguished in the process of evolution of Denisovans. The first stage was the migration of *H. heidelbergensis* from Africa to Eurasia ca 800 ka BP. This marked the genetic split of a single ancestral taxon *H. erectus* into modern humans evolving in Africa, and Neanderthals and Denisovans who evolved in Eurasia. The second stage was the dispersal of one part of late *H. heidelbergensis* from the Near East (Levant) ca 400 ka BP to Europe, and of the other to Asia, which led to the genetic separation between Neanderthals and Denisovans. The third stage was the genetic and morphological formation of the Denisovan taxon in the process of migration of late *H. heidelbergensis* from the Near East (Levant) to Central Asia in the period of 400–350 ka BP and their assimilation with the indigenous population (Derevianko, 2019, 2022).

Dispersal of late *H. heidelbergensis* across Iran and the initial stage of development of Denisovans

Dispersal of hominins across Iran during the Pleistocene depended largely on environmental changes. Iran is a mountainous country located mainly in the subtropical zone, between 25 and 40° N. The West Asian highlands demonstrate a great diversity of landscapes. Their main feature is the combination of high mountain ranges alternating with valleys where the arid climate prevails, with an excess of evaporation over influx of moisture. Mountain ranges with individual peaks reaching a height of 4–5 thousand meters form two huge arcs that stretch across the entire territory of Iran: the northern range runs from the Iran-Turkey border to the east along the Caspian coast; the southern range stretches from western and eastern Azerbaijan to Pakistan in the southeast. The vast deserts of Dasht-e Kavir, Dasht-e Lut, and others are located between these orographic systems.

In the Pleistocene, hominins could have migrated to South, East, and Southeast Asia from Africa only through the Iranian Plateau. During the cool periods, the climate was arid here, and the drylands of the Iranian Plateau became unsuitable for habitation and hardly passable for hominins heading to the east of the Asian continent. At that period, the most beneficial west to east routes for hominins were those along the border of the Kavir Desert, passing through the northern foothills of the Alborz Mountains and the plains of the Caspian Lowland; the southern route passed along the coast of the Persian Gulf. There are about 60 deserts of varying sizes in Iran. The availability of lithic resources and permanent water sources was of great importance for the dispersal of hominins (Shoaee et al., 2023).

During almost 70 years of studying the Iranian Paleolithic, only 13 Early Paleolithic, 30 Middle and 39 Upper Paleolithic sites have been discovered in the area of transit for the hominins exiting Africa and moving to South, Central, and East Asia (Ibid.; Shoaee, Nasab, Petraglia, 2021). During the same time, in India, several hundred Early and Middle Paleolithic sites have been discovered; and in Mongolia, the Joint Soviet-Mongolian and Russian-Mongolian expeditions have found about one thousand Stone Age sites in the recent 40 years alone.

Acheulean sites in Iran

The majority of the Acheulean sites in the region have been identified as short-term camps with a disturbed surface cultural layer, containing small amounts of finds. The sites were discovered mainly in the western part of the country.

In northwestern Iran, in the Sahand Range (Central Iranian Range), on river terraces at an altitude of 1400–1800 m, seven open-air localities and three cave sites were examined, yielding a small number of Lower Paleolithic artifacts. On the terraces, cultural remains were redeposited; and near the caves, artifacts lay on the surface. The assemblages of lithic artifacts include choppers, pebble cores, retouched flakes, polyhedrons (Fig. 1, *4*), spheroids, and a pick-type tool (Fig. 1, *7*).

Several Paleolithic sites were established along the Mahabad River, to the south of Lake Urmia, southwards of the Sahand Range. Among these, the Shiwatoo site presents the greatest interest (Jaubert et al., 2006). It is located on the left bank of the Mahabad River, at an altitude of 1380 m asl. Lithic artifacts (ca 100 spec.) were scattered over an area of approximately 1 hectare. Most of the artifacts were made of andesite, quartz, and basalt boulders. The finds include single- and multiplatform

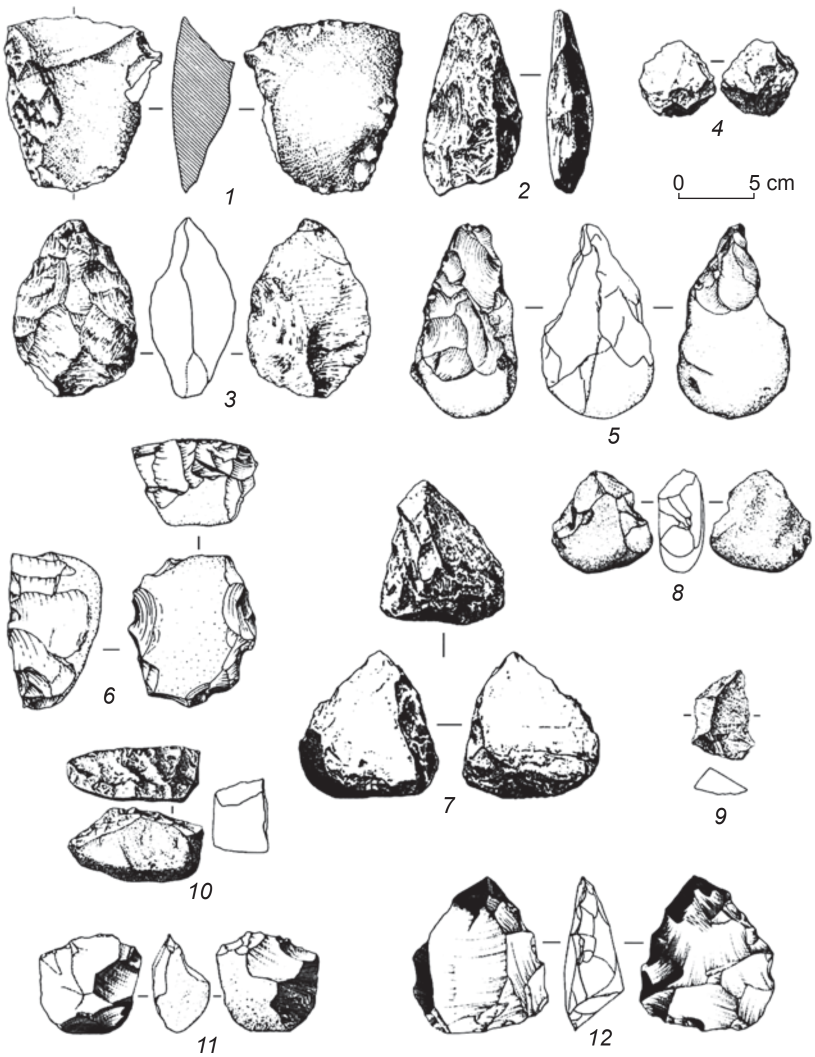

Fig. 1. Lithic tools from the sites with the Acheulean industry (after (Biglari, Jahani, 2011)).
1 – Shiwatoo; *2* – Quri Gol; *3*, *6* – Ganj Par; *4, 7* – Sahand; *5*, *8* – Amar Merdeg; *9*, *10* – Kashafrud; *11*, *12* – Pal Barik.
1 – cleaver; *2*, *3*, *5*, *12* – bifaces; *4* – polyhedron; *6* – end-scraper on core; *7* – trihedron (pick); *8* – pointed chopper (partial biface); *9* – flake; *10* – single-platform core; *11* – chopping tool on core.

cores, discoidal cores bearing negative scars of radial flaking, and pebble cores. A cleaver-like tool made on a cortical flake was identified (Fig. 1, *1*). One of its edges bears the continuous negatives of small flake removals and retouch; the opposite edge bears discontinuous traces of flaking.

In the southwest of Iran, in the hilly Zagros region, approximately 10 km southwest of the Kermanshah Valley, on one of the terraces of the Qarasu River at an altitude of 1260 m asl, the expedition headed by R.J. Braidwood (1960) found a biface and a large number of flakes and cores. These lithic artifacts clearly belonged to various chronological periods; most of them referred to the Late Stone Age. The biface, probably Acheulean, is 16.5 cm long, almond-shaped. In 2006, two bifaces, Levallois cores, and debitage were found 25 km from the village of Gakia, near Harsin.

Some 150 km southeast of the village of Gakia, at the foots of the southwestern slopes of Zagros, in the Amar Merdeg area, small amounts of stone tools were found among pebbles on tops of hills at an altitude of 200–300 m. Chopping-like cores prepared on rounded pebbles are noteworthy. Some of them, after being used as cores, could have served as heavy-duty chopping tools. There are pebbles with traces of unifacial treatment, which the researchers called “pointed choppers” (partial bifaces?) (Fig. 1, *8*). The site also yielded prepared cores of various types, including Levallois, and four bifaces. One triangular biface bears various-sized signs of careful continuous trimming over one face, except for the proximal end retaining pebble crust (Fig. 1, *5*). The opposite end is worked by small flake removals and retouch. All lithic artifacts are made from local raw materials—chert, sandstone, and quartzite pebbles.

The Acheulean site of Pal Barik is located 65 km from the Kermanshah Valley, in western Iran. It sits on a flat hilltop, at an altitude of 975 m asl. An area measuring 50 × 80 m yielded heavily patinated lithic artifacts (89 spec.). The cores included single- and double-platform, discoidal, and orthogonal varieties. Side- and end-scrapers, denticulate-notched tools, chopping tools (Fig. 1, *11*), and other implements were fashioned on flakes. There was also a small biface (Fig. 1, *12*) showing traces of large and small flake removals all over the surface; its distal end was especially well treated by small flake removals and retouch.

In northern Iran, 1 km southeast of Lake Quri Gol, a sub-triangular biface with a truncated top made of quartzite sandstone was found (Fig. 1, *2*). Its surface showed flaking scars of various sizes, was covered with a deep patina, and smoothed.

Typologically, the lithic assemblages from the three Acheulean sites in central part of western Iran have much in common. The main difference is that at Gakia and Amar Merdeg, Levallois cores were often used for primary reduction, while at Pal Barik only one small core of this type was found.

An Acheulean site was discovered in the western skirt of the Desert of Dasht-e Kavir, in central Iran. The site of Geleh is located at an altitude of 1100 m asl, on the eastern slopes of the Karkas Mountains. Two shallow riverbeds run to the east and west from Geleh. A total of about 30 lithic artifacts were collected here (Biglari, Shidrang, 2006). The assemblage includes large flakes and pebble cores up to 27 cm long. Primary flakes are large in number. Some flakes demonstrate signs of discontinuous retouch. The category of large prepared flakes includes cleaver-shaped artifacts made on primary flakes, and a large broken biface, with its faces worked by flaking and the lateral edges by retouch.

The earliest Acheulean site, Ganj Par, is located in the western part of the Alborz Range, in northern Iran (Biglari, Heydari, Shidrang, 2004; Biglari, Shidrang, 2006; Biglari, Jahani, 2011). It is situated on the terrace of the Sefid-rud River on the Rostamabad Plain. The terrace rises 230 m asl and 90–100 m above the valley floor. The site is located above terrace IV; researchers do not exclude that the archaeological materials were previously deposited in more ancient terraces (Biglari, Jahani, 2011).

During three visits of archaeologists, about 140 lithic artifacts were discovered at this site, with an area of ca 0.5 hectare, judging by the distribution of finds. The artifacts were made of red sandstone, quartzite, andesite, basalt, and tuff. The well-rounded pebbles and boulders lying on the surface and in the river alluvium served as blanks. The share of small flakes is minor among the finds, which suggests that most of these were transported by water currents from their original location to another place.

The assemblage contains single- and multiplatform, discoidal, amorphous, and bipolar cores. These were made mostly from silicified limestone. The tool kit includes choppers fashioned on cores, side-scrapers, hammerstones, bifaces (Fig. 2, *1*), cleavers (Fig. 2, *2*), and a trihedron. The sub-triangular and oval shaped bifaces were prepared on large flakes and pebbles. Their both faces show negative scars of large and medium-sized flake removals, the edges were additionally prepared with retouch. The cleavers were made on flakes (Fig. 2, *2*). Carinated side-scrapers are typical of the Early Paleolithic sites in the Caucasus (see Fig. 1, *6*). Researchers point to certain common features of the Ganj Par lithic industry with those of the Caucasian Acheulean (Biglari, Shidrang, 2006: 166).

Darband cave site was discovered 16 km east-southeast of Ganj Par. This is a single-chamber cave 21 m long, with the entrance zone 7 m wide (Ibid.). The lithic collection includes side-scrapers on flakes, core-like and end-scrapers, notched tools, borers, a chopper on core, and retouched flakes. Most of the stone products are heavily patinated. The presence of a flake that could have been removed from a biface suggests that the biface was used as a core; hence, the Acheulean technique was practiced at the site (Ibid.). Notably, the faunal remains in the cave were dominated by bones of the cave bear of the Caucasian population.

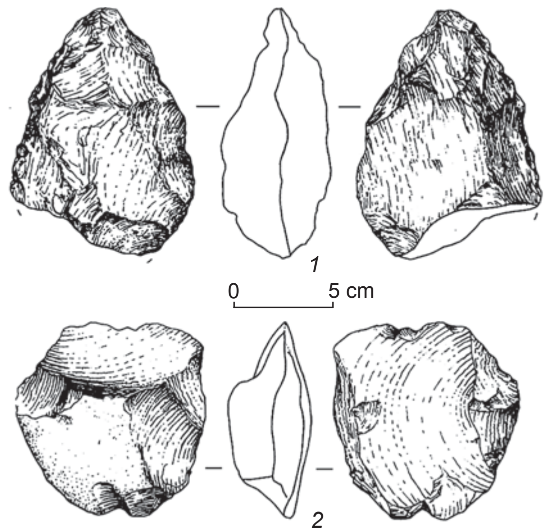

Fig. 2. Biface (*1*) and cleaver (*2*) from the site of Ganj Par (after (Biglari, Jahani, 2011)).

At most Acheulean sites where culture-bearing layers were either destroyed or scattered on the surface, only a few dozens of artifacts were discovered: cores, flakes, choppers, side-scrapers, as well as solitary bifaces and cleavers. Thus, all these sites are non-stratified and are characterized by a small number of stone tools.

Two types of Acheulean sites have been established in Iran: the first with large cores from which large flakes were removed and used as blanks for tool manufacturing, including flakes with traces of bifacial working, resembling cleavers and bifaces; the second with cores and blanks typical of the Levallois strategy of primary reduction. These archaeological materials apparently evidence two migration flows of hominins from the Near East to Iran. The first migration wave was associated with the dispersal of *H. heidelbergensis* with the Acheulean industry, moving from the Levant to Iran and South Asia around 700 (600) ka BP. The technical and typological characteristics of the Acheulean industry was similar to the industry of Gesher Benot Ya'aqov, which was based on removing large flakes from large cores and on manufacturing bifacially prepared tools—bifaces, cleavers, and pick-type tools (picks, hoes). The second wave was associated with the dispersal of late *H. heidelbergensis* (in the course of morphological and genetic evolution towards Denisovans), moving from the Levant to Iran and South Asia around 400–350 ka BP; this explains the appearance of Acheulean sites with the Levallois technique of primary reduction in these territories.

Summarizing the data of the review of the Early Paleolithic of Iran, and the Acheulean industry in particular, we should be emphasize the paucity of Acheulean sites so far discovered in this region. There are two main reasons for this. One of them is the insufficient amount of knowledge on the regional archaeology. The other reason is rather harsh living conditions, especially during cold periods, when the arid climate became even more arid, hominins could not survive at such places for a long time and migrated to more favorable areas. The small number of stratified complexes is a problem that requires further study, because Iran during the Pleistocene could have been the only transit territory for the migration of hominins from Africa and the Near East and their dispersal over the eastern regions of the Asian continent.

Middle Paleolithic sites in the territory of Iran

In the area under consideration, 30 Middle Paleolithic sites have been identified (Shoaee et al., 2021). Despite the hypothesis that in the second half of the Middle Pleistocene small hominin populations could have settled in this region even in the most extreme environmental conditions, it is hardly possible to trace the continuity between the Early and Middle Paleolithic industries because of the small number of Acheulean sites.

The lithic industry attributable to the terminal stage of the Middle and first half of the Upper Pleistocene in Iran is often correlated with the Zagros Mousterian, although it differs significantly from the European Mousterian in many technical and typological features. Taking this into account, I believe it is correct to attribute this industrial complex to the Zagros Middle Paleolithic. The industrial complexes from the mentioned sites show the greatest similarity with those of the Levantine Middle Paleolithic. Nevertheless, owing to the small number of anthropological finds, I do not rule out that both Denisovans and Neanderthals could have settled in Iran in the Late Middle to the first half of the Upper Pleistocene. It is quite understandable that all researchers associate the Zagros Mousterian only with Neanderthals: before the discovery of the Denisovan taxon, the Middle Paleolithic of Eurasia was associated mainly with the Mousterian industry and Neanderthals. The study of the Denisovan taxon is just beginning, and I am sure that in the future many generally accepted points of view on the Middle Paleolithic of Eurasia will be revised, because the Denisovans dispersed over a vast territory of the Asian continent.

The largest number of Late Pleistocene sites have been discovered in the western and northwestern parts of Iran, especially in the Zagros Range: the ecological conditions in the intermountain depressions were quite beneficial for human habitation. The areas of the Kermanshah and Khorramabad valleys and others in the western Central Zagros were a kind of refuge for hominins. Mountain ranges prevented penetration of cold air masses to the valleys. Archaeological studies have shown the availability of permanent sources of fresh water and sources of high-quality raw materials for the manufacture of lithic tools in the valleys. During the Late Pleistocene, a relatively dry and cool climate prevailed in the valleys (Van Zeist, Bottema, 1977; Kehl, 2009). The environmental conditions in Iran were especially beneficial for hominin habitation during the period corresponding to MIS 5 (Shoaee et al., 2023).

The sites in the caves and rock shelters of Kunji, Warwasi, Bisitun, Yafteh, Ghamari, Arjeneh, Mar-Aftab, Mar-Dodar, Buf, Qaleh-Bozi, and others provided the greatest amount of information. One of the key Middle Paleolithic sites is Bisitun Cave; it was excavated by C.S. Coon in 1949 (Coon, 1951). Archaeological materials from this rockshelter were also studied by J. Skinner (1965) and H. Dibble (1984).

Dibble provided the most profound and comprehensive analysis of the Bisitun lithic industry; he drew attention to the drawbacks made by Skinner when studying the excavation materials. Dibble noted that many cultural remains were discovered by researchers in the 1930s and 1940s, when excavation methods were far from being perfect and stratigraphy issues remained unresolved; consequently, there was a problem of identifying the exact position of artifacts in lithological layers relative to each other (Ibid.: 24). These problems evidently existed during the excavations carried out by Coon. He reported that in two weeks, 39 m^3 of cave deposits were removed in Bisitun Cave, while in Denisova Cave, for example, it takes three months to excavate no more than 3 m^3. Removal of Denisova deposits is carried out in strict accordance with stratigraphy, interlayers 3–5 cm thick are removed in order to accurately record the position of each find in the sequence. After the removal of cultural layers, all loose sediments are washed and sieved in order to collect the smallest archaeological finds.

Dibble conducted a thorough analysis of the Bisitun lithic industry. The vast majority of artifacts in the collection were side-scrapers of various shapes (Fig. 3, *1–3*, *5*, *8*). Most of these were made on flakes, mainly Levallois flakes, and showed traces of careful retouching. Dibble identified three types/classes of side-scrapers: longitudinal, double, and convergent.

A small number of other tools were also found in Bisitun Cave. All the burins, except one, were made on fragments of retouched items (Fig. 3, *4*, *6*, *7*). These tools can be classified as combination tools. Dibble identified more than ten typical borers in the tool kit, seven of which were made on flakes. Among the small number of typical and atypical backed knives, the scholar distinguished a

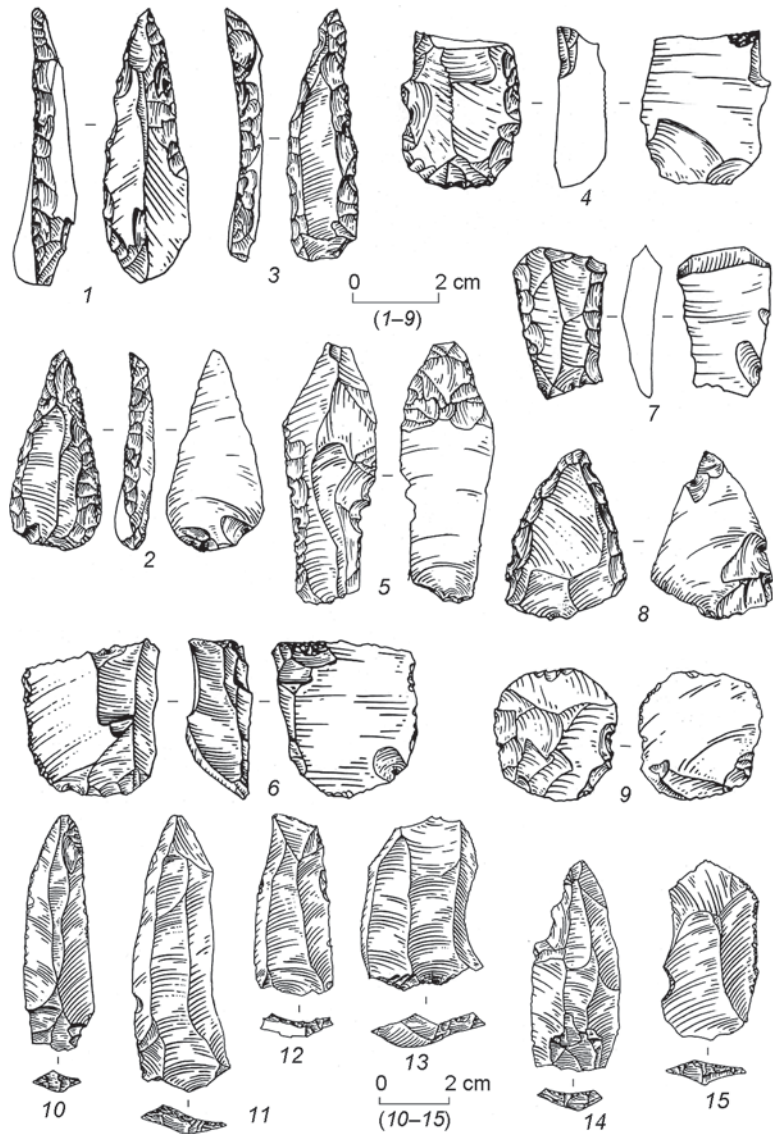

Fig. 3. Lithic tools from Bisitun Cave (after (Dibble, 1984)).
1–3 – convergent side-scrapers; *4*, *6*, *7* – burins; *5* – tool with the retouched distal end and the pointed tip prepared by multifaceted retouch on the ventral face (Kostenki-type knife); *8* – convergent side-scraper; *9* – small Levallois flake with the truncated proximal end; *10–15* – Levallois blades.

special Kostenki type (Fig. 3, *5*). Based on the retouch over ventral surface of the distal ends of these items, Coon classified the artifacts as points that were attached to shafts.

According to Dibble, the Bisitun reduction technique is characterized mainly by unidirectional and bidirectional knapping. The share of blades (Fig. 3, *10–15*) is small, while that of laminar flakes is large.

The role of Levallois reduction in producing blanks is important for understanding the character of the Bisitun industry. Skinner recorded only 15 atypical Levallois flakes in the collection, with an IL_{ty} index of 2.4. Dibble identified more than 100 typical and atypical Levallois flakes, which, in his opinion, corresponds to IL_{ty} of 10.6, and the Levallois index value including the share of the retouched Levallois flakes is 55.8 for the entire collection. Dibble concluded that the finds from Bisitun Cave are almost indistinguishable from the products from Jerf Ajla and Nahr Ibrahim. However, there exists another assessment of the Bisitun Cave industry (Baumler, Speth, 1993).

Dibble's conclusion is partially acceptable, because numerous parallels to the Bisitun stone products have been recorded in the archaeological materials from the Middle Paleolithic sites of the Near and Middle East, as well as Central Asia (Obi-Rakhmat Cave site in Uzbekistan). Similarities in technical and typological features over a vast territory can be attributed to the dispersal of Denisovans and Palestinian Neanderthals, because their lithic industry was developed largely on the basis of the Acheulo-Yabrudian and Amudian traditions of the Levantine Paleolithic.

The lack of the Early Paleolithic sites with reliable geochronological data in Iran does not make it possible to determine the time of occupation of this territory by either the first wave of *H. heidelbergensis* migrants with the Acheulean industry (it can be dated to ca 700 (600) ka BP), or the second wave, Denisovans (400–350 ka BP). The earliest date established by a bone fragment from the Khumian site in Iran is 148 ± 35 ka BP. However, the date raises doubts because of the controversial assessments of the stratigraphic position of the bone (Shoaee, Nasab, Petraglia, 2021: 19).

Since only one taxon, *H. s. neanderthalensis*, inhabiting Eurasia in the Late Middle to Early Upper Pleistocene, has been known until recently, a small number of anthropological fossils dating from the first half of the Upper Pleistocene found in Iran were also attributed to Neanderthals.

The earliest archaeological find, a hominin tooth, originates from Qaleh Kurd, dated to 150 ka BP. Fossils from Bisitun Cave also refer to early periods. According to Coon, a tooth and a fragment of radius were found in the Middle Paleolithic layer. These materials were later examined by E. Trinkaus; he identified the tooth as the left 12th or 13th lower incisor, possibly of a bull (Trinkaus, Biglari, 2006). The other fossil turned out to be the proximal half of the diaphysis of a human radius. Its both ends were broken off obliquely. The comparative analysis of the remains of Neanderthals and early modern humans showed that the morphology of the Bisitun fossil shared many features with the fragments of Neanderthal bones from Shanidar Cave and other sites in the western part of Eurasia.

Notably, the Denisovan dental system with many archaic features could have developed in the course of Denisovan dispersal across Central Asia, as a result of assimilation with the indigenous population. Interbreeding was possible because these taxa had an open genetic system. It cannot be ruled out that the physical abilities allowing Denisovans to master the highlands were gradually evolved in the course of their adaptation to local conditions during the occupation of the Tien Shan and Pamir regions.

The two taxa—Neanderthals and Denisovans—having evolved 400–350 ka BP on the ancestral base of *H. heidelbergensis* had common morphological features. However, in the process of dispersal across the territory of Iran and Central Asia, assimilation into the indigenous population, and adaptation to new environmental conditions, Denisovans acquired certain new morphological and genetic characteristics that distinguished them from the Neanderthals. Apparently, at the initial stage of settling in Iran, the Denisovans' morphology differed insignificantly from that of the indigenous population.

Some experts do not exclude the possibility of existence of two different groups of hominins with slightly different industries in the region under consideration during the period corresponding to MIS 3. One group, with the Mousterian industry, settled in Zagros (Shoaee et al., 2023). These hominins rarely used the Levallois knapping strategy. Their sites yielded numerous well-retouched side-scrapers; the tool kit included denticulate-notched items and quite few bifacially processed tools such as handaxes. Researchers attribute this industry to Neanderthals and date it to the period of 70–42 ka BP. The Middle Paleolithic sites located in the northern regions of Iran contained a lithic industry close to the Levantine Middle Paleolithic.

Possible migration routes of the emerging Denisovan taxon from Iran to Central Asia

In the eastern part of Iran, as compared to the western, quite few Paleolithic sites from the Pleistocene period have been found that could evidence the dispersal of Denisovans to East Asia. Apparently, this disproportion should be associated with the harsh environmental conditions for human habitation during that period, as well as with the insufficient field investigations in this territory.

The sites of Kashafrud and Darungok seem to have produced the earliest Paleolithic finds in the eastern Iranian Plateau, but owing to their small number and the lack of diagnostic stone implements (despite their evident Early Paleolithic morphology) it is hardly possible to attribute these sites with surface occurrence of cultural remains either to the pre-Acheulean or Acheulean period.

Over the recent 20 years, in the eastern Iranian Plateau, scholars discovered several Paleolithic sites with surface occurrence of artifacts, mainly attributable to the Middle Pleistocene (Barfi, Soroush, 2014; Nikzad, Sedighian, Ghasemi, 2015; Nasab, Hashemi, 2016, 2018; Sadraei et al., 2017, 2018, 2019; Sadraei, Anani, 2018; Sadraei, Garazhian, Sabori, 2021; and others).

Reconstruction of possible migration routes of hominins in the Middle Pleistocene should be based on field materials from the Nishapur intermountain valley in northeastern Iran (Sadraei, Garazhian, Sabori, 2021). The valley is bounded by the Binalud range in the north, the Neyzehband, Siah Kooh, and Namak mountains in the south, the Milajough and Yalpalang heights in the east, and the Sabzevar valley in the west. A total of 37 archaeological sites with various concentrations of lithics were discovered in the Nishapur plain. Four sites were identified in the southern part of the Binalud foothills, at an altitude over 1400 m asl. One of them was attributed to the Early Paleolithic, the other three to the Middle Paleolithic. The hominins inhabiting these sites used mainly flint rocks; chert, quartz, and jasper were less common (Ibid.: 5).

The above-mentioned sites yielded small numbers of artifacts. From the site of Mushan Tappeh, attributed to the Early Paleolithic, 13 items were reported: cores (4 spec.), tools (retouched, 4 spec.), and fragments (5 spec.). The category of tools contained three side-scrapers (including a bifacial one) and a core-chopper.

The small lithic assemblages from the Middle Paleolithic sites of Ali Abad, Qezel Tappeh, and Dar Behesht comprise 9, 13, and 14 items, respectively. The Dar Behesht site yielded cores and core-like items (3 spec.), flakes (4 spec.), formal tools (5 spec.) including a déjeté-type scraper, and fragments (2 spec.). The Ali Abad site also produced formal tools (5 spec.) and retouched items (2 spec.). The Qezel Tappeh collection was dominated by flakes, and included two cores (Ibid.: 8).

The sites of Kaftar Kouh, with products of Levallois reduction (flakes and blades) (Sadraei et al., 2017), and Kalat-e-Shour (Sadraei, Anani, 2018) have been attributed to the Middle Paleolithic.

The industry of the sites under consideration presents four main flaking strategies: unidirectional, typical of unifacial cores and core-choppers; bipolar; parallel flaking, recorded on at least two cores; and centripetal, recorded on three cores. Researchers did not identify the Levallois reduction technique; however, in the lithic assemblages, they recorded Levallois flakes, a bifacial scraper made on a Levallois blade, and a fragment of a Levallois point with irregular retouch. A series of Middle Paleolithic sites was found in South Khorasan (Barfi, Soroush, 2014).

In general, in the eastern Iranian Plateau, a considerably small number of Middle Paleolithic sites have been found. According to A. Sadraei and his co-authors, between the Kashafrud site in the Mashhad Plain and Kiaram Cave in the Gorgan Plain, in a 500 km long area, no important sites with Middle Paleolithic industry have been established (Sadraei et al., 2017). In case this conclusion is based on the results of a thorough survey of this area, it means that some regions of Iran were very sparsely populated by hominins. It should also be noted that almost all the local Middle Paleolithic sites are characterized by surface occurrence of cultural remains and the small number of finds.

The Sorheh complex, located in the southern slopes of the Alborz Mountains, 80 km northwest of Tehran, is of great interest (Hariryan et al., 2021). It includes six caves and rock shelters. In one of these karst cavities, the stratigraphic sequence was severely disturbed by amateur excavations. Five other rock shelters, located 20–70 m from each other, yielded only thin loose deposits. The Sorheh collection contains 118 lithic artifacts, including 12 tools. The industry is clearly blade-based. Blanks are dominated by blades, Levallois blades, and points.

Another locality, Mirak, is an open-air site in the northern part of the Central Iranian Range. Seven hills from of 4 to11 m high were discovered in the area of 2.5 km on the southern slopes of the Alborz mountain system, 5 km south from the modern city of Semnan. This hills are surrounded by several seasonal and permanent water sources, including the permanent watercourse of the Geyno River, which were very important for the hominin dispersal in this extremely dry region. At Mirak, researchers identified two relatively large sites with a lot of artifacts assembled from the surface (Nasab, Clark, Turkamandi, 2013; Nasab et al., 2019; Rezvani, Nasab, 2010).

Taking into account the significant area of lithic artifact dispersion (1.6 km^2) and the large number of surface collected items, the researchers divided the site into eight sections. The sections for artifact collection, measuring 4 × 10 m each, were established arbitrary. All lithic material was collected at each section. A total of 7744 artifacts were collected, including 6222 blanks subdivided into flakes (5504 spec.), blades (304 spec.), and small bladelets (414 spec.). The radial flaking predominated in primary reduction at the site; the Levallois index was high, IL = 46.0. According to the Levallois index, the Mirak collection was second only to the Bisitun site (IL = 55.8) and surpassed the Kunji (IL = 10.1) and Warwasi sites (on average, IL = 10). Other features of the Mirak industry included the predominance of tools on flakes; the predominance of faceted and dihedral striking platforms; a high proportion of flakes without pebble crust (89 %), which suggests that the primary reduction most probably took place beyond the site; a high share of complete blanks (more than 50 %) with traces of use, edge wear, and damage, indicating their use without retouching the working blade; the most frequent use of such raw materials as flint and chalcedony; partial retouching—hominins did not aim at changing the shape of blanks or standardizing tools; low intensity of retouch in general, although 3816 artifacts showed varying degrees of edge retouching.

The collection of tools is dominated by side-scrapers with longitudinal or transverse working edges (36 %), as well as uni- and bifacial convergent forms. A small number of pointed tools, denticulate-notched tools, and Upper Paleolithic type tools were found. There are no geochronological data for the Mirak locality; however, on the basis of technical and typological features, it was dated to the Late Middle Paleolithic.

I have presented the data on a small number of finds from the Middle Paleolithic sites in Iran. However, in recent years, the amount of available information has significantly increased. In 2015–2016, the team of the Iranian-French expedition carried out excavations at Mirak 8, where the greatest number of surface artifacts were recorded (Nasab et al., 2019). During the works, they exposed deposits at an area of 36 m^2, subdivided into three sections (19, 12, and 5 m^2) on the northern, eastern, and southern slopes of the mountains. The excavations revealed 6266 artifacts, including 2709 recovered from stratigraphic context at a depth of 4–7 m. Along with stone tools, heavily modified bones and teeth of large animals, including teeth belonging to equine species, were found.

In the stratigraphic sequence (9 m), two units were identified. The lower unit was an alluvial horizon, while the upper one consisted of wind-blown sediments. Each unit was subdivided into separate smaller strata. The OSL-dating of the lower strata, containing three main culture-bearing layers, produced the following dates: layer 1 – 28 ± 2 ka BP; layer 2 – 28 ± 2 to 38 ± 2 ka BP; layer 3 – 47 ± 2 to 47 ± 4 ka BP (Ibid.).

The artifact collection from upper layer 1 was dominated by blades and bladelets, but there were neither Arjeneh points, nor Dufour blades typical of the Baradostian or Zagros Aurignacian. Only ten tools were identified, most of which were burins. Cultural layer 2 contained the mixed Upper Paleolithic industry: blades and bladelets occurred along with Levallois flakes with typical *chapeau de gendarme* platforms. The observed combination provided the grounds to characterize layer 2 as a mix of the Upper and Middle Paleolithic industries.

The materials recovered from layer 3 demonstrated that primary flaking was carried out mostly by Levallois technique; blades and small bladelets accounted for about 5 % of the debitage. The tool kit included numerous Middle Paleolithic implements; dominated by side-scrapers and points with faceted striking platforms. In general, the industry of layer 3 showed distinct Middle Paleolithic features. The Mirak lithic industry, collected both from the surface and from the stratified context, was attributed to the terminal Middle and Early Upper Paleolithic. It showed similarities with the Zagros Middle Paleolithic complexes.

The lack of sites with long stratigraphic sequences and chronological determinations in the territory of Iran, as well as the small number of anthropological finds, do not provide reasonable grounds for establishing the taxa that could have inhabit this region in the late Middle to the first half of the Upper Pleistocene. It cannot be ruled out that both Denisovans and Palestinian Neanderthals occupied the region at that time, since both taxa had an open genetic system; they could interbreed and produce fertile offspring. As a result of acculturation, very diverse lithic industries were developed; such variability is observed at sites of both the Middle and Upper Paleolithic.

The eastern part of the Iranian Plateau is the only possible area through which Denisovans could have migrated to Central Asia and Southern Siberia. H.V. Nasab with co-authors (Nasab, Clark, Turkamandi, 2013), on the basis of the Paleolithic sites found in this area, proposed three possible migration routes passing through intermountain depressions.

Route A (Southern) consists of two parts: through the Strait of Hormuz (from Balochistan to Makran); from the strait along the northern shore of the Persian Gulf. Route B (Northern) runs along the southern coast of the Caspian Sea and the northern foothills of Alborz. This route provided the way for hominins to go east—towards Turkmenistan and Afghanistan, and west—reaching the territory of Ukraine. Route C is an internal corridor between the southern foothills of Alborz and the northern part of the Iranian Central Desert.

With the discovery of new Paleolithic sites, Sadraei and co-authors proposed two possible routes through the northeastern part of the Iranian Plateau (Sadraei, Garazhian, Sabori, 2021: 10). The first corridor, designated Hezar Masjed – Binalud, may have passed through the mountain plains where the large cities of Ashkhaneh, Bojnord, Quchan, and Mashhad are currently located (Fig. 4, *a*). The second corridor can be subdivided into two parts covering the southern portion of the Binalud and Jaghatai Mountains. This corridor borders the Jajarm and Esfarayen plains in the north, and Sabzevar and Nishapur plains in the south (Fig. 4, *b*). The researchers noted that the reconstruction of the two routes was carried out taking into account the ecological potential of the region and the small amount of available data (Ibid.).

Although all Paleolithic sites in the area are localities with surface occurrence of artifacts, scholars believe in the great archaeological potential of these two corridors, which hominins could have used to move from the Iranian Plateau to Central Asia.

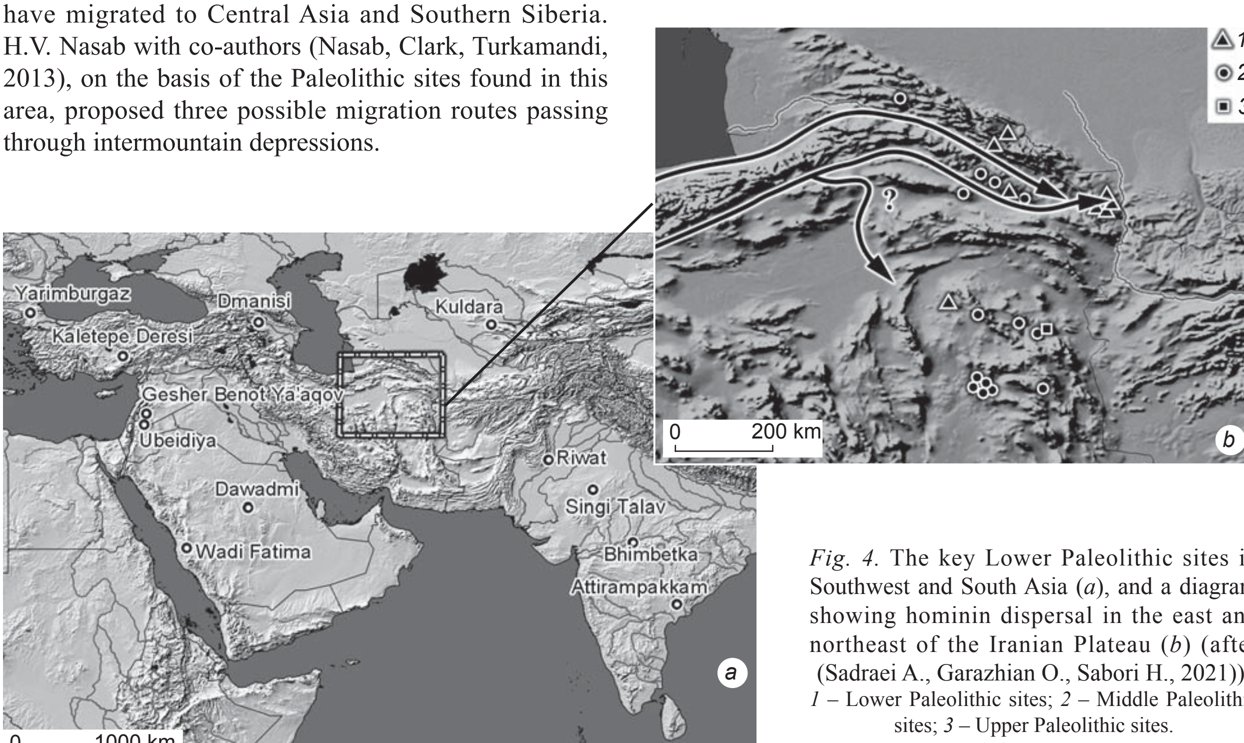

Fig. 4. The key Lower Paleolithic sites in Southwest and South Asia (*a*), and a diagram showing hominin dispersal in the east and northeast of the Iranian Plateau (*b*) (after (Sadraei A., Garazhian O., Sabori H., 2021)).
1 – Lower Paleolithic sites; *2* – Middle Paleolithic sites; *3* – Upper Paleolithic sites.

Conclusions

Owing to the lack of well-stratified sites of the Early and Middle Paleolithic, with reliable geochronological determinations and representative anthropological evidence, it is hardly possible to convincingly prove that the territory of Iran was a transit area for the hominins inhabiting South and Central Asia. Nevertheless, certain irrefutable facts allow us to accept this assumption as the main hypothesis. There were several migration flows.

1. The early migration flows led to the dispersal of *Homo erectus* populations. In Georgia and Dagestan, *H. erectus* sites with pebble-flake industry dating back 1.75–1.6 Ma BP have been found (Gabunia et al., 2002; Messager et al., 2010; Amirkhanov, Trubikhin, Chepalyga, 2009; Derevianko, 2015; and others). The Pabbi Hills and Riwat sites in South Asia are dated by researchers to the Late Pliocene to the initial Early Pleistocene (Hurcombe, Dennell, 1993; Dennell, 2004a, b). In Tajikistan, the Kuldara site with microlithoid industry dating back 800–900 ka BP has been discovered (Ranov, 1988; Ranov et al., 1987), in the Altai the Karama site with pebble-flake industry dating back to about 800 ka BP (Derevianko, Shunkov, 2005; Derevianko et al., 2005). Thus, the dispersal of *H. erectus* populations from Africa across Central and South Asia could have occurred only through the Iranian Plateau.

2. Emergence of the Acheulean industry in South Asia ca 700 (600) ka BP could have also been the result of the migration of the first wave of *H. heidelbergensis* from the Levant to the territories of Pakistan and India (Derevianko, 2018: 132, 181). Hundreds of Acheulean sites have been discovered in India.

3. In the Indian Acheulean, the early and the late stages have been identified (Shipton, Petraglia, Paddayya, 2009). The Late Acheulean, in contrast to the early one, is characterized by small, thinner, and shorter bifaces, bearing a large number of flake negative scars, indicating thorough treatment. But most importantly, the primary reduction strategy shows traces of the Levallois technique. The Levallois method of primary reduction is particularly evident in the assemblages from the sites in western Pakistan. The emergence of the Levallois reduction in western regions of South Asia can be associated exclusively with the second migration flow of late *H. heidelbergensis* (evolving Denisovans) from the Levant. Notably, the Denisovan genetic heritage can be traced in some populations of South Asia (Bergström et al., 2021; Skoglund, Jakobsson, 2011). Around 400–350 ka BP, a small group of Denisovans from the Levant could have migrated through the Iranian Plateau to the western regions of South Asia and assimilated into the indigenous population.

4. The initial stage of the Denisovan dispersal over Central Asia is represented by bifacially prepared tools of the handaxe type reported from the western regions of Turkmenistan (Okladnikov, 1953; Vishnyatsky, 1996). The Denisovans migrated from Iran to the territory of Turkmenistan along the most ecologically beneficial corridor between the Caspian Sea and the northern foothills of the Alborz mountain system. The Karakum Desert in southern Turkmenistan was not beneficial for early human habitation; no Acheulean-type sites indicating the presence of Denisovans have yet been discovered in the region.

The hypothesis that Iran was the only transit area for hominins migrating from Africa and the Near East (Levant) to South and Central Asia is currently insufficiently evidenced. Nevertheless, the emergence of a new Denisovan taxon can be described as follows: Denisovans' homeland was the Levant; their dispersal to the Altai could have occurred only through Iran and Central Asia. The aim for future studies is the search for new archaeological sites that could support the idea on the existence of this migration route.

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Methodological Issues in Pollen Analysis of Pleistocene Deposits in Denisova Cave

Denisova Cave, in the northwestern Altai, is a key Paleolithic complex in North Asia. Pleistocene deposits in the cave contain lithic industries and human fossils documenting the evolution of the cultural traditions of Denisovans in the second half of the Middle and in the Upper Pleistocene. This study addresses methodological issues in paleogeographic interpretation of pollen records relating to Quaternary deposits of cave sites. We present the results of the analysis of recent and subrecent spectra of cave sediments and soil samples taken at sites of characteristic plant communities in natural zones of the Anui River valley near Denisova Cave. Findings from taphonomic study of pollen microremains from loose sediments in the East Chamber of the cave make it possible to obtain a correct climato-stratigraphic and climato-phytocenotic interpretation of pollen spectra from Pleistocene deposits in Denisova Cave.

Keywords: *Denisova Cave, Pleistocene, cave sediments, pollen spectra, pollen taphonomy, subrecent samples.*

Introduction

Pollen analysis of Pleistocene sediments provides a sufficient amount of information concerning the climatostratigraphy and detailed reconstructions of landscape-climatic changes that occurred in the course of the environment's development, since pollen and spores of higher plants as study objects are the only paleobotanical and paleontological fossil group present in deposits of all lithological facies and all stratigraphic subdivisions of the Quaternary. Microscopic sizes and features of the morphological structure of pollen and spores contribute to their distribution over the surface of land and water areas, as well as deposition in loose sediments. Thus, fossil pollen spectra from the Pleistocene and Holocene deposits should be considered a representation of the paleovegetation of the surrounding territory; and the noted changes in the pollen composition up the profile considered the most complete record of climatic-phytocenotic and floristic changes throughout the studied stage of the Quaternary.

Pollen analysis of deposits of Paleolithic sites is widely used to establish the geological age of Pleistocene strata and their particular climato-stratigraphic subdivision, as well as to determine the rank and relative age of warm and cold climatic stages, which alternated successively during the accumulation of loose sediments. Pollen data are the only source of paleobotanical information to reconstruct a detailed history of changes in the components of prehistoric man's habitat. These changes occurred under the influence of global climatic fluctuations and were reflected in changes of zonal vegetation types, floristic complexes, and regional and local climatic conditions during the alternation of interglacial and periglacial environments. Pollen records show repeated successions of plant communities and landscape-climatic transformations, which occurred during interglacial and cold stages. Throughout the regions of Northern Eurasia, climatic events of cold periods of glacial rank affected the environment to varying degrees. In some cold epochs, severe climatic conditions led to the spread of vast ice sheets on plains and glaciers in the mountains; and during other cold periods, contributed to the formation of underground glaciation—significant or insular development of permafrost rocks. Derived pollen data, showing the dominance or a significant amount of arctic-alpine and arctic-boreal taxa of tundra and forest-tundra vegetation in the periglacial pollen spectra, are often the only basis for identification of epochs of permafrost development in the paleoclimatic record.

The number of papers describing the findings of pollen studies of deposits in Paleolithic cave sites in the mountainous regions of Northern Eurasia is considerably smaller than that of publications addressing pollen records of Pleistocene deposits of continental plains in this territory.

E.M. Malaeva studied the Pleistocene strata in the Main Chamber and the Entrance Zone of Denisova Cave located in the valley of the Anui River, and proposed the first profound paleogeographic reconstructions of the northwestern Altai, based on the results of pollen analysis of the cave deposits (Derevianko, Malaeva, Shunkov, 2000; Derevianko et al., 2003). Further pollen study of Pleistocene deposits in the Anui basin—the Early Paleolithic site of Karama, the East Chamber of Denisova Cave, and the terminal Paleolithic layers of Kaminnaya Cave—made it possible to establish a comprehensive climatic and stratigraphic classification of the sites and to reconstruct the landscape and climatic conditions of interglacial and glacial epochs, as well as interstadial and stadial stages during the deposition period (Bolikhovskaya et al., 2011, 2017; Bolikhovskaya, Shunkov, 2014, 2020; Derevianko et al., 2000). The results of the study of pollen spectra from the deposits of the Middle Paleolithic site in Chagyrskaya Cave provided the basis for an assessment of the natural and climatic conditions of the Late Pleistocene in the Charysh River valley (Derevianko et al., 2018; Kolobova et al., 2020; Rudaya et al., 2017).

In other mountainous regions of Northern Eurasia (except for Western Europe), thorough pollen studies have been carried out and profound reconstructions of Pleistocene environments have been made at the Paleolithic cave sites in the Caucasus—the Tsutskhvat multi-layered system (Mamatsashvili, 1978), Ortvala and Sakazhia (Nioradze et al., 1978; Nioradze, Mamatsashvili, 1989), Kudaro I and Kudaro III (Levkovskaya, 1980; Lyubin, 1989), Apiancha (Klopotovskaya, 1985), Vorontsovskaya (Levkovskaya, 1992), Barakaevskaya (Levkovskaya, 1994), Ortvala-Klde, Dzudzuana, Khvedelidzeebis-Mgvime, Tsiltos-Ngvime, and Rganis-Klde (Lordkipanidze, 1989, 1992), and Treugolnaya (Levkovskaya, 2007). Abundant pollen materials were collected and environment reconstructions were made at Paleolithic sites in the caves of Molochny Kamen in Ukrainian Transcarpathia (Gladilin, Pashkevich, 1977) and Bukovynka in the foothills of the Carpathians (Gerasimenko, Ridush, Avdeyenko, 2019), cave sites in the foothills of the Crimean Mountains (Gubonina, 1985) and Mountainous Crimea (Gerasimenko, 2005; Gerasimenko, 2004, 2007; Gerasimenko et al., 2014; Gerasimenko, Ridush, Avdeenko, 2016).

The majority of the above-mentioned studies provide methodical substantiation of pollen indication of paleoclimatic and paleophytocenotic events in the time of accumulation of cave sediments, based on a comparative analysis of pollen spectra derived from recent and subrecent samples collected in caves and at zonal and local plant community sample sites in the adjacent areas. However, the publications provide little information on the taphonomic features of pollen, spores, and other palynomorphs in cave sediments, which would serve as a confirmation of the representativeness of the derived pollen materials. To determine all factors in the formation of pollen complexes and to differentiate between the autochthonous or allochthonous components therein, pollen analysis of cave deposits should be supplemented with studies of the composition and taphonomic features of all plant microremains present in the macerate of each sample.

In order to get a substantiated climatostratigraphic and paleophytocenotic interpretation of the derived pollen data, traditional methodological studies were carried out, identifying the degree of correspondence between the composition and percentage of pollen and spores in samples of modern sediments collected at geobotanical sites of the Anui River valley, and those of their producing plants. Furthermore, taking into account the features of cave sedimentation at sites of limited exposure and the low probability of the influx of plants from outside, a comprehensive study of the taphonomic peculiarities of all plant microremains presented in macerates of samples from Pleistocene deposits in the East Chamber of Denisova Cave was performed.

Denisova Cave is located in the upper Anui River valley, which stretches from the southeast to the northwest between the Bashchelak (2420 m asl) and Anui (1800 m) mountain ranges (Fig. 1). In the area of the cave, the transverse profile of the valley is asymmetrical and close to V-shaped. The left side of the valley rests on the slopes of Mount Karakol (1315 m asl), the right side on the slopes of Mount Sosnovaya

Fig. 1. Upper Anyi River valley. The arrow marks the location of Denisova Cave.

(1112 m asl). The width at the bottom is about 120 m. The water-edge elevation mark is 662 m asl. The slope of the left side of the valley is slightly concave; that of the right side is convex, turning at the bottom into subvertical walls up to 10–15 m high.

The cave faces southwest; it is located on the right side of the valley, in a large block of Silurian limestones, 30 m above the modern river edge. The cave consists of three subhorizontal gallery-like chambers interconnected through the Main Chamber. The East and South Chambers stretch deep into the cave speleosystem and demonstrate the same stages of filling with loose sediments as those in the Main Chamber. To provide a reliable paleogeographic interpretation of the entire amount of pollen data derived in the process of detailed pollen analysis of Pleistocene deposits in the East Chamber, the studies were carried out focused on resolution of the main methodological issues of the palynology of cave sites.

This article presents the results of the palynotaphonomic study of plant microremains collected from Pleistocene deposits of the East Chamber of Denisova Cave and the findings from the analysis of recent and subrecent spectra from the cave, as well as from sample sites of distinctive plant communities of various environmental zones in the Anui valley.

Palynotaphonomic studies of Pleistocene deposits in the East Chamber

Scientific publications rarely contain full information on the composition of pollen complexes and on the taphomorphological features of pollen and spore grains in cave deposits. Therefore, during the study of the Pleistocene deposits in the Denisova East Chamber (Bolikhovskaya et al., 2017), special attention was paid to palynotaphonomy. The profile of Pleistocene deposits in this chamber consists mainly of loams with light, medium, or heavy granulometric composition, varying in thickness and color, and unevenly saturated with fragments of bedrock, detritus, bone remains, and coprolites of small and large mammals. According to the lithological and genetic analysis, the Pleistocene stratum of the East Chamber can be subdivided into three units, separated by clear signs of sedimentation hiatus (Fig. 2). The lower unit (layers 17.2 and 17.1) is composed of ocher-yellow loams

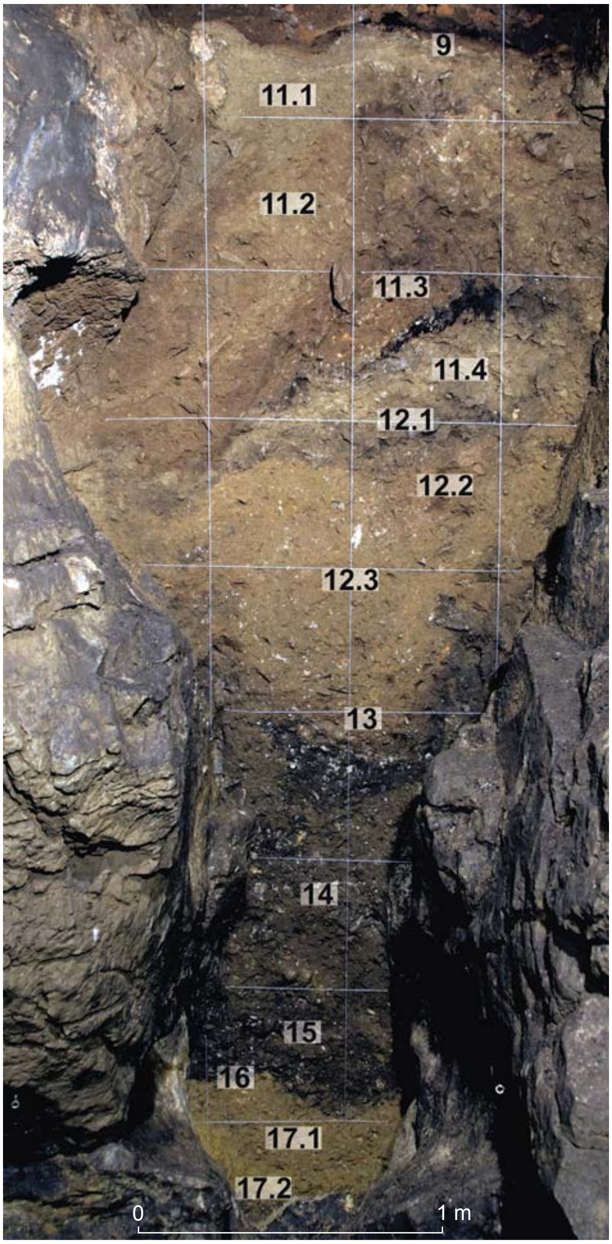

Fig. 2. Pleistocene deposits in the East Chamber of Denisova Cave.

(cave "terra rossa") with inclusions of limestone rubble, boulders, and leached dripstone formations. The middle unit (layers 16–11.1) is lenticular-layered variegated soft loams saturated with boulder-rubble material. The upper unit (layer 9) includes soft loess-like loams with lenses and isolated inclusions of grus and fine rubble. It is characterized by a high saturation with sooty organic matter, although, the degree of saturation is lower than that in the overlying Holocene sediments. Pleistocene deposits of the East Chamber were accumulated mostly owing to the subaerial aeolian, deluvial, and eluvial processes, with a significant biogenic-anthropogenic effect.

Material and study methods

In total, 138 pollen samples were collected from the section in the East Chamber: 79 samples from layers 17.1–9 of the southeastern wall of the trench, and 59 samples from layers 17.1 and 17.2 of the northwestern wall.

Unlike subaqueous sediments (lake, marsh, floodplain), which are classic objects for pollen analysis, cave deposits show a relatively low concentration of pollen and spores. Hence, palynomorphs were isolated from 50-gram portions of a sample, using a modified version of the separation method developed for the isolation of pollen and spores from subaerial and plant-microremains-poor Pleistocene sediments in the Paleobotanical Laboratory of the Faculty of Geography of Moscow State University (Bolikhovskaya, 1995). Much attention was paid to achieving maximum dispersion of the processed sediments in order to free pollen and spores from the "shell" of amorphous silica, iron and manganese oxides, silty quartz particles, calcite, clay minerals, and organic compounds. When the amount of pollen and spores in the portion was insufficient for statistical calculations, these were isolated from another (50- or 100-gram) portion of the sample. If necessary, pollen concentrates were purified from a large amount of silt and pelitic particles using 40 % hydrofluoric acid (HF). A thorough pollen analysis of macerate solutions was carried out for 79 samples from lithological layers 17.1–9. Representative pollen data were derived for 51 samples. Most of these samples contain from 320 to 1381 grains of pollen and spores of the autochthonous complex. Analysis of ten samples from layer 17.2 showed a very low concentration of pollen and spores.

Palynotaphonomic studies and palynomorphological determinations were carried out with the aid of an Axio Imager D1 microscope. Fossil photographic images were made with an AxioCam digital camera. For each sample of Pleistocene deposits containing an amount of pollen and spores statistically sufficient to derive representative spectra, a collection of digital images of plant microfossils was compiled. These include well-preserved autochthonous pollen and spore grains; pollen and spore grains belonging to an allochthonous complex with mineralized, loose, thinned, torn shells damaged during diagenesis, long-distance transportation or multiple redeposition; and also pre-Cenozoic diatoms, dinoflagellate cysts, and other redeposited palynomorphs, as well as non-pollen microremains. The photo-collection of samples also includes pollen and spore grains belonging to the allochthonous complex, which had mineralized, loose, thinned, torn shells, damaged during diagenesis, long-distance transportation, or repeated redeposition.

Almost all samples of Pleistocene deposits in the East Chamber contain a considerable amount of microorganic remains in the form of carbonaceous and humified particles, as well as marine diatoms, dinocysts, and sponge spicules, which were imported to the deposits from the destroyed limestone bedrock of the cave. Along with pollen and spores of higher plants, the autochthonous complexes contain so-called non-pollen palynomorphs—spores of soil fungi, testate amoebae *Arcella*, fragments of insects and leaf blades of plants with stomata, and other microfossils. Among the autochthonous and allochthonous non-pollen palynomorphs, macerate solutions most often reveal Pleistocene plant microremains with stomata and redeposited pre-Cenozoic marine diatoms. Three samples from the lower part of the Pleistocene sequence contained the largest number of pre-Cenozoic diatoms: 86, 77.7, and 77.5 % of the total number of pollen, spores, and non-pollen palynomorphs. In other samples, the proportion of diatoms was much smaller: from 0.2–10.0 to 16–22 %. At the same time, no paleoclimatic correlation of the maximum content of pre-Cenozoic marine palynomorphs with either interglacial or cold stages in the deposition of Pleistocene layers in the East Chamber was noted.

When considering the taphonomic aspects of cave deposits palynology, it should be borne in mind that the preservation state of some sporopollenin membranes of pollen and spores in the samples was relatively average. This is due to the sedimentation character of subaerial deposits; another possibility is that before fossilization some pollen and spore grains experienced biogenic-chemical effects in the digestive system of herbivores and then predatory animals. Therefore, in order to obtain representative data in the process of pollen studies, palynotaphonomic analysis was carried out to differentiate autochthonous and allochthonous components in the Pleistocene pollen and spore grains. Pollen and spores with heavily destroyed shells were excluded from the composition of autochthonous complexes.

In addition to pollen and spores with destroyed shells, the samples contained pollen and spore grains with clots of amorphous silica. During the diagenesis of the Quaternary subaerial deposits, the organic matter of the cytoplasm of pollen and spores with apertures (pores, furrows, false furrows, slits, and other thinned or open areas) were replaced by amorphous silica. The morphological features of the exine of most of these grains were not distorted by these "new formations", and were suitable for determining the genus and species of the pollen of woody and shrubby plants, and the family of the pollen of herbaceous plants; therefore, these were included in the autochthonous palynomorphs. In order to avoid errors in the pollen grain determination as woody or shrubby forms (since the grain sizes and morphology of the pore openings were distorted), some *Betula* pollen grains were excluded from the autochthonous palynoflora; these grains were completely filled with amorphous silica, distorting their morphological characteristics, or were almost completely covered with tiny mineral particles, mineral and organic-mineral shells.

Recent and subrecent pollen spectra as a basis for paleophytocenotic interpretation of pollen data from cave deposits

The study of pollen spectra from recent samples collected in caves (pollen samples from the air, collected with special traps and devices) and subfossil samples from cave sediments, along with pollen spectra from recent samples and samples of modern sediments from the vicinity of caves, has shown that pollen spectra from cave sediments adequately reflect the composition of zonal, regional, and local vegetation (De Porras, Mancini, Prieto, 2011; Fiacconi, Hunt, 2015; Gerasimenko, Ridush, Avdeyenko, 2019). Analysis of pollen in the air collected with the aid of the Tauber traps inside three caves and in the adjacent area in New York State, in the northeastern United States, has shown that the caves' recent spectra not only correspond to the composition of regional and local vegetation, but also are close to those of subrecent lake samples (Burney D.A., Burney L.P., 1993). A study of recent pollen samples from four cave sites at Creswell Crags (Sheffield, England) and beyond them, has shown that the cave pollen complexes reliably represented vegetation in the immediate vicinity of the caves and in the broader surroundings (Coles, Gilbertson, 1994). The proportions of tree-shrub and herbaceous-shrub pollen in recent spectra from the caves corresponded to the proportions of forest and non-forest areas both in the immediate vicinity and within a 5 km radius. It was noted that in two caves the number of grains in the samples decreased in the more rear parts of the cave, while in another cave, vice versa, the number of pollen grains was greater in samples from the rear parts of the cave.

The palynotaphonomy study of archaeological cave sites in Kurdish Iraq (Fiacconi, Hunt, 2015) and in Patagonia in southern Argentina (De Porras, Mancini, Prieto, 2011) has led to similar conclusions. Analysis of subrecent pollen spectra from Shanidar Cave and the adjacent territory has shown the complete correspondence of pollen complexes from the interior of the cave and its environs with those from the adjacent territory (Fiacconi, Hunt, 2015). At the same time, a large proportion of anemophilous plant pollen was observed in the samples collected at the cave's entrance, and an increased proportion of entomophilous plant pollen in samples from the cave's interior. Similar results were achieved in the studies of subfossil spectra from Bukovynka Cave and the surrounding area in the south of the Eastern Carpathian foothills (Gerasimenko, Ridush, Avdeyenko, 2019).

The results of pollen analysis of cave hyena coprolites are also used for the reconstruction of environmental settings: these reflect not only the local vegetation in the vicinity of caves, but also the vegetation cover over a larger area of the predator's hunting grounds (Scott, 1987; Carrión et al., 1999, 2018; Yll et al., 2006; Gerasimenko, Ridush, Avdeyenko, 2019).

Recent and subrecent pollen spectra as a representation of modern phytocenoses and a basis for the pollen identification of Pleistocene vegetation in the vicinity of Denisova Cave

Denisova Cave is located in the mountain-taiga belt of the geobotanical zoning scheme (Atlas…, 1991). In the valley of the upper Anui, mid-mountain forest-steppe and forest landscapes predominate. The right-side slope of the valley, containing the cave, shows solitary tracts or areas of sparse birch-pine forest. The left side of the valley opposite the cave is covered with a dense birch-larch forest. The vegetation cover of the upper Anui valley, from the bottom to the watershed, includes floodplain-meadow, meadow-steppe, forest (with birch, pine, and larch), mountain-steppe, and mountain-tundra communities. Floodplain areas show meadow and grass associations. Large areas of the riverbed parts of the floodplain and the low above-floodplain terrace are covered with willow-birch forests with shrub-willow undergrowth of currant, caragana (pea shrub), bird cherry, and other vegetation. Meadow-steppe associations are common at absolute altitudes from 680 to 1100 m. Meadow grass-forb and sedge-grass-forb steppes occupy areas of floodplains and adjacent slopes. The shrub steppe communities include spirea, caragana, honeysuckle, rose hips, barberry, gooseberry, and cotoneaster (Ogureeva, 1980). Meadow steppe with shrub thickets is developed on low terraces and gentle slopes; the thickets' co-edificators are Dasiphora *Dasiphora fruticosa* and Siberian grass *Sibiraea altaiensis* (*laevigata*) (Kuminova, 1960). Larch-birch forests with a shrub layer of caragana, spirea, currant, honeysuckle, and dasiphora are spread on the shaded and most humid slopes of the northern exposure at an absolute altitude of 700–1300 m. Birch-pine forests, sometimes with an admixture of larch, and with Siberian spruce and Siberian pine in the areas close to the tops cover the slopes of southeastern and southwestern exposure at an altitude of 650–1200 m. Siberian pine forests, with an admixture of spruce, larch, and fir, are widespread in small valleys and on slopes at an altitude of 1500–2000 m (Smagin et al., 1980). Above the mountain-taiga belt, there are subalpine Siberian pine and larch forests, with a typical representative of the subalpine and mountain-tundra belts—the round-leaved birch shrub *Betula rotundifolia*—in the undergrowth. Dwarf communities, with a predominance of round-leaved birch and not so numerous spirea, juniper, and shrub willow, form shrub tundra on high-mountain plateaus, smooth passes, and in saddles at an altitude of 1800–2300 m. Subalpine and alpine meadow associations, moss-lichen, dryad, lichen-rubble, and other tundra communities are also present in high-mountain landscapes.

The pollen determinations of the Pleistocene landscape and climatic conditions were made from the results of pollen analysis of 115 subrecent samples of subaerial deposits of modern soils and subaqueous sediments collected in the areas of mountain-taiga, mountain-forest-steppe, and mountain-steppe belts in the valley of the Anui River and its tributaries, as well as in the areas of mountain-tundra and mountain-forest-tundra plant communities of the nearest ridges. The results of the pollen analysis have shown that the composition and percentage of components in the pollen spectra of samples of modern subaerial deposits reflect quite properly the composition and percentage of pollen and spores of the yielding plants in the sample sites that characterize the zonal, regional, and local features of the plant communities of the Anui valley (Table 1). The analytical data from a large number of subrecent soil samples from the Anui valley also demonstrate that their spectra correspond to the composition and percentage ratio of plants in the phytocenoses of the sample sites. In the mountain-tundra spectra with high content of pollen of dwarf birch *Betula rotundifolia* and Siberian pine *Pinus sibirica*, the pollen of shrubs and herbaceous-dwarf shrub taxa predominates, illustrating the development of open landscapes. The pollen spectra of mountain-forest communities are dominated by pollen of Scotch pine *Pinus sylvestris*, silver birch *Betula pendula*, and Siberian pine *Pinus sibirica*. The pollen composition spectra of the mountain-forest-steppe belt, similarly to those of the flat forest-steppe regions of Northern Eurasia, show close values of the contents of two predominant groups: pollen of trees and grass-shrub plants (Bolikhovskaya, Ogureeva, Rudaya, 2005). In the steppe spectra, pollen of grasses and shrubs (cereals, wormwood, and forbs) prevails, and in the arboreal group, pollen of birch and pine, which vegetate forest areas on mountain slopes of steppe landscapes of the northwestern Altai.

At the same time, there is an increased content of tree pollen in the overall composition of spectra in subrecent soil samples collected outside the Anui basin in open and forested areas of the tundra and steppe belts, and in non-forested areas of high-mountain steppe basins. First of all, a high content of Siberian pine pollen is recorded in subrecent samples of tundra and steppe soils collected in the areas near upper and lower boundaries of the mountain-taiga belt (Pelankova, Chytrý, 2009) and in the bottoms of high-mountain steppe depressions, the surrounding mountains of which are vegetated with Siberian pine forests. The spectra with high content of

Table 1. **Examples of pollen spectra of subrecent soil samples collected in the Anui valley, %**

Indicator	Vegetation type					
	mountain-taiga		mountain-forest-steppe		mountain-steppe	
	The Shinok valley, abs. alt. 1510 m. Flood-plain soil covered by dwarf vegetation Sample No. 36/06	The Karakol valley, abs. alt. 1600 m. Soil from Siberian pine forest. Sample No. 27/06	The Karakol valley, close to the river mouth, abs. alt. 720 m. Soil from meadow-steppe area with larch. Sample No. 7/06	The Karama valley, abs. alt. 530 m. Flood-plain soil with forbs and shrubs. Sample No. 23/06	The Karama valley, abs. alt. 700 m. Black soil from birch-larch forest. Sample No. 19/06	The Karama valley, abs. alt. 530 m. Soil from grass-forb steppe. Sample No. 9/08
Arboreal pollen	28.5	75	64	34	49	24.5
Shrub pollen	16.5	9	–	1	–	0.5
Grass and small shrub pollen	47.5	14	28	58	47	71
Spores	7.5	2	8	6	4	4
Pollen of trees and shrubs:						
Abies sibirica	6	1	11	4	5	9
Picea obovata	3.4	2	1.5	3	1.3	1
Pinus sibirica	42	74	16	6	13	10
Larix sibirica	3.4	1.3	24	6	10.5	0
Pinus sylvestris	3.4	1	28	57.5	32	50
Betula pendula	6	10	19	19	38	28
Betula rotundifolia	36	10.3	–	–	–	–
Alnaster/Duschekia	0.5	0.2	–	–	–	–
Salix spp.	0.6	–	–	3	–	–
Juniperus spp.	–	–	0.3	0	–	–
Padus avium	–	–	–	0.5	–	–
cf. *Spiraea*	–	–	–	–	–	1
Ribes alpinum	–	0.5	–	–	–	1
Pollen of grasses and small shrubs:						
Ericales	1	5	–	–	–	–
Poaceae	25	16	20	34	36	11
Cyperaceae	25	–	17	14	2	3
Cannabis	–	–	–	0.5	–	–
Artemisia (subgenera)	8	54	20	1.2	21	25
Chenopodiaceae	3	5	8	1.2	2	2
Herbetum mixtum	37	20	35	43	39	59
Pollen of aquatic plants	–	–	–	6	–	–
Spores:						
Bryales	37	4*	23	2*	23	4*
Sphagnum	13	–	0	1*	19	–
Polypodiaceae	22	3*	70	2*	56	3*
Dryopteris sp., *D. fragrans*	–	2*	–	–	–	–
Botrychium	9	–	–	–	–	–
Lycopodium sp.	–	–	–	–	2	–
Equisetum	19	–	7	18*	–	9*
Total pollen and spore grains	716	453	532	360	1088	398

*Number of grains.

Table 2. **Composition of pollen and spores in subfossil samples from the Altai Mountains, %**

Indicator	Forest-steppe		Steppe		
	The Anui valley close to Karama	The Ursul valley close to Ongudai	Kurai basin	Kan basin	
	Soil	Soil	Soil	Soil from flood plain	Soil from terrace
1	2	3	4	5	6
Pollen of trees and shrubs	32.9	88.9	91.0	43.7	51.4
Pollen of grass and small shrubs	57.2	9.2	8.5	50.5	43.5
Spores	9.9	1.8	0.5	5.8	5.2
Pollen of trees and shrubs:					
Abies sibirica	8.1	1.5	0.8	2.2	4.3
Picea obovata	1.3	4.1	9.9	8.1	2.9
Pinus sibirica	6.0	91.2	78.9	47.7	68.1
Pinus sylvestris	43.0	0.1		6.4	1.1
Larix sp.	1.3	1.2	8.8	3.2	4.3
Betula sp.	–	1.4	0.3	–	–
B. pendula	30.2	–	–	27.1	16.5
B. cf. *rotundifolia*	–	–	0.3	0.5	1.8
Salix spp.	–	–	0.1	4.6	–
Grossulariaceae	0.7	0.1	0.1	–	–
Viburnum sp.	–	–	–	0.2	–
Lonicera sp.	–	0.1	–	–	–
Rosaceae	–	0.1	–	–	–
Spiraea sp.	9.4	–	–	–	–
Zygophyllaceae			0.1	–	1.1
Pollen of grass and small shrubs:					
Poaceae	45.6	8.0	4.8	22.8	15.7
Cyperaceae	2.3	13.3	56.6	40.2	11.4
Ephedra sp.	–	–	2.4	–	1.3
Artemisia s.g. *Euartemisia*	13.9	26.7	12.0	19.5	35.2
A. s.g. *Dracunculus*	–	–	–	0.2	–
A. s.g. *Seriphidium*	–	–	–	3.8	3.4
Chenopodiaceae	4.6	25.3	12.0	3.2	6.8
Rosaceae	3.1	4.0	–	1.5	–
Sanguisorba sp.	0.8	–	–	–	–
Apiaceae	0.8	–	–	0.2	0.4
Rubiaceae	0.8	–	–	–	–
Brassicaceae	–	–	–	0.4	–
Plantaginaceae	–	–	–		1.3
Polygonaceae	–	2.7	3.6		1.3
Gentianaceae	–	–	–	0.2	–
Onagraceae	0.4	–	–	0.4	0.4
Primulaceae	–	–	–	0.2	0.4
Lysimachia maritima	–	–	–	–	0.4
Ranunculaceae	1.2	–	–	–	–
Ranunculus sp.	–	–	–	0.2	–

Table 2 (end)

1	2	3	4	5	6
Thalictrum sp.	–	–	–	0.2	1.3
Polemoniaceae	0.4	–	–	–	–
Lamiaceae	1.2	5.3		0.2	0.4
Caryophyllaceae	–	5.3	1.2	–	1.3
Fabaceae	3.1	4.0	2.4	–	1.3
Liliaceae	–	2.7	–	0.6	0.8
Urtica sp.	–	–	–	0.6	–
Zygophillaceae	0.8	–	–	–	–
Plumbaginaceae	–	1.3	2.4	–	–
Saxifragaceae	–	–	–	0.4	–
Juncaceae	–	–	–	0.6	0.8
Euphorbiaceae	–	–	–	0.2	–
Asteraceae	4.2	–	1.2	3.8	13.1
Cirsium sp.	–	–	–	0.4	–
Echinops sp.	1.2	–	–	–	–
Chenopodiaceae	13.9	1.3	–	–	3.0
Indifferent herbs	1.9		1.2	–	–
Spores:					
Bryales	13.3	10*	1*	40.7	22*
Sphagnum		1*	–	–	1*
Polypophyta	13.3	3*	3*	–	2*
Cryptogramma crispa	–	1*	–	–	–
Botrychium sp.	–	–	–	–	1*
B. lunaria	–	–	–	–	1*
Diphaziastrum alpinum	–	–	1*	–	–
Equisetum sp.	73.3	–	–	59.3	1*
Total pollen and spore grains	453	814	975	936	543

*Number of grains.

Pinus sibirica showing a noticeable admixture of pollen of wormwood *Artemisia* and amaranth Amaranthaceae and a low content of spores, usually represented by single grains, indicate their affiliation to steppe and forest-steppe phytocenoses (Table 2).

The pollen composition of soil samples from the Denisova Cave deposits and the composition of subrecent samples from its environs point to a high representativeness of the pollen spectra. To study the features of cave deposit sedimentation and the influx of pollen and spores in the soil, a sample was taken from the surface layer of eluvial-subaerial fine earth accumulated on a small ledge in the wall of bedrock at the cave's entrance. The derived pollen spectrum corresponds to those of surface samples of subaerial deposits (soils) collected on the sample sites of plant communities in the areas of the valley closest to the cave, in particular, to their botanical zonal affiliation and the composition of the plants yielding pollen and spores (Table 3).

All the pollen spectra of the subrecent samples collected beyond the cave show tree pollen domination (62–93 %); this group includes the following co-edificators: Scotch pine *Pinus sylvestris*, Siberian larch *Larix sibirica*, and silver birch *Betula pendula*, which indicates a zonal mountain-taiga type of vegetation in this section of the Anui valley and the composition of edificators of forest associations in the sample sites (see Table 1). Notably, in cases where sample areas were established in small forest associations, the percentage of tree pollen composition in these spectra corresponded to the composition of the forest association dominating on this slope of the valley.

The pollen spectrum of the recent sample from Denisova Cave reflects adequately the zonal type of mountain-taiga vegetation in the surroundings of the cave and the composition of local forest association near the site. The cave entrance zone of the slope is vegetated with larch-birch-pine sparse forest. The spectrum

Table 3. **Results of pollen analysis carried out on surface samples of subaerial deposits in Denisova Cave and the adjacent areas in the mountain-taiga zone of the Anui valley, %**

Indicator	Sampling places				
	At the cave's entrance	Right side of the valley. Soil from the high floodplain covered by birch-larch forest	Left side of the valley. Soil from the slope covered by birch-larch forest	Right side of the valley. Soil from the high floodplain covered by birch-pine forest	Right side of the valley. Soil from the slope covered by pine-birch-larch forest
	Sample No. 1/2015	Sample No. 3/06	Sample No. 10/06	Sample No. 42/06	Sample No. 1/09
Tree pollen	54	62	70	72	93
Shrub pollen	16	1	6	0.2	1
Grass and small shrub pollen	21	28	21	21	4
Spores	9	9	3	7	2
Pollen of trees and shrubs:					
Abies sibirica	–	5	2.5	9	9.4
Picea obovata	0.75	4	1	2	5.6
Pinus sibirica	12	5	3	12	4
Larix sibirica	4	13	13	6	5
Pinus sylvestris	34	43	26	42	61.5
Betula pendula	26.5	26	47	29	13.2
Betula cf. sect. *Nanae*	–	–	0.2	0.2	–
Alnaster / Duschekia	–	0.1	–	–	–
Salix spp.	–	3.5	–	–	–
Juniperus spp.	0.75	1.5	–	–	–
Lonicera tatarica	–	–	0.5	0.2	1
Rosaceae, *Dasiphora fruticosa*	–	–	7	–	0.3
Humulus lupulus	22	–	–	–	–
Pollen of grass and small shrubs:					
Poaceae	20	22	12	52	46
Cyperaceae	–	1.5	3	21	–
Artemisia (subgenera)	12.5	16	3	5	34
Amaranthaceae	10	2	–	1	10
Herbetum mixtum	57.5	55	84	21	10
Pollen of aquatic plants	–	3.5	–	–	–
Spores:					
Bryales	3*	34	5*	37	16
Polypodiophyta	15*	9	9*	37	77.5
Pteridium aquilinum	–	31	–	–	–
Ophioglossaceae	–	–	3*	–	–
Lycopodium sp.	–	–	–	2	6.5
Equisetum	–	26	–	24	–
Total pollen and spore grains	190	971	619	678	1253

*Number of grains.

is dominated by pollen of trees and shrubs (70 % in total): Scotch pine *Pinus sylvestris*, silver birch *Betula pendula*, and Siberian larch *Larix sibirica* (see Table 3). The proportion of pollen of Siberian pine *Pinus sibirica* (12 %) corresponds to the presence of this species in the upper belt of mountain forests in this area. A noticeable proportion (22 %) in this group (arboreal pollen) of the spectrum of hop pollen *Humulus lupulus* is explained by its flowering during sampling. The composition and percentage of pollen from grass-shrub plants—cereals Poaceae, forbs Herbetum mixtum, wormwood *Artemisia*, and amaranth Amaranthaceae—indicate grass-forb associations, clumps of wormwood, and goosefoot Chenopodioideae growing near the cave. The presence of spores of fern and green mosses in the sample points to the forest type of the composition spectrum of this sample. In addition to pollen and spores of modern plants, a large number of carbonaceous organic microparticles and pre-Cenozoic marine palynomorphs were noted in the preparations of the recent sample. Each preparation contained approximately 30–35 palynomorphs (diatom valves, dinoflagellate cysts, sponge spicules, etc.) and 7–8 pollen grains. In general, the content of pre-Cenozoic palynomorphs amounted to 55 % of the total number of pollen objects in the recent sample. In terms of preservation and taphonomic features, pollen and spores from modern cave deposits do not differ from those of subrecent samples of modern soils on the slopes in the vicinity of the cave. These findings indicate the representativeness of the pollen data obtained from the Pleistocene deposits of Denisova Cave. A distinctive feature of subrecent samples of modern soils from the Anui valley slopes is the absence of palynomorphs from the bedrock of its surrounding mountains.

Conclusions

Palynotaphonomic studies of pollen objects and palynomorphological determinations of pollen and spores from Pleistocene sediments of the East Chamber of Denisova Cave have shown a high degree of correlation between the derived pollen data. Analysis of pollen spectra from recent, subrecent, and fossil samples from cave sediments, as well as spectra from samples of modern subaerial deposits collected at sample sites of various phytocenoses of all environmental zones of the Anui valley, indicates that the pollen spectra from cave sediments adequately reflect the composition of the zonal, regional, and local vegetation of the surrounding area. The palynotaphonomic studies of cave deposits have shown that the main agents transporting pollen and spores into the cave cavities were subaqueous and eolian processes, along with humans, large and small mammals, birds, and insects—bees and bumblebees, transferring pollen of entomophilous plants. Plant microparticles (objects of pollen study) were transferred with the air mass through the cave entrance, located in the steep rock wall of the southwestern exposure, as well as through a hole in the western part of the vault of the Main Chamber.

Numerous marine diatoms, dinocysts, and spicules of Porifera in the recent samples and their almost constant (from 0.2–10.0 to 78–86 % of the total number of pollen objects) occurrence in samples from the Pleistocene deposit sequence suggest a significant role of loose decomposed limestones, which are the bedrock containing the karst cavity of the cave, in the composition of fine fractions of sediments in the East Chamber. Marine palynomorphs were also added to Pleistocene deposits in the form of mineral coprolites, when large mammals used weathered salt-bearing marine sediments as kudyurites.

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Small Blade and Bladelet Production in Central Asia at the Turn of MIS 7 and 6: Cores from Kulbulak Layer 23

We describe 27 parallel, narrow-faced, and burin-cores for small blades and bladelets from Kulbulak layer 23, Western Tien Shan, excavated in 2016 and 2017. In terms of typology, flat-faced (longitudinal and transverse), prismatic (carinated, subconical, and subcylindrical), and narrow-faced cores (including burin-cores) were identified. Scar pattern analysis suggests that regardless of the typological affiliation of cores, a uniform technological scheme was used—staggered sequence of blanks. This Middle Paleolithic non-prismatic pattern probably indicates the initial steps in the formation of a technology that would subsequently influence the Middle Paleolithic blade industries in western Central Asia and become one of the sources for the regional Upper Paleolithic in the second half of MIS 3. It is concluded that small blade technology emerged within Middle Paleolithic industries of western Central Asia at the turn of MIS 7 and 6. In the Obi-Rakhmat industry (MIS 5a), this technology is represented in its fully developed form.

Keywords: *Bladelet production, scar pattern analysis, staggered sequence of blanks, Middle Paleolithic, MIS 6, MIS 7, Western Tien Shan.*

Introduction

Studies of key Stone Age sites in western Central Asia in the 21st century revealed early signs of the most important technological innovations dating back to the Middle Paleolithic. In particular, traces of systematic use of a developed small-blade technique of stone knapping were noted in the archaeological collections of the Obi-Rakhmat cultural affinity from the period of not younger than 80–70 ka BP (Krivoshapkin, 2012). According to the published data, among the Middle Paleolithic complexes from this broad region, the Obi-Rakhmat lithic industry is the only probable basis for developing local Upper Paleolithic industries focused on production of small blades and bladelets (Kolobova, 2014; Kolobova, Krivoshapkin, Pavlenok, 2014; Kolobova et al., 2013; Krivoshapkin et al., 2012).

The data of recent comprehensive geomorphological, sedimentological, and stratigraphic studies (Taratunina et al., 2020) provide the reasonable grounds to classify the lithic industry of layer 23 at Kulbulak (the period corresponding to the turn of MIS 6 and 7) as the oldest evidence of small-blade production in western Central Asia. This article presents the results of a comprehensive analysis of the small-blade component of the lithic industry of layer 23 (excavations of 2016–2017). The study includes typological analysis, scar pattern analysis, and statistical procedures. The scar pattern analysis was based on the principles described and substantiated by A. Pastoors (Pastoors, Schäfer, 1999; Pastoors, 2000), J. Richter (2001), E. Boëda (2001), M. Kot (2013, 2014), as well as K.A. Kolobova and A.V. Kharevich (Shalagina) (Shalagina, Kolobova, Krivoshapkin, 2019; Kolobova et al., 2019). This method makes it possible to reconstruct the process of preparation of a lithic artifact on the basis of negative scars of removals noticeable on the artifact surfaces, and to determine the sequence of these removals (Kolobova et al., 2022).

Chronostratigraphic position of Kulbulak layer 23

The open-air site of Kulbulak in Eastern Uzbekistan is located near the spring of the same name, on the terraced surface of the left bank of the Kyzyl-Alma sai, a right tributary of the Akhangaran River, at the foot of the southeastern slope of the Chatkal Range (Western Tien Shan) (Fig. 1). In 2007–2019, excavations unearthed the undisturbed deposits in the northwestern corner of pit 3, made during the previous works headed by M.R. Kasymov (Kasymov, Godin, 1984; Kasymov, Tetyukhin, 1981). Owing to the paucity of data, when determining the age of the oldest cultural strata (layers 24 and 23), we relied on the TL-date of 111 ± 19 ka BP for the closest dated layer 16, which corresponds to MIS 5e (UG-7094) (the date was derived by S. Fedorovich, Department of Geomorphology and Quaternary Geology, University of Gdańsk, Poland) (Pavlenok K.K., Pavlenok G.D., Kurbanov, 2020). Based on the age determinations made for layer 16 and the paleogeographic reconstruction (Taratunina et al., 2020), layers 24 and 25 in the lowermost part of the profile were tentatively attributed to a pronounced warming stage corresponding to the second half of MIS 7 (Pavlenok G.D. et al., 2023).

The deposits of layer 23, overlying layer 24, are composed of light-brown sandy loam, which turns into the gray loam of layer 22 (Fig. 2). These layers correspond to the stage of increasing climatic contrast as compared to the stable conditions characteristic of the period of accumulation of layers 24 and 25. Heavy showers, which were the main cause of erosion of sediments in the area under study, became frequent. This assumption is supported, in particular, by the erosion area between layers 23 and 22 (Fig. 2). The overlying layers 21–18 are alternating proluvial-mudflow sediments with thin interlayers of lacustrine loams of gray and grayish colors. This period of catastrophic mudflow processes can apparently be correlated with the cooling stage corresponding to MIS 6 (Taratunina et al., 2020). Judging by the data of paleogeographic reconstructions, layer 23 can be tentatively correlated to the period of the turn of MIS 7 and 6.

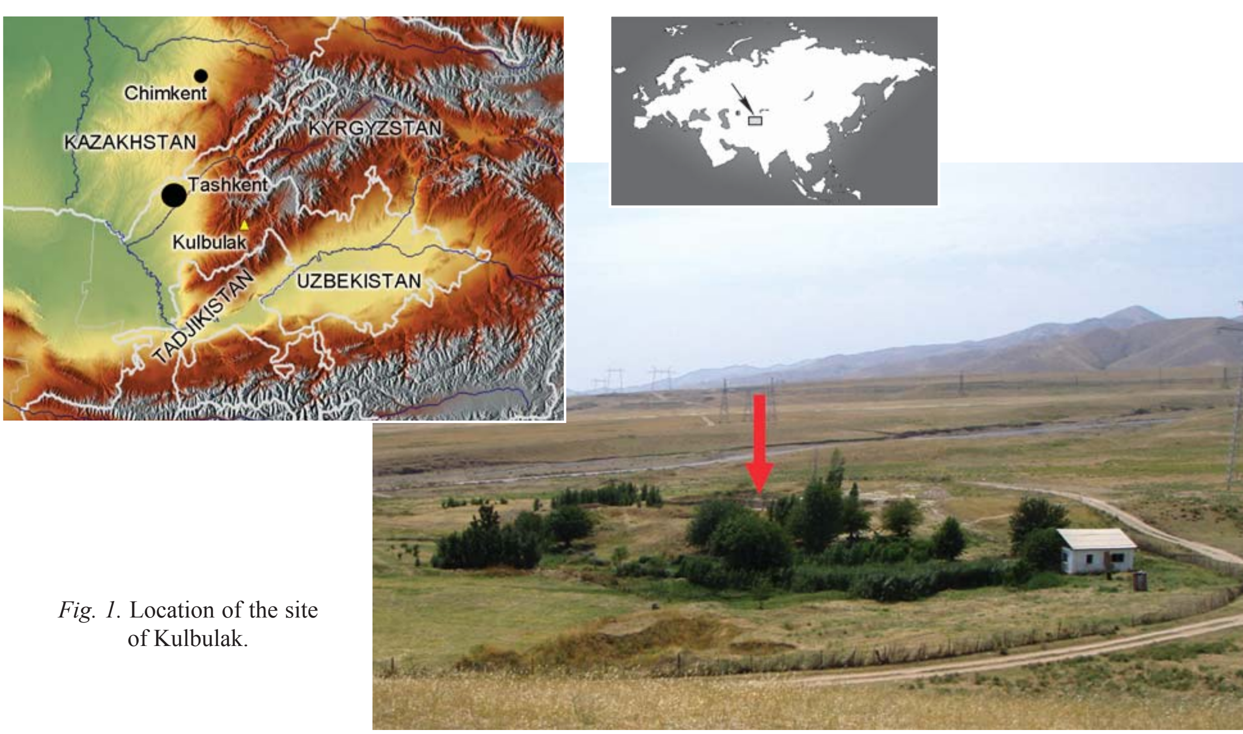

Fig. 1. Location of the site of Kulbulak.

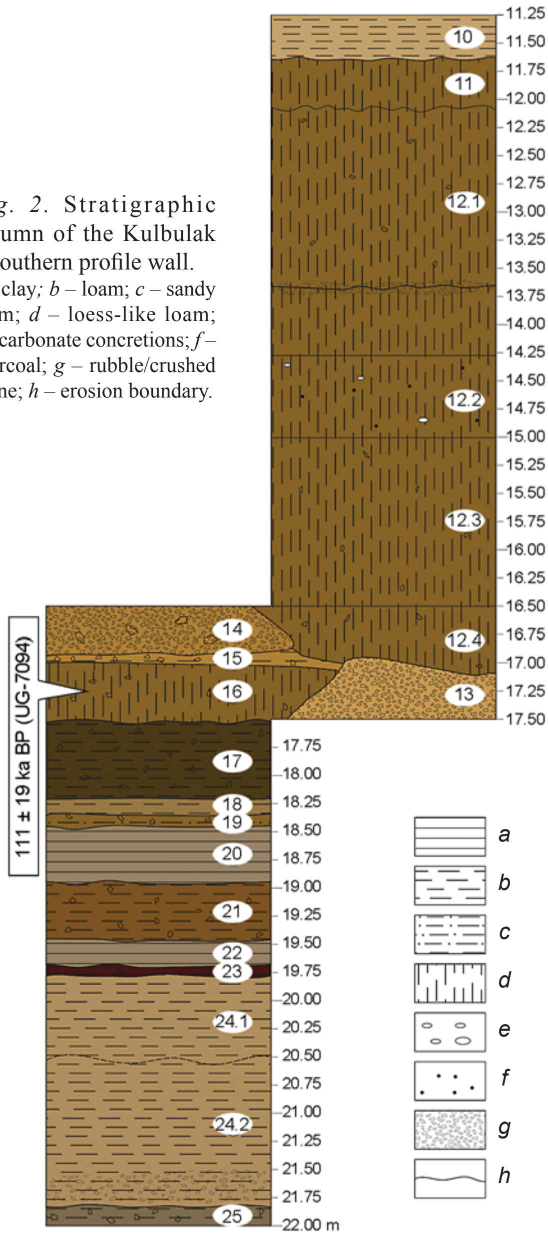

Fig. 2. Stratigraphic column of the Kulbulak southern profile wall. *a* – clay; *b* – loam; *c* – sandy loam; *d* – loess-like loam; *e* – carbonate concretions; *f* – charcoal; *g* – rubble/crushed stone; *h* – erosion boundary.

Technological context of lithic industry in layer 23

Formerly, the lithic industry of Kulbulak layer 23 (collection 2010; 4997 spec.) was attributed to the early stage of the Obi-Rakhmat cultural tradition (Krivoshapkin, 2012; Krivoshapkin et al., 2010; Kolobova et al., 2018). The technological analysis of the lithic collection 2016–2017 (21,884 spec.) has shown that the primary reduction was based on the Levallois sequence (Pavlenok K.K., Pavlenok G.D., Kurbanov, 2020; Pavlenok et al., 2018). This technology proposes various techniques of preparation of the working surface of cores, which is evidenced by the direction of the negative scars of modifying flakes and facets (Shea, 2013). The industry of layer 23 demonstrates the use of mainly Levallois recurrent centripetal method. Discoidal and orthogonal core reduction techniques were also used for the production of flakes. The Nahr Ibrahim technique was used to obtain truncated-faceted products (Shalagina, Krivoshapkin, Kolobova, 2015). The industry also contains narrow- and wide-faced cores showing signs of simple parallel flaking; the removed blanks include bladelets.

The well-developed Middle Paleolithic complex contains an impressive small-blade component. The objectives of the present study are: examination of blades and bladelets for technological differences; scar pattern analysis of the cores targeted at the production of small blades and bladelets by parallel, narrow-faced, and burin knapping; comprehensive characterization of the small-blade component of the lithic industry.

Description of archaeological materials

The total of 739 lithic artifacts was analyzed from the assemblage of flake found in 2016–2017 in Kulbulak layer 23 (ca 3200 spec.): 589 blades and bladelets (less than 12 mm wide) and 132 core-trimming elements with proportions of blades and bladelets. From the collection of typologically definable cores (173 spec.), all the cores aimed at the production of small blades and bladelets by parallel, narrow-faced, and burin knapping (27 spec.) were analyzed. The rest 146 cores demonstrate the Levallois, orthogonal, or discoidal reduction patterns; longitudinal and transverse flake cores are also present.

The typological analysis of the sample of 27 cores under study has shown the following varieties: longitudinal (13 spec.), transverse (2 spec.), narrow-faced (6 spec.), subconical (2 spec.), subcylindrical (1 spec.), burin-cores (2 spec.), and carinated (1 spec.). Only one core was made of effusive rock, the other were made of flint.

The box plot of the length of cores (27 spec.), complete core-trimming elements with proportions of blades and bladelets (66 spec.), and complete flake-blanks with proportions of blades and bladelets (126 spec.) shows that the ranges of length values of the items in these three categories overlap to a significant extent (Fig. 3). At the same time, the cores (residual product of reduction) are slightly smaller than target and core-trimming elements. This allows the assumption to be made that exactly variously-sized elongated blanks were the target products; bladelets were not a by-product of knapping the cores intended to obtain larger elongated flakes.

In order to determine whether specialized lithic flaking strategies focused on bladelet production were used, a histogram of the distribution of core types by widths of the latest negative scars was constructed. The category of cores with bladelet negative scars (less than 12 mm wide) and small blades (13–18 mm wide) (Fig. 4) shows the greatest variability in the types of artifacts. A few artifacts—subconical, subcylindrical, carinated, and burin-cores—bear traces of flaking aimed exclusively at bladelet production (Fig. 5).

The relationship between the shape of core flaking surface and the parameters of target spalls (width of the final negative scar) were analyzed. Most of the artifacts (cores with final negative scars from 5 to 24 mm wide) show similarities in the number of oval and rectangular flaking surfaces (Fig. 6, *a*, *b*), and differ in the number of subtriangular flaking surfaces (Fig. 6, *c*). More than 50 % of the bladelet cores (≤ 12 mm) bear subtriangular flaking surfaces. In the next size category (13–18 mm), the share of such cores decreases to 25 %. Among the cores with final negative scars 19–24 mm wide, those with the subtriangular flaking surfaces are absent.

The sub-triangular shape of the flaking surface was prepared through rejuvenation of the tip and lateral sides (see Fig. 4, *3–6*, *8*); only in few cases was it determined by the choice of the blank. The most indicative category is narrow-faced cores: the base was additionally narrowed and sharpened by bifacial retouch on four of the six specimens (see Fig. 4, *4–6*, *8*). Retouch was observed both over the base zone and lateral zones. The carinated and two longitudinal cores demonstrate similar processing by lateral flaking on both sides (see Fig. 4, *1*, *3*, *6*).

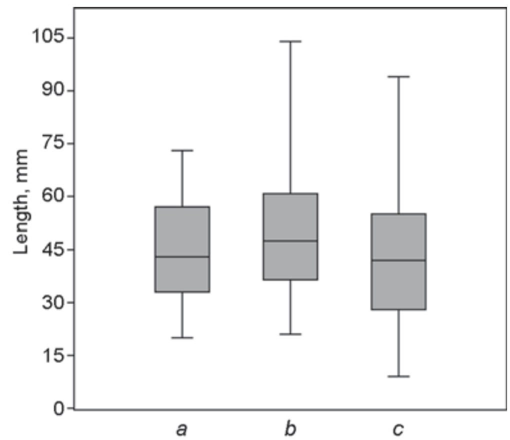

Fig. 3. Distribution by length of cores for the production of laminar flakes (*a*), core-trimming elements (*b*), and target blade spalls (*c*).

The analysis of distribution of striking platform types has shown that the bladelet cores (5–12 mm) and small blade cores (13–18 mm) bear smooth and natural platforms (Fig. 7). In larger cores, platforms were formed through several removals, or the natural surface was used.

The examination of the preservation stage of the working edge (between the striking platform and the flaking surface) has shown that 7 of 27 cores (26 %) have no traces of rejuvenation. No connection of this feature with the typology of cores and the platform design has

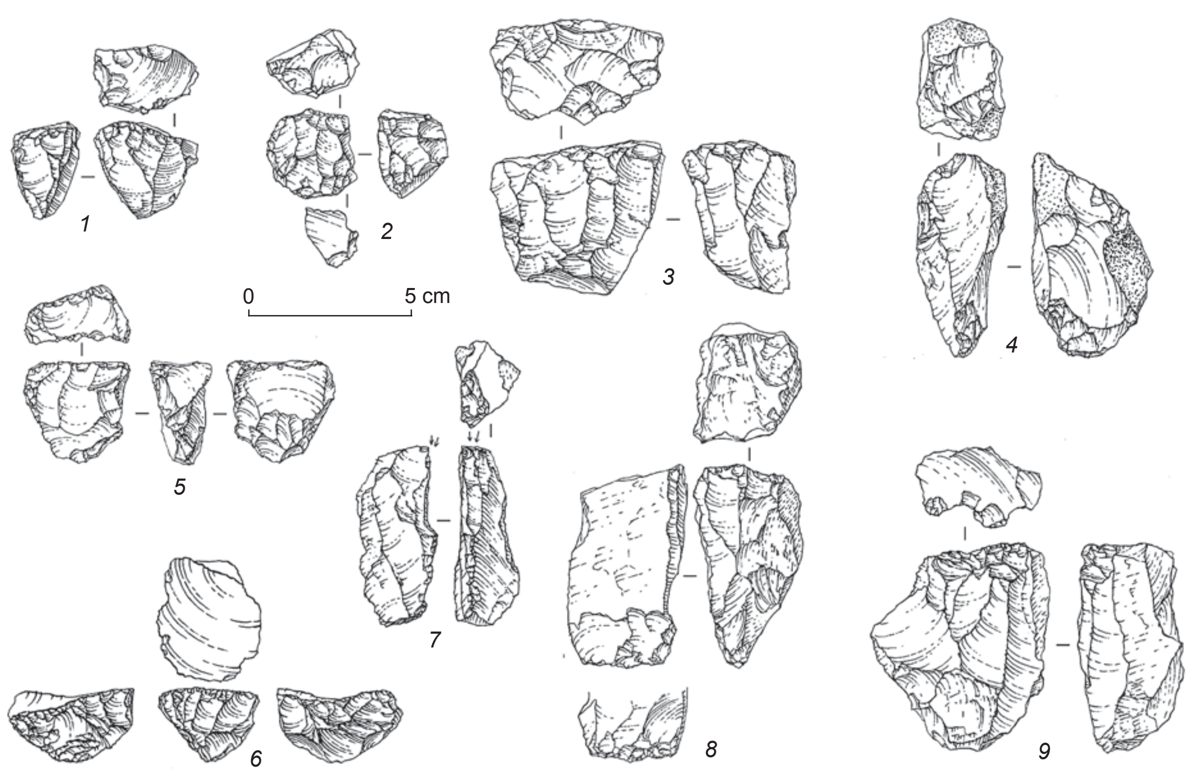

Fig. 4. Small blade and bladelet cores.

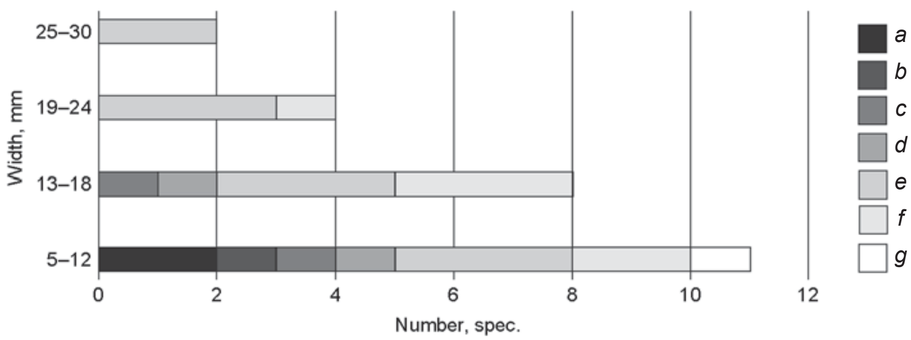

Fig. 5. Distribution of cores by the width of the final negative scar.
a – subconical; *b* – subcylindrical; *c* – burin-cores; *d* – transverse; *e* – longitudinal; *f* – narrow-faced; *g* – carinated.

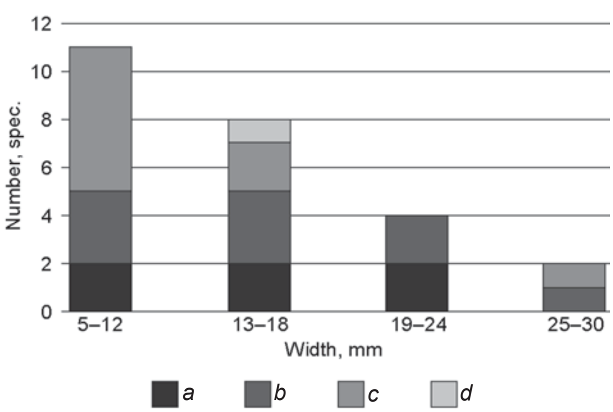

Fig. 6. Distribution of cores by the shape of the flaking surface with respect to the final negative scar.
a – oval; *b* – rectangular; *c* – subtriangular; *d* – angular.

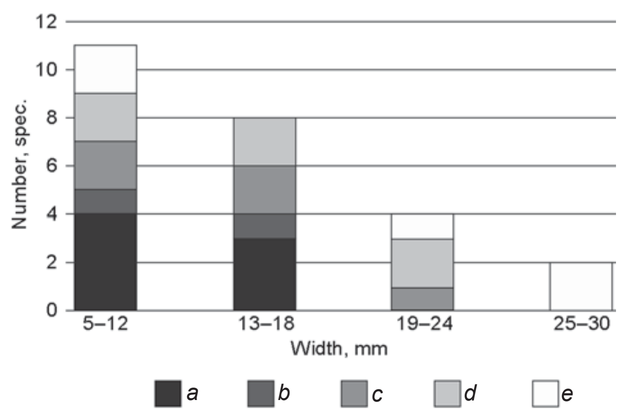

Fig. 7. Distribution of cores by the type of the striking platform with respect to the width of the final negative scar.
a – smooth; *b* – natural; *c* – polyhedral; *d* – faceted; *e* – fragmented.

been established; therefore, a similar index (lack of rejuvenation of the striking platform edge) was derived for the target spalls; it was 55 %. This allows us to assume that the reduction of core edge was not an integral part of the technological scheme.

Scar pattern analysis

The cores used to obtain small blades and bladelets by parallel, narrow-faced, burin and prismatic (carinated) flaking were analyzed. Scar patterns were reconstructed for two of 13 longitudinal cores, two of 6 narrow-faced cores, two subconical, one subcylindrical, one carinated core, and one of 2 burin-cores.

The analysis of the longitudinal core used for small blade production (see Fig. 4, *9*; 8, *A*) has shown that the main flaking zone was located at the corner between the wide and narrow faces. Most of the narrow-faced surface retains natural crust. The general pattern of negative scars on the flaking surface represents the centripetal reduction strategy; but flaking was carried out from the prepared striking platform only in the longitudinal direction (series of scars 1, 3, 4 in Fig. 8, *A*). Flaking directed from the back surface to the left lateral side (2, 6, 5, in Fig. 8, *A*) was an auxiliary technique, since it was made from situational platforms—negatives of previously removed spalls. The identified location of flaking zone and the orientation of auxiliary spalls show a significant similarity of this scheme to that of asymmetric reduction of blade cores reconstructed on the basis of archaeological materials from the sites in the Tien Shan lowlands dating to the period of MIS 3 and 4 (Kot et al., 2022, 2024). The target laminar removals from the core were made not sequentially (I–II–III), with a gradual shift of the percussion point along the working edge of the core (Fig. 9, *B*), but in a staggered sequence (I–III–II). Owing to this strategy, extreme negative scars (series of negatives) I and II formed a central bulge, which was later detached by final removal III (Fig. 9, *A*).

A similar scar pattern has been noted on the other longitudinal blade core (see Fig. 8, *B*): extreme scars I and Ia form a bulge on the flaking surface, scar II partially removes it.

The scar pattern analysis of the narrow-faced cores (see Figs. 4, *4*, *8*) indicates a similar staggered sequence of blanks (see Fig. 9, *A*). A distinctive feature of the reduction of these cores is the use of both transverse flake removals (Fig. 10, *A*, scars 1a, 2; *B*, scars 2, 4b) and longitudinal laminar removals (Fig. 10, *A*, scar 1; *B*,

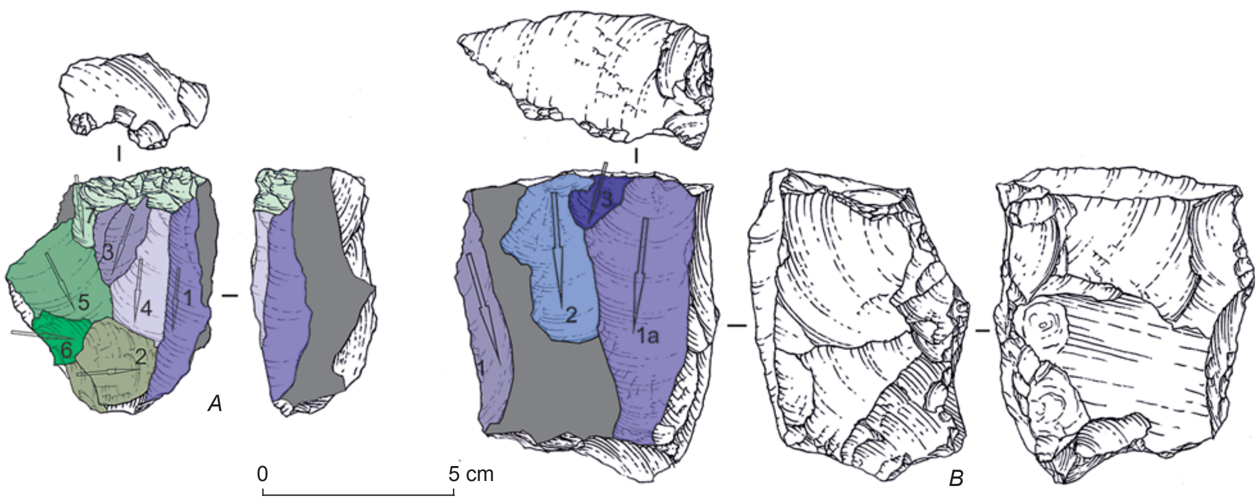

Fig. 8. Longitudinal core reduction schemes.

scar 5) to form the required shape of the flaking surface. The noted fragment of a retouched ridge in the terminal part of the flaking surface on both cores reveals the use of the technique of shaping and removing an initial crest spall (Fig. 10, *A*, scar series 2; *B*, scar series 1, 1a, 4, 4a).

The burin-core (see Fig. 4, *7*; 10, *B*) shows a staggered sequence of blanks: the ridge is formed by scar series 2 and scar 3, and then removed by scar 4, followed by rejuvenation of the edge of the striking platform (scar 5).

The subconical core (Fig. 11, *A*) also shows a staggered sequence of blanks on the flaking surface; initially, the ridge was formed by scars 1, 2 and 2a, and removed by two successive scars (4 and 5) because of the formation of a conchoidal fracture. Scar 7 represents most likely the beginning of a new flaking cycle; at this stage, the ridge was formed by scars 5 and 7, and the final removal was not completed. The other subconical core (Fig. 11, *B*) demonstrates a similar design—staggered sequence of blanks on a wide surface: preparatory scars 1 and 1a; medial scar 3; scar 2, which is slightly out of the pattern, at the edge of the flaking surface; and a longitudinal scar on the adjacent narrow surface (scar 4), which is not related to the others.

The examination of the subcylindrical blade core showing bidirectional knapping (Fig. 11, *D*) has revealed that flaking was carried out in separate areas of a very long prepared working edge. Area 1 contains preparatory scars 1 and 1a, medial scar 2, modifying scars 3 and 3a. Area 2 on the adjacent surface in the opposite direction contains preparatory scars 4 and 4a, medial scar 5 and retouch 6. Both these areas show a staggered sequence of blanks (I–III–II) (see Fig. 9, *B*). Thus, we have identified flaking zones shifted regarding one another, which were flaked from opposite platforms in stages. The use of a similar flaking pattern (semi-rotating bidirectional core) has been recorded in archaeological complexes of the Levant aged

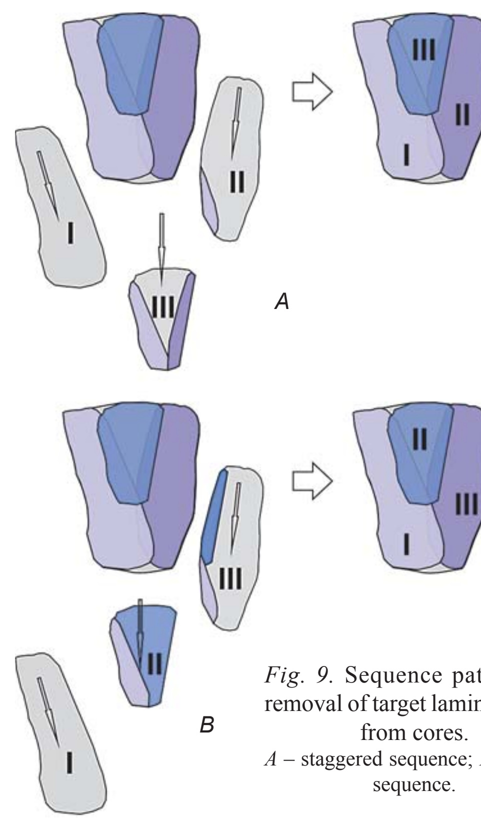

Fig. 9. Sequence patterns of removal of target laminar flakes from cores.
A – staggered sequence; *B* – linear sequence.

~240–150 thousand years, marking the Early Middle Paleolithic of the regional Stone Age scale (Misliya Cave; layer F of Hayonim Cave, and others) (Meignen, Bar-Yosef, 2020; Zaidner, Weinstein-Evron, 2020).

Three stages can be traced in the knapping process of the carinated core (Fig. 11, *B*). Initially, the right lateral side was prepared by scars of group 1 in the course of correction of the rear part and scars of group 2 executed from the striking platform. The next stage was the removal of bladelets from the flaking surface. Two separate

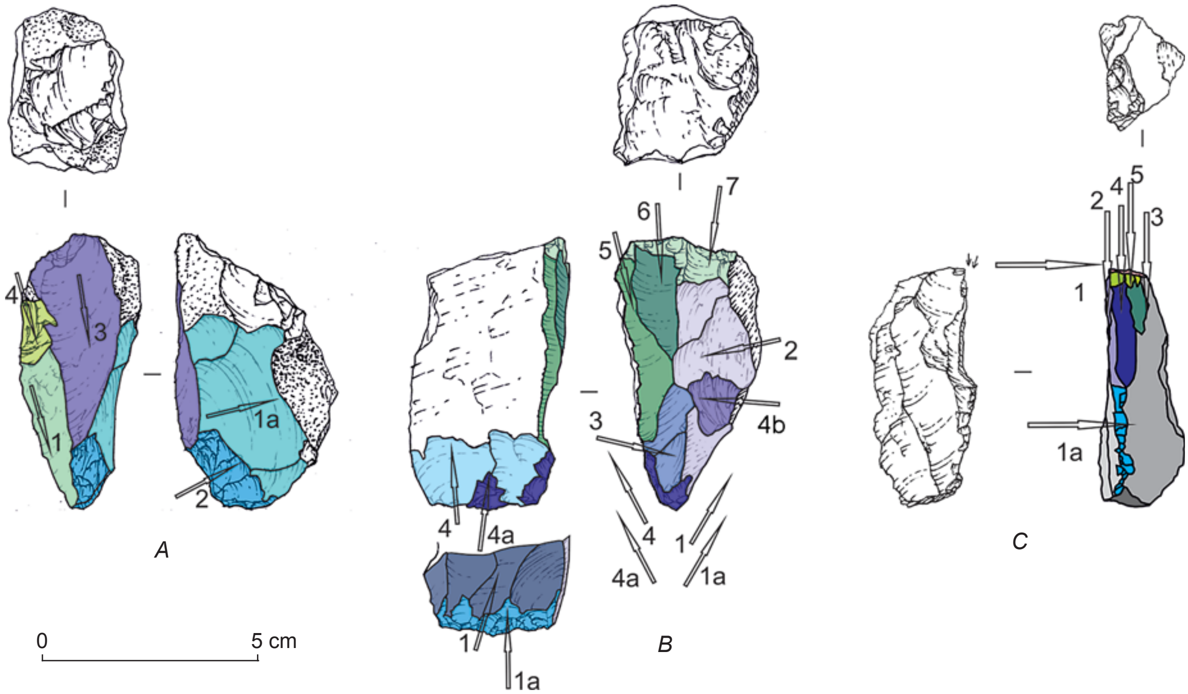

Fig. 10. Narrow-faced core reduction pattern (*A*, *B*), burin-core reduction pattern (*C*).

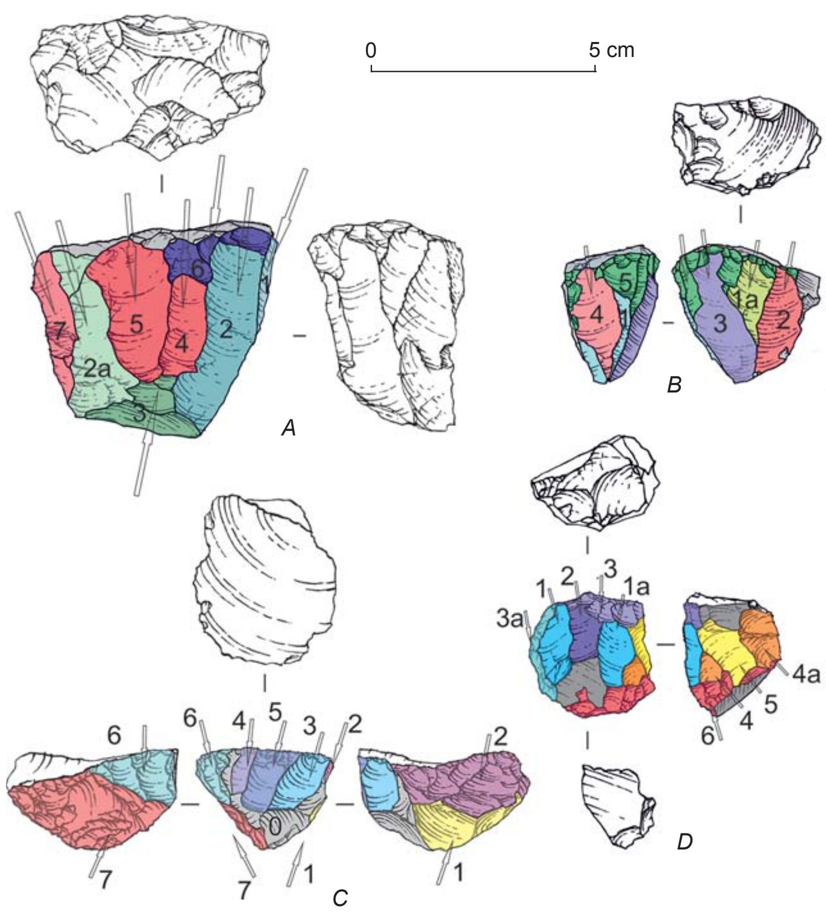

Fig. 11. Reduction patterns of subconical (*A*, *B*), carinated (*C*), and subcylindrical (*D*) cores.

working areas are noted on the flaking surface (area 1 – scars 3, 4 and 5; area 2 – scars of group 6), separated by a fragment of the negative scar related to the so-called zero stage (associated with the shaping of core preform). The first (main) area shows a staggered sequence of blanks (I-III-II): side scars 3 and 4 were detached, then scar 5 was removed between them. In the second area (scar series 6), the scar pattern can hardly be reconstructed. The final stage of reduction of this core included removals on the left lateral side directed from the base (scars 7).

Discussion

The analysis of cores with traces of simple parallel, narrow-faced, burin, and carinated reduction provides a generalized characteristics of non-Levallois blade and small blade production in the industry of Kulbulak layer 23 (2016–2017 collection).

The simple parallel and narrow-faced flaking patterns are most typical in the small blade and bladelet production. The size of the resulting blanks apparently depended on the initial dimensions of the used rocks, the longitudinal/transverse orientation of the core, and on the stage of core exhaustion. This assumption is confirmed by the presence of cores bearing negative scars of both blades and bladelets. It has been shown that the reduction of the working edge of core was not an integral part of the knapping scheme of these cores and other types of nuclei; it was associated with situational decisions in the course of rock knapping. The narrow-faced cores revealed the use of both longitudinal and transverse laminar flaking aimed at achieving the required shape of the flaking surface.

Technological analysis of bladelet cores belonging typologically to the prismatic category (two sub-conical cores, a sub-cylindrical core, and a carinated core) has not revealed any grounds for distinguishing a specialized pattern of volumetric core technique (Boëda, 1988). Scar pattern analysis of the cores has identified small isolated areas on the wide core flaking surfaces of cores bearing three negative scars (or related groups of negatives). All the cores show a staggered sequence of blanks (scheme I-III-II) (see Fig. 9, *A*). When choosing a place for staggered flaking on the core surface, preference was given to the most convex areas, on which the converging edges of previous flaking formed the most acute ridge. This algorithm finds parallels with the Levallois reduction sequence, which is one of the main techniques in this complex (Pavlenok K.K., Pavlenok G.D., Kurbanov, 2020; Pavlenok et al., 2018). The use of two flaking zones, offset from each other, was identified on the subcylindrical core; such a technique is known from the Early Middle Paleolithic materials of the Levant (~240–150 ka BP, Misliya Cave; layer F of the Hayonim Cave, and others) (Meignen, Bar-Yosef, 2020; Zaidner, Weinstein-Evron, 2020).

Another specific feature in the reduction of carinated cores has been established during a recent study of the Upper Paleolithic carinated cores from Kulbulak (Kolobova et al., 2022; Kolobova at al., in press). The reduction sequence of some carinated cores included the multiple (up to three episodes) production of target blanks from the flaking surface: the spall removals alternated with rejuvenation of the surface by corrective flaking and/or overhang trimming. The core under discussion from layer 23 (collection of 2016) reveals only one episode of bladelet removal from the core flaking surface.

Conclusions

The results of the analysis of blade and bladelet cores from Kulbulak layer 23 (2016–2017 excavations) indicate the existence of variable small-blade production in the Western Tien Shan during the period corresponding to the turn of MIS 7 and 6. Residual cores have been attributed to various types: longitudinal, narrow-faced, subcylindrical, subconical, as well as specific cores-burins and a carinated core. However, the noted scar pattern is based on the uniform staggered sequence of blanks (I–III–II). No traces of volumetric core technique has been identified, i.e. in terms of technology, subconical cores fell within the same category with longitudinal and narrow-faced cores, where the reduction strategy was targeted at detaching both small blades and bladelets. The use of the semi-rotating bidirectional core reduction strategy, which was represented on the exhausted subcylindrical core, makes it possible to draw parallels between the studied complex and the Early Middle Paleolithic complexes of the Levant, where similar cores were used to produce small blades and bladelets. Thus, the reduction of burin-cores and a carinated core, which demonstrate staggered sequence of blanks, was aimed exclusively at bladelets. This scar pattern is fully consistent with the general technological and chronological contexts of the studied industry. The noted Middle Paleolithic approach to removing small blades and bladelets characterizes the early stages of the development of small-blade technology in western Central Asia.

It should also be noted that the core reduction strategy involved the use of techniques typical of the Upper Paleolithic small blade technology: special rejuvenation of the rear parts, detachment of lateral spalls to control the width and shape of the flaking surfaces of cores. This observation is consistent with the previous assumptions that the Obi-Rakhmat industries aged ca 80 ka BP (MIS 5a) demonstrated the well-developed small blade reduction technology. Archaeological materials and the chronological position of Kulbulak layer 23 confirm that by that time (MIS 5a), the technique of removing bladelets from various forms of cores had already become widely used by the inhabitants of the region, and had undergone evolutionary changes, which resulted in the growing variability of the resulting products (cores, core-trimming elements, and bladelets). This technological tradition reached an important milestone in its development in the Upper Paleolithic (MIS 2 to the second half of MIS 3), when the small blade component took a dominant position in the structure of regional Stone Age industries.

Acknowledgments

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Identification of Adhesives for Repairing Ancient Ceramics: The Case of the Neolithic and Chalcolithic of Far Northeast Europe

This study focuses on the composition of the adhesives used to repair clay vessels, and on the technique of their preparation in the Late Neolithic and Chalcolithic (late 4th to early 3rd millennia BC) sites of Far Northeast Europe (the Republic of Komi and the Nenets Autonomous Okrug). Remains of adhesives were detected on 70 of 171 repaired pots. To date, five samples of ceramics from dwellings of the Chuzhyael culture have been analyzed. Gas chromatography-mass spectrometry revealed no markers of coniferous trees or bitumen; but did reveal markers of birch, suggesting that fractures and cracks on broken pots were plastered with birch tar. The composition of organic compounds in samples indicates the use of two vessels in the technological process: in one of them, birch bark was subjected to pyrolysis, while the other was a receptacle for tar. This comparatively complex technology reveals one more specialization in the domestic manufacture of the taiga hunter-gatherers, including the use of special furnaces. Analytic procedures employed by us open up new prospects for the study of the material culture of Far Northeast Europe, extend our knowledge of domestic manufacture, and offer new material for AMS dating.

Keywords: *Ancient ceramics, repair, birch tar, gas chromatography-mass spectrometry, Neolithic, Chalcolithic.*

Introduction

Traces of pottery repair and remains of materials used for that constitute relatively well-preserved data for studying the process of repairing objects in ancient times. Every scholar of ancient pottery has encountered them in their work. The method of repairing an ancient pot was simple: paired opposite holes were made near the edges of the crack; "clamps" were placed in the holes by pulling together and attaching the fragments with them; finally, seams and holes were sealed with adhesive material. The role of "clamps" could be played by cords or ropes made of organic materials, whose traces are very rarely preserved in the form of imprints (Fig. 1, *3*).

Remains of adhesive materials have been discovered on the fragments of 70 pots out of all the repaired vessels studied by V.N. Karmanov (171 spec.), which belong to the Neolithic and Chalcolithic collections of Far Northeast Europe. These substances have survived in the form of black spots and stripes (Fig. 1–3) up to 2–3 mm thick. In ten cases, these partially or completely filled the repair holes. Remains of such materials are usually absent from cracks' surfaces, so, in our case, it is more correct to speak about sealants rather than adhesives.

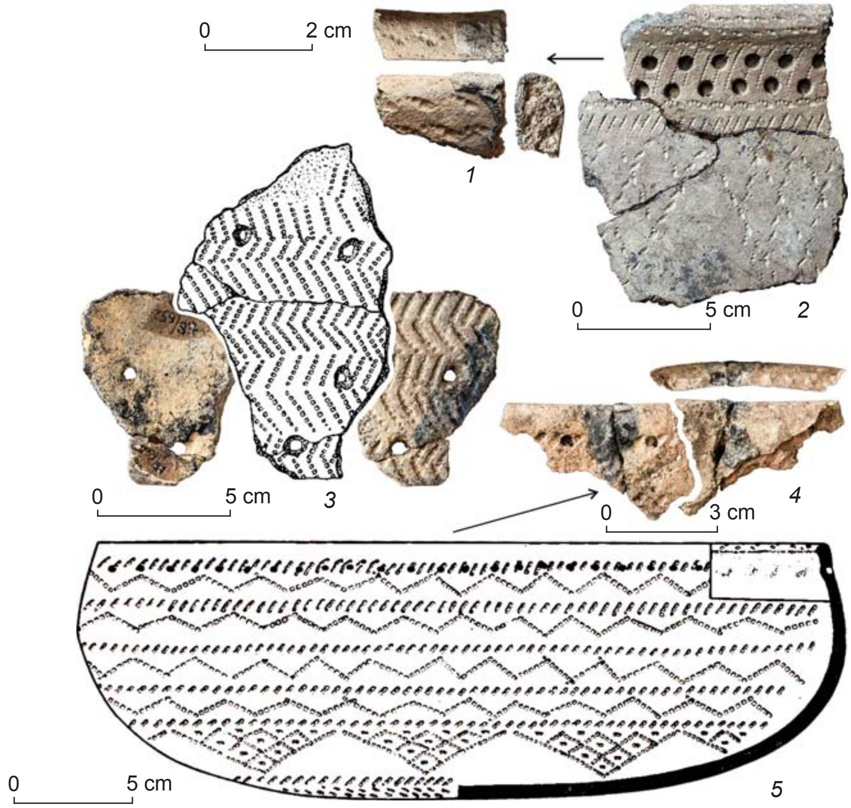

Fig. 1. Photograph and drawing of pottery (*1–4*), graphic reconstruction of vessel (*5*).
1, *2* – Muchkas, dwelling 8; *3* – Oshchoy I, dwelling 6 (Stokolos, 1986: Fig. 57, *7*); *4*, *5* – Oshchoy V, dwelling 3 (Ibid.: Fig. 78).

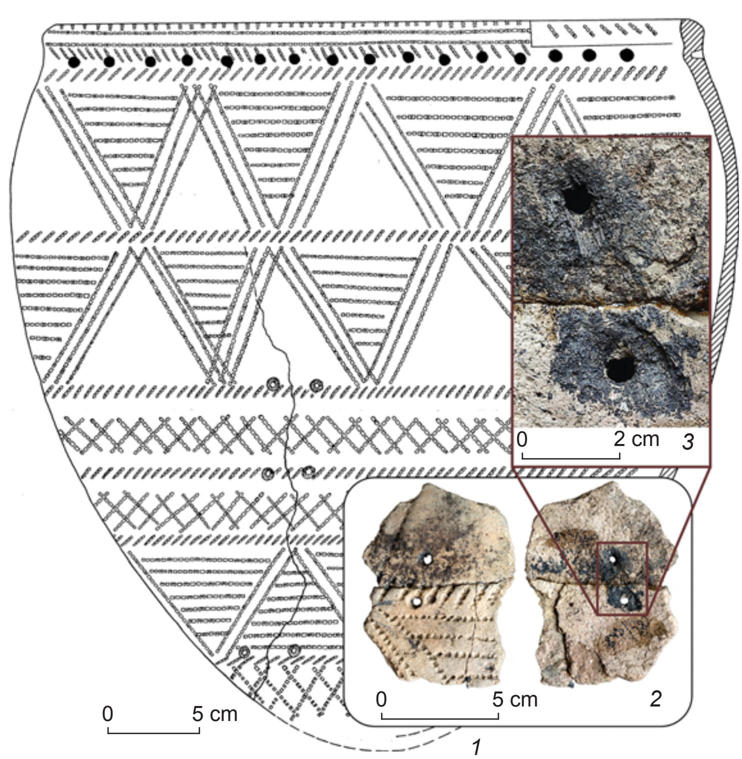

Fig. 2. Graphic reconstruction of vessel (Stokolos, 1986: Fig. 37) (*1*); photographs of vessel fragments from the outer and inner sides, with an imprint of a "clamp" made of untwined plant (?) fiber (*2*, *3*). Chuzhyael I, dwelling 5.1.

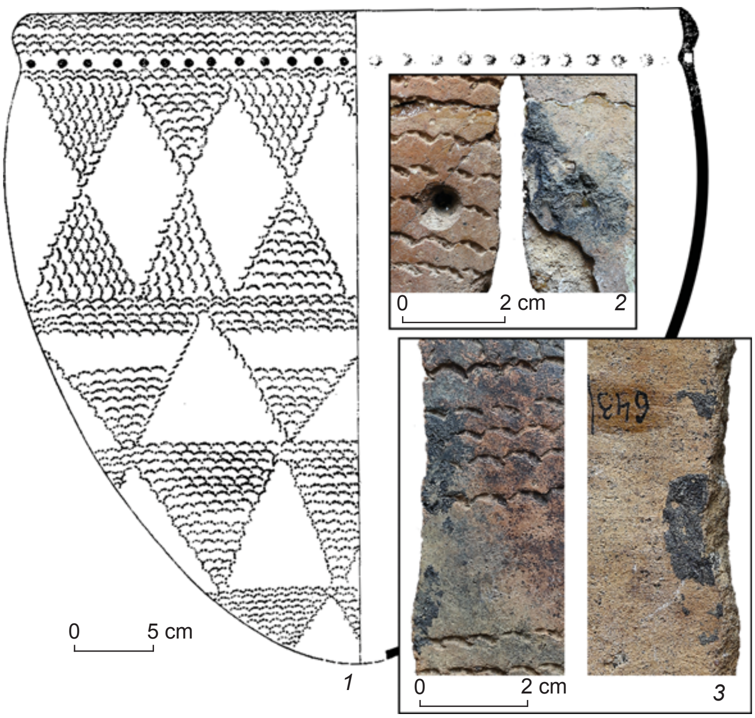

Fig. 3. Graphic reconstruction of vessel (Stokolos, 1986: Fig. 31) (*1*), photographs of its surface parts (*2*, *3*). Chuzhyael I, dwelling 4.

The use of sealants distinguishes the repair of vessels from other applications of adhesive materials, such as attaching inserts into the grooves of composite tools or attaching arrowheads to shafts.

Conclusions about the preferences in applying the sealant to the inner or outer surface of a vessel are only tentative, since these depend on the preservation of the pottery. and are based on visual inspection without a microscope. Remains of adhesive have survived on 21 fragments on both surfaces, on 31 fragments on the outer surface, and on 18 fragments on the inner surface.

This study is the first step in the instrumental research on adhesives and their manufacturing technology applied to pottery repair by the ancient population of Far Northeast Europe. The work intends to establish the composition of sealants and their production technology, using gas chromatography-mass spectrometry.

Study history

Russian-language scholarly publications include only a few specialized works discussing the pottery repair of vessels of the Sintashta culture and contemporaneous sites in the steppe zone of the Urals and Northern Kazakhstan (Gutkov, 2000; Gavrish, 2018), and in the Baikal region (Ivanova, Shergin, 2021). International scholars also mention insufficient knowledge about the processes associated with pottery repair (Miloglav, 2020: 120). Only one book summarizes and systematizes archaeological and ethnographic evidence on repairing pottery (Geiko, 2013).

Much more attention is paid to studying the remains of putty in the cracks on the vessels' walls. Scholars are primarily interested in the composition of adhesive substances. They try to identify them on the basis of general ideas about what they might have been (see, e.g., (Dyakonov, 2012: 110)), sometimes using ethnographic evidence (Glushkov, 1996: 86), but more often using scientific methods (Charters et al., 1993; Pesonen, 1999; Deryugin et al., 2018; Connan et al., 2020; Chen et al., 2022). Depending on the results, they establish the age of birch tar or pine resin residues (Pesonen, 1999), or sources of natural bitumen (Deryugin et al., 2018).

The range of natural materials that could have been used for the production of adhesives was wide (for more details, see (Langejans et al., 2022)). The most common residues discovered in archaeological evidence included birch tar, pine resin (Charrié-Duhaut et al., 2013; Helwig et al., 2014), and natural bitumen or asphalt (Boëda et al., 2008; Brown et al., 2014). These were used either alone or in combination with each other and with other additives, such as animal fat or beeswax (for the bibliography, see (Miloglav, 2020: 121; Chen et al., 2022: 227)). Very rarely, possibly owing to poor preservation, traces of cracks have been found that were sealed with clay (Pesonen, 1996: Fig. 2) or "liquid clay fabric, possibly with addition of organic matter, such as resin" (Lokhov, Rogovskoy, Dudarek, 2013: 122, fig. 4, *4*).

Instrumental studies of materials from Far Northeast Europe aimed at detecting sealant residues have been carried out only once. An employee of the Institute of Geology of the Komi Branch of the USSR Academy of Sciences (now, the Institute of Geology of the Komi Science Centre of the Ural Branch of the Russian Academy of Sciences, Syktyvkar), V.F. Udot, using a luminescent-bitumen analysis, discovered residues of resinous bitumen of petroleum origin on a vessel from the settlement of Niremka I (Kosinskaya, 1987: 133). We used the gas chromatography-mass spectrometry method.

Material and methods

One hundred and seventy one pots with clear signs of repair were identified among the Neolithic and

Chalcolithic pottery discovered in the region, including 70 vessels with sealant residues. To determine the nature and manufacturing technology of this material that ensured impermeability, using gas chromatography-mass spectrometry, five samples of pottery from the reference complexes of the Chuzhyael archaeological culture were analyzed: two from dwellings 4 and 5 of the Chuzhyael I site (see Fig. 2, 3), from dwelling 6 of the Oshchoy I site (see Fig. 1, *3*), from dwelling 3 of the Oshchoy V site (Stokolos, 1986: 7–91) (see Fig. 1, *4*, *5*), and from dwelling 8 of the Muchkas site (Stokolos, 1995) (see Fig. 1, *1*, *2*).

When selecting the evidence, it was taken into consideration that complexes of this culture are the most representative source for pottery study, including its repair. Out of 190 examined vessels, signs of repair have been found on the fragments of 61 vessels, and remains of adhesive materials on 38 pots. The complexes of the Chuzhyael culture are well studied and dated (Stokolos, 1986: 7–91; 1988: 25–47; 1997: 213–229; Karmanov, Kosinskaya, 2021; Karmanov, Zaretskaya, 2021), which makes it possible to verify radiocarbon determinations further. Sealant residues are a finite source and need to be studied gently, taking into account the development and improvement of methods for their study and possible verification of results obtained, as well as the need to reserve samples for dating.

Analytical studies were carried out in the "Geonauka" Center for Collective Use at the Institute of Geology of the Komi Science Centre of the Ural Branch of the Russian Academy of Sciences. Samples of substances that were scraped from pottery fragments and weighed 5–10 mg were placed in a 1.5 ml vial for gas-liquid chromatography, and extracted with benzene for 72 hours by infusion in the dark at room temperature. After removing the solvent by evaporation, the extract was exposed to 100 μl of N,O-bis(trimethylsilyl)trifluoroacetamide (BSTFA) and 5 μl of tetraethylacetate added as a catalyst. The temperature of derivatization was 80 °C; the time was 1 hour. One ml of benzene was added to the solution as a solvent for analyzing TMS derivatives of the extract components.

Chromatography-mass spectrometry was carried out using a Shimadzu 2010 Ultra unit. Column HP-5, 30 m × 0.25 mm, with 0.10 μm thickness of stationary phase layer, temperature from 110 to 300 °C, and rate 5 °C/min was used. Injector temperature was 300 °C; detector temperature was 250 °C. The signal was recorded in the full spectrum scanning mode (SCAN).

Terpenoid derivatives were identified on the basis of the published mass spectra and data on the retention order of the components (Organic Mass Spectrometry…, 2009; Aveling, Heron, 1998; Binder et al., 1990; Regert, 2004; Charters et al., 1993; Rageot et al., 2019, 2021). The composition of carboxylic acids of the extract from the studied samples was determined using the NIST Mass Spectral Library.

Study results

Gas chromatography-mass spectrometry has shown that the qualitative composition of the studied samples was identical (Fig. 4). The following substances were confidently identified in it: betulin, betulone, allobetuline,

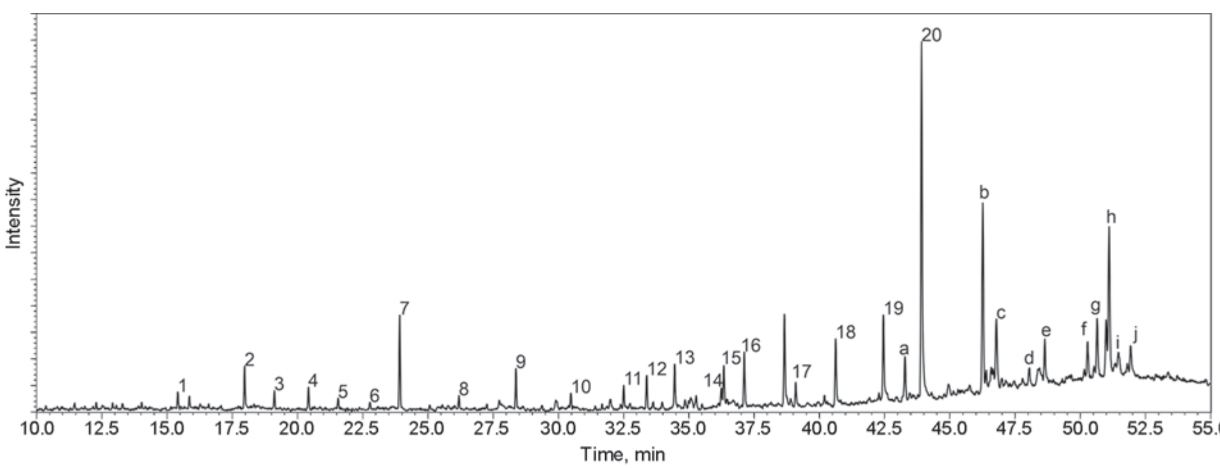

Fig. 4. Total ion current mass-chromatogram (TIC) of the BSTFA-derivatized adhesive extract of the sample from Muchkas, dwelling 8. *1–20* – peaks of TMS derivatives of carboxylic, dicarboxylic, and hydroxycarboxylic acids.
1 – octanedicarboxylic; *2* – nonanedicarboxylic; *3* – tetradecanoic; *4* – decadicarboxylic; *5* – pentadecanoic; *6* – undecanedicarboxylic; *7* – hexadecanoic (palmitic); *8* – heptadecanoic; *9* – octadecanoic (stearic); *10* – nonadecanoic; *11* – icosanoic; *12* – hexadecanedicarboxylic; *13* – heneicosanoic; *14* – cis-13-docosenoic; *15* – docosanoic; *16* – octadecanedicarboxylic; *17* – hydroxyicosanoic; *18* – icosanedicarboxylic; *19* – hydroxydocosanoic; *20* – docosanedicarboxylic. *a–j* – peaks of triterpenoids and their TMS derivatives: *a* – lupa-2,20(29)-diene; *b* – lupa-2,20(29)-diene-28-ol; *c* – allobetul-2-ene; *d* – lupenone; *e* – lupeol; *f* – 28-oxoallobetul-2-ene; *g* – betulone; *h* – botulin; *i* – 3-oxoallobetulane; *j* – allobetuline.

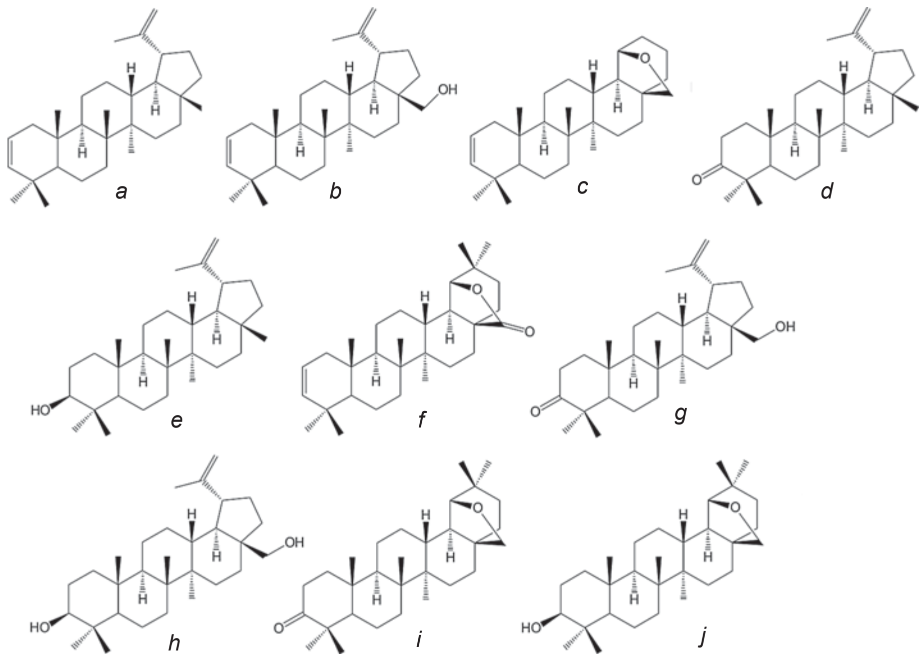

Fig. 5. Peaks of triterpenoids and their TMS derivatives (*a–j*); structures of betulin (*h*) and lupeol (*e*), as well as their derivatives.
a – lupa-2,20(29)-diene; *b* – lupa-2,20(29)-diene-28-ol; *c* – allobetul-2-ene; *d* – lupenone; *e* – lupeol; *f* – 28-oxoallobetul-2-ene; *g* – betulone; *h* – betulin; *i* – 3-oxoallobetulan; *j* – allobetulin.

28-oxoallobetul-2-ene, 3-oxoallobetulane, allobetul-2-ene, lupeol, lupenone, lupa-2,20(29)-dien-28-ol, and lupa-2,20(29)-diene (Fig. 5), as well as dicarboxylic and hydroxycarboxylic acids. All these chemical compounds are either present in birch bark in their original form or are developed in the course of its thermal decomposition during production of birch tar. The biomarkers of coniferous trees (resin acids with diterpenoid structure) and traces of fossil bitumen were not found in the extracts studied.

Data on the composition of organic compounds—birch bark markers—indicate that the adhesive under study was made of birch tar. In addition, these markers make it possible to reconstruct the technology of its production. Previous studies have identified two main technologies for obtaining birch tar: "single-pot" and "double-pot" (Rageot et al., 2019: Fig. 2). In the former method, tar is not separated from the original birch bark and is subjected to more prolonged heating, since it is not removed from the hot zone. In the latter method, the resulting product flows down from the hot zone to colder zone, and therefore is not contaminated by original bark and is not subjected to secondary thermal transformation. From the chemical point of view, the products obtained by these methods show significant differences. The "single-pot" tar contains no dicarboxylic acids, but a relatively large number of markers of deep degradation/oxidation of the original birch bark biomarkers, which include allobetuline, 3-oxoallobetulane, 28-oxoallobetul-2-ene, and allobetul-2-ene (Rageot et al., 2019) (see Fig. 4).

In all the sealants studied, the main components are dicarboxylic acids of the C_{18}-C_{22} composition, as well as birch bark biomarkers that did not undergo strong thermal degradation/oxidation. Markers of deep degradation/oxidation are present in the extracts from the studied samples in insignificant concentrations (see Fig. 4, 5). This suggests that the studied substances were obtained by using the more sophisticated "double-pot" technique.

Discussion

Tar is a liquid product of pyrolysis—a process of heating substances to high temperatures, with limited air access. The most productive raw material in this case is birch bark, from which up to 14.3 % of tar can be extracted in laboratory conditions from the total mass of processed bark (Hayek et al., 1990: 2039). Methods of tar production are simple and were already known to the Neanderthals in the Middle Pleistocene (Kozowyk et al., 2017). The results of scientific experiments related to the reconstruction of ancient methods of obtaining tar have been published (see, e.g., (Ibid.)).

The identified signs of using the "double-pot" technique indicate another specialization of domestic manufacture in the Neolithic and Chalcolithic, which involved the use of a special heating device. No traces of such a furnace have yet been found in the examined dwellings. Possibly, tar production was located outside residential areas. Thus, along with devices for pottery firing, the remains of places for producing adhesives are another category of sources that "eludes" archaeologists. The design of the device has not yet been determined either. The question of how the finished product was accumulated also remains open: did it flow from the upper container into a vessel located below and deepened into the ground for cooling (Rageot et al., 2019: Fig. 4b), or was it taken out of the fire pit along a chute?

The results of the instrumental analysis of the adhesive composition open up new prospects for specialized interdisciplinary studies of the Neolithic and Chalcolithic of Far Northeast Europe, thanks to the high epistemic capacities of the studied category of records. For example, remains of sealants constitute promising evidence for direct AMS-dating of artifacts, which results are especially important in cases when it is impossible to determine the time of sources by independent methods. Traces of sealant were found on 70 vessels, which, given the use of wood resins and tar, is many times greater than the number of samples with organic crust—an imperfect material for dating.

Conclusions

This study has established that pottery from the referential sites of the Chuzhyael culture was repaired using birch tar. Tar was obtained in two vessels: one of these was used for pyrolysis of birch bark, and the other for the resulting product. So far, the study has identified the nature and technology of manufacturing a sealant for the repair of pottery belonging to the same tradition from the sites in the Mezen River valley. Research in this direction should be continued in order to identify the dynamics of using adhesives in space and time.

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Slag Inclusions in Iron Artifacts from Cemeteries at Kichigino I and Krasnaya Gorka, and the Metallurgy of the Early Iron Age Itkul Culture

Silicate slag inclusions in iron artifacts from the Trans-Urals and in iron slags from sites of the Itkul culture were analyzed to assess the geochemical characteristics of iron ore sources exploited during the Early Iron Age. Slag inclusions were found in 19 out of 25 samples from Kichigino I and Krasnaya Gorka. For comparison, we used 12 iron slag samples from Early Iron Age and medieval sites near Lake Irtysh and from Zotino mine. Via statistical analysis, four geochemical groups were separated, each including one or more Kichigino artifacts, which suggests a variety of iron ore sources used by the nomads. Slags and artifacts of the first group are associated with infiltration-sedimentary ironstone ores of the Middle Trans-Urals. Smithing slag from the Itkul site of Shatanov V suggests that these ores were already smelted in the Early Iron Age. The fact that group 1 includes only one artifact from Kichigino I demonstrates that the nomads of the Southern Trans-Urals obtained iron mainly from other sources. Group 2 is characterized by a higher content of Mn and sometimes Ba and S in inclusions. This may attest to the use of Fe-Mn ironstone associated with barite-polymetallic deposits of Central Kazakhstan. Group 3 shows an elevated content of CaO and MgO, indicating the use of ironstone from platform carbonate strata. In the fourth group, the content of K_2O is high, and that of MnO, low.

Keywords: *Kichigino I cemetery, Itkul culture, iron, silicate slag inclusions, Early Iron Age, bloomery slags.*

Introduction

Nomadic communities of the Scytho-Sarmatian circle provide the earliest example of wide use of iron products in ancient times. However, in most cases, the sources of ore for iron smelting are still unknown, which is caused both by the absence of traces of metallurgical production at nomadic sites represented by burials, and the difficulties in identifying and analyzing slag inclusions in iron items (Buchwald, Wivel, 1998; Leroy et al., 2012; Stepanov et al., 2020). This study analyzes silicate slag inclusions in corroded iron items to establish ore sources and/or, if the exact source cannot be determined, geochemical features of ore used for iron smelting.

This study was carried out both because of complete lack of information on the sources of iron in the nomadic communities of the Early Iron Age in the Steppe Eurasia* and because of poor knowledge of iron ore raw materials of that mega-region, including raw materials used by the carriers of the Itkul culture of the Urals, who are believed to be one of the main suppliers of pure copper and iron to the nomads of the Ural-Kazakhstan region (Beltikova, 2005; Tairov, 2019: 194–196). Even though the Itkul people specialized in copper production, it is unclear whether they had any knowledge of iron smelting (Beltikova, 1993; Koryakova, Epimakhov, 2007: 196–197). This is due to the relatively small number of iron products found at the Itkul sites (about 30 items). In addition, metallurgical products (slag and blooms) rarely occur at single-layered Itkul sites. Examination of Early Iron Age assemblages belonging to this culture found at the sites on Lake Irtyash (Irtyashskoye I and Shatanov V) revealed fragments of iron-smithing slag (Stepanov et al., 2021). Smithing slag and blooms were also found at the Zotinskoye III and Krasny Kamen fortified settlements on the Bagaryak River (Beltikova, 2005; Borzunov, 2018; Stepanov, Blinov, Artemyev, 2023). Slag discovered at the settlements resulted mainly from secondary metallurgical processing and was formed during the forging of blooms.

Ore sources for bloomery iron that the Itkul metallurgists received for processing, as well as primary slag formed during ore smelting, have not been clearly identified. Despite the location of the Itkul area near rich deposits of ironstone ores in the Middle Trans-Urals (Artemyev, Stepanov, Ankusheva, 2022), the fact of iron smelting in the Early Iron Age has not been confidently verified, since the sites with primary iron-smelting slag are frequently multilayered (Irtyashskoye II, VIII, Guseva Gora, Zotino mine, Zotinskoye III, Palatki, Verkhnyaya Makusha, and Gora Petrogrom), where the Early Iron Age layers are overlapped by the medieval layers with the evidence of the Petrogrom or Bakal cultures (Beltikova, 2005; Naumov, 2016; Borzunov, 2018).

Study methods

The origin of the ore used to create ancient iron items can be determined by analyzing the chemical composition of silicate slag inclusions within the metal or the corroded matrix of the iron item, using scanning electron microscopy with energy-dispersive analysis (SEM-EDA). Silicate slag inclusions in iron artifacts emerge in the bloomery process, where iron is reduced to metal in the solid state rather than melted, resulting in a porous mass, i.e. a bloom, which includes a significant amount of slag substrate. Further forging of the bloom and manufacture of an item from it cannot completely remove slag microinclusions from the metal. Since the bloomery process is a relatively low-temperature procedure (within 1100–1300 °C), most of impurities in ore are not reduced to a metallic state, but concentrate in slag, which makes the latter suitable for reconstructing the composition of the ore protolith and identifying iron ore sources. The SEM-EDA method for silicate slag inclusions in iron artifacts reveals the content of main macroelements (Si, Al, Fe, Ti, Mg, Ca, Mn, Na, K, and P) therein. This approach has been widely used in international studies (Buchwald, Wivel, 1998; Charlton, 2015). Since the content of macroelements depends on the composition both of ore and of clay with temper used in making iron-smelting furnaces (source of Si, Al, Ti, Ca, and Mg), charcoal ash (source of Ca, K, Na, and Mg), and fluxes, the ore source can be established only with a certain degree of probability (Blakelock et al., 2009). A further development of this method is its combination with analysis of rare and trace elements using laser-sampling mass spectrometry (Desaulty et al., 2009; Stepanov et al., 2020), which involves indicator elements only weakly affected by clay and ash, such as Th, U, Y, Nb, Hf, and rare earth elements. Unfortunately, the small sizes of silicate slag inclusions (<20 μm) in the corroded artifacts under study did not allow for its use.

For SEM-EDA analysis, small pieces of metal were embedded in epoxy resin, and the samples were ground and polished. The samples were analyzed using a Tescan Vega 3 sbu electron microscope Oxford Instruments X-act, with the system of energy-dispersive microanalysis, over the entire area of silicate slag inclusions. Predominantly wustite inclusions were not studied, because of their depletion of Al, Mg, Ca, and K down to values close to the detection limit. Four to fifteen silicate slag inclusions were analyzed for each item. In the corroded items, the size of the unchanged part of silicate slag inclusions usually did not exceed 5–10 μm (Fig. 1). Since most of the studied items have been completely corroded, the inclusions in them also underwent chemical changes (Stepanov et al., 2020). In this regard, the homogeneity of composition in silicate slag inclusions was assessed for each item, and statistical outliers were excluded from the sample. Relics of metallic iron, which were

*Following A.A. Chibilev and his co-authors, the Steppe Eurasia is understood as “a transcontinental geographic space—a mega-region that covers not only the steppe landscape zone of Europe and Asia, but also the forest-steppe and semi-desert (desert-steppe) zones adjacent to it on the north and south” (Chibilev, Levykin, Shcherbakova, 2019: 3).

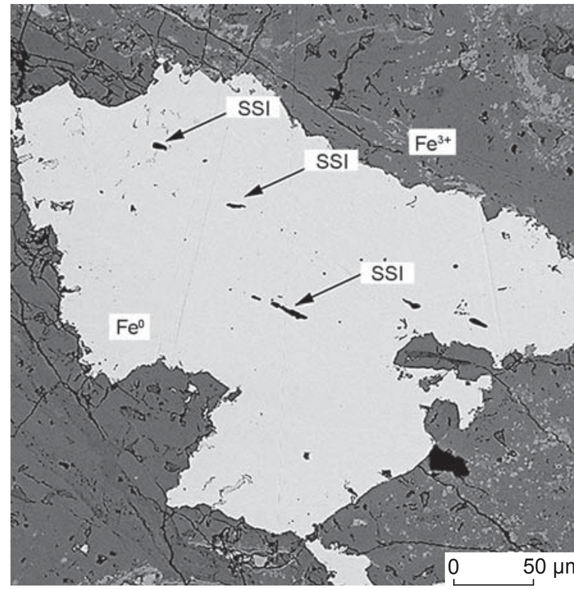

Fig. 1. Microphotographs of typical silicate slag inclusions in the corroded matrix of iron items from Kichigino I.

preserved in the matrix of some corroded items, did not contain impurities of other chemical elements. The poor preservation of the items did not make it possible to carry out classic the metallographic analysis used in the study of ancient iron products. Nevertheless, the study of thin sections has revealed the presence of relic carbonized structures in the artifacts, suggesting the use of hypoeutectoid raw iron.

The averaged content values of six main oxides (SiO_2, Al_2O_3, MgO, CaO, MnO, and K_2O) for each item were transformed by logarithmic normalization and subjected to statistical processing using principal component analysis according to the common methodology (Charlton et al., 2012; Stepanov et al., 2020). The FeO/Fe_2O_3 values were not included in the sample because of significant variations in their concentration due to the capacity of iron oxides to be reduced to a metallic state under bloomery smelting conditions and then re-oxidized during forging processes. The compositions of silicate slag inclusions were compared with those of not only the supposed ore, but also of smelting slag from the sites located on Lake Irtyash and the Bagaryak River, because of the similarity in the nature of their formation. The composition of dumps of smelting slag can be accepted as a geochemical marker of the iron ores used (Disser et al., 2016).

Study objects

The objects of this study were iron products and slag (over 40 spec.) from the Early Iron Age and the Middle Ages sites: artifacts from the South Ural cemeteries of Kichigino I and Krasnaya Gorka, products and slag from single- and multilayered (Early Iron Age and the Middle Ages) settlements on Lake Irtyash (Irtyashskoye II, VIII, Shatanov V) and Lake Kunashak (Kunashakskoye), as well as slag from the recently discovered Zotino mine (Stepanov, Blinov, Artemyev, 2023).

Over twenty corroded iron artifacts were initially selected from the Kichigino I site. However, since most of these were poorly preserved, it was possible to discover silicate slag inclusions in only twelve of them. A comparative analysis of the geochemical signatures of these twelve items originating from mounds 3–6 and 8 is provided herein. Most of the items were attributed to the Early Iron Age, although some of them might have belonged to the Middle Ages (Table 1), which is especially likely for the rod Kich-16 (mound 4), showing good preservation. The materials from Kichigino I have been dated, while the artifacts from the sites on Lake Irtyash, Krasnaya Gorka cemetery, and Kunashak fortified settlement were surface finds, and many of them are not corroded (Table 1). The composition of silicate slag inclusions in some of these artifacts should probably be considered as an indirect geochemical description of the medieval iron, which, unlike the Early Iron Age items, can be viewed as locally produced.

In addition to our silicate-slag inclusions analysis, the comparison included published data on six samples of bloomery slag obtained from the sites on Lake Irtyash (Irtyashskoye II, VIII, Shatanov V) and the Bagaryak River (Zotino mine) (Stepanov et al., 2021; Stepanov, Blinov, Artemyev, 2023). Two of the samples (from Irtyashskoye II and Zotino mine) have been interpreted as primary slag, since these were obtained during the ore-smelting process, and four samples (from Irtyashskoye II, VIII, and Shatanov V), as secondary, emerging during forging of an iron bloom. According to the common opinion (Dillmann, L'Héritier, 2007), the analysis of smithing slag is considered unreliable for reconstructing the geochemical composition of the original iron ore, owing to the greater contribution of molten clay and ash as compared to primary slag. Nevertheless, according to the studies, four samples of smithing slag from Shatanov V were similar in composition to the primary smelting slag from Lake Irtyash (Stepanov et al., 2021). One of them (Sht-V/5295) is of the greatest interest, since it can be unambiguously dated to the Early Iron Age (7th–3rd centuries BC), which is supported by the accompanying finds (several fragments of iron smithing slag, a completely corroded iron item, pottery from the Itkul and Gamayun cultures, a three-bladed copper arrowhead, and a talc-casting mold) (Ibid.). For this reason, as well as in view of the similar mineralogical and

Table 1. **Iron artifacts from the Kichigino I and Krasnaya Gorka cemeteries, and from the Early Iron Age and medieval sites**

Sample (lab code)	Site	Context	Artifact	Dating
Kich-1 (P2.41k1-6/1)	Kichigino I	Mound 6, grave 1, burial 1	Spear	4th century BC
Kich-2 (P2.41k1-6/3)	"	"	Dagger	4th century BC
Kich-4 (P1.41k1-5/64)	"	Mound 5, grave 2	"	Second half of the 6th – first half of the 5th century BC
Kich-7 (P2.41k1-8/1)	"	Mound 8	Ring	4th century BC
Kich-8 (P1.41k1-5/77)	"	Mound 5, grave 2	Bridle bit	Second half of the 6th – first half of the 5th century BC
Kich-9 (P2.41k1-6/5)	"	Mound 6, grave 1, burial 2	Knife	2nd–3rd centuries AD
Kich-10 (P2.41k1-8)	"	Mound 8	Item (?)	4th century BC
Kich-13	"	Mound 5, grave 1	Dagger	Second half of the 7th century BC
Kich-14 (41k1-4/10)	"	Mound 4, southeastern sector	Ring	Middle Ages (?)
Kich-18	"	Mound 5, grave 2	Dagger	Second half of the 6th – first half of the 5th century BC
Kich-19	"	Mound 3, grave 1	Bridle	First half of the 4th century BC
Kich-16 (41k1-4/7)	"	Mound 4	Rod	Middle Ages (?)
KrG-1	Krasnaya Gorka	Surface finds	Hook/bridle bit	Second half of the 6th – first half of the 5th century BC
KrG-2	"	"	Chisel	"
KrG-3	"	"	Saw	"
KunashG-1	Kunashak fortified settlement	"	Hook	Early Iron Age / Middle Ages (?)
Irt-2/20	Irtyash II fortified settlement	Sq. A/2	"	Middle Ages / 17th–19th centuries (?)
Irt-2/22	"	Surface finds	Knife	"
Irt-2/23	"	"	"	"
Irt-2/24	"	"	Axe	"
Sht-2/10	Shatanov V settlement	"	"	"
Irt-8/001	Irtyash VIII fortified settlement	"	Forge slag	Possibly, Early Iron Age or Middle Ages (?)
Irt-8/002	"	"	"	"
Irt-2/001	Irtyash II fortified settlement	"	Smelting slag	"
Irt-2/002	"	"	Forge slag	"
Sht-5/5295	Shatanov V settlement	Exploratory pit	"	7th–3rd centuries BC
Zot-3/SmSl1	Zotino mine	"	Smelting slag	Early Iron Age

Note. The preservation of items from Kichigino I, with the exception of the rod (Kich-16), was poor (completely corroded). Preservation of items from the rest of the sites was good.

geochemical composition of smithing slag Sht-V/5295 and probably medieval smelting slag from the multilayered sites of Irtyashskoye II and VIII, this sample became the first reliable evidence on the use of the local infiltration-sedimentary ironstone ores in the Early Iron Age.

The dating of slag and iron items found at Irtyashskoye II, VIII, and the Zotino mine is less clear, because of the good preservation of many items and the presence of the medieval Petrogrom pottery along with Itkul pottery (Naumov, 2016). Moreover, single-layered medieval sites (Uzhovy Ostrov I, II, Kirety I) with a large amount of bloomery iron slag are also known on Lake Irtyash.

Results and discussion

The results of our study of the composition of silicate-slag inclusions and subsequent statistical principal component analysis allowed the classification of the sample of iron artifacts from the Early Iron Age and Middle Ages with slag data into four main chemical groups, which were further subdivided into subgroups depending on the P_2O_5 content (Fig. 2; Table 2). Subgroup 2.3 was identified on the basis of the increased concentration of BaO and S. The absence of P_2O_5 in the initial statistical sample resulted from its high heterogeneity in the bloomery-iron slag (Dillmann, L'Héritier, 2007). The identified groups show different types of iron ore sources, which differ significantly in chemical composition depending on the geological origin of iron ores and the associated rocks. In addition, these subgroups may reflect process conditions of smelting and the composition of fluxes used. Since the division based on statistical analysis with a small number of elements is to some extent arbitrary, some of the identified subgroups can be refined if rare element or isotopic data become available.

The principal component analysis has shown that the increased MnO content significantly affected the identification of clusters in statistical groups 1 and 2. In both cases, manganese-containing iron ores were probably used: those weakly enriched in combination with Al_2O_3, SiO_2 (group 1), and those high-manganese in combination with CaO and MgO (group 2). Group 1 is the easiest to interpret, since it includes six samples of iron slag, three iron items from the sites on Lake Irtyash, one sample from the Kunashak fortified settlement, and the Kich-10 item from mound 8 in Kichigino I (4th century BC). The fact that group 1 includes both slag and items from the sites on Lake Irtyash makes it possible to link it with ironstone ores of the infiltration-sedimentary type associated with karstified limestones and dolomites of the volcanogenic-sedimentary strata of the Middle Trans-Urals. Such an ancient mine (Irtyashskoye IX (Naumov, 2016)) is known near the Irtyashskoye II fortified settlement. The presence of the Irt-2/22 item (subgroup 1.2) with silicate slag inclusions enriched in P_2O_5 (up to 4.7 wt%) in this group is generally consistent with phosphorus-containing ironstone ores of Irtyashskoye I (Stepanov et al., 2021).

Given that ironstone ores were the predominant raw material used in the Middle Urals from the Early Iron Age to the Modern Age, it is interesting to note that the population associated with the Kichigino I cemetery

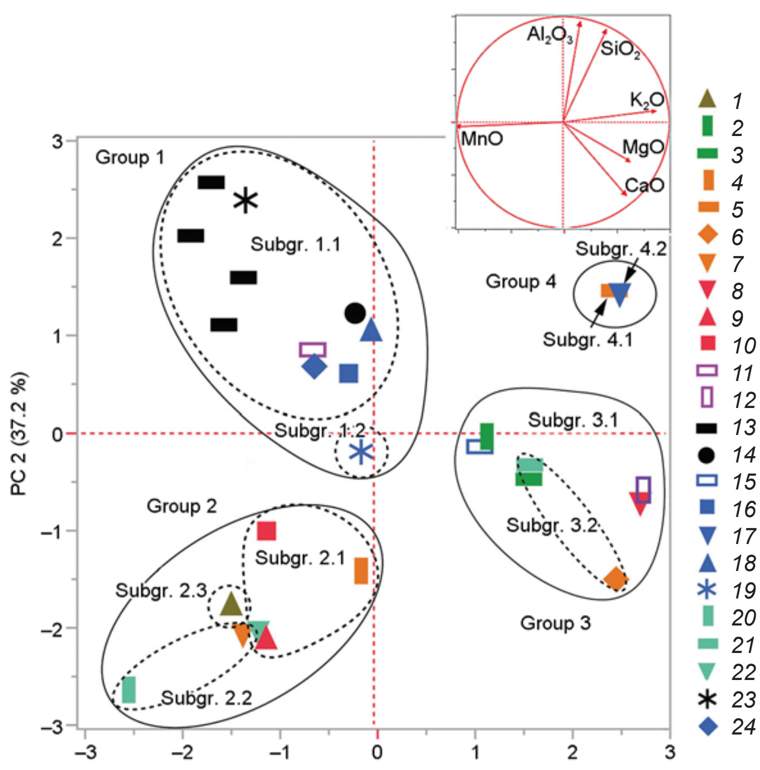

Fig. 2. Principal component analysis of chemical composition in silicate slag inclusions.

1–12 – items from Kichigino I: *1* – Kich-19, *2* – Kich-14, *3* – Kich-16, *4* – Kich-4, *5* – Kich-8, *6* – Kich-13, *7* – Kich-1, *8* – Kid-9, *9* – Kid-2, *10* – Kid-1, *11* – Kid-10, *12* – Kid-7; *13* – bloomery slag from Irtyashskoye II and VIII; *14* – smithing slag from Shatanov V; *15* – item from Shatanov V; *16–19* – items from Irtyashskoye II: *16* – Irt-2/23, *17* – Irt-2/20, *18* – Irt-2/24, *19* – Irt-2/22; *20–22* – items from Krasnaya Gorka: *20* – KrG-1, *21* – KrG-2, *22* – KrG-3; *23* – bloomery slag from Zotino mine; *24* – item from Kunashak. Ellipses mark statistically identified groups, as well as subgroups standing out by their phosphorus content. The inset shows the distribution of elements in the principal component analysis.

Table 2. **Chemical composition of silicate slag inclusions in iron artifacts and slags (wt%) and their classification based on principal component analysis**

Sample	n	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	MnO	FeO	Group	Subgroup
Kich-10	8	2.5	1.5	12.5	57.1	0.1	1.3	7.6	0.3	2.4	13.9	1	1.1
KunashG-1	4	0.5	2.7	11.6	48.9	1.0	1.4	3.2	0.5	3.1	26.9		
Irt-2/23	6	1.2	3.0	15.1	66.4	0.1	1.7	7.1	0.6	2.4	2.1		
Irt-2/24	7	1.5	3.8	19.9	62.8	0.1	1.4	5.3	0.8	1.6	3.2		
Irt-8/001*	8	0.1	0.6	7.3	25.2	0.5	0.4	1.0	0.2	2.6	62.3		
Irt-8/002*	5	0.3	0.5	9.4	25.0	0.2	0.3	1.0	0.4	1.6	61.3		
Irt-2/001*	6	1.4	1.1	6.7	19.9	0.2	0.5	0.9	–	2.6	66.7		
Irt-2/002*	5	0.1	1.0	10.0	26.4	0.2	0.9	0.9	0.3	3.2	56.9		
Sht-5/5295*	5	0.7	0.5	4.2	13.6	0.2	0.4	1.5	0.1	0.4	78.6		
Zot-3/SmSl1*	5	0.3	0.5	7.7	29.4	0.4	0.6	1.3	0.2	1.8	58.0		
Irt-2/22	5	0.8	2.2	10.0	43.3	4.7	1.1	10.6	0.5	1.4	25.2		1.2
Kich-1	2	0.2	2.6	7.3	46.8	0.1	1.7	8.4	0.4	6.6	25.9	2	2.1
Kich-2	4	0.5	2.8	8.9	43.5	0.2	2.6	23.5	0.5	8.3	9.2		
Kich-4	2	1.1	2.7	12.0	33.5	0.3	1.1	29.5	0.4	1.6	18.0		
KrG-3	6	0.5	4.0	5.0	45.0	0.1	1.5	9.8	0.3	9.0	24.4		
Kich-18	7	0.3	2.4	7.7	30.8	5.3	1.7	19.1	0.4	5.5	27.0		2.2
KrG-1	6	0.3	2.5	6.3	30.9	1.2	0.9	16.2	0.4	18.2	22.2		
Kich-19**	3	0.9	2.8	5.6	28.2	0.3	0.9	6.9	–	6.3	46.8		2.3
Kich-7	5	1.0	7.7	13.0	52.7	0.1	2.8	17.2	0.6	0.2	4.6	3	3.1
Kich-9	5	1.1	5.3	8.9	44.4	0.3	2.9	26.1	0.4	0.1	10.7		
Kich-14	7	0.9	3.5	14.0	57.1	0.1	3.2	12.7	0.5	0.9	7.1		
Sht-2/10	2	1.7	2.9	8.6	38.1	0.2	1.5	7.6	0.4	0.5	38.3		
Kich-13	3	0.5	1.4	2.7	20.6	1.6	1.5	15.2	–	0.1	56.3		3.2
Kich-16	8	0.6	7.0	14.0	58.9	0.1	2.8	12.7	0.6	0.6	2.8		
KrG-2	4	–	1.4	2.0	13.7	10.8	0.3	2.4	–	0.1	69.1		
Kich-8	9	0.7	1.6	12.4	52.0	0.1	2.5	10.3	0.7	0.1	19.6	4	4.1
Irt-2/20	6	0.2	1.0	10.1	32.9	3.4	2.7	6.9	0.4	0.1	42.3		4.2

*Data from (Stepanov et al., 2021; Stepanov, Blinov, Artemyev, 2023).

**As established, SO_3 = 0.4 wt% and BaO = 0.9 wt%.

appears to have used them so little. The inclusion of smithing slag Sht-V/5295 from the Itkul site of Shatanov V in subgroup 1.1 is indirect evidence of the use of these ores in the 4th–3rd centuries BC, which corresponds to the previous assumption by G.V. Beltikova (2005) about the development of iron technology by the Itkul population at the final stage of this culture's existence. However, it is difficult to assess the scale of iron smelting in the Early Iron Age in the Urals because of the limited archaeological data.

The similarity of the chemical composition of slag samples from the Zotino mine and from the sites on Lake Irtyash, as well as the similarity of the mineralogical composition of the ancient slag and bloomeries of the 18th century from Lake Shuvakish (Erokhin, Zakharov, Erokhina, 2021), located next to the Iset cluster of the Itkul sites, confirms the uniformity of infiltration-sedimentary ironstone ores of the Middle Trans-Urals. In all the cases, slag consisted of manganese-containing fayalite, wustite/magnetite, and hercynite, and was enriched by Al_2O_3. The inclusion of item Irt-2/20 into group 4, which is distinguished by increased content of Al_2O_3 and SiO_2, may indirectly indicate the use of another type of ironstone ore by the ancient population of the Lake Irtyash area. Thus, despite the fact that the composition of infiltration-sedimentary ironstone ores of the Middle Trans-Urals corresponds to group 1, artifacts of group 4 may also reflect an unidentified Trans-Ural source of iron ore.

Group 2 is distinguished by correlation and increased contents of MnO, CaO, and MgO. It includes five items from Kichigino I (two from mounds 5 and 6; one from mound 3) and two items from the Krasnaya Gorka cemetery. The inclusion of five items dated to the 6th–4th centuries BC into this group may indirectly indicate the prominence of group 2 in the iron metallurgy of the nomads of the Southern Trans-Urals over a long period. The source of iron ore for this group was ironstone deposits with an increased concentration of Mn. An example of such sites is the Zhayrem ore cluster in Central Kazakhstan, which includes the stratiform Zhayrem and Ushkatyn iron-manganese and barite-polymetallic deposits in sedimentary carbonate strata (Brusnitsyn et al., 2017). Notably, subgroup 2.3 with increased content of Ba and S in silicate slag inclusions also confirms the association of manganese-iron ores with barite.

Group 3 is distinguished by increased content of CaO, MgO, and K_2O, and includes five items from Kichigino I (two items from mound 4; one each from mounds 5, 6, and 8), and artifacts from Krasnaya Gorka and Lake Irtyash. The interpretation of this group is ambiguous. Despite the unclear archaeological context of the artifacts, the similarity of the composition of silicate slag inclusions and the good preservation of one of two items from mound 4 (Kich-16 and Kich-14) suggest that these artifacts could have belonged to the Middle Ages. This is indirectly supported by the discovery of an iron buckle from the Kimek-Kipchak period (10th–11th centuries) in mound 4 and the presence of item Kich-9 (mound 6) of the Xiongnu-Sarmatian period (2nd–3rd centuries AD) in group 3. Thus, the fact that four out of seven items from this group may possibly date back to the Middle Ages, when iron became a common and easily accessible material, points to their non-local origin due to increased migration and exchange processes, and the engagement of many iron ore sites into the set of available ore raw materials. The probable source of this iron could have been ironstone ores in platform calcite-dolomite-siderite carbonate strata, which are known in the Urals or Volga-Kama region.

Two artifacts from group 4 show low concentrations of MnO and higher values of K_2O. However, the interpretation of their source is problematic, owing to the small number of items and the small amount of chemical macroelements studied.

Note that the items from Kichigino I and Krasnaya Gorka do not gravitate to any particular part of the plot (Fig. 2), but are distributed throughout the entire field, entering each of the four groups. This suggests that the early nomads of the Southern Trans-Urals obtained iron of different origin. This allows us to doubt their independent development of any particular deposit. Most likely, ferrous metal was regularly supplied by different manufacturers, or could have been obtained accidentally (for example, during military operations).

Conclusions

The main result of this study is the conclusion about the diversity of ore sources for iron items from the Kichigino I and Krasnaya Gorka cemeteries, which correlates well with the high mobility and specific features of the nomad economy. In the Early Iron Age, when ferrous metal was in high demand among the nomads for producing tools, weaponry, and horse equipment, its supplies were most likely ensured in different ways, possibly including collection of tribute from the sedentary population familiar with the technology of bloomery smelting.

In addition, an important result of this study is the confirmation of the hypothesis of G.V. Beltikova (2005) about the development of iron metallurgy in the Middle Trans-Urals at the final stage of the Itkul culture (4th–3rd centuries BC). The totality of the results points to the use of infiltration-sedimentary ironstone ores associated with karst limestones of volcanogenic-sedimentary strata during that period. These deposits are the dominant type of ore in the Middle Trans-Urals, where their area coincides with the territory of the Itkul culture. The Itkul metallurgists might have been the first in the Urals to exploit these resources for iron production. The fact that only one out of twelve items from Kichigino I can be associated with these ores suggests that the nomads of the Southern Trans-Urals obtained iron mainly from other sources. This is especially noteworthy given that a significant part of the non-ferrous metal items of the nomads from the South Urals were made from the Itkul "chemically pure" copper (Tairov, 2019: 196, 262; Artemyev et al., 2024). The presence of iron artifacts from Kichigino I in the sample, which are distinguished by an increased concentration of Mn in silicate slag inclusions, indicates another, earlier, pre-Itkul source, which could have been ironstone ores from deposits in Central Kazakhstan, associated with barite-polymetallic mineralization. It is difficult to establish the source of ore for iron items of group 3 from macrocomponents, but the increased content of elements such as Ca, Mg, and Fe might have resulted from the use of ironstone ores from stratiform carbonate strata of platform structures of Eurasia. The orientation of the early nomads (7th–4th centuries BC) of the Southern Trans-Urals toward other iron suppliers was possibly caused by very late adoption of the bloomery smelting by the Itkul metallurgists. The finds of bloomery slags are also known from the layers of the 5th–3rd centuries BC in the Kama region, and smithing slag was found at the Early Iron Age fortified settlements in the Bashkir Cis-Urals (Zavyalov, Rozanova, Terekhova, 2009: 69–72; Oborin, 1960: 40; Grigoriev, 2016). This indicates that these regions could have been the centers of iron production for the nomads of the Southern Trans-Urals. Notably, the conclusions of this study are based on a small sample, and require verification by further systematic archaeological research using radiocarbon dating.

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Radiocarbon Chronology and Isotope Data of Ust-Tartasskiye Kurgany Mound 51, the Baraba Forest-Steppe

Results of radiocarbon dating of items from mound No. 51 of Ust-Tartasskiye Kurgany burial ground are presented. This is a key site of the Sargat culture in Baraba. Characteristics of samples and pretreatment procedure are provided. Twenty-four radiocarbon dates were generated. Radiocarbon ages correlate with biological ages of the deceased persons. Bayesian KDE chronology modeling suggests a short-term intense use of the site for burying those who died between the 3rd and 1st centuries BC. Based on MCMC-modeling, a conclusion is reached about two periods in the use of the space allotted for graves between 200–40 BC. Burials of the "first period" (~25 %) could have been repeatedly made before 150 BC. Most burials (~75 %) were likely arranged between 150–120 BC. The last burial in the mound (no earlier than 110 BC) is No. 13. Minor differences in ^{15}N isotope apparently evidence various diets of males and females at the second period.

Keywords: *Baraba forest-steppe, Sargat culture, mound, burial ground, radiocarbon dating, Bayesian KDE, MCMC-chronology modeling.*

Introduction

The Sargat culture, encompassing the basin of the Tobol, Ishim, and Irtysh rivers and the Baraba Lowland, is one of the best studied Early Iron Age cultures in the West Siberian forest-steppe. Bearers of this culture dwelt there for almost a thousand years. On the basis of the regional specifics, specialists separate several local variants of the Sargat culture (Koryakova, 1988; Matveeva, 1993, 1994; Mogilnikov, 1997). The eastern periphery of this culture spread is referred to as the Baraba variant, which moved through four stages of development (Polosmak, 1987: 96).

By now, 15 sites of the Sargat culture have been examined in the Baraba forest-steppe. Ust-Tartasskiye Kurgany burial ground occupies a special place among them. The site has been known since the 18th century (Polnoye sobraniye…, 1824; Ekspeditsiya…, 1768–1774; Florinsky, 1889). S.M. Chugunov conducted the first excavations there in 1895 and

1896 (Archives of the Institute of Material Culture RAS. F. 1, Inv. 1. 1895, D. 80; F. 1, Inv. 1. 1896, D. 71) (Chugunov, 1900; Troitskaya, Avtushkova, 2010). The site was studied by A.M. Molotilov (1912), I.A. Talitskaya (1953), T.N. Troitskaya (1966), and V.A. Borzunov (1971). Excavations were conducted at the site under the leadership of V.I. Molodin (Molodin, 1979; Molodin, Novikov, 1998), D.G. Savinov, and N.V. Polosmak (Savinov, Polosmak, 1985; Polosmak, 1987).

Ust-Tartasskiye Kurgany is the largest burial ground of the Sargat culture in Baraba. According to V.M. Florinsky (1889: 46), it included 256 mounds. S.M. Chugunov mentioned as many as 122 mounds. According to the data received by the State Science Center for Preservation of Cultural Heritage of the Novosibirsk Region, 54 mounds were preserved in 2017 (Knyazev, 2018); the rest of them were annihilated during decades of plowing and repair of the Moscow Highway.

In 2022, archaeological teams from the Institute of Archaeology and Ethnography SB RAS excavated burial mound (kurgan) No. 51 (Mylnikova et al., 2022). Ust-Tartasskiye Kurgany is located on the left bedrock terrace of the Tartas River, and from the confluence of the Tartas and Om rivers, on the right fluvial terrace of the Om (Tai tract), on both sides of the Vengerovo-Kuibyshev road (the so-called Old Moscow Highway), in the Vengerovsky District of the Novosibirsk Region (Fig. 1). Mound No. 51 is situated 5.14 km southeast of a bell tower in Vengerovo village (Molodin, Novikov, 1998; Troitskaya, Molodin, Sobolev, 1980). Excavations in the burial space surrounded by a small ditch revealed 22 burials attributable to a single epoch, but made at different times (Mylnikova et al., 2022). In terms of topography and stratigraphy, several periods were separated. The main burial of the mound was central grave No. 9 (Fig. 2). The grave of an adult man was almost completely looted. Simultaneously with the main burial (before the mound was formed), graves No. 7, 11, 12, 16–18, and 20 had been made along the perimeter. Their common trait was a shallow depth (up to 0.4 m). Despite their looting, almost every grave contained remains of birch bark used as a cover. Graves No. 14, 15, 19, and 21 were built in the rows of the above-mentioned ones. Their distinguishing trait was a considerable depth (up to 2 m). Grave No. 13, possibly, the latest one among the flat burials, had no birch bark cover. Most graves contained burial goods typical of the Sargat culture. Graves No. 13–15, 19, and 21 were not looted. Nine intrusive burials,

Fig. 1. Location of mound No. 51 of the Ust-Tartasskiye Kurgany burial ground.

apparently secondary (Ibid.), were found in the mound (No. 1+3; 2, 4, 5, 6, 8, 10, 22, 23). Female (No. 5, 11, 13, 15–17, 19), male (No. 3, 4, 6, 7, 9, 10, 14, 21, 22), infant (No. 18), and unidentifiable (No. 1, 2, 8, 12, 20) burials were recognized.

Material and methods

Twenty-four samples were subjected to pretreatment for accelerator mass spectrometry (AMS) in the Center for Collective Use "Geochronology of the Cenozoic" (Institute of Archaeology and Ethnology SB RAS): 16 human teeth separated from bone fragments; 1 fragment of a human bone, 5 fragments of birch bark, 1 fragment of wood from the roof, and 1 charcoal (see *Table*).

Teeth and bone fragments were cleaned, washed with distilled water, dried, and ground down into powder in Freezer Mill cryogenic grinder. Then the powder was purified using the dichlormethane solvent, with continual stirring at room temperature during 2 days; the powder was dried at 60 °C. The bone was demineralized in 1 M HCl solution at 4 °C during a day and a half. After that, the solution was centrifuged; the received precipitate was washed with distilled water to reach pH = 7. To remove humic contaminants from collagen, the precipitate was treated with 0.1 M NaOH solution at room temperature to receive a colorless solution; then the precipitate was washed with distilled water to pH = 7. The washed precipitate was again put in 1 M HCl solution for 30–60 minutes and then treated with distilled water to receive the suspension with pH = 3. The suspension was kept in a thermostat at 70 °C during 3 days. The precipitate was extracted from the solution in centrifuge. The purified solution was kept at −20 °C before freeze-drying to receive collagen powder. Immediately before carbonization,

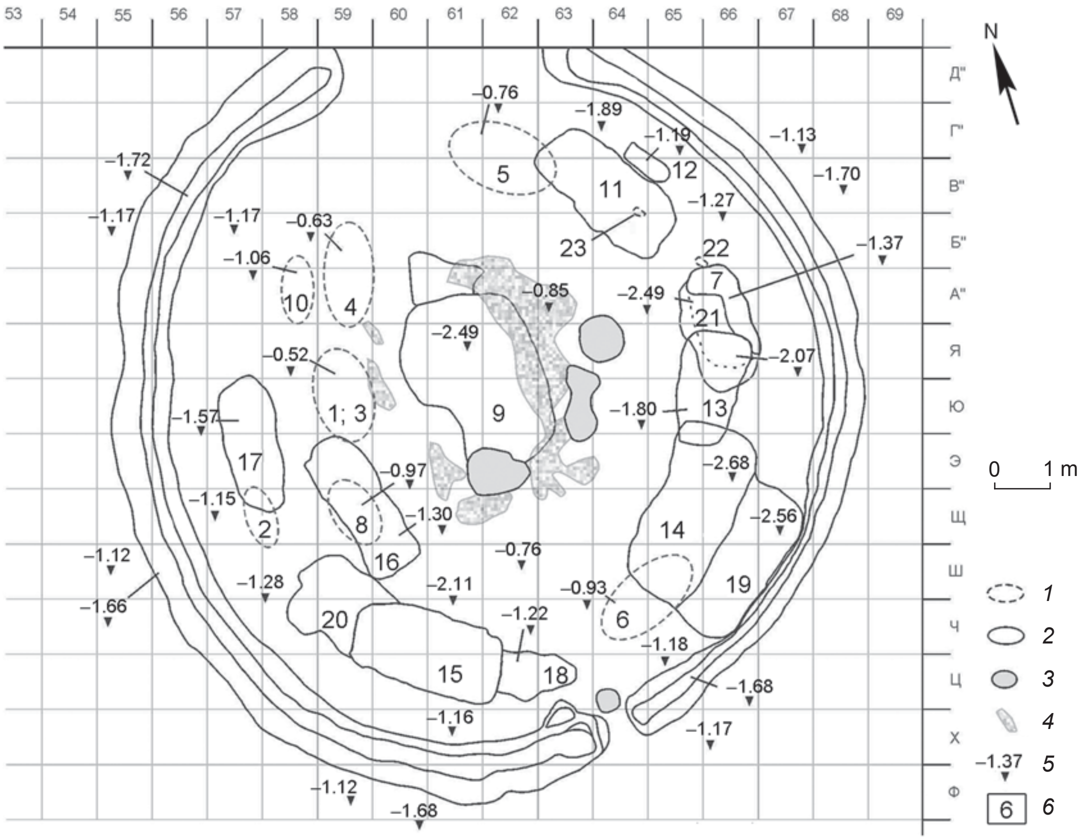

Fig. 2. Plan of mound No. 51 of the Ust-Tartasskiye Kurgany burial ground.
1 – burial in the mound; *2* – burial dug into the ground; *3* – charred earth; *4* – birch bark; *5* – level mark; *6* – burial number.

prepared solutions were freeze-dried in a FreeZone Labonco drier.

In order to extract cellulose from birch bark and wood, the samples were cleaned (roots and other visible contamination were removed), ground, and subjected to solvent extraction with the use of automatic ASE™350 (Accelerated Solvent Extractor – Dionex Corporation) by mixture of ethylene chloride and ethanol in the ratio of 2:1 at 90 °C during 10 minutes, with subsequent washing with distilled water at 90 °C during 10 minutes. Then the samples were repeatedly processed in the following way. Each sample was placed in the 20 ml solution of catalyst and oxidant and kept there for two or three days under boiling conditions. The catalyst and oxidant solution was received by dissolution of 0.2 g of sodium tungstate dehydrate in 40 ml of 5 % sulfuric acid. The formed yellow precipitate was dissolved in 40 ml of 10 % hydrogen peroxide solution. During this period, the catalyst solution has been changed several times. After that, the samples were repeatedly washed with distilled water and treated by 0.5 M NaOH at 70 °C during 20 minutes to reach pH = 7. This procedure was repeated twice. Then the cellulose samples were bleached. Each sample was placed in the solution consisting of 4 ml of $NaClO_2$, 16 ml of H_2O, and 300 mcl of 1 M HCl and kept there at 80 °C to the maximal discoloration of the solution and the samples. After that, the samples were washed with distilled water to pH = 7 и freeze-dried in a FreeZone Labonco drier.

Acid-Base-Acid pretreatment was used for charcoal sample. First, the sample powder was placed in 1 M HCl, kept there during 20 minutes at 80 °C, and washed to pH = 7. Then the precipitate was poured into 1 M NaOH and kept there during 20 minutes at 80 °C. After that, the specimen was washed several times with 1 M NaOH solution and distilled water to pH = 7. Then the precipitate was kept in concentrated HF for 48 hours, poured into concentrated HCl, and kept there during 30 minutes at 80 °C. Finally, the charcoal sample was washed with distilled water to pH = 7 and dried at 60 °C.

All prepared and dried samples were delivered for AMS-analysis to the AMS Golden Valley (GV) Center, where they were carbonized using AGE-3 (Ionplus) graphitization equipment and examined by AMS

Radiocarbon and calendar ages of samples from mound No. 51 of the Ust-Tartasskiye Kurgany burial ground

No.	Burial number	Laboratory code	Dated material	Radiocarbon age, years	Calendar age, years BC 1σ	d^{13}C, ‰ graphite	d^{13}C, ‰ collagen	d^{15}N, ‰	C/N
1	14	GV-4235	Human tooth	2203 ± 32	372–174	−23.6	−22.2	12.6	3.1
2		GV-4236	Birch bark	1967 ± 32	42–126	−36.5	−28.6	–	–
3	21	GV-4245	Human tooth	2173 ± 32	362–241 (49.4 %) 236–106 (46.0 %)	−23.1	−22.7	13.5	3.2
4		GV-4243	Birch bark	2010 ± 42	106–122	−25.6	−26.8	–	–
5		GV-4244	Charcoal	1995 ± 41	96–72 (2.6 %) 57–125 (92.8 %)	−26.6	−25.1	–	–
6	6	GV-4247	Human tooth	2163 ± 32	359–276 (38 %) 235–97 (53.4 %)	−17.0	−22.8	13.8	3.2
7	19	GV-4242	"	2149 ± 32	354–284 (26.9 %) 229–90 (63 %) 80–53 (5.6 %)	−23.1	−21.2	12.3	3.1
8		GV-4241	Birch bark	2026 ± 32	106–78	−30.7	−29.6	–	–
9	5	GV-4226	Human tooth	2142 ± 32	351–290 (21 %) 210–52 (73.8 %)	−23.6	−22.6	13.0	3.2
10	16	GV-4238	"	2129 ± 32	349–311 (11.6 %) 206–48 (83.9 %)	−22.0	−22.5	12.9	3.1
11	4	GV-4225	"	2125 ± 34	349–311 (10.4 %) 206–46 (85 %)	−25.3	−22.7	12.3	3.3
12	3	GV-4224	"	2120 ± 41	351–290 (12.1 %) 210–40 (82.5 %)	−22.2	−22.4	11.5	3.2
13	9	GV-4230	Human bone	2117 ± 32	343–321 (5.7 %) 202–47 (89.7 %)	−23.2	−21.8	12.4	3.3
14		GV-4229	Human tooth	2095 ± 32	198–39 (93.1 %) 11–2 (1.9 %)	−20.8	−20.8	12.1	3.3
15		GV-4228	Birch bark	2224 ± 34	387–197 (95.4 %)	−31.0	−29.9	–	–
16	22	GV-4246	Human tooth, skeleton 1	2113 ± 33	343–322 (4.9 %) 201–45 (90.6 %)	−21.1	−21.1	12.3	3.2
17	7	GV-4227	Human tooth	2104 ± 31	339–326 (2.2 %) 199–43 (93.3 %)	−23.0	−21.5	12.7	–
18	15	GV-4237	"	2098 ± 32	198–41 (93.2 %) 9–1 (1.2 %)	−20.3	−22.2	13.2	3.2
19	11	GV-4232	"	2094 ± 32	197–39 (93.3 %) 11–2 (2.1 %)	−24.8	−22.0	12.8	3.3
20		GV-4233	Birch bark	1985 ± 33	46–120	−31.6	−27.1	–	–
21	10	GV-4231	Human tooth	2091 ± 32	197–37 (92.4 %) 14–4 (3 %)	−20.8	−21.1	11.7	–
22	13	GV-4234	"	2087 ± 32	197–35 (91.4 %) 15–6 (4.1 %)	−19.7	−21.5	13.5	3.2
23	18	GV-4240	"	2085 ± 32	196–33 (90.7 %) 16–7 (4.7 %)	−23.4	−21.3	12.3	–
24	17	GV-4239	Wood fragment	1923 ± 34	22–212	−24.7	−27.1	–	–

MICADAS-28 (Ionplus) facility. Radiocarbon age was estimated using the BATS software. Normalization was performed using the standard OX-I (SRM 4990B) sample by subtraction of the baseline value, estimated from the standard polyethylene sample (BN 268530 Thermo Scientific) corrected for isotopic shift measured for ^{13}C in graphites on MICADAS-28.

Calibration of radiocarbon age estimates and modeling of chronology were performed using the OxCal 4.4 software. Preliminary KDE-modeling was carried out in accordance with (Ramsey, 2017), and improved traditional MCMC-modeling in accordance with (Ramsey, 2009). Convergence of models was determined by the agreement index (A_{model}), without limits on time and number of modeling steps. Stability of results was estimated through at least 10 repetitions with $A_{model} > 60$.

Measurements of $\delta^{13}C$ and $\delta^{15}N$ in the tooth and bone samples were conducted using Delta-V-Advantage mass spectrometer, under conditions of continuous flow of high-purity (grade 6.0) helium: $\delta^{13}C$ and $\delta^{15}N$ were estimated for sample weights of 0.150–0.250 mg by CO_2 and N_2, obtained through decomposition of substances at 1020 °C, relatively to CO_2 extracted from a standard of ANU sucrose and IVA urea, respectively, obtained under the same conditions. Isotopic shift was measured by ^{13}C for wood samples and by ^{13}C and ^{15}N for bone samples. Reproducibility of the generated values was within ± 0.2 %.

To determine the quality of collagen in teeth and bone samples, content of C, N, and H was measured with Flash-2000 (ThermoScientific) analyzer, under conditions of continuous flow of helium (grade B) for sample weights of 4.0–6.0 mg by CO_2 and N_2, obtained through decomposition of substances at 920 °C, relatively to the same substances that were extracted from a standard of urea (Urea, ThermoScientific) under the same conditions. Each sample was analyzed twice; experimental reproducibility (standard deviation of the mean) equaled 0.02 and 0.08 wt% for C and N, respectively.

Statistical analysis was carried out with the JASP 16.4 software. Associations between variables were assessed by the Spearman's R criterion, and linearity of association, by the Pearson's correlation coefficient under the assumption of positive link between biological and radiocarbon ages. Age variations between groups of burials were evaluated using traditional and Bayesian analyses of variance (ANOVA); age differences between wood and bones, using traditional and Bayesian ANOVA with repeated measurements; a posteriori comparison of group means was conducted via the Benjamini-Hochberg criterion. Differences in isotopic shifts were evaluated by $\delta^{13}C$ and $\delta^{15}N$ for collagen samples using traditional and Bayesian two-way covariance analysis (ANCOVA), with "sex" as covariate, with regard to burial order. Variation coefficients were compared with the asymptotic test (Feltz, Miller, 1996). When necessary, results were corrected for multiple comparisons. To evaluate the tendencies, significance level was set at $p < 0.10$, and for statistically significant results, at $p < 0.05$.

Results and discussion

All the biological and calibrated age estimates are correlated (without burial No. 13: $R_{(13)} = +0.47$, $p = 0.038$; including burial 13: $R_{(14)} = +0.31$, $p = 0.12$), suggesting a short time span. Preliminary Bayesian KDE-modeling also supports a short time interval over which most burials were arranged, specifically, one of the periods between 220 and 50 BC with at least two peaks ($A_{model} = 87$) (Fig. 3). A weak linearity of correlation between the biological and calibrated ages ($r_{(13)} = +0.36$, $p = 0.097$) likely suggests several periods of activity at the site. The results of preliminary modeling support excavation findings: all the samples fall in three groups: burials in the mound; those simultaneous with the central grave; and those in the "first period" graves along the perimeter. The latest burial No. 13 stands apart.

The linear correlation between the biological and calibrated ages for graves in the mound indicates broadly the same period for these burials. A tooth from burial No. 6 apparently moved from an earlier burial to the mound (without burial No. 6: $r_{(3)} = +0.76$, $p = 0.070$; with burial No. 6: $r_{(4)} = +0.43$, $p = 0.19$) (Fig. 4). A similar comparison of age estimates for the central grave and for the "second period" burials in the mound likewise points to contemporaneity (with burial No. 15: $r_{(3)} = +0.57$, $p = 0.12$; without burial No. 15: $r_{(2)} = +0.55$, $p = 0.17$).

According to ANOVA, burials in the mound are broadly contemporaneous with the central grave, whereas "first period" burials are indeed earlier than others ($F_{(2.12)} = 20.6$, $p = 0.0001$, $B_{10} = 336.7$). Similarly, a high correlation between the biological and calibrated ages of those buried in the mound and those contemporaneous with the central grave also suggests that both groups may be broadly contemporaneous ($r_{(8)} = +0.65$, $p = 0.021$) (Fig. 5).

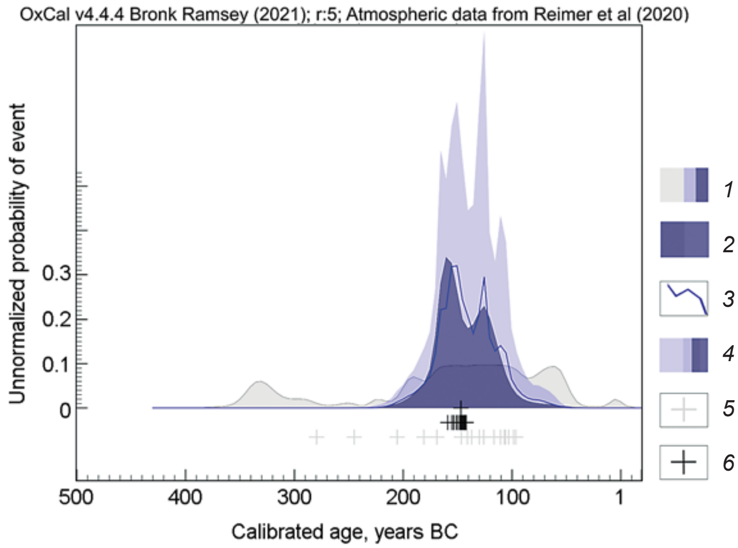

Fig. 3. Bayesian KDE-modeling of chronology (after (Ramsey, 2017)).
1 – integral a priori probability of events; *2* – integral a posteriori probability of events; *3*, *4* – averaged LOWESS-regression lines with one s.d. error modeling ranges for posteriori distributions; *5* – a priori ages of individual burials (based on modeling); *6* – a posteriori median ages of individual burials (based on modeling).

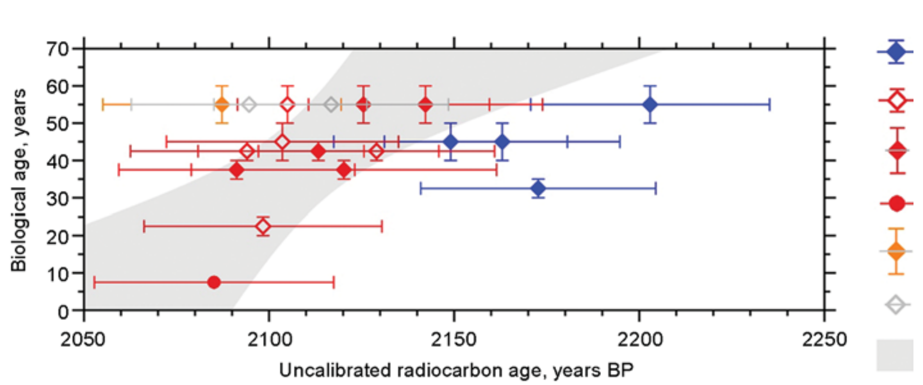

Fig. 4. Correlation between uncalibrated radiocarbon estimates and biological ages of samples from various burials of the complex. Individual estimates are represented as mean values plus significance intervals.
1 – "first period" burials; *2* – "second period" burials; *3* – burials in the mound; *4* – infant burials; *5* – burial No. 13; *6* – a bone and a tooth of a single individual; *7* – range of individual dates contemporaneous with the "second period" burials and those in the mound.

Improved Bayesian modeling of chronology with two peaks and a separate late burial No. 13 (A_{model} = 166) (Fig. 6) points to the active use of the site between 200–40 BC; the "first period" burials (~25 %) may have been earlier than 150 BC. The peak of the site usage (~75 %) probably coincided with the 150–120 BC interval, and the latest burial (No. 13) was no earlier than 110 BC (Fig. 7).

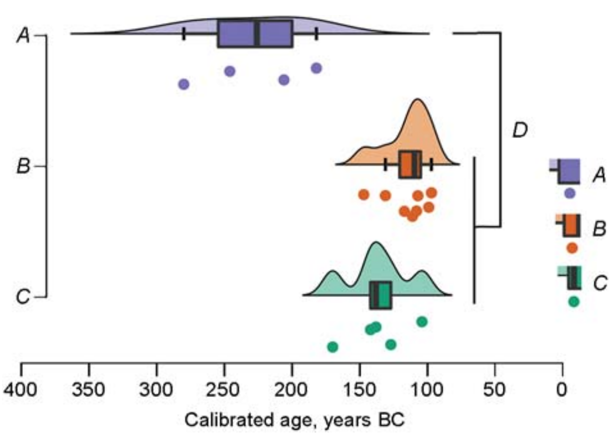

Fig. 5. Calibrated median age estimates.
A – "first period" burials; *B* – "second period" burials; *C* – burials in the mound; *D* – $p < 0.001$ as compared to the buried in the "first period" burials. Groups were compared using ANOVA.

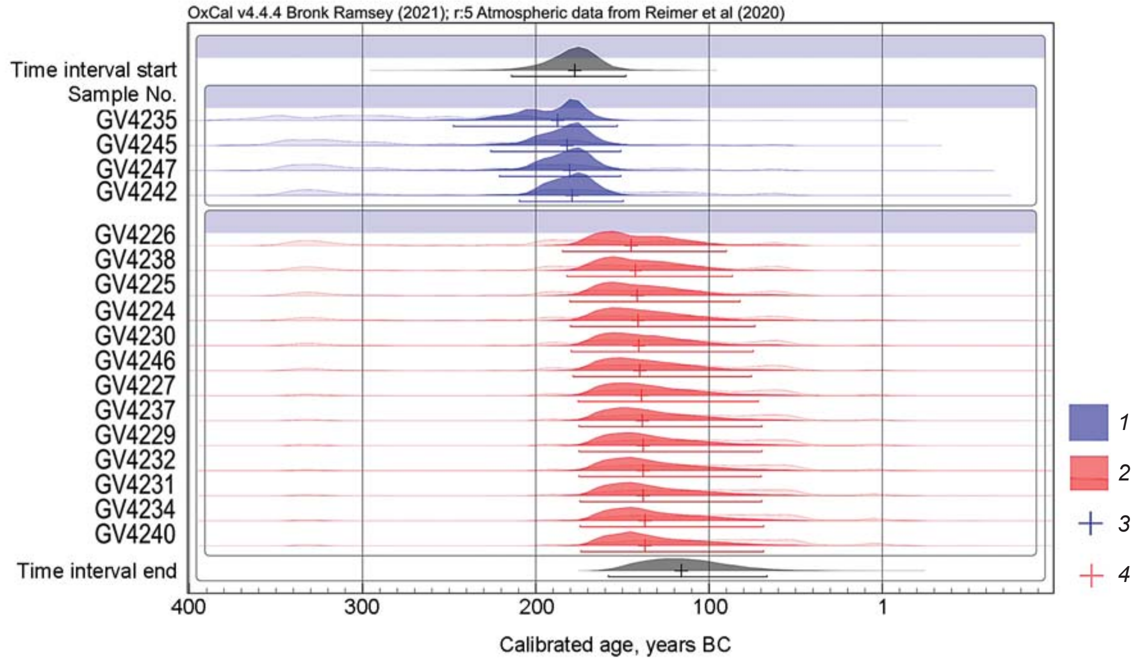

Fig. 6. Bayesian KDE-modeling of chronology (after (Ramsey, 2009)). Distributions and time intervals for burials.
1 – "first period" burials; *2* – "second period" burials, including burial No. 13 (GV-4234) and those in the mound; *3*, *4* – a posteriori modeling of median ages (intervals show 95.4 % probability for each sample).

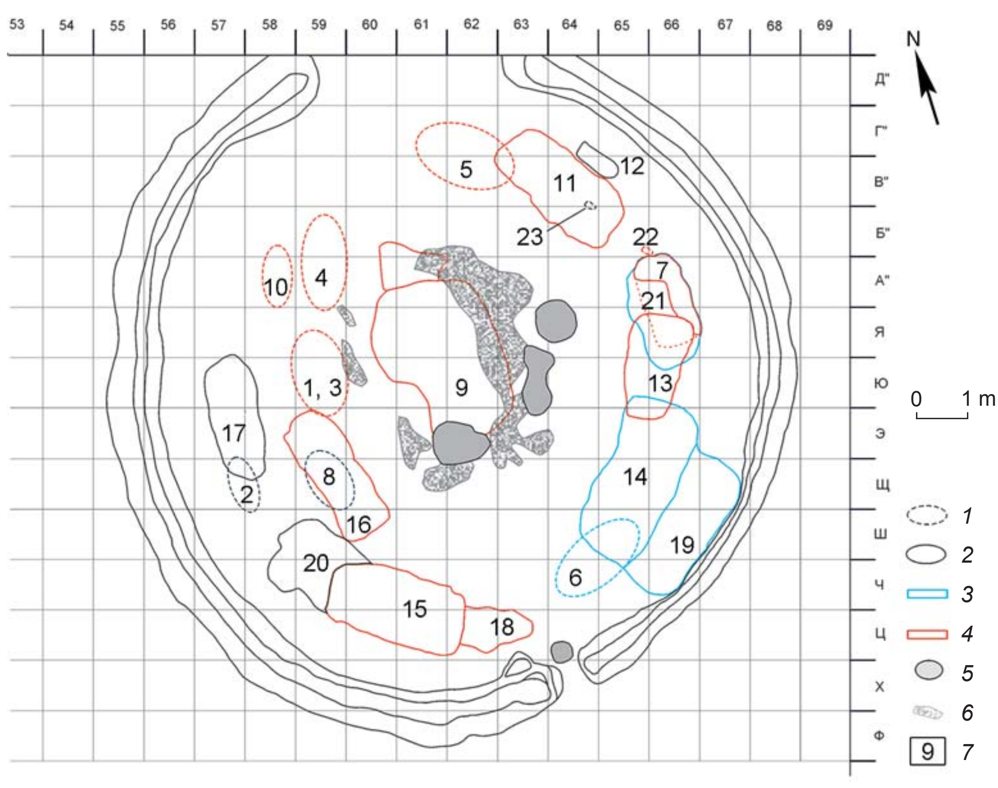

Fig. 7. Plan of mound No. 51 of the Ust-Tartasskiye Kurgany burial ground.
1, *2* – undated burials; *3* – "first period" burial; *4* – "second period" burial; *5* – charred earth; *6* – birch bark; *7* – burial number.

Notably, calibrated radiocarbon ages based on wood samples (birch bark, planks of the roof, and charcoal), with the exception of sample GV-4228 from burial No. 9, are significantly younger than those acquired from teeth and bones ($F_{(1.4)} = 52.03$, $p = 0.002$, $BF_{10} = 568.4$) (Fig. 8; see *Table*). This age difference may be a result of a microbiological stress on wood after burial. Sample GV-4228, judging by its darker, almost black color, had probably been subjected to fire, and was therefore unaffected by later biological changes, hence no carbon had been admixed to the original one contained in the wood. The radiocarbon age of this sample suggests that the earliest burials date to the late 4th century BC. It also cannot be excluded that some wood may be earlier than the burials. To control the effect of standard procedures of sample preparation on the content of radioactive carbon in cellulose and to reveal the reasons underlying the discrepancy between radiocarbon estimates for cellulose and collagen within 150 years, AMS analysis of the same samples of wood was conducted using other methods of chemical processing. The achieved result was the same.

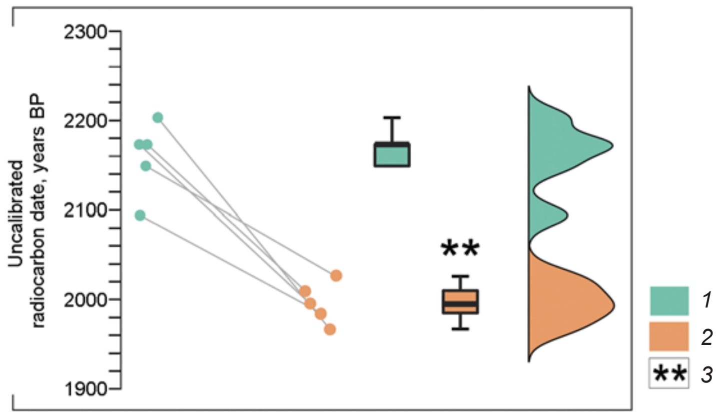

Fig. 8. Uncalibrated radiocarbon dates.
1 – bone samples; *2* – wood samples; *3* – $p < 0.002$ as compared to human remains. Groups were compared using ANOVA with replications.

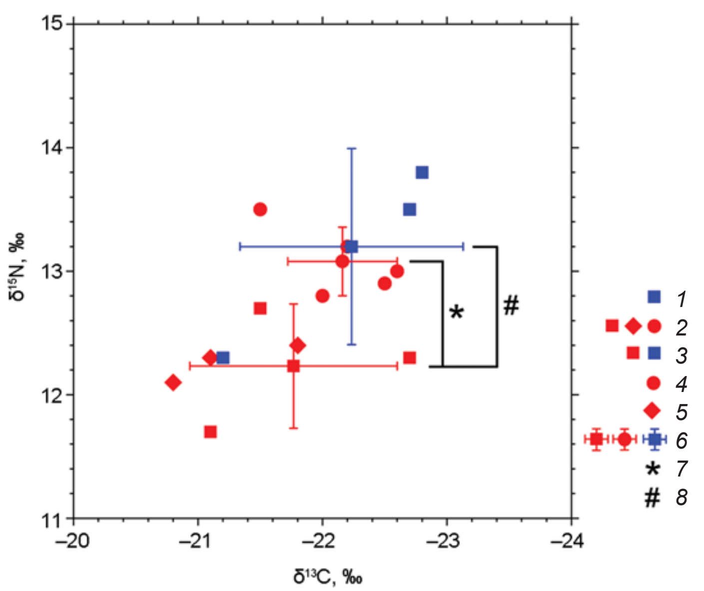

Fig. 9. $\delta^{13}C$ and $\delta^{15}N$ for the collagen samples from burials of the two periods.
1 – "first period" burials"; *2* – "second period" burials; *3* – male burials; *4* – female burials; *5* – remains unidentified with regard to sex; *6* – mean values for groups of the buried; *7* – $p = 0.020$ as compared to buried women of the "second period"; *8* – $p = 0.049$ as compared to burials of the "first period".

All the burials revealed a small variation in isotopic changes: ^{13}C – 2 ‰ (20.8–22.8 ‰), ^{15}N – 2.3 ‰ (11.5–13.8 ‰) (see *Table*) This suggests that all those buried in the mound had subsisted on a similar diet, and that the gap between the periods of intense use of the burial space was rather short.

Isotopic shifts in ^{13}C for dental and bone collagen in samples from burials of both periods are comparable (burial order: $F_{(1.8)} = 0.33$, $p = 0.69$; sex: $F_{(1.8)} = 0.29$, $p = 0.62$; $BF_{10} = 0.310$ for the "order + sex" model). However, averaged isotopic shifts in ^{15}N for males buried in graves of the "second period" were lower than those for females of the same group and for burials of the "first period" (burial order: $F_{(1.8)} = 5.41$, $p = 0.049$; sex: $F_{(1.8)} = 5.18$, $p = 0.052$; $BF_{10} = 0.786$ for the "order + sex" model). Consequently, unidentified remains form burials No. 3, 9, and 22 of the "second period", showing low values of isotopic changes in ^{15}N, are likely those of males.

Coefficients of variation for isotopic changes in ^{13}C based on dental and bone collagen for burials of the periods of $CV_{\text{“first period”}} = 4.0$ %, $CV_{\text{males, “second period”}} = 3.8$ %, and $CV_{\text{females, “second period”}} = 2.0$ % are comparable ($p = 0.42$). The coefficient of variation for isotopic changes in ^{15}N (2.1 %) for female burials of the "second period" is somewhat lower ($p = 0.10$) than that for male burials of the "first period" (6.0 %) and "second period" (4.1 %) (Fig. 9).

Small differences in ^{15}N isotopic shifts between the groups of burials suggest that during the second period of site usage, the diet of females contained more protein than that of males. In addition, a lesser variation of ^{15}N changes in females as compared to males indicates a more stable protein diet and a more sedentary life of females on a river abundant in fish. The observed differences may have been caused by sharp climatic changes in the late 2nd century BC in the Iranian highland (Sharifi et al., 2015) and elsewhere in Central Asia (Fedotov et al., 2012).

Conclusions

Multidisciplinary studies have yielded age estimates for 17 of 22 burials excavated in elite mound No. 51 at Ust-Tartasskiye Kurgany, the largest cemetery of the Early Iron Age Sargat culture in the Baraba forest-steppe. This is the first such analysis of a Sargat site. A large series of absolute dates (24) has been assessed, suggesting that the mound dates to the period from the 3rd to the 1st centuries BC. The correlation between radiocarbon ages and the spatial arrangement of burials suggest that the burials were made during largely the same period, on the same platform surrounded by a ditch. Burial rite and accompanying artifacts suggest likewise.

According to the absolute age estimates, there were two overlapping stages in the intense use of the burial platform (see Fig. 6), suggesting that all the burials belong to the same historical period. Four burials of the "first period" were evidently arranged on a small platform encircled by a ditch and open for further burials. Then burial No. 9 was arranged, and the "second period" burials were dug into the virgin soil. During the same period, the mound was constructed, within which more bodies were buried.

The entire time span over which burials were made can be estimated at somewhat more than a century. Given the large size of the cemetery, these periods could differ between the mounds, depending on several factors or their combination, such as the local or social (?) group to which the deceased person belonged, as evidenced by funerary items and physical type (Mylnikova et al., 2022, 2023). An additional analysis of paleogenetic data may be especially informative, being relevant to the origin and kinship of the buried.

The analysis of diet is no less important. At the second period of the mound use, females consumed a more protein rich food than did males. Reasons may include greater mobility of males caused by their pastoral lifestyle, and a sedentary life of women in villages where meat and fish were more available. Interestingly, similar conclusion was reached with regard to a Pazyryk male, whose diet, according to O'Connel (2000), consisted of fish at best rather than meat.

Such interesting and largely unexpected findings concerning the possible diet of the Sargat people need further testing. Results by N.P. Matveeva, based on 14 bone samples from Sargat burials at the Staro-Lybrevo-4 cemetery and Shchelkovo-2 settlement, indicate inequality in resource distribution, specifically deficit of protein in the diet of women and children, and its dominance in the diet of males (Matveeva, Larina, Koliukh, 2003).

The social impact on diet may have been likewise important. It would be interesting to compare diet reconstructions for low-status and elite cemeteries, for instance, for males from the Sidorovka mound (Matyushchenko, Tataurova, 1997).

The study of the Sargat diet has only been started. Findings by N.P. Matveeva (1998, 2000) and her colleagues (Larina, Matveeva, Koliukh, 2001; Matveeva et al., 2003; Chikunova, 2006) concerning social differentiation of burials of that culture, and average indicators of the Sargat diet, can substantially extend our knowledge of the large and diverse ethno-cultural phenomenon such as the Sargat culture in Western Siberia.

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Raw Materials in the Paste of Ceramics of the Kulaika Culture Surgut Variant (Based on Samples from Barsova Gora)

A multidisciplinary analysis of ceramics from six sites of the Surgut variant of the Kulaika culture at Barsova Gora was made. Technology was assessed using traceological, petrographic, and X-ray phase analyses. At all the sites, the potters used ferruginous clays tempered with grus, grog, sand, and organic material. Fragments in the clay were either rounded, as in sand, or coarse, as in grus. The sand was mainly represented by feldspar and quartz, suggesting that this type of raw material was extracted from nearby non-metallic mineral deposits. The grus consisted of fragments of basaltoids, amphiboles, and pyroxenes, evidencing that it came from igneous common rocks associated with the Surgut volcanic field and spread over a large area. Rocks were probably mined near settlements, perhaps on the floodplain of the Ob. Grog in all the samples was similar to the basic clay in terms of its composition. Three groups of sites were identified, differing in the composition of the clay of which the ceramics were made. This may indicate the presence of several groups within the Iron Age Kulaika population, utilizing various sources of clay.

Keywords: *Archaeology, Early Iron Age, Surgut stretch of the Ob, Kulaika culture, pottery, multidisciplinary approach.*

Introduction

The Barsova Gora group of sites is located on the right bank of the Ob River, 8–15 km west of the present-day boundary of the city of Surgut. To date, approximately 400 archaeological sites from the Neolithic to the Modern Age have been discovered over an area of less than 6 km^2 (Chemyakin, Zykov, 2004: 9, 164). Over 60 of them can be attributed to the Surgut variant of the Kulaika culture or cultural-historical community (Ibid.: 182–184; Chemyakin, 2008: 78–79). Pottery fragments are the most common category of finds at the sites of this community. Analysis of the pottery production technology has made it possible to establish the contents of the craftsmanship and provides sources for reconstructing cultural and historical processes among the carriers of the Surgut variant of the Kulaika culture (see, e.g., (Bobrinsky, 1978, 1999; Tsetlin, 2012; Zhushchikhovskaya, Mylnikova, 2020;

Molodin et al., 2020)). Pottery-making technology at sites within a single closed landscape (microregion) reveals the specific skills of potters at different stages and levels of production, as well as their transformation over time.

Previously, one of the authors of this article analyzed the ceramics technology of the Surgut variant of the Kulaika culture using evidence from the fortified settlements of Barsov Gorodok (hereafter, BG) I/4, BG I/5, BG I/7, BG I/20, BG I/32, BG III/6 and settlement of Barsova Gora III/2 (Selin, Chemyakin, Mylnikova, 2021; Selin, Chemyakin, 2021, 2022a, b, c). It was established that ferruginous clays were used and the main recipe for the paste was unmixed, consisting of clay and grus. At some settlements this paste was used for 2/3 of the total number of vessels. The selection of artificial additives was wide and included grus, grog, sand, and various organic materials. In addition, a specific feature of the pottery-making technology in the Surgut variant of the Kulaika culture was variability in the composition of pastes at the same settlement. For example, at the BG I/5 site, nine recipes were identified. Hollow forms were constructed primarily using patch and sometimes also coil technique. A distinctive feature was the additional decoration of the vessel's rim with a rounded band up to 1 cm in diameter. Pottery of this variant also revealed a variety of combinations of devices used for processing the vessels' surfaces. For example, 39 methods of combination were identified at BG I/4. In addition, at all the studied sites, a specific technique for processing the internal surface was observed: smoothing the transition area from shoulder to body with a serrated tool.

Upon undertaking technical and technological analysis of pottery from different sites of the Kulaika culture Surgut variant, only binocular microscopy has been used to determine the specific features of the raw materials and artificial additives. Scientific methods could provide the data that are not available through binocular microscopy. Identification of the mineral composition of the plastic raw material makes it possible to establish its similarity or difference at the same site, determine the region of clay extraction, and detect pottery made of non-local raw materials.

The Barsova Gora microregion is located in the Central-Western Siberian fold system. It crosses the Western Siberian plate from northwest to southeast, from the Kara Sea to the spurs of the Altai-Sayan, and connects with the structures of the Altai-Sayan fold belt. The structure of the system was faulted and complicated during the Triassic rifting stage, when the Surgut volcanic field emerged in this region. For example, the area where the sites under study are located shows Triassic deposits of the Turinsk series (Fig. 1), consisting of sandstones, basalts, basaltic andesites, siltstones, tuffaceous-sedimentary rocks, andesites, and their tuffs. Around Barsova Gora, deposits of non-metallic minerals have been found (Fig. 1). For instance, at a distance of 7–10 km north of the sites, there are deposits of sand and gravel. About 8 km to the east, there are deposits of construction sand, and to the south deposits of brick clays can be found (Gosudarstvennaya geologicheskaya karta…, 2012).

Pottery from the BG I/5, BG I/7, BG I/8, BG I/15, and BG I/30 bank fortified settlements, located on the terrace of the Utoplaya channel, was analyzed. For comparison, evidence from Barsova Gora III/2 was used. In the Kulaika period over this relatively small area, there might have been a single fortified settlement, which was moved by its inhabitants along the terrace (the distance between the outermost fortified settlements is no more than 0.55 km). Therefore, the mineral composition of clays used in pottery-making from these settlements is of particular interest; it may reveal similarities or differences in the skills of selecting raw materials. For the first time, this pottery was studied using a set of interdisciplinary methods. The purpose was to describe the plastic raw material and artificial additives used by the carriers of the Surgut variant of the Kulaika culture for the manufacture of pottery at different settlements of the Barsova Gora locality.

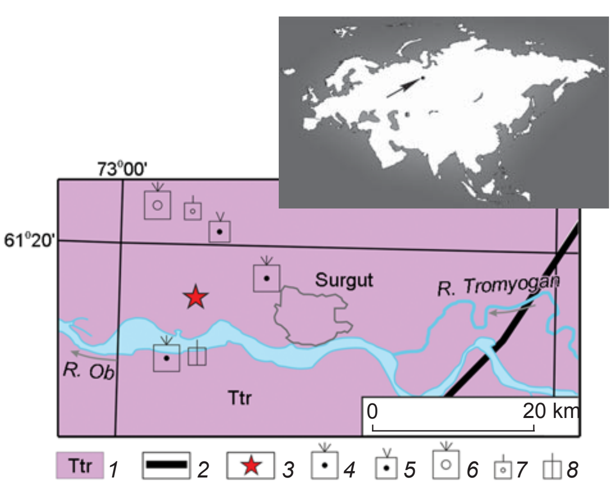

Fig. 1. Location of the Barsova Gora locality.
1 – Tura series; *2* – fault; *3* – location of sites; *4*–*8* – mineral deposits: *4*, *5* – construction sand (*4* – large; *5* – medium); *6*, *7* – sand and gravel (*6* – large; *7* – small); *8* – small deposit of brick clays.

Methods and materials

This study was carried out using interdisciplinary synthesis, where methods from different sciences and digital technologies complement one other (see, e.g., (Fiziko-khimicheskoye issledovaniye…, 2006; Drebushchak V.A., Mylnikova, Drebushchak T.N., 2018; Molodin et al., 2019; Zhushchikhovskaya, 2022; Karasik, Harush, Smilansky, 2020; Chistyakov, Bocharova, Kolobova, 2021)). The pottery-making technology was analyzed using the methodology elaborated by A.A. Bobrinsky (1978, 1999). Surfaces and fresh fractures of shards were examined using a binocular microscope (Leica M51). The traces identified were compared to the experimental base of technological traces on pottery. When identifying and interpreting the specific features of the technology, scholarly literature and the "Catalogue of Standards for Ceramic Trace Analysis" by I.N. Vasilieva and N.P. Salugina were also used (see, e.g., (Bobrinsky, 1978, 1999; Tsetlin, 2012, 2017; Vasilieva, Salugina, 2020)).

Mineralogical and petrographic study of thin sections involved the polarization microscopy (Zeiss Axio Scope A1 microscope). Ceramic petrography was used to establish the mineral composition of the plastic raw material and artificial additives. In the descriptions, the "matrix" refers to the plastic raw material (clay). The clastic material included mineral grains that were unevenly distributed throughout the clay and were predominantly of artificial origin. X-ray phase analysis was used for the determination of the mineral phases of the raw material with a Stadi MP (Stoe) X-ray powder diffractometer.

Technical and technological analysis was carried out for the pottery from five fortified settlements of the Surgut variant of the Kulaika culture: BG I/5 (33 spec.), BG I/7 (5 spec.), BG I/8 (19 spec.), BG I/15 (26 spec.), BG I/30 (12 spec.), and one settlement Barsova Gora III/2 (50 spec.). Samples from BG I/5 (15 spec.), BG I/7 (3 spec.), BG I/8 (7 spec.), BG I/15 (10 spec.), BG I /30 (5 spec.), and Barsova Gora III/2 (10 spec.) were subjected to petrographic study and X-ray phase analysis.

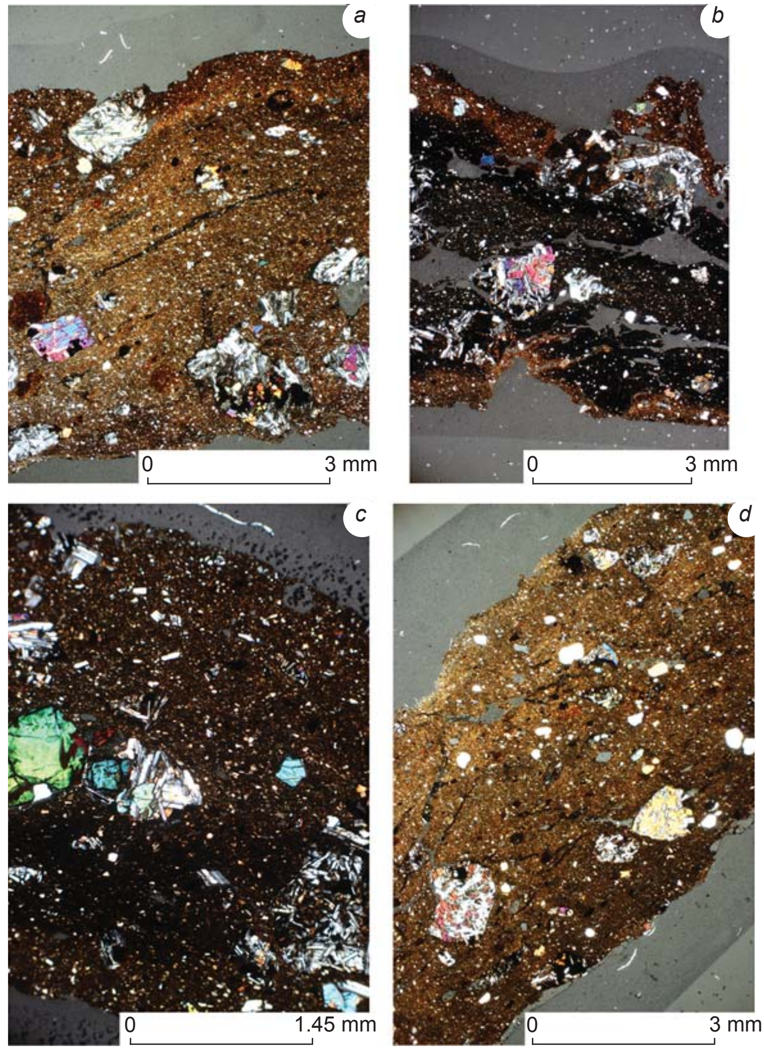

Fig. 2. Thin sections of pottery from the sites of the first group.
a – BG I/5 site, sample No. 5; *b* – BG I/8 site, sample No. 25; *c* – BG I/15 site, sample No. 32; *d* – Barsova Gora III/2 site, sample No. 41.

Study results

Technical and technological analysis of the vessels from BG I/5 has revealed that they were manufactured with the use of ferruginous clays tempered with grus, grog, sand, and organic material. Nine recipes for pastes have been identified: 1) clay + grus (13 spec.); 2) clay + grog (8 spec.); 3) clay + grus + grog (3 spec.); 4) clay + grus + + sand (3 spec.); 5) clay + grog + sand (1 spec.); 6) clay + + grog + sand + organic material (1 spec.); 7) clay + sand + + organic material (2 spec.); 8) clay + grus + organic material (1 spec.); 9) clay + grus + grog + organic material (1 spec.) (Selin, Chemyakin, 2022b). The pottery from this site demonstrated a large amount of matrix (from 69 to 97 %) and up to 30 % of clastic material. The grog content reached 10 % (Fig. 2, *a*). The matrix predominantly consisted of silty micaceous clay with fragments of pyroxenes, feldspars, and muscovite. The clastic material included plagioclases, gabbroids, and pyroxenes. Six samples contained rounded grains of potassium feldspars. The grog contained rounded grains with rare inclusions of feldspars, and was mostly dark. In two thin sections, the matrix of the main ceramic body appeared to be similar in mineral composition to the grog. The mineral composition of clays was similar in all analyzed pottery samples from that site, which indicates that the raw materials were procured in the same area.

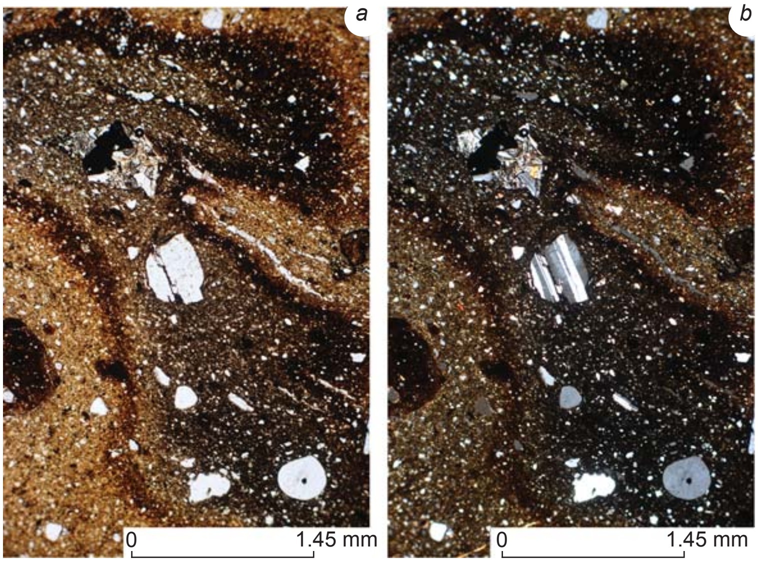

Fig. 3. Sample No. 18 from BG I/7, the site of the third group.
a – in transmitted light; *b* – in crossed nicols.

Pottery from BG I/7 was made of ferruginous clays tempered with grus, grog, and organic material. Three recipes for the paste were identified: 1) clay + grus + + organic material (2 spec.); 2) clay + grog (2 spec.); 3) clay + grus + grog (1 spec.) (Selin, Chemyakin, 2022b). Pottery from that site was distinguished by a predominance of matrix (75–93 %), and a smaller amount of clastic material as compared to the ceramics described above (up to 10 %), and a slightly higher content of grog (up to 20 %) (Fig. 3). The matrix was mostly aleuropelite micaceous clay with grains of muscovite and feldspars. The composition of the clastic material was plagioclase, gabbroids, and pyroxenes. Rounded grains with inclusions of feldspar were identified in the grog. In one thin section, the grog matrix was micaceous and similar in mineral composition to the main ceramic body. In all the analyzed samples, the mineral composition of the clays was similar, which indicates that raw materials were procured in the same area.

At the BG I/8 fortified settlement, ferruginous clays tempered with grus, grog, sand, and organic material were used. Six recipes were identified: 1) clay + grus (12 spec.); 2) clay + grog (1 spec.); 3) clay + grus + grog (1 spec.); 4) clay + grus + sand (2 spec.); 5) clay + grog + + organic material (1 spec.); 6) clay + grus + sand + organic material (2 spec.). The ceramics demonstrated a high matrix content (63–94 %). The share of clastic material was 5–30 %. The content of grog reached 10 % (see Fig. 2, *b*). The matrix was predominantly silty micaceous clay with fragments of pyroxenes, feldspars, and muscovite. The clastic material included gabbroids (predominantly), pyroxenes, and plagioclases. Elongated voids were observed, which indicated the use of an organic material. This additive was also identified by technical and technological analysis. Almost all grog inclusions were dark, which complicates the determination of the similarity or difference between the matrix of grog and the main ceramic body. The mineral composition of the clays was similar in all pottery samples analyzed, which indicates that raw materials were extracted from the same area.

Pottery from BG I/15 was also made of ferruginous clays tempered with grus, grog, sand, and organic material. Five recipes were identified: 1) clay + grus (18 spec.); 2) clay + grog (2 spec.); 3) clay + grus + + grog (3 spec.); 4) clay + sand (1 spec.); 5) clay + sand + grog (1 spec.); 6) clay + grog + organic material (1 spec.). A large amount of matrix (65–92 %) was observed in thin sections of the pottery. The proportion of clastic material was 5–30 % (see Fig. 2, *c*). As compared to pottery from the three fortified settlements described above, the grog content was lower (under 5 %). The matrix was mainly silty micaceous or silty clay, with fragments of pyroxenes, feldspars, and muscovite. The clastic material consisted of gabbroids (predominantly), pyroxenes, and plagioclases. The grog contained small rounded dark grains, with rare inclusions of plagioclase. The grog matrix was similar in mineral composition to the main ceramic body. The mineral composition of the clay was similar in all the pottery samples analyzed from that site, which indicates the same area of extracting raw materials.

Pottery from BGI/30 was made of ferruginous clays tempered with grus, grog, and sand. Three recipes have been identified: 1) clay + grus (4 spec.); 2) clay + grog (7 spec.); 3) clay + sand + grog (1 spec.). Pottery from that site was characterized by a high matrix content (68–94 %) and a small amount of clastic material (1–2 %) as compared to other sites. In only one sample was the proportion of clastic material 30 %. The grog content was small, under 8 % (Fig. 4). The matrix was predominantly aleuropelite micaceous clay, with the predominance of feldspars; muscovite and pyroxenes were also present. The clastic material consisted mainly of the rounded grains of feldspars. Small rounded grains with a micaceous matrix and feldspar fractions were identified in grog. The grog matrix was similar in mineral composition to the main ceramic body. The mineral composition of the clay was similar in all the pottery samples analyzed from the site, which indicates the same area of raw material extraction.

Pottery from Barsova Gora III/2 was made of ferruginous clays tempered with grus, grog, and organic material. Four paste recipes were identified: 1) clay + + grus (32 spec.); 2) clay + grus + grog (14 spec.); 3) clay + grus + organic material (3 spec.); 4) clay +

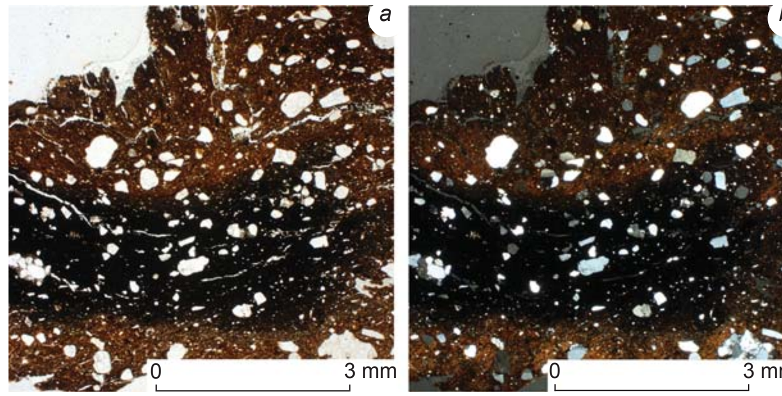

Fig. 4. Sample No. 37 from BG I/30, the site of the second group.
a – in transmitted light; *b* – in crossed nicols.

+ grus + grog + organic material (1 spec.) (Selin, Chemyakin, 2022a). The matrix content in the samples was 63–97 %; the clastic material content was 2–25 % (see Fig. 2, *d*), and the grog content was under 5 %. The matrix consisted predominantly of aleuropelite, micaceous, silty clay, with a predominance of feldspars; muscovite, biotite, and pyroxenes were also present. The clastic material was represented by gabbroids, pyroxenes, and feldspars. Some samples contained rounded feldspar grains. The grog showed the presence of predominantly rounded fractions with micaceous matrix and feldspar grains. The inclusion of grog in the grog was detected. In both cases, the matrix was similar in mineral composition to the main ceramic body. The mineral composition of the clay was similar in all the pottery samples analyzed from the settlement, which indicates that raw materials were extracted from the same area.

Fragmental material artificially added to the clay can be divided into two types: rounded (sand) and coarse (grus). The sand consisted predominantly of feldspars and quartz, which indicates that the raw material might have been extracted from nearby non-metallic mineral deposits (see Fig. 1). The second type of fragmental material was represented by basaltoids, amphiboles, and pyroxenes. This grus could have resulted from igneous rocks of basic composition that are associated with the Surgut volcanic field and are spread over a large area. Raw materials for the grus might have been procured in the Barsova Gora locality, near the sites under discussion, probably on the floodplain of the Ob River. The matrix of grog and of grog in grog was similar in mineral composition to that of the main ceramic body, which indicates that potters of the Surgut variant of the Kulaika culture had stable skills in selecting plastic raw materials.

Discussion

Pottery from the sites of the Surgut variant of the Kulaika culture differs in the mineral composition of the raw materials. Yet they all were procured in the region confined to the Surgut volcanic field. Not a single site contains vessels made of imported plastic raw materials. The potters who lived in these settlements extracted clay in the same area, but from different outcrops.

X-ray phase analysis (Table 1, Fig. 5) was carried out for all the pottery studied by the petrographic method. The results of the comprehensive study made it possible to identify three groups of sites with pottery differing in mineral composition of the plastic raw materials. The first group includes the fortified settlements of BG I/5, BG I/8, BG I/15, and Barsova Gora III/2. The samples

Table 1. **Results of X-ray phase analysis of pottery samples, wt%**

Site	Quartz	Plagioclase	Mica	Amphibole	Pyroxene
BG I/5	49–78 65	16–36 25	2–16 9	5–8 6	10
BG I/7	63–65 64	20–27 24	9–15 11	–	–
BG I/8	39–69 58	20–38 30	3–9 6	8–14 11	4–7 6
BG I/15	45–67 56	22–42 32	3–12 6	6	5–11 9
BG I/30	67–76 72	17–23 19	7–11 10	–	–
Barsova Gora III/2	52–72 60	18–37 29	5–13 9	5–7 6	2–5 4

Note. The numerator is the range; denominator is the average value.

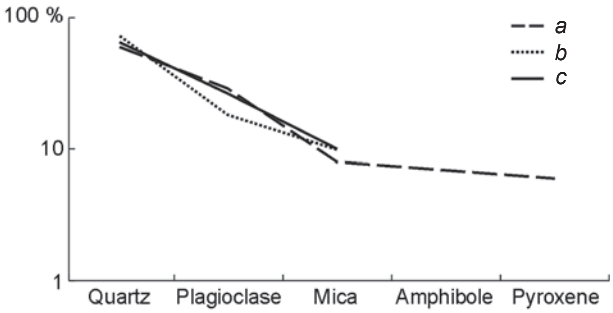

Fig. 5. XRF graphs of pottery samples from the sites of the first (*a*), second (*b*), and third (*c*) groups.

show a quartz content of 39–78 wt%, a plagioclase content of 16–42 wt%, a mica content of 2–16 wt%, an amphibole content of 5–14 wt%, and a pyroxene content of 2–11 wt%. Notably, only in this group were dark-colored minerals (amphiboles and pyroxenes) identified using X-ray diffraction data. Plastic raw materials that were used for the pottery manufacture at these sites had a micaceous siltstone composition with fragments of pyroxenes, feldspars, and muscovite.

The second group is represented at BG I/30. These ceramics demonstrate a higher quartz content (67–76 wt%), smaller content of plagioclase (17–23 wt%), and comparable content of mica (7–11 wt%) as compared to pottery of the first group. The matrix is predominantly aleuropelite micaceous clay, with a predominance of feldspar fragments and inclusions of muscovite and pyroxenes. It differs from the raw materials used at other settlements by a higher content of feldspars and lower content of plagioclases, which could have been due to the raw material having been extracted from a different outcrop of clay.

The third group is associated with BG I/7. The quartz content in the samples is in the range of 63–65 wt%, the plagioclase content is 20–27 wt%, and the mica content is 9–15 wt%. The raw material is mainly aleuropelite micaceous clay, with inclusions of feldspars and muscovite. This group differs from the first group by the absence of pyroxenes and amphiboles, and from the second group by a greater amount of plagioclase and mica, which indicates a different place of clay extraction.

The analysis of paste recipes has also shown some differences between these groups (Table 2). Pottery from the sites of the first group has a wide range of artificial additives. However, up to 2/3 of the vessels were made using the unmixed recipe of clay + grus. At all sites of this group, the recipe clay + grus + grog was identified, which indicates the beginning of mixing different pottery skills. The use of organic materials was also observed.

It is very important that the BG I/30 fortified settlement, which was assigned to a separate group based on its plastic raw material, also differed in its paste recipes. The main recipe was clay + grog, which was atypical of the pottery of the Kulaika culture Surgut variant. The mixed recipe clay + grus + grog and organic material that were used by the potters from the sites of the first group, were not found at this site.

The main paste recipes for the pottery from BG I/7, assigned to the third group, were clay + grog and clay + + grus + organic material. The latter material did not appear in the second group, while the unmixed recipe clay + grus, typical of the first group, was not used by the potters from this settlement.

The similarity of plastic materials in the grog and in the main ceramic body was observed at almost all the sites (BG I/5, BG I/7, BG I/15, BG I/30, Barsova

Table 2. **Correlation of paste recipes from the sites of the Kulaika culture Surgut variant**

Recipe	BG I/5	BG I/7	BG I/8	BG I/15	BG I/30	Barsova Gora III/2
clay + grus	13	–	12	18	4	32
clay + grog	8	2	1	2	7	–
clay + sand	–	–	–	1	–	–
clay + grus + grog	3	1	1	3	–	14
clay + grus + sand	3	–	2	–	–	–
clay + grog + sand	1	–	–	–	1	–
clay + grus + organic solution	1	2	–	–	–	1
clay + sand + organic solution	2	–	–	–	–	–
clay + grog + organic solution	–	–	1	1	–	–
clay + grus + grog + organic solution	1	–	–	–	–	1
clay + grog + sand + organic solution	1	–	–	–	–	–
clay + grus + sand + organic solution	–	–	2	–	–	–

Gora III/2), which indicates that clay selection skills were stable among the potters of each settlement.

Conclusions

This study has identified three groups of sites whose pottery differs not only in the mineral composition of the plastic raw materials, but also in recipes of paste. The chronology of the Kulaika artifacts from Barsova Gora was based on the evolution of pottery (Chemyakin, 2008: 90). The earliest site among those analyzed in this article is the fortified settlement of BG I/7. Its pottery was made from raw materials that have not been found at other settlements. This clay could have been procured from outcrops that became inaccessible to potters at a later time. There may be a chronological gap between the BG I/5, BG I/8, BG I/15 fortified settlements and the Barsova Gora III/2 settlement, which were placed in the first group, but their pottery was made of plastic raw materials similar in mineral composition. This suggests that it was procured from nearby outcrops. BG I/30 was chronologically close to the sites of the first group, but the potters from that settlement used clay of different mineral composition, which also points to a different extraction place of raw materials.

The difference in the mineral composition of plastic raw materials at different sites of the Kulaika culture Surgut variant, identified by multidisciplinary analysis, suggests that several different populations lived in the Barsova Gora locality, leaving fortified settlements and a village. Potters could have used various clay outcrops in the same area. Since Barsova Gora is a prominent object in the terrain, groups of the Kulaika population from neighboring territories would probably come there at different times. They had their own pottery skills, and various traditions mixed during the interaction of human groups, which led to variability in the selection of clays, variety of artificial additives, paste recipes, and combinations of devices for processing vessels' surfaces.

Further comprehensive analysis of the Early Iron Age pottery in the Surgut Ob region will make it possible to reconstruct historical and cultural processes, identify migration routes of various populations, establish directions of trade relations, and determine patterns of interaction between different cultures.

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A Bronze Age Site on the Northern Coast of West Java

This study describes an early site on the northern coast of West Java, affected by the Austronesian culture—Subanglarang near Binong in the Subang Regency. Geologically, during the 2000–1000 BP interval, it was part of the coastline of the northern coast of West Java, situated more than 5 m asl. During the 2013 surveys and excavations in 2016 and 2018, five burials were revealed. On the basis of the fragments of red-slipped pottery, pickaxes, beads of various shape and size, and metal weapons, the site is dated to the Bronze Age. Artifacts similar to those of early Austronesians were discovered. The analysis of various beads from Subanglarang attests to trade relations with other areas. Further excavations on the northern coast of West Java will hopefully shed more light on the life of the Bronze Age people of that area.

Keywords: *West Java, Subanglarang, coastal site, Bronze Age, culture, trade relations.*

Introduction

The Subanglarang site, which is administratively part of the Binong subdistrict area, is located approximately 20 km north of Subang city, at the edge of the Cijati stream, part of the low-wavy morphological area of the Subang Regency. This regency is divided by three large river streams, which all flow to the northern coast of Java: namely Cilamaya, Ciasem, and Cipunagara. The Cijati is one of the Ciasem's tributaries (Silitonga, 1973). Subang region is part of the northern coast of West Java, and regionally is included in the Jakarta-Cirebon, Java Island, Indonesia. The Coastal Plain Block is formed from alluvial deposits, whose constituent material comes from the mountains of South Bandung (Bemmelen, 1949: 28). This condition causes the morphology of the region, which can be divided into three types of landscape: 1) coastal plains, 2) swamp plains, and 3) flood overflow plains. This landscape has a slope percentage of 0–2.4 % and an altitude of 0–4.8 m asl. The main vegetation is mangroves and coconut trees. The swampland area is affected by tides of seawater and is uninhabited. The flood overflow plains area follows the flow of the Cilamaya River in the west, the Ciasem River in the middle, and the Cipunegara River in the east. The villages are scattered in several locations along these rivers, as well as along the irrigation canals and tributaries of the Ciasem and other rivers. The Ciasem River empties into Ciasem Bay in the Java Sea, precisely in the eastern part of Blanakan (Armin et al., 1980: 3–4).

The existence of the Subanglarang site as part of the northern coast of West Java in the past, especially in the period of 5000–1000 BP, can be seen from the reconstruction of changes in the northern coastline of West Java (Fig. 1) carried out based on data obtained from the General Bathymetric Chart of the Oceans (GEBCO) 2014 with a spatial distance resolution of 15 m. The extraction of elevation data (*x*, *y*, and *z* coordinates) was exported using Global Mapper series 17 software and ArcGIS series 10.3 to produce a 3D-map in Digital Elevation Model (DEM) format. DEM maps were then reprocessed using the Triangulated Irregular Network (TIN) method to analyze spatial and height differences more accurately. By referring to the research from de Klerk (1983), which simulated the coastline change on the basis of a DEM map, its influence on West Java's coastline development could be seen very well (Zaim, Hascaryo, 2021: 4–7).

Judging by the paleontological and archaeological studies that have been carried out so far in the Subang Regency, geomorphologically the evidence was generally found along the Ciasem River. In the upstream part, vertebrate fossils were found (Mulyana, 2004: 9); while in the downstream part, artifacts with Paleolithic characteristics, funnel axes, and kettledrums (Armin et al., 1980: 8; Herlina et al., 2020: 11), as well as pottery fragments and beads partly exposed to the surface owing to agricultural activities (Yondri, 2016: 35). Similarly to the location selection for residential area in the past, the land selection was not done randomly but in a patterned way. In the field of archaeology, the term "settlement pattern" refers to the evidence of the physical remnants of communities and networks within a given region (Hodder, Orton, 1976: 33). That evidence is used to interpret the way interdependent local groups of people interacted in the past (Hirst, 2020).

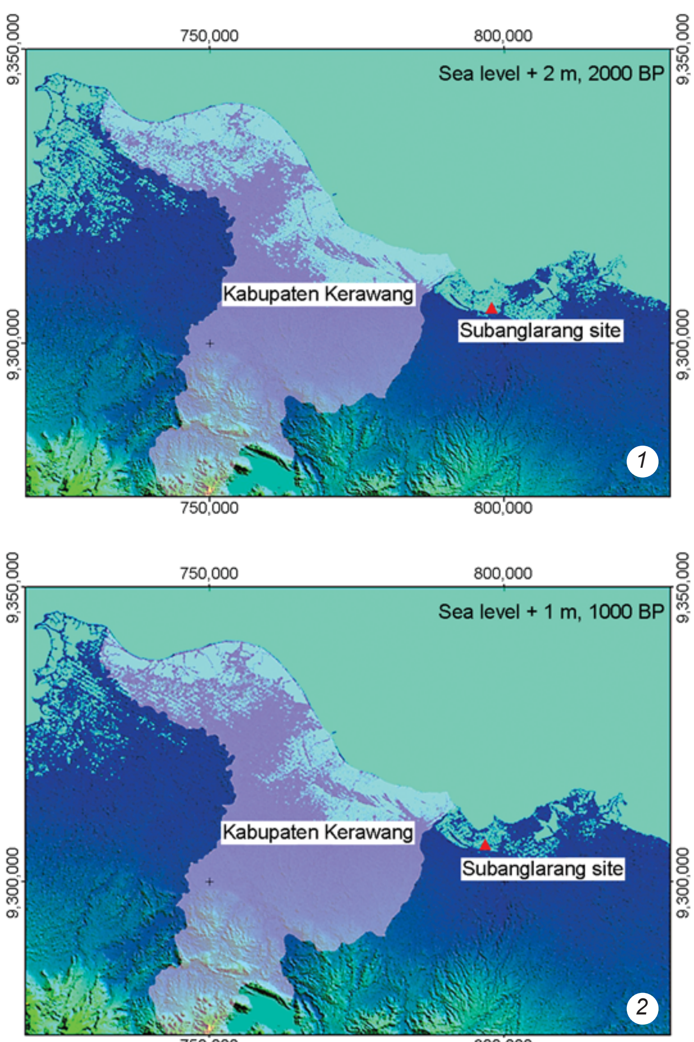

Fig 1. Location of the Subanglarang site in relation to the coastline in the northern part of West Java 2000 (*1*) and 1000 (*2*) BP (after (Zaim, Hascaryo, 2021: 88)).

Study methods

The data used in this article were derived from the archaeological research carried out at the Subanglarang site and its surroundings in 2013 by a collaboration team from the cultural institution of the West Java government, the West Java Archaeological Office, and the Banten Cultural Heritage Conservation Office (Yondri, 2013: 1); the survey and excavation of the Subanglarang site conducted in 2016 by a collaboration team from the cultural institution of the Subang Regency government and the West Java Archaeological Office (Yondri, 2016: 2); and the analysis of the excavation materials conducted by a team from the West Java Archaeological Office (Ramadhani, 2019: 12; Yondri, 2018: 5). The data include the size, type, and technology of the artifacts, the chronology of occupation, and the environment in the Subanglarang area.

Spatial analysis was based on the dynamics of sea-level changes on the northern coast of West Java, which were reconstructed by a geological team through the simulation of the coastline changes during the Late Holocene (Zaim, Hascaryo, 2021: 4). Analysis of artifacts involved determining their technology, typology,

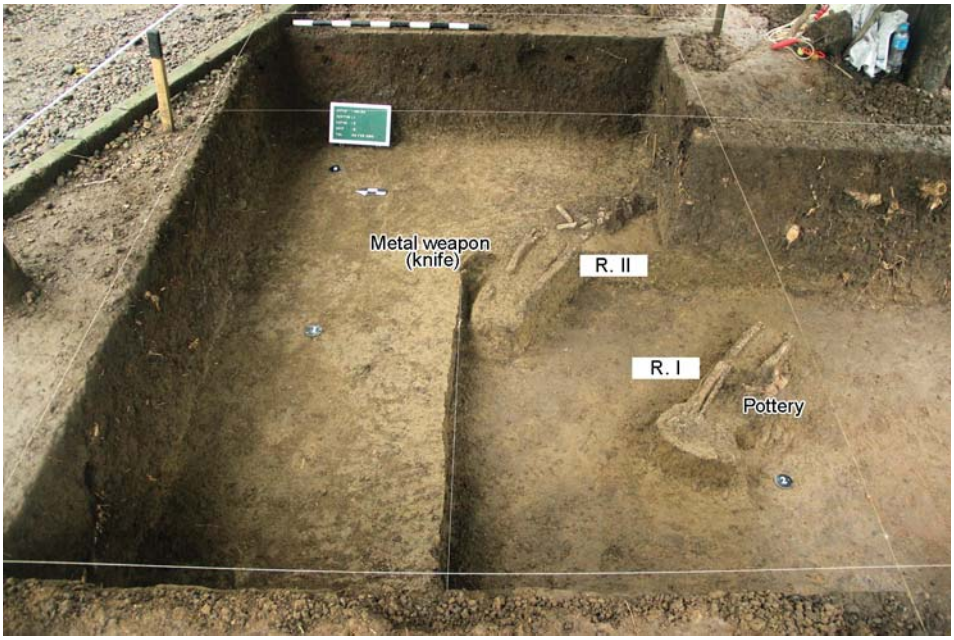

Fig 2. Skeletons R.I and R.II at a depth of 70 cm (after (Yondri, 2016: 24)).

and frequency in the context of the character and intensity of occupation of this territory. The site's function was determined on the basis of the identification of cultural groups occupying the area, including the artifacts from each object, along with chronological data. Data interpretation then proceeded through several stages by developing explanations based on interrelated patterns of the site locations, the life support resources in the environment, and the characteristics of the finds, as well as the morphology and function of each object. These data are expected to elucidate the behavior of Austronesian speakers in relation to their concepts of the physical environment around the main site (Subanglarang).

Archaeological finds at the Subanglarang site

Archaeological finds from the Subanglarang site became the focus of discussion and the exchange of ideas between Indonesian and Russian scholars during the visit in 2019 as part of a scientific relations and joint publications program (see, e.g., (Nesterkina et al., 2022: 46)). The excavations have yielded various finds, both artifacts and anthropological materials. Five human skeletons were discovered: two in 2016, and three (plus a part of a mandible) in 2018. According to the order of detection, they were given the indices R.I, R.II … R.V. Skeleton R.III was the only anatomically intact one. It was found in a horizontal position, in a SE-NW orientation (Yondri, 2013: 15; 2016: 24; 2018: 16).

Skeletons R.I and R.II were located side by side, at a distance of ca 1 m and at a similar depth of 70 cm from the current ground level (Fig. 2). Both skeletons were found in a fragile state. They were incomplete, some parts were missing. Only the femurs and tibias had a good state of preservation. These were in a parallel, longitudinal position, with a NW-SE orientation. It can be estimated that these were primary burials*. The bodies were found in extended supine positions. On top of the tibia bones of R.I, there lay a ceramic vessel. To the right of R.II, a metal knife was located (Fig. 2).

R.III was the most anatomically intact skeleton, although the bones were fragile. The tarsals, metatarsals, and phalanges were missing. The deceased was oriented with its head to the north-west (Fig. 3). Around the skull, there were grave goods, such as a metal weapon stretched over it, 40 cm long and 6 cm wide at the tip. In addition, there were also randomly scattered beads: round-shaped golden beads, single and double round-shaped glass beads, and multifaceted sandstone beads (Fig. 4).

Skeleton R.IV was represented by leg bones. Near them, metal knives, a pickaxe, and ceramic fragments were found (see Fig. 3).

Skeleton R.V was located in a box (SBLRG/1/10/2018). It was fragile and incomplete, consisting of the femur,

*Lutfi Yondri divides prehistoric burials into two types: the secondary (delayed) and the primary (direct) (2005: 95). Secondary burials are reburials of skeletal parts and do not preserve the anatomical order of bones. Primary burial is arranged directly after the human dies. Such burials show the anatomical order of skeletal bones. There are two types of primary burials: in an extended position with the hands on or beside the body, and in a flexed position.

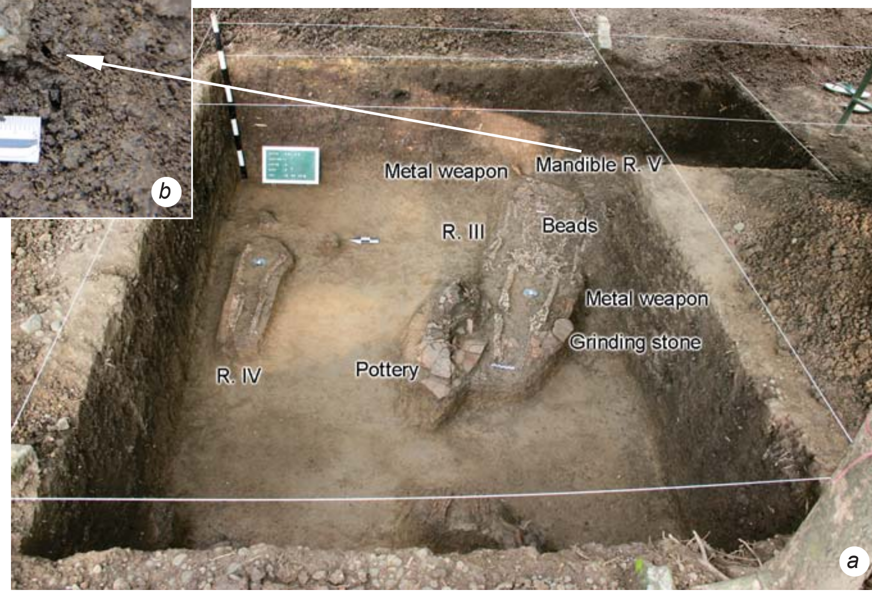

Fig 3. Skeletons R.III, R.IV (*a*) and fragments of the R.V maxillary (*b*) at a depth of 60 cm (after (Yondri, 2018: 68)).

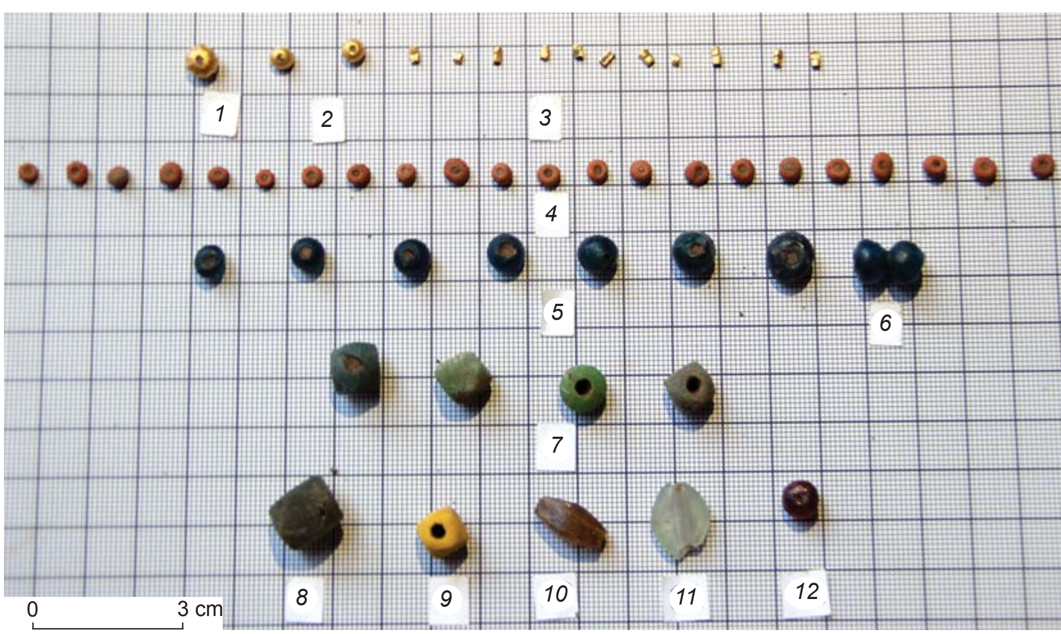

Fig 4. Beads (after (Yondri, 2018: 76)).
1–3 – golden; *4* – clay; *5*, *6*, *11* – glass; *7–9* – sandstone; *10*, *12* – carnelian.

tibia, and fibula (Yondri, 2018: 57). The most interesting is the burial position of R.III and R.IV closer to the surface than that of any other finds. This suggests that these burials were made later. In addition to golden beads, excavation yielded fragments of fragile golden plates. These were found in box SBLRG 1/8/2018.

The discovery of golden plates in prehistoric sites has never happened previously in coastal areas in West Java but at the Pasir Angin site, Cibungbulang District, in Bogor Regency. The site is located on a small hill with a height of ca 210 m asl, to the north of the Cianten River. The Pasir Angin site was researched in 1970–1973, and in 1975 by a team from the National Archaeological Research Center. Excavation results included artifacts made from stone, iron, bronze, clay, obsidian, and glass (square pickaxes; bronze and iron axes, including bird-tail-shaped funnel axes; bronze sticks; bronze, stone, and glass beads; and spearheads), as well as pottery.

Other artifacts found in excavations at Subanglarang in 2016 and 2018 were fragments of terracotta that had been transformed so that the shape of the vessel was very difficult to recognize, andesite stones, and chunks of iron slag (Fig. 5, 6). The andesite stones seem to have been processed or sharpened to produce oval or rounded shapes. From the traces of use found in the middle parts of the stones, it could be estimated that in the past these were used as grinding stones or hammer stones in the pottery-production process. The chunks of iron slag were found in the form of blackish-brown lumps with hollow cavities caused by air bubbles that came out. The slag is very heavy, which points to the presence of iron content. Iron slags were also found during surface surveys. These are the residues from ironwork in this area (Yondri, 2016: 48; 2018: 83).

Since the 1970s, many residents have found beads and pottery in the Subanglarang area and its surroundings. In addition to agricultural activities, the finds were exposed to the surface owing to an illegal search for treasure (looting). Golden items people found were often traded. Other finds that had no sale value (stone bracelets and beads, glass, terracotta, pottery, square pickaxe, and worn-out bronze axes) were still stored within the community. Those finds were then collected and stored by Mr. Sonjaya. The community formed the Subanglarang Foundation to maintain the discoveries and the locality. Since the discovery of the tomb around the site, which is believed to belong to Prabu Siliwangi's daughter, Nyai Subang Larang, the treasure-hunting activity has begun to stop. The local people seem to value the tomb more and think that all the artifacts they found while working on the land belonged to Nyai Subang Larang. They give their finds to Mr. Sonjaya to be stored.

There are quite a lot of artifact collections stored in the Subanglarang Foundation, including pottery, stone bracelets, jugs, pickaxes, and bronze axes, as well as beads (1569 spec.) of various shapes, sizes, and colors. When combined with the finds from excavations of 2013, 2016, and 2018, there are 1657 items in total, subdivided into 22 varieties (Ramadhani, 2019: 13; Yondri, 2018: 19; 2020: 58).

Fig 5. Andesite stone with traces of use (after (Yondri, 2018: 77)).

Fig 6. Iron slag (after (Yondri, 2018: 78)).

Subanglarang site as a trade-traces area on the northern coast of West Java

From the late period of prehistoric times, it may be noted that human and cultural migrations increasingly occurred in the territory of Indonesia, which is evidenced by artifacts originating from various regions, including those from outside the archipelago, from 2000–1000 BP. This might be because of Indonesia's position between two continents, Asia and Australia, and two oceans, the Indian and the Pacific. In the past, it was a strategic crossing of exchange and trade routes. Indonesia's position certainly intersects various areas, especially those easily accessible and not at high risk for berthing, such as the northern coastal area of West Java.

Judging by the results of geological studies carried out on the coastline by Y. Zaim and A.T. Hascaryo (2021: 4), there were three recorded changes on the northern coast of West Java: 5000 BP, 2000 BP, and 1000 BP. Around the period of 2000–1000 BP, territory of the site was closer to the coast. Looking at the soil layer in the 2018 excavation and correlating it with the outcrops on the edge of the Cijati River, it can be ascertained that it was a land area in the past. Therefore, it was natural for this location to be used for a settlement.

The question has arisen of who lived in Subanglarang in the past. The analysis of artifacts found during excavation and those stored in the Subanglarang Foundation has shown that some have the characteristics of Austronesian society, such as pickaxes or red-slipped pottery. The presence of pig bones and teeth in the materials from the site points to domestic animals. Radiocarbon analysis (^{14}C) of cultural remains has provided a chronology of 1854±100 BP (Yondri, 2020: 8).

Some experts tried to elaborate theories about the distribution and origins of Austronesian culture based on studies of the typology of square pickaxes in mainland Asia and the Asian islands. The comparative analysis has revealed the similarity between the Malayan and Indonesian cutting tools. This led to the assumption that the Austronesian culture originated from the southern part of the Malayan peninsula (Duff, 1970: 145). Wilhelm G. Solheim proposed the theory of distribution of this culture based on pottery finds. His theory states that the initial areas of origin were the islands of Palawan, Western Borneo, and Sulu, marked by the discovery of pre-Sa-Huynh-Kalanay pottery. The area began to be settled from the early 2nd century BC (Solheim, 1975: 146).

The discovery of the main features of the Austronesian culture at the Subanglarang site is related to the Austronesian migration in prehistoric times to the northern coast of West Java. It is quite interesting to analyze more deeply the variety of beads found from surveys, excavations, and by residents around Subanglarang. Although no laboratory-specific analysis has been done, these can be compared with similar finds from various sites in Indonesia and with those described in "The History of Beads: From 30,000 B.C. to the Present" by L.S. Dubin (1995: 112). Noteworthy is the similarity of some beads found at Subanglarang with golden beads of the period around 200 BP from Greece; and the yellowish double-barreled beads show similarity in shape with the 100 BP Roman beads. Specimens made of precious/semi-precious stones (amethyst, quartz, carnelian) and cobalt-blue glass are also similar to beads from mainland Asia. Generally, the beads circulating in South and Southeast Asia originated in India around the Early Metal Age (Nasruddin, 2017: 18).

Regarding the discovery of pottery (both simple and red-slipped pottery), as well as square pickaxes, both of which are part of Austronesian cultural products at the site; until the latest survey in the Subang Regency no traces of industry of either of the two categories of artifacts have been found.

Conclusions

On the basis of the above study results, it can be preliminarily concluded that the Subanglarang site, which is now situated along the Cijati stream (a tributary of the Ciasem River) on the northern coast of West Java, was once located in the coastal area. We assume that this site was inhabited by a group of people who had settled in the form of a community that had developed a funerary tradition accompanied by the placement of burial goods in the form of metal artifacts, beads, and clay vessels.

Judging by the results of the absolute dating of two skeletons found in 2016 in a layer of soil that was stratigraphically almost homogenous, we can determine the ^{14}C-date of the finds as ca 1750 ± 70 BP. At that time, the inhabitants of the site had relations with outer regions in the form of both trade and exchange, as evidenced by various kinds of artifacts that did not originate from Subanglarang; including beads that have similar characteristics to those manufactured in Southeast Asia, Persia, Rome, and Europe.

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Gratitude is extended to the local government of West Java and the Subang Regency, who have supported this research; especially to Prof. Dr. Yahdi Zaim and Dr. Agus Tri Hascaryo, who had carried out geological research in the northern part of West Java. Their findings have supported the team in interpreting the relationship between the Subanglarang site and its past geographical surroundings.

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Microstructural Study of Medieval Crucible Steels from Archaeological Sites in Central and Northwest Asia: Identifying the Bulat

The microstructure of 9th–15th century artifacts made of crucible steel, found at sites in Central and Northwest Asia, is described. Metallographic study of items from settlements and burials with precise data on chronology, location, and accompanying artifacts is important for reconstructing the history of bulat steel and the technology of melting and processing ultra-high-carbon crucible steel. The study of the macro- and microstructure, and the chemical analysis of such items indicate an extremely high content of carbon—1.7–2.1 %. The characteristic feature of their microstructure is a dark matrix with white inclusions of ledeburite and iron carbides. The combination of structural components is reflected in the patterned structure of the metal. These properties suggest that such metal is identical to bulat steel. Findings of macrostructural analysis extend our knowledge of the varieties of this metal, its structural features, phase composition of separate groups of ultra-high-carbon crucible steel, smelting technology, plastic and thermal treatment, and physical properties.

Keywords: *Central and Northwest Asia, Middle Ages, ferrous metallurgy, metallographic analysis, crucible steel, bulat steel.*

Introduction

Until the mid-18th century, crucible cast steel, which was long considered the summit of metallurgical technology, was produced exclusively by artisans from the East. In the Middle Ages, it was used for making the best saber blades that possessed legendary properties. Items made of crucible steel were distinguished by high elasticity and exceptional compressive strength. Their qualities were not inferior to items made of modern tool steel.

According to information from the Central Asian encyclopedist and scholar Abu Rayhan al-Biruni contained in his treatise on mineralogy, two types of crucible steel were known in the East. The first type, without visual distinguishing features, was used to produce tools. The second type demonstrated a sharp heterogeneity of composition resulting in a specific pattern (*firind*) on the surface of the items, visible to the naked eye. This steel was called *fulaz* ("bulat" in Russian) and was used primarily for manufacturing bladed weaponry (Biruni, 1963: 235).

The first attempts to study cast bulat steel were undertaken by physicists and metallurgists in Western Europe in the early 19th century, which was triggered by the need for new types of tool materials for the developing industry. At that time, scholars came to contradictory conclusions about the chemical composition, quality of bulat steel, and reasons for emergence of patterns on its surface. The general recognition was that the unusual properties of bulat steel resulted from additives such as aluminum, platinum, silver, chromium, and other elements (Gurevich, 1985: 67–68).

In 1828, the Russian engineer P.P. Anosov began to study bulat steel and carry out metallurgical experiments. The results of his work were published in *Gorny Zhurnal* ("Mining Journal") in 1841 under the title "On bulat steel". In this work, Anosov not only described the course of metal smelting experiments, but also made a number of interesting observations and conclusions. The most important was the conclusion that "Bulat steel is not a mixture of steel with some metal, but the mixture of iron and carbon, as with steel", and that "the reason for the emergence of large patterns should be most closely sought in the method of combining iron and carbon" (Anosov, 1954: 129). A comparison of various bulat alloys showed that the larger the patterns were, "the harder the bulat steel was and, consequently, the more carbon it contained" (Ibid.: 135). Thus, the most important law of metal science—dependence of the properties of metal on its crystalline structure—was discovered.

In the 20th century, studies on the problems of bulat steel were published both in Russia and internationally. The overwhelming majority of these studies were carried out by metallurgical engineers. In Russia, research aimed at identifying and theoretically substantiating the technology for producing alloy steels intensified in the 1950s, causing a surge of interest in bulat steel. The most famous study was done by the team from the Zlatoust Metallurgical Plant, supervised by I.N. Golikov, who elaborated his own theory of bulat steel and its production. He claimed that "the reason for the bulat pattern and specific properties of bulat steel is preservation of suspended, under-melted particles with lower carbon content in the volume of liquid metal during steel smelting" (Golikov, 1958: 25). Y.G. Gurevich, the author of many scholarly works on metal production technology, including studies on the problems of bulat steel (Gurevich, 2006; Gurevich, Papakhristu, 1992a, b), effectively worked on Golikov's team. His publications on two medieval items—a tool of the 9th–13th centuries from the Akhsiket (Fergana) fortified settlement and a chainmail ring from the same period from Samarkand (Gurevich, Papakhristu, 1992a, b)—are of particular interest from an archaeological point of view. These items were heavily corroded, which was typical of Central Asia, but the author managed to find metal particles in them that could be studied under a microscope. The condition of the samples precluded an objective description of microstructure of the steel. The conclusions drawn were largely hypothetical ("it can be assumed", "the dark gray component could represent") (Ibid.), and therefore seem unconvincing.

In the 1960s–1990s, international metallurgists who studied modern ultra-high-carbon steels became interested in producing and processing crucible bulat steel. Research teams from Stanford University headed by O. Sherby and from Iowa State University headed by D. Verhoeven deserve special attention. Both groups claimed to have rediscovered the process of producing bulat steel. Sherby proposed and defended his theory on the origin of the bulat pattern, called the "Wadsworth-Sherby Mechanism" (Wadsworth, Sherby, 1992). His team also identified the superplastic behavior of ultra-high-carbon steels with increasing temperature, and discovered high-strength materials, opening up great prospects for their use in modern industry (Sherby, Wadsworth, 1995). During the experiments of Verhoeven's team, a technique for reproducing surface patterns and the internal microstructure of bulat steel blades, based on adding a small amount of carbide-forming elements such as vanadium, molybdenum, and chromium into the metal, was elaborated (Verhoeven, Peterson, 1992; Verhoeven, Pendray, Wagstaff, 2018). The authors clarified the mechanism of carbide formation during smelting and its arrangement into a row-like structure (Verhoeven, Pendray, 1993), determined the temperature conditions for plastic processing of metal, and proposed the main characteristics of bulat steel (Verhoeven, Peterson, 1992).

In present-day Russia, metallurgists are still quite interested in bulat steel, as can be seen from the publications of scholars (Gurevich, 2005, 2006, 2008, 2010; Sukhanov, Arkhangelsky, 2015; Sukhanov et al., 2019; Taganov, Ivanov, Nechaev, 2007) and practitioners (Arkhangelsky, 2007). Their motives are not only scientific, but also applied, such as creation of a resource-saving technology for producing cutting tools.

There are only a few metallographic studies of items made of crucible bulat steel that have archaeological context. These studies yielded three finds from the 1st and 5th centuries AD from Taxila (Punjab), a Sassanid sword from the 6th–7th centuries from Iran, a sword from Nishapur (late 8th–9th centuries), four blades from the Alanian and Khazar burials in the North Caucasus (Feuerbach, 2005: 28–29), a blade of the 12th–13th centuries made of hypercarbon steel with cementite network and excess cementite in the form of needles, found in a collective burial in the city of Yaroslavl (Zavyalov, Engovatova, 2020), and a sword made of ultra-high-carbon steel from an Iron Age megalithic burial in Telunganur (India) (Park, Rajan, Ramesh, 2020).

Thus, there is substantial historiographic literature on the topic, including studies on crucible steels of the Middle Ages. However, many problems of bulat steel remain controversial to this day. Authors disagree on the chemical composition of bulat steels, their microstructural components, cooling rate of melts, nature of formation of carbide layers in the metal, and conditions for the emergence of the bulat pattern. The common drawback of studies of medieval metal items is usually the lack of accurate dating, dubious location of finds, and ambiguity of their origin.

This article presents the results of microstructural analysis of archaeological evidence from sites in Central Asia (Southern Kazakhstan) and Western Siberia. Advantages of this study include the origin of evidence from settlements and burial complexes that have a precisely established chronology, location, and set of artifacts, which is of great importance for identifying the history of the available metal, and establishing the technology of its smelting and mechanical processing.

Material and methods

This study focuses on items made of ultra-high-carbon crucible steel (according to the AISI classification) that were discovered at medieval archaeological sites in Central and Northwest Asia. It is important to mention that these items constitute an insignificant part of the overall collection of artisanal items studied: no more than 1 % in Semirechye (out of 400 forged items) and no more than 0.16 % in Western Siberia (out of 2400 items). Macro- and microstructural analysis was carried out on: a pair of scissors and blacksmith's chisel from the Talgar fortified settlement (Northeastern Semirechye), dating to the 9th–13th centuries; a fragment of a saber of the 10th–13th centuries from the Kipo-Kulary fortified settlement (Omsk Irtysh region); two sabers of the 12th–14th centuries from the burial ground at the mouth of the Malaya Kirgizka River (Tomsk region of the Ob); and one saber of the 14th–15th centuries from the Ust-Balyk burial ground (Yugansk region of the Ob). Judging by the microstructure and known sources, these finds from Western Siberia were imported items, most likely produced in the nearest urban artisanal centers of Central Asia.

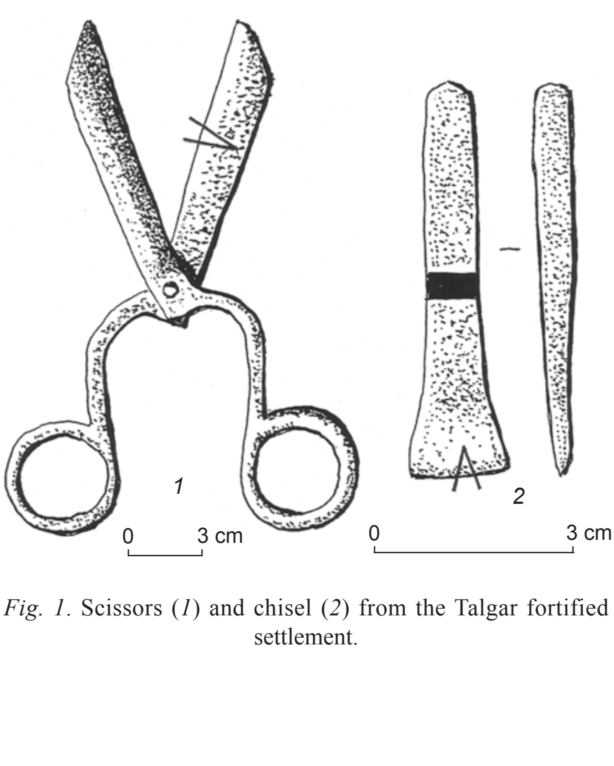

Fig. 1. Scissors (*1*) and chisel (*2*) from the Talgar fortified settlement.

This study has followed the methods of metallographic analysis, including studying the macro- and microstructure of the samples and measuring the microhardness of metal. The microstructures will be described using the standard terminology of metallography.

Study results and discussion

Metallographic and chemical analysis of the items has revealed an extremely high concentration of carbon (1.7–2.1 %) in the metal. In Russian metal science, such iron-carbon alloys are called high- or supercarbon steels, in international science ultra-high-carbon or hypercarbon steels. According to the structural classification, these belong to the ledeburite and carbide classes. The microstructure of the studied alloys shows the presence of ledeburite (structural component of white and mottled cast iron) and iron carbides (Fe_3C).

Items made of steel belonging to the ledeburite class included the hinged scissors, two saber blades, and small blacksmith's chisel. The hinged scissors were quite large; their design was similar to modern scissors (Fig. 1, *1*). Macro- and microstructural analysis of the cross-section of the working blade showed that the item was forged from ultra-high-carbon crucible steel of the ledeburite class and hardened in cold water. The striated microstructure of the metal consisted of a martensite matrix, inclusions of iron carbides (in the form of elongated grains, less often individual needles), and zones of ledeburite eutectic (Fig. 2). Individual rows were formed by alternating particles of carbides and ledeburite inclusions, and were elongated towards the blade. Their thickness was uneven. To study the pattern on the external surface, one of the blades of the scissors was polished to a mirror shine, etched with a chemical reagent (4 % solution of nitric acid in alcohol), and subjected to microscopic analysis. Since different structural components of the metal reacted differently to the action of acid, etching clearly revealed the patterned structure of the steel consisting of a combination of the dark matrix (martensite), light carbide inclusions in the form of netlike (needle-like) branches, large and small clusters of angular and rounded shapes, as well as zones of ledeburite eutectic (Fig. 2, *2*). The location of carbide particles and ledeburite zones had a dendrite nature.

For establishing the composition of the steel, a sample from the scissors was subjected to chemical analysis, revealing an iron-carbon alloy with extremely high carbon content (2.1 %). According to this indicator, it was in the border zone between cast iron and steel, and, according to international terminology, it belonged to the category of ultra-high- or hypercarbon steels. However, chemical analysis showed the absence of the main carbide-forming elements, such as vanadium, tungsten, molybdenum, and titanium, and an extremely low concentration of chromium (0.01 %). It is known that manganese is an essential carbide-forming element, yet its content in the studied alloy was relatively small (0.62 %). Manganese becomes an alloying agent and is able to impart special properties to steel only at concentrations over 1 % (Blanter, 1963: 252). Nevertheless, such a manganese content also positively affects the steel elasticity (Ibid.: 288). All of this indicates that the formation of carbides and ledeburite eutectic in the alloy under study resulted not from the addition of metals, but from increased carbon concentration.

Two specimens of saber blades were of particular interest. The first one was the fragment of a saber (the end of a blade) found at the Kipo-Kulary fortified settlement. External examination of the item showed obvious traces of reforging, which ended in failure possibly due to the blacksmith's lack of experience in handling such materials (Fig. 3, *1*). Numerous cracks visible under a microscope clearly confirmed this. A study of the sample's microstructure showed that the blade was made of crucible steel with a large amount of carbon. Such iron-carbon alloys are on the border between steel and cast iron in terms of carbon concentration (according to the iron-carbon phase diagram). For this reason, such metal was difficult to forge at traditional metal heating temperatures. The alloy structure consisted of finely dispersed pearlite, a cementite net, and a substantial amount of both individual and grouped ledeburite zones (Fig. 4). Significant differences in the size and shape of ledeburite particles and their uneven distribution across the cross-section of the sample were observed.

The second saber was found in grave 2, burial mound 63 at the medieval cemetery located at the mouth of the Malaya Kirgizka River, near Tomsk (see Fig. 3, *2*). The item

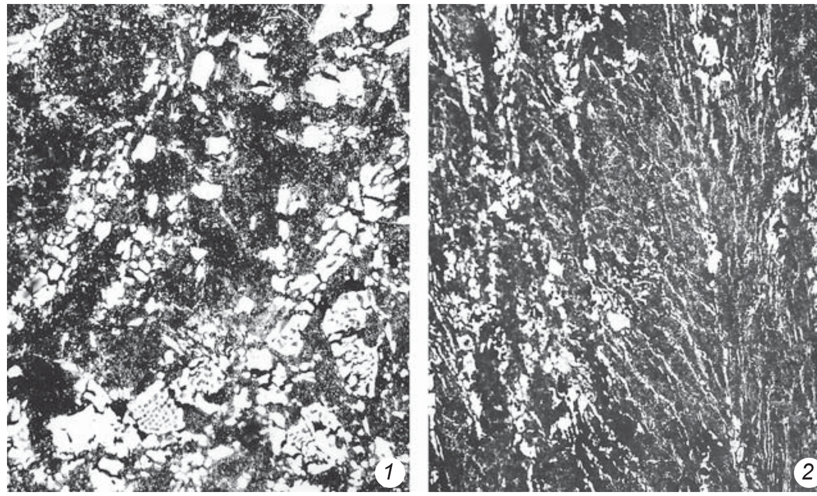

Fig. 2. Microstructure of the scissors' surface, at ×250 (*1*) and ×50 (*2*) magnification.

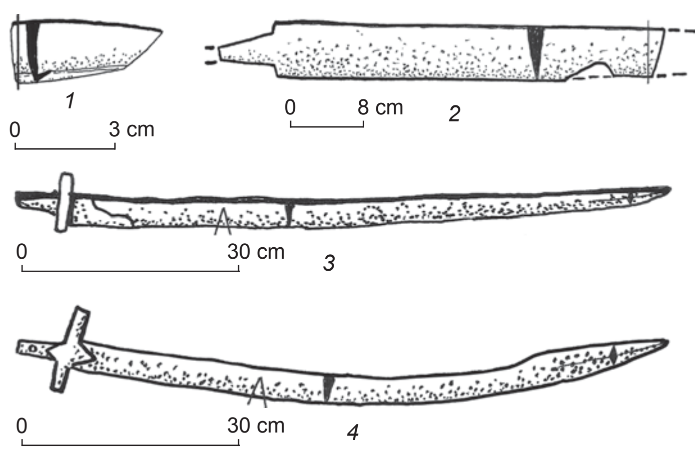

Fig. 3. Sabers.
1 – Kipo-Kulary; *2* – Malaya Kirgizka, burial mound 63, grave 2; *3* – Malaya Kirgizka, burial mound 62, grave 2; *4* – Ust-Balyk, grave 214.

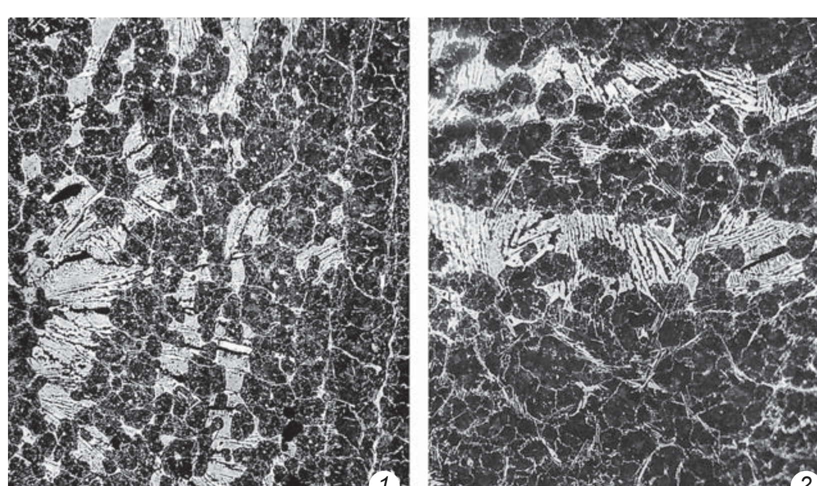

Fig. 4. Microstructures of a saber from the Kipo-Kulary fortified settlement.
1 – cross-section, ×100; *2* – surface, ×200.

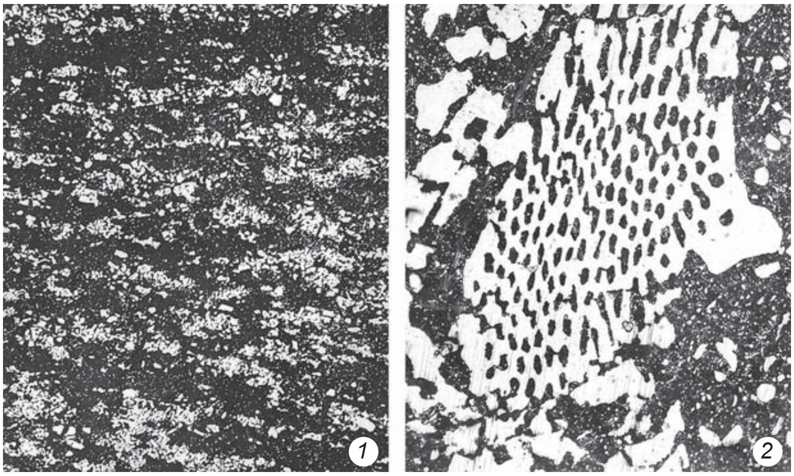

Fig. 5. Microstructure of the longitudinal cross-section of a saber from grave 2, burial mound 63 of the Malaya Kirgizka cemetery, at ×25 (*1*) and ×400 (*2*) magnification.

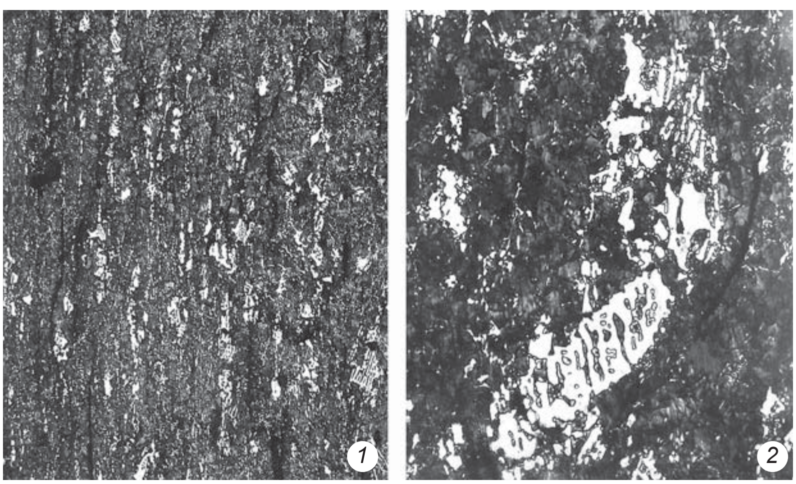

Fig. 6. Microstructure of the transverse cross-section of a chisel from the Talgar fortified settlement, at ×100 (*1*) and ×500 (*2*) magnification.

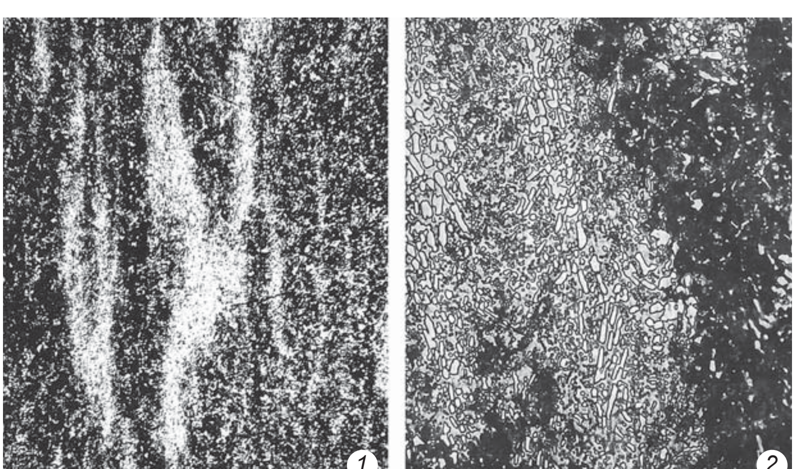

Fig. 7. Microstructure of the transverse cross-section of a saber from the Ust-Balyk cemetery, at ×100 (*1*) and ×500 (*2*) magnification.

has survived in fragments. The blade was slightly curved. Its total length was 96 cm; the width was 3 cm. Metallographic analysis revealed a microstructure of troostite with carbide precipitation in the form of small and large inclusions of round and angular shapes, as well as individual zones of ledeburite (Fig. 5). Distribution of carbides over cross-sections was uneven. It was uniform in the transverse cross-section, while the arrangement of carbide particles was row-like in the longitudinal cross-section (Fig. 5, *1*). The structural components had the following microhardness: troostite – 376–397 kg/mm^2, carbides – 1170–1290 kg/mm^2, and ledeburite – 762 kg/mm^2.

Finally, the last item made of steel of the ledeburite class was a small chisel for cutting metal (see Fig. 1, *2*). Metallographic examination showed that it was forged from ultra-high-carbon steel and was subjected to thermal hardening (quenching). The microstructure of the metal consisted of troostite, inclusions of iron carbides (Fe_3C), and ledeburite eutectic. In the cross-section, the carbide inclusions and zones of ledeburite were grouped into clusters and were extended along the forging line (Fig. 6). The microhardness of the troostite was 412–457 kg/mm^2 and of the ledeburite was 946–1225 kg/mm^2.

The group of ultra-high-carbon crucible steel of the carbide class was represented by saber blades. This article will discuss two of them in some detail. One blade came from the late medieval grave 214 at the Ust-Balyk cemetery (see Fig. 3, *4*). The saber band was curved and ended with a double-edged yelman (false edge). The handle grip was inclined towards the blade. The crossguard was straight. The total length of the blade was 92 cm; the width was 3 cm, and the length of the handle grip was 8.2 cm. Metallographic analysis revealed a troostite structure and carbide inclusions in the form of individual grains and light areas of clusters located in a row along the plane of the polished section (Fig. 7). The density of particles in the clusters was extremely high

(Fig. 7, *2*). Carbide inclusions had rounded outlines. Areas with martensite structure were observed at the edge of the blade. Judging by the microstructure, the concentration of carbon in the metal was about 2 %. The finished item was hardened. Microhardness of the troostite was 367–466 kg/mm^2, and that of the carbide phase was 1006 kg/mm^2.

Another saber was found in grave 2, burial mound 62 at the medieval cemetery located at the mouth of the Malaya Kirgizka River (see Fig. 3, *3*). The length of the saber was 91 cm; the length of the handle was 5.8 cm. The blade was slightly and evenly curved along its entire length. The handle was slightly bent toward the blade. The crossguard was straight. The band beneath it had a non-ferrous, metal fitting. Microstructural analysis of a polished section taken from the cross-section of the blade revealed the structure of the ultra-high-carbon steel, which consisted of sorbite and carbide inclusions in discontinuous rows and clusters. The width of the rows varied from three or four to eight or nine cementite particles. The carbide particles had rounded outlines (Fig. 8). The carbon content was about 1.7 %. The microhardness of the sorbite was 367 kg/mm^2, and that of the carbides was 946–1144 kg/mm^2.

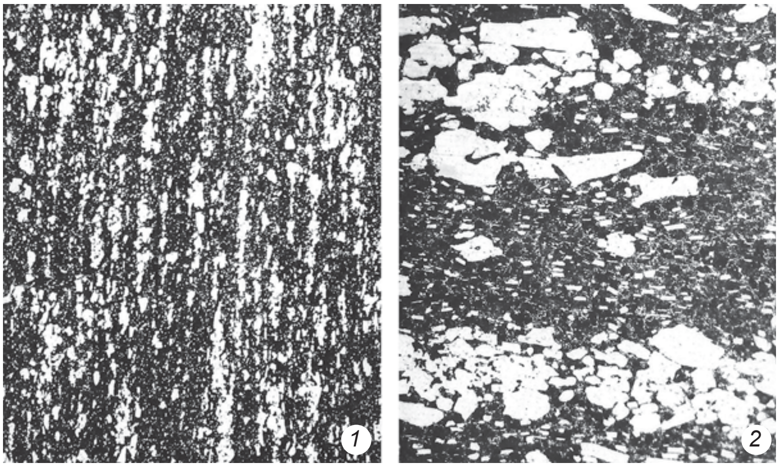

Fig. 8. Microstructure of the transverse cross-section of a saber from grave 2, burial mound 62 of the Malaya Kirgizka cemetery, at ×50 (*1*) and ×320 (*2*) magnification.

In addition to the above two main and distinct groups of ultra-high-carbon steel (the ledeburite and carbide classes), a so-called intermediate group can also be identified. In addition to a predominance of carbides, its metal structure showed rare zones of ledeburite eutectic.

The results of macro- and microstructural analysis, as well as data from historical sources and publications of previous experiments, have made it possible to reconstruct the process of producing and processing ultra-high-carbon crucible steels in the pre-industrial period. A special source among other historical sources is the treatise of the Khorezm encyclopedist of the 11th century, Abu Rayhan Biruni (1963). In the chapter “Iron”, he presented his ideas about ferrous metal and carbon alloys, described recipes for smelting crucible steel and individual technological operations for manufacturing tools and bladed weaponry. In accordance with the classification of ferrous metal he followed, al-Biruni distinguished between natural (“non-composite”) and “composite” iron (Ibid.: 231, 235). “Non-composite” iron was divided into two varieties: soft (iron proper) – *narmakhan*, called female, and hard (steel) – *shaburkan*, called male. The latter iron demonstrated increased hardness, could undergo hardening, and did not yield to even the slightest bending (Ibid.: 231). In fact, this description includes the most important properties of pure iron (softness and associated plasticity) and steel (hardness, reponsiveness to hardening in order to increase hardness while simultaneously increasing the brittleness of the metal).

According to al-Biruni, “composite” iron included two components—*narmakhan* and *daus* (cast iron), and was called *fulaz* (bulat steel) (Ibid.: 235). The author wrote that *daus* was “a hard [metal], white with a silvery tint” (Ibid.: 231). This description of cast iron is quite accurate, since in modern metal science, when visually assessing an iron-carbon alloy of this type, the criterion of the color of the metal fracture is used. White cast iron corresponds to a light, white color of fracture. Metallographic studies of ferrous metal carried out by the author of this article in Semirechye and Southern Kazakhstan indicate its widespread distribution in the Central Asian region during the Middle Ages (Zinyakov, Savelieva, Voyakin, 2013: 32–34).

In describing the technology for obtaining “composite” iron (crucible steel or bulat steel), al-Biruni mentioned that its production consisted of the joint smelting of soft iron and cast iron in a clay crucible. Depending on the technological mode of smelting, steel of different compositions, possessing different physical properties, was obtained. “The method of obtaining steel [of different] composition is twofold: either *narmakhan* [‘pure iron’ – *N.Z.*] and its water [*daus*, ‘cast iron’ – *N.Z.*] are smelted in a crucible over a calm fire, and both of them are combined in such a way that they are indistinguishable from each other, and such steel is suitable for files and the like… Or they are smelted in a crucible sequentially, and there is no complete fusion between the two, but the particles of both are located alternately, so each separately is clearly visible from their two shades; [this pattern] is called *firind* (from the Persian word *pirind*, ‘silk patterned fabric’)” (Ibid.: 235). “*Firind* in Khorasan [historical region that included Northeastern Iran, the Merv Oasis, Southern

Turkmenistan, Northern and Northwestern Afghanistan, and a part of Uzbekistan – *N.Z.*] is called *dzhaukhar*" (Ibid.: 236).

Thus, al-Biruni described two technological processes used for obtaining crucible steel in the Middle Ages. According to the first process, the combined long-term smelting of *narmakhan* ('soft iron', which can mean both plain iron and low-carbon steel, which has similar properties) and *daus* (cast iron introduced in the form of powder or dust) led to complete dissolution of the latter in liquid metal and formation of a relatively homogeneous high- or ultra-high-carbon steel (depending on the quantity and quality of cast iron introduced), consisting of pearlite and cementite. According to the second technological process, smelting of the charge components was done sequentially. Cast iron that was introduced into the melt, dissolved only partially. During smelting and timely stopping of the metallurgical process, one part of the *daus* underwent carburization and became dissolved, while the other part was preserved in the ingot in the form of individual ledeburite inclusions, with their size and shape depending primarily on the duration of the smelting process and the size of the cast iron chips. In this regard, one of al-Biruni's statements cited in his treatise, is quite indicative: "A man who had visited Sindh told me that [once] he was sitting and watching the work at a blacksmith's while the latter was making swords; the iron for them was from *narmakhan*; he sprinkled it with some kind of medicinal product in the form of a fine powder of a reddish color… and I realized that this was *daus* which he mixed with the *narmakhan*… just as ovoid blooms are made from it by smelting in Herat" (Ibid.: 240).

In modern metal science, iron-carbon alloys formed under such conditions belong to the carbide and ledeburite classes, in accordance with their structure. A distinctive feature of these steels is the presence of a large number of carbides in the structure of metal in the former case, and particles of ledeburite eutectic in addition to numerous carbide inclusions in the latter case. Microhardness of carbides is 1144–1413 kg/mm^2 and that of ledeburite 946–1314 kg/mm^2. Thus, the resulting steel is a three-dimensional combination of heterogeneous components: a solid metal base in the form of pearlite, sorbite, troostite, or martensite, with even harder carbides and ledeburite, having different physical and mechanical properties, being dispersed in the solid metal.

An important feature of *fulaz* (bulat) steel is the pattern (*firind*) on its external surface, which results from color contrast of the constituent parts of the iron-carbon alloy—the metal matrix, carbides, and ledeburite—after exposure to plant juice, acid, or other chemicals. When acid is applied to the polished surface, the metal matrix of such steel becomes black, while carbides and ledeburite inclusions remain white and shiny. Heterogeneity of the metal due to a three-dimensional assortment of grains, nodules, clusters, areas of carbides, as well as small and large inclusions of ledeburite, produced an intricate pattern. According to al-Biruni, "the [pattern] of *firind* is not obtained according to a set purpose when manufacturing [the sword] and does not emerge according to someone's will, for it is random" (Ibid.: 237). In practice, this led to the appearance of items with a wide variety of patterns. First of all, they differed in the ratio of white and black colors. "The best of its varieties <*dzhaukhar*> and the most valuable one is called *palark*… Of the two colors of this *dzhaukhar*, there is more white than black" (Ibid.). In its other variety (*umrani*), "the black color is predominant and is the most beautiful… and there are intermediate variants between these two" (Ibid.).

Metallographic analysis of ultra-high-carbon crucible steel, which revealed the presence of a large number of white carbides grouped into rows, conglomerates, clusters, etc., and ledeburite eutectic, show these structures as the basis for the pattern formed on the external surface of metal due to the special arrangement of light components against a general dark background. Carbide and ledeburite inclusions in the original bloom were arranged by special forging techniques that were known to individual artisans and were kept in secret. One such technique was described in the treatise of al-Biruni: "…The bloom is forged not along its length, but starting from its head until it flattens like a plate, then it is cut in a spiral, after which its roundness is leveled into a plane; swords are forged from this and end up being with *dzhaukhar mukhawwas* ['decorated with sparkles' – *N.Z.*]" (Ibid.: 238).

Some types of patterns (loop-shaped or rosette-like) could have been obtained by notching and cutting out the metal on the blank of a saber band. The use of such a technology of plastic steel processing by Eastern artisans was confirmed by experiments on reconstructing bulat steel production (Verhoeven, Pendray, 1993). Scholars discovered that if ultra-high-carbon steel was forged at sufficiently low temperatures (from 800 to 600 °C), the carbide fibers moved and a pattern was formed. According to experimental data, intense forging was required to obtain a beautiful pattern. For example, Verhoeven pointed out that even with 27 forging cycles the distribution of carbides in steel appeared random, whereas after 70 its geometry in the metal appeared to be quite well formed (Verhoeven, Pendray, Wagstaff, 2018).

The pattern and primer were the main indicators of the quality of bulat steel, as was repeatedly mentioned by al-Biruni and the medieval authors he cited. The Russian metallurgist of the mid-19th century P.P. Anosov, who operated with later information, wrote: "Asians know the quality of bulat steel from the pattern, the color of the primer, or the gaps between the patterns, and from the sheen of the surface under indirect rays of light. Asians believe: the larger and clearer the pattern, the higher the quality of the metal" (Anosov, 1954: 122). The size and clarity of the patterns, in his opinion, were determined by the amount of carbon in the steel, and their different arrangement could be explained by different degrees of perfection in the combination of the carbon and iron (Ibid.: 143). A comparison of various patterns of bulat steel items showed that the larger the patterns, "the harder the bulat steel was, and consequently, the more carbon it contained" (Ibid.: 135). Following up on this idea, Anosov divided the known bulat steels into hard and soft, and made one very important observation during the forging process: if the blank is heated to white-hot (1200–1400 °C, the initial forging temperature for ordinary carbon steels), then "in the case of hard bulat steel it loses its malleability and crumbles, and in the case of soft steel it loses its patterns" (Ibid.: 147).

The observations and suppositions of Anosov have been confirmed and substantiated by modern microstructural studies. Large patterns can be associated primarily with a fairly high concentration of ledeburite inclusions, and small ones with carbide inclusions. Structural and chemical analysis indicates that crucible steel of the ledeburite class contains more carbon than steel of the carbide class. Consequently, the former can be identified with hard bulat steel, and the latter with soft steel. The metal structure revealed during the study of archaeological evidence also explains the behavior of hard bulat steel when heated to a high temperature. Relatively low-melting inclusions of ledeburite melt when heated to white heat, resulting in metal destruction in the case of its deformation.

As studies have shown, hardening of the finished product was one of the most important technological operations in manufacturing items of crucible steel, both for tools and bladed weaponry. Microstructural analysis of the metal indicates that in order to obtain the needed set of mechanical properties, medieval artisans used hardening modes that corresponded to the purpose of their products.

Conclusions

Macro- and microstructural study of items made of iron and iron-carbon alloys from medieval sites in Central and Northwest Asia clearly demonstrates the use of crucible ultra-high-carbon steel by the local population. Carbon content in the metal of individual samples was 1.7–2.1 %. Chemical analysis did not reveal sufficient amounts of carbide-forming elements, such as vanadium, tungsten, molybdenum, titanium, chromium, and manganese. The nearest crucible steel production facilities were located in Central Asian urban artisanal centers. The identified groups of iron-carbon alloys of the carbide and ledeburite classes have specific features of their macro- and microstructure, consisting of a dark matrix (depending on the nature of heat treatment, this can be pearlite, sorbite, troostite, or martensite), with white inclusions of ledeburite eutectic and cementite. Such steel may have been obtained by joint smelting of bloomery iron and cast iron. Two possible technological processes of the crucible metallurgical production have been described above, but clearly, there existed also other processes.

The presence of carbide and ledeburite clusters in the form of rows, areas, and conglomerates, which manifested itself in the patterned structure of the steel, together with an extremely high concentration of carbon, gives grounds to identify the studied metal as being identical to Eastern bulat steel from which weaponry, as well as chopping and cutting tools, was made. The pattern of the crucible steel was determined by the technology of metal production and processes of its plastic deformation. Numerous finds of crucible steel with ledeburite heterogeneity show that medieval metallurgists used special methods of metal smelting, which ensured preservation of ledeburite in its structure.

This research expands our knowledge on the existing varieties of bulat steel, structural features and phase composition of individual groups of ultra-high-carbon crucible steel, reflecting the technology of crucible smelting, plastic processing, and physical properties of iron-carbon alloys.

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Textiles from the Ust-Voikary Hillfort Site (Based on Materials from 2012–2016 Excavations)

The article describes 366 samples of clothing (some of them attributable), collected in 2012–2016 from cultural layers of the 15th to middle 18th centuries at the Ust-Voikary hillfort site in the subarctic zone of Western Siberia. We provide technological characteristics: size, state of preservation, color, properties of threads and fibers, interlacing system, technological errors, cut, and traces of repair. Both animal and plant fibers are present, and plain and twill weaving are attested. Ethnographic and zoological data provide information on the textile technologies used by residents of the polar zone of Western Siberia, and allow us to compare them with those known from other sites. We conclude that types of textiles for clothing remained virtually the same from the 15th to the 18th centuries. Fabrics, mostly woolen, were imported.

Keywords: *Northwestern Siberia, Ust-Voikary hillfort site, wool fiber, plant fiber, plain weave, twill weave.*

Introduction

Textiles, as a source, have a rich capacity in archaeological research, since their study reveals both the features of the finished textile product and the technology of its manufacture, and also social and economic factors that influenced the choice of textile fabric or product, as well as the aesthetic and value preferences of a specific society and various forms of cultural contacts.

The entire process of textile production can be divided into several stages: selection and processing of raw materials, formation of yarn and production of threads, creation of woven fabrics using various tools, and dyeing (which can be done at any stage). Additional information on the manufacturing technology of textile items can be provided by historical and ethnographic sources, and analysis of archaeozoological and archaeobotanical evidence, as well as tools for creating textile products discovered at archaeological sites.

By now, a significant collection of samples of ancient textiles from archaeological sites of the late 15th–19th centuries in Northwestern Siberia has been accumulated. These finds have been studied and described only partially. Textile evidence obtained during archaeological research in 2012–2016 at the Ust-Voikary hillfort site was presented at conferences (Novikov, Senurina, 2016; Novikov, Mukhyarova, Senurina, 2015). This study provides the first full analysis of textile materials from Ust-Voikary.

Description of the collection of woven materials

The study of the Ust-Voikary hillfort site has a long history (Garkusha, 2020). Archaeological works at the site were carried out from 2003 to 2008 under the supervision of A.G. Brusnitsyna and N.V. Fedorova; and from 2012 to 2016 under the supervision of A.V. Novikov. The studies have revealed that the site was a multilayered settlement, which developed from the late 13th to the 19th centuries. These time boundaries were established from the dendrochronological data (Gurskaya, 2008; Garkusha, 2022).

Scholars identify the Ust-Voikary hillfort site with Fort Voikary (Brusnitsyna, 2003; Arkheologicheskaya karta…, 2011: 84, 92; Garkusha, 2020: 142). The first mention of Fort Voikary, going back to 1594, is associated with a campaign by the Koda Ostyak servicemen to the lower reaches of the Ob River, to the outskirts of the town of Voi-kar, whence they brought back several captives (Perevalova, 2004: 39). G.F. Miller mentioned the Ostyak town of Voi-karra: “This town stands on the left bank of the Ob River”, and “the Ostyaks still live there; but the Samoyeds often come there, too” (1787: 205). The ethnic composition of the settlement’s inhabitants has not been definitively established. However, taking into account the ethnic history of the region, this population can be tentatively considered Ugro-Samoyed with a Komi-Zyryan component (Martynova, 2005; Perevalova, 2004: 231–233).

Permafrost ensured good preservation of items made of organic materials at the site. During the excavations, an assemblage of textile materials and items required for fabric handling (thimbles, needle cases, needles, cutting boards, and a spindle-type tool) was collected. The fabrics discussed in this study were discovered during the examination of cultural layers dated to the mid-15th to mid-18th centuries (Garkusha, 2023) at the Ust-Voikary hillfort site in 2012–2016.

Textile fragments were found both in the inter-dwelling space and inside the buildings. In total, 366 fabric samples were studied, which is 96 % of the textile materials (the collection also included fragments of felt, ropes, and threads; knitted items were absent). The technological study of the textiles included visual examination, analysis of the samples and their structure by the methods of materials science, a search for technological parallels, and reconstruction of the manufacturing methods.

The studied samples were of different shades of brown, red, or green. However, note that during the time when the samples were in soil, their color (differently for different materials) could have been changed significantly by biochemical factors. Some brown samples might originally have been dyed red, and green samples could well have been blue. The chemical composition of the fabric dyes was not determined; but in some cases, colored fibers were detected using optical microscopy.

According to the type of raw material, the fabrics from the collection can be divided into two groups: those made of raw materials of plant origin—bast and cotton fibers (Fig. 1, *1–4*); and those made of raw materials of animal origin—wool (Fig. 1, *5*, *6*). Fabrics from plant fibers included only two samples; all the rest were made of wool.

In terms of structure, the discovered fabrics can be classified as plain weave and twill weave. Plain weave is typical for fabrics from plant fibers. Woolen fabrics are distributed depending on the type of weave as follows: plain weave fabrics – 331 samples; twill weave – 21 samples; indeterminate – 14 samples.

The major part of the textile collection is plain-weave fabrics. It is one of the basic weaves with the repeat pattern limited to only two threads and two passes: each warp and weft thread alternately passes over one thread of another system and under the next thread; odd and even threads are opposite at each pass (Ierusalimskaya, 2005: 34). Woolen fabrics of plain weave include woolen cloth and broadcloth. In woolen cloth, unidirectional twist threads (Z/Z or S/S) are used in the warp and weft; there is no underlay. In broadcloth, multidirectional twist threads (Z/S or S/Z) are used in the warp and weft.

Woolen twill fabrics in the textile collection from Ust-Voikary include only a small number of samples. Twill weave, like plain weave, is considered basic. Diagonal lines are formed on the surface of twill textile by a special order of alternated warp and weft threads: the first warp thread overlaps the first weft thread; the second warp thread overlaps the second weft thread, etc. (Ibid.: 38). In the Ust-Voikary fabrics, the twill repeat pattern is 2 warp threads to 2 weft threads (2/2 twill). Twill wool fabrics are included in the wool twill group; they have unidirectional twist threads (Z/Z or S/S) in the warp and weft; only two samples have threads of opposite twist (Z/S or S/Z).

Woolen fabrics of plain and twill weave of the 15th–18th centuries are known in Northwestern Siberia from the evidence of the following sites: the Chastukhinsky Uriy and Ust-Balyk cemeteries, the Endyr-1 fortified settlement, and the Endyr-1 and Endyr-2 cemeteries, as well as the Mangazeya, Berezovo, and Staroturukhansk fortified settlements (Glushkova, 2002: 45–55; Katalog…, 2013: 24–34, 55–57, 60; Vizgalov, Parkhimovich, 2008: 76–77, 228; Vizgalov, Parkhimovich, Kurbatov, 2011: 182).

In the fabrics from Ust-Voikary, it was often impossible to determine the weft and warp threads owing to the absence of edges and a number of other features. A large number of technological errors have been observed

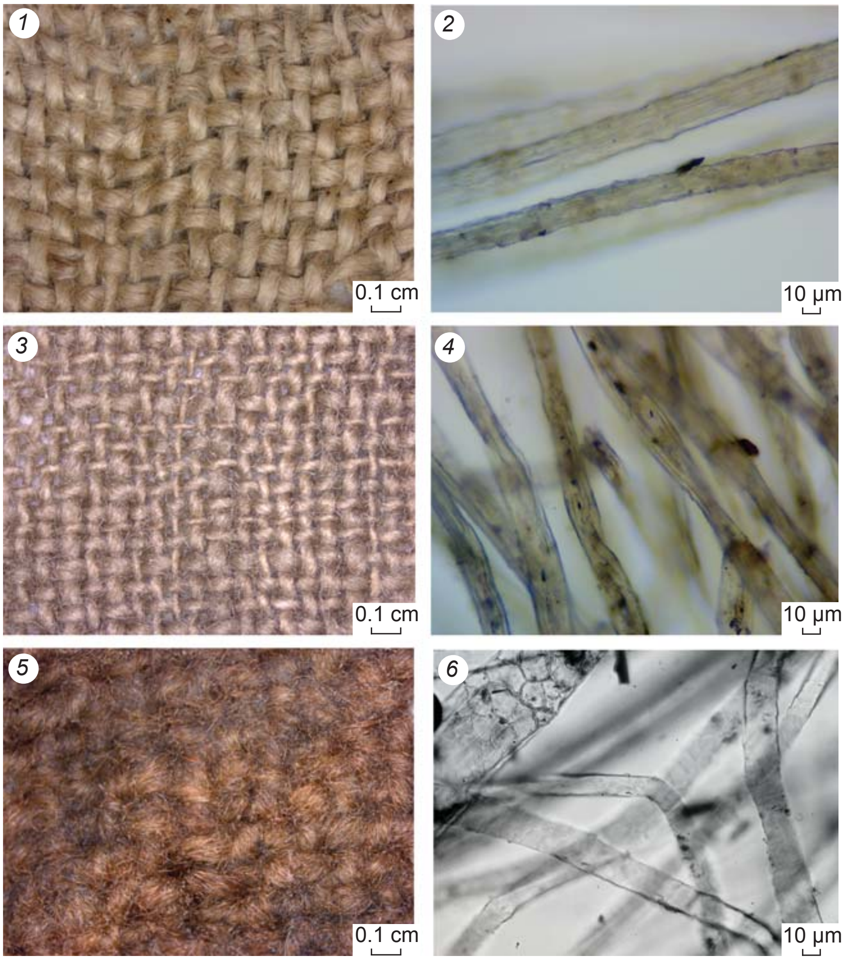

Fig. 1. Microphotographs of textiles. The Ust-Voikary hillfort site.
1 – fabric made from plant fibers (bast fibers); *2* – bast fibers (×400); *3* – fabric made from plant fibers (cotton fibers); *4* – cotton fibers (×400); *5* – woolen fabric; *6* – wool fibers (×400).

during the study of archaeological textiles from Ust-Voikary. In 23 % of samples dating back to the late 15th – 17th centuries, there are identical weaving errors, which in some cases may reflect specific features of looms. During manual feeding of threads, errors may occur in any weft row resulting from incorrect thread grip: when working with one shed, they are possible only in the row where manual feeding takes place, and in the presence of heddle thread loops, errors may occur because of failure in threading warp threads into thread loops (Glushkova, 2002: 107–109, 125; Orfinskaya, Mikhailov, 2020: 53).

Two types of textile errors were observed in the textile evidence from the Ust-Voikary hillfort site: doubled warp or weft threads throughout the entire row; and overlapping of threads of one system with two or three threads of another system. The former error can be considered a technological error in weaving caused by unfastened warp threads, or a broken weft thread (Glushkova, 2002: 46; Orfinskaya, Mikhailov, 2020: 53). The second error may be associated with manufacturing fabric on a vertical or horizontal loom in which warp threads were not rigidly fixed with special devices (Glushkova, 2002: 46). Identical weaving errors may indicate that the textiles were made in a single production-center.

No weaving tools or devices were found at Ust-Voikary, which suggests the absence of manufacture of threads and fabrics in this region. However, it is noteworthy that the evidence studied comes from only a part of the site. Tools associated with textile production, such as needles and thimbles, have been discovered, which suggests that the locals sewed and repaired their clothing themselves.

The analysis of clothing fragments from the collection has shown that the edges of the items were sometimes left unprocessed or were folded with a fold height of 0.5–0.7 mm; a double fold with a closed edge was made. Items with unfolded edges or with small folds (aimed at saving the fabric) were possibly made directly at the Ust-Voikary site. The items that had standard processing of textiles could have been brought from other areas where there were no problems with the fabrics. The great number of patches on the items also indicates careful treatment of fabrics (Fig. 2). All patches, square or rectangular, were sewn on the inside of the outfit.

Discussion

In the evidence from the Ust-Voikary hillfort site, textiles appear mainly in fragments. Only 65 samples show traces of sewing, and can be associated with fragments of sewn products. Only one item—a cotton scarf—is suitable for complete identification. Therefore, despite the large number of woven samples, it is not yet possible to reconstruct specific varieties of clothing.

Some textile materials were found in buildings, and can be synchronized with wooden structures. The evidence found in the inter-dwelling space was considered as textiles used by the dwellers from the mid-15th to mid-18th century.

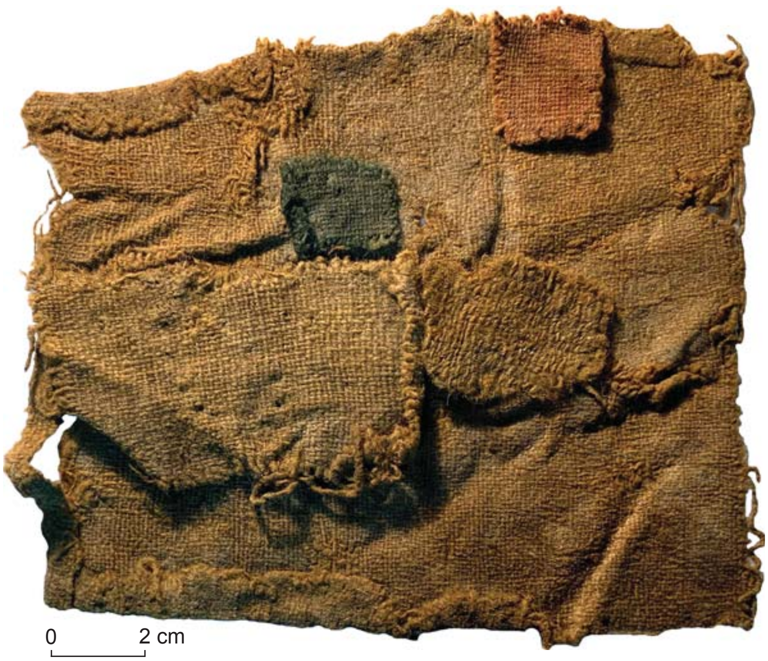

Fig. 2. Fragment of textile item with patches. The Ust-Voikary hillfort site.

Forty-eight samples of textiles were attributed to the 15th century. One of these was identified as thick woolen twill; one sample was not identified, and the rest belonged to the woolen-cloth group. Twill textile was made with errors in the weaving pattern. The errors were not systematic, which suggests manual feeding of threads in a possible attempt to reproduce the weave of the fabric threads not typical for that particular production area. Plain-weave fabrics are divided into following groups: 1st – thick woolen cloth with unidirectional S-twist threads; 2nd – medium woolen cloth; thick broadcloth, and 3rd – medium broadcloth. There are no thin fabrics. Samples of fabric created with technological errors amount to 39.5 %.

There are 80 samples of fabric attributed to the 16th century, of which the technological features of six samples have not been identified. Thin fabrics are present (7 samples), including: 1) thin broadcloth; 2) thin woolen fabric with S-twist threads (1 sample with weaving errors), and 3) thin woolen fabric with Z-twist. Medium fabrics (37 samples) are divided into the following groups: 1st – medium woolen twill with unidirectional Z-twist threads; 2nd – medium twill with unidirectional S-twist threads (presence of errors in the fabric); 3rd – fabric made of raw materials of plant origin. Thick fabrics are classified as follows: 1st – thick woolen twill with unidirectional Z-twist threads; 2nd – thick fabric with unidirectional S-twist threads; 3rd – thick broadcloth. Fabric samples made with technological errors make up 25 %, which is 14 % less than among the 15th-century fabric samples found in the dwellings.

Forty nine samples of textile were found in the 17th-century dwellings. The technological features of three samples have not been identified. Fabric is divided into the following groups: 1st – thin cloth; 2nd – thin woolen twill with unidirectional Z-twist threads (errors in the fabric); 3rd – thin woolen fabric with unidirectional Z-twist threads; 4th – medium cloth; 5th – medium woolen fabric with S-twist threads; 6th – medium woolen fabric with Z-twist; and 7th – thick cloth. Samples of fabric produced with weaving errors constitute 26.5 % of fabric fragments that were found in the 17th century buildings.

Nine fragments of fabric were found in the 18-century buildings. They can be classified as follows: 1st – thin broadcloth; 2nd – medium woolen cloth with unidirectional Z-twist threads; 3rd – medium woolen cloth with unidirectional S-twist threads; 4th – medium woolen twill with unidirectional Z-twist threads; and 5th – thick woolen twill with unidirectional Z-twist threads. There are no fabrics with technological errors.

Fabrics made from plant fibers, dating back to the 16th century, were represented in the collection by two samples. Samples of plain weave fabrics dominate among the materials of the late 15th–17th centuries. Samples of twill-weave fabrics are dated mainly to the early 18th century. The number of technological errors in the fabrics becomes noticeably reduced by the 16th century, and no errors have been found in the fabrics of the early 18th century. Textile materials from the layers of the late 15th–mid-18th centuries demonstrate that the population living in this area used mainly woolen fabrics of plain weave.

To study the problems of raw material supply for the manufacture of fabrics by the inhabitants of the Ust-Voikary hillfort site, we should use different sources. According to archaeozoological studies, a single astragal found at the site belonged to Capra et Ovis* . Probably, the inhabitants of the settlement did not breed small ruminants. Ethnographic evidence contains information that "the following domestic animals appear in greater or lesser quantities among the ethnic population. Dogs, horses, cows, sheep and deer are found in greater or

*Archaeozoological analysis of the evidence from Ust-Voikary-1 was carried out by Dr. O.P. Bachura, Senior Researcher at the Institute of Plant and Animal Ecology of the Ural Branch of the Russian Academy of Sciences (Yekaterinburg). The authors are grateful to O.P. Bachura for the research and information provided.

lesser quantities. However, sheep… are very rare. They are kept by those Ostyaks who have the opportunity to keep cows in their households" (Dunin-Gorkavich, 1996: Vol. 3, pp. 116–117). Dogs were of great importance to the indigenous population of Western Siberia in all places. As A.A. Dunin-Gorkavich noted in his diaries, which are kept in the archives of the Tobolsk State Historical and Architectural Museum-Reserve, "for a reindeer herder, they are shepherds of reindeer herds; for a hunter, they are indispensable companions in the trade both as trackers and as working animal pulling a sled with provisions behind; in a household, they are a workforce which the indigenous person uses when he needs to transport water, firewood, hay, luggage, etc. As a result, the indigenous people treat dogs with care, and the Ostyaks have developed precise concepts about the features that determine the merits of a dog" (Novikov, 1999). However, it is important to emphasize that despite the diversity of dog functions in the traditional culture of the indigenous population of Northwestern Siberia, none of the scholars has mentioned the use of dog wool as raw material for weaving. Ethnographers have not mentioned processing of wool materials and spinning of wool as a traditional occupation of the Khanty and Mansi in Northwestern Siberia. On the contrary, it is asserted that "the above-mentioned peoples do not spin on their own and do not have their own native material, that is wool, for such yarn" (Sirelius, 1907: 41). U.D. Sirelius wrote that "the Sosva Voguls make their ribbons from yarn obtained from stockings that they buy from the Zyryans" (Ibid.).

Thus, specialized animal-breeding for producing woolen yarn was not typical for the indigenous population inhabiting the northern part of Western Siberia. Sheep and goats were kept in very small numbers, and usually in Russian towns. It can be argued that the traditional economy of the indigenous population in the north of the region did not have a material base for the mass production of woolen fabrics. Such fabrics had been known in this area since the Bronze Age (Glushkova, 2002: 64); yet, since there was no raw material for their production, it may be assumed that most of these fabrics were imported.

Paleobotanical studies of cultural deposits at Ust-Voikary has shown that plant communities in the area of the site were typical of the northern taiga subzone. The Ust-Voikary population used local plant resources only for construction, as well as medicinal and food purposes (Zhilich et al., 2016, 2023), but they cannot be considered raw materials for fabric manufacturing. Thus, there is every reason to believe that the Ust-Voikary dwellers did not have their own animal or plant fibers for manufacturing fabrics. Moreover, no tools for manufacturing woven fabrics were found during archaeological works at the site.

According to ethnographic descriptions from the 17th–19th centuries, the Khanty people used grass, reeds, and nettles in their everyday life. "Mats and small round rugs are made from unscutched sedge. Insoles are made from couch grass and are inserted into winter footwear. Carpets are woven from reeds. Threads are spun from nettle and canvas is woven" (Dunin-Gorkavich, 1996: Vol. 3, p. 92). Women "weave canvases from nettle fiber, sew shirts, embroider with colored woolen threads, and the rich can embroider with silk threads. They weave mats for beds from grass" (Opisaniye Tobolskogo namestnichestva, 1982: 167). Sirelius recorded the use of nettle, hemp, and flax by the Khanty and Mansi. Nettle "is not widespread throughout the entire area where these peoples live. Along the Ob and Irtysh within the Ostyak lands, it occurs in the north almost up to Berezovo or approximately up to 65 degrees of north latitude; and then it gradually starts to be encountered less frequently, until finally it disappears entirely… In the area of the sources of the Vakh, it should not be found either. People say that previously it was not found even at the mouth of this river and that it first appeared there only when the Russians began to cross the river on horseback on the ice. The growth of nettle is the most abundant along the Irtysh, Demyanka, Konda and Salym" (Sirelius, 1906: 18). Sirelius observed that "hemp is currently known everywhere and is an object of trade, but earlier it was probably found only on the Konda… Flax is less widespread, but recently it began to be cultivated on the Konda" (Ibid.).

Historical and ethnographic studies mention traditions of making fabrics and clothing in Northwestern Siberia among both the indigenous and incoming (Russian) population, as well as significant import of textiles (Klein, 1925, 1926; Bakhrushin, 1952; Boyarshinova, 1960; Bogordaeva, 2006; Vilkov, 1967; Lukina, 1985; Prytkova, 1952, 1953, 1961a, b; 1970a, b; 1971; Sokolova, 2009; Syazi, 2000; Fedorova, 1978, 1993, 1995; Fekhner, 1956, 1975, 1977, 1982). Their own technologies for fabric manufacture among the indigenous population of Northwestern Siberia probably started to spread in the 18th–19th centuries, under the influence of traditions of the population arriving from the Eastern European regions. Before that time, the appearance of fabrics from both plant and animal fibers among the indigenous population of the region could only derive from imports. Incidentally, the remoteness of the northern regions of Western Siberia from political and economic centers, and the lack of convenient communication routes with them, did not hamper active trade with the European part of the Russian Empire.

In this regard, information from of the customs books of Siberian towns is of great interest. According to the published data, linen, silk, and woolen fabrics were imported to the north of Western Siberia. For example, linen fabrics, making up 41 % of the total amount of textile goods, were imported to the area of Berezovo. The share of woolen fabrics was ca 47 %, and silk fabrics 11 %. Most likely, goods of poor quality were imported for sale to the indigenous population of the northern territories. For example, in 1687/88, the customs book recorded that “forty-six used shirts [costing] four rubles and twenty altyns, and thirteen used kaftans [costing] five rubles and two grivnas” were imported to Berezovo (Tamozhenniye knigi…, 2004: 77).

As noted above, fabrics (even woolen) in the collection from the Ust-Voikary hillfort site were made with a large number of errors. Taking this into account, it can be assumed that owing to the lack of raw materials and necessary equipment, the local population did not make textiles, but used imported fabrics (or ready-made clothing).

Conclusions

The textile collection from the Ust-Voikary hillfort site consists of plain-weave woolen fabrics, twill woolen fabrics, woolen fabrics with uncertain technological features, linen fabrics made of raw materials of plant origin, felt, ropes, and threads. The absence of knitted items in this collection is noteworthy, even though items knitted with a single needle have been known in Northwestern Siberia since the 17th century. Socks, stockings, and mittens knitted with a single needle are a part of archaeological collections from the Russian sites such as Berezovo and Mangazeya fortified settlements (Vizgalov, Parkhimovich, 2008: 227, 229; Vizgalov, Parkhimovich, Kurbatov, 2011: 184, 188). This may have been caused by the absence of a tradition of knitting clothes among the indigenous inhabitants of the northern regions.

Although items made of organic raw materials have been very well preserved in permafrost, textiles made of plant fibers were found in very small quantities at Ust-Voikary; most likely these were very rare. A small number of samples are thin woolen fabrics of uniform density. Owing to the high cost resulting from the remoteness and inaccessibility of the area, fabrics made of plant fibers and thin woolen fabrics were not thrown away but were carefully preserved.

A significant part of the collection consists of fabric samples made of medium and thick threads. Fragments of woolen fabrics are especially numerous, amounting to about 300 specimens, or 80 % of the total number of finds. Thick and medium woolen fabrics were widespread for obvious reasons. The population of the northern regions of Western Siberia needed warm and windproof clothing made of thick textiles with lining, and multidirectional Z- and S-twist threads provided good density. The absence of whole items among the evidence from the site can be considered a sign of the careful treatment of fabrics. Most likely, the clothes were repeatedly re-sewn until they wore out, and then the remains of the fabric were used for patches. The special attitude to fabrics, and the absence of tools for spinning and weaving among the evidence from the Ust-Voikary hillfort site, demonstrate that textiles were not made on site but were imported.

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Shaman Tambourines of the Northern Ob Ugrians (18th to Early 21st Centuries)

Shaman tambourines of the northern Khanty and Mansi (18th to early 21st centuries) are described. Sources include publications by other specialists and the author's field materials collected in the Khanty-Mansi Autonomous Okrug–Yugra and the Yamal-Nenets Autonomous Okrug. A shaman performing rites with a tambourine is called koipyng-nyait. The process of making a tambourine is described. Information on 44 tambourines is summarized in a table with reference to shape, number of resonators, etc. The few available descriptions of rites are provided. A separate section concerns anthropomorphic images of patron spirits, carved on handles and beaters or represented as figurines inserted in tambourines. The Lyapin Mansi practiced a custom of providing tambourines with figurines of guards, koipyng-pupyg. Traditionally, after the tambourine's owner had died, the tambourine became a family patron spirit, whose image was supplied with specially sewn men's clothes. In my view, the northern Ob Ugrian shamanism was underdeveloped, as evidenced by the shaman's limited functions, absence of special attire, etc. The shamanic paraphernalia used by Khanty and Mansi are much scarcer than those associated with the cult of Mir-Susne-Khum. The main distribution areas of tambourines in the 20th to early 21st centuries are the basins of the Lyapin River (Mansi) and the Synya River (Khanty). Both belonged to the territory that, in the 18th–19th centuries, was the contact zone between Ob Ugrians and Nenets.

Keywords: *Shamans, shaman tambourines, Khanty, Mansi, rite, patron spirits.*

Introduction

The term "shamanism" first appeared in the Russian sources no later than 1648. According to S.V. Bakhrushin, the identification of a special category of people possessing the gift of communicating with spirits from above—"knowledgeable shamans" or *shaitanshchiki* ('servants of the shaitan') (1935: 29, 30)—generally refers to the 17th century. In the early 18th century, mentioned in the sources are *shamanchyki* ('shamans'), *zhretsy* ('pagan priests'), and *volshebniki* ('sorcerers') (Novitsky, 1884: 48), and in the late 18th century, *shamany* ('shamans'), *volkhvy* ('soothsayers'), and *vorozhei* ('fortune tellers') (Zuev, 1947: 41). In the 18th to mid-19th centuries, references to shamanic tambourines were sporadic: "…shamans are appointed… from those who frequently interpret dreams… however, this is not enough, because without any knowledge from previous sorcerers and without using a tambourine, he cannot embark upon such a fearful task for them" (Ibid.: 43); "During their rituals and sacrifices, male and female shamans appear wearing a special outfit, unique to them, with a tambourine in their hands" (Belyavsky, 1833: 115); "A shaman… needs a magic tambourine. Ordinary speech does not reach the ears of the gods; he must converse with them by singing and beating a tambourine" (Kastren, 1860: 187).

The shamanism of the Ob Ugrians is known to be a debated topic in ethnography. The scholars considering it underdeveloped include K. Karjalainen, V.N. Chernetsov, E.D. Prokofieva, and V.M. Kulemzin, who believed that shamanism among the Mansi and Khanty had less pronounced forms than among other Siberian ethnic groups (Sokolova, 2009: 641). According to Z.P. Sokolova, the shamanism of the Ob Ugrians "developed in the same vein as among other peoples of Siberia (but was not more weakly developed), and it has lost a number of features or disappeared only under the influence of the early entry of Western Siberia into Russia, and Christianization" (Ibid.: 652–654).

The author of this article agrees with the point of view about underdeveloped shamanism among the northern Ob Ugrians. The figure of the shaman did not play a primary role among them, since their ritual practices had the character of home sanctuaries where the owner of the house acted as an intermediary between people and spirits in everyday life and during the ritual. A shaman had the task of communicating with spirits in critical (illness, loss, or natural disaster) or borderline (fortune telling at the birth of a child or at the coffin of the deceased) situations. According to the evidence of the 20th century, shamans or their attributes were observed mainly along the western and eastern periphery of the "Vogul" wedge, in the contact zones of the Ugrians and Samoyeds (the upper reaches of the Lyapin and Synya rivers; the Kazym River basin), which suggests the Nenets influence. However, scholars did not observe the full shaman's outfit (headdress, robe, and footwear) among them. The main attribute of a shaman confirming his status among the northern Ob Ugrians was the tambourine.

This article examines the evidence only on the northern Mansi and Khanty, since first, their shamanism differs in many ways from that of the eastern Khanty, and second, specific features of the latter have been described in detail by Kulemzin (1976). The chronological framework of this work is the 18th to early 21st centuries. The geographical region extends from the Irtysh River's mouth to the Gulf of Ob, and from the Urals to the right bank of the Ob in the Khanty-Mansi Autonomous Okrug–Yugra and Yamal-Nenets Autonomous Okrug*.

***Koipyng-nyait*—shaman with a tambourine**

In the Mansi and Khanty languages, *koip* means 'tambourine'. Accordingly, the shamans who performed shamanic rituals with tambourines were called *koipyng-nyait* ('a man with a tambourine'). Perhaps this was how they differed from fortune tellers, who mainly used a saber, axe, knife, or sacred chest to communicate with spirits*.

Becoming a future shaman with a tambourine was not easy: "…not everyone becomes a shaman. Some people suddenly start to get sick. Puksikov got sick when he was about fifteen and was sick for about two years. Some people are sick up to three years. A man seems to be drunk; he walks on all fours, does not eat anything. Sergei ran away into the forest and could not be found for a long time. Finally, *Mir susne khum* ['a man who watches over the world', the youngest son of the supreme god Numi-Torum. – *A.B.*] and *oparishch* ['ancestors' (Mansi) – *A.B.*], *pupykh* [correctly *pupyg* 'patron spirit' (Mansi) – *A.B.*] come to the man and tell him to start performing shaman's rituals, beat the tambourine…" (from the diary of V.N. Chernetsov, 1931) (Istochniki…, 1987: 154); "When a man becomes a shaman, he gets sick. If he is to become *koiupyng nyait*, he is sick for a long time, does not recognize anyone, does not eat, does not drink, goes into the forest, and lives there nobody knows how. Then an *oparishch*, *pupykh* in the form of a totem, comes to him and tells him to make a tambourine and start performing shaman's rituals" (Ibid.: 158).

Among various categories of shamans of the Ob Ugrians, Sokolova also mentioned *koipyn nyait* ('shamans with a tambourine') primarily among two groups, namely the Kazym and Synya Khanty. The main purpose of such shamans was to treat diseases (Sokolova, 2009: 644; 2016: 259–260, 492–494). On the Synya, shamans who perform rituals with tambourine are called *kuipyn iki* ('a man with a tambourine'), or *kuipyn sepan iki* ('man fortunetelling with a tambourine') (Synskiye khanty, 2005: 175–176). According to informant E.G. Fedorova, from the upper Lozva River, the Mansi had four categories of shamans, including *koipyn nyait* or *nyaityn oika* ('shaman with a tambourine'), and *lylyng pupin nyait* ('shaman of a living (speaking) spirit'), who closely communicated with spirits, was the most powerful, and also had a tambourine. Only shamans with tambourines could cause harm (Fedorova, 1991: 166–167).

G.E. Soldatova distinguishes two categories among those engaged in shamanic activities: shamans proper and parashamans; they differ in their active or passive role in the ritual. The former perform actions: heal or cause harm, return hunting luck or take it away, etc. The latter focus on recognition: they predict, prophesy, or determine the cause of misfortune and the way to eliminate it. Ownership of a tambourine is typical of the first category (Soldatova, 2014: 78).

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*This article mentions the settlements in the Berezovo (Yasunt, Shchekurya, Khoshlog, Khurumpaul, Lombovozh, Aneevo, Menkv-ya-paul, Tutleim) and Beloyarsky (Yuilsk) Districts of the Khanty-Mansi Autonomous Okrug–Yugra, as well as the Shuryshkary (Tiltim, Vytvozhgort, Ovgort, Yamgort, Lorovy, Lokhpodgort) and Priuralsk (Zeleny Yar) Districts of the Yamal-Nenets Autonomous Okrug.

*An exception is mentioned in the records by S.I. Rudenko (1909): "…tambourines were also used by fortune tellers, who made predictions using a tambourine, but did not perform shamanic rituals" (1958: 297) (see also (Ibid.: 281, 296)).

General information about shaman tambourines

S.I. Rudenko noted the uniformity of tambourines of the Ob Ugrians and Nenets people (1958: 296). I.N. Shukhov emphasized that the Kazym "tambourine and beater are somewhat different in shape and appearance from those of the Vakh, Obdorsk, and Samoyed shamans. The tambourine shape is almost perfectly round" (1916b: 31–32). According to Soldatova, organologically, all tambourines of the Synya Khanty belong to the same type. This has an oval shape, a U-shaped handle (solid or composite), a frame with small posts laid along it, and brackets with rings and bells, attached to the frame on the inside. No images are present on the tambourine; the beater is covered with fur (Synskiye khanty, 2005: 179).

A. Kannisto and V.N. Chernetsov recorded the Mansi names of tambourine parts—frame, membrane, resonators, handle, beater, etc. in great detail (Kannisto, 1958: 411; Istochniki…, 1987: 38). Among the Mansi, "a tambourine is made mainly of elk-skin, sometimes of deer-skin and even of dog-skin, stretched raw over a hoop two to three vershoks wide and up to an arshin or more in diameter; when dry, the raw skin tightly stretches over the hoop, then it is lightly sewn to the rim, to which rings, chains, bells, and various other sound-making objects are attached; from the inside, two sticks are inserted crosswise, with the help of which the tambourine is held in the hand…" (Gondatti, 1888: 12).

Rudenko wrote that the rim of tambourine was made of larch growing at a sanctuary. After cutting down a tree for this purpose, a silver coin was driven into its stump (1958: Fol. 281, 297). According to Chernetsov, among the Mansi, "the shaman makes a tambourine by himself. The frame is made of spruce growing in a sacred place near the family clan *pupykh*" (Istochniki…, 1987: 156).

"On the upper Lozva and Sosva rivers, small posts [resonators – *A.B.*] are fastened along the outer edge of the tambourine; on the Sosva, there are usually… 14 or 21 of them, but there can also be 13, 15, 17, or 19. These posts are called *yur** 'animal of the magic tambourine'. This is why a tambourine on the Sosva River is called 'full drum occupied by seven *yur*-animals'" (Kannisto, 1958: 411).

A tambourine was also covered with skin of domestic deer (Shukhov, 1916b: 31), burbot (Shukhov, 1916a: 104; Baulo, 2017: 82), or bear (Sokolova, 2016: 558; Baulo, 2016b: 265). After the skin was dressed and before it was stretched onto the frame, a small round object with the size of a three- or five-kopeck coin was sometimes tied to the center of the membrane. This was done so that when the skin dried, there would remain some extra skin and the membrane would not burst. During the sacrifice, the membrane of the tambourine was sprinkled with the blood of the deer or horse. If repairs were needed, it was glued with cloth or fish skin.

The circumstances of manufacturing tambourines among the Synya Khanty in the late 20th century have been recorded. According to A.K. Kurtyamov from the village of Vytvozhgort, his father and uncle were shamans, and Afanasy himself was destined to become a shaman. To make a tambourine, one had to make a sacrifice at the sacred place in the basin of the Kempazh River—the area of residence of the Lyapin Mansi, who were the closest neighbors and often relatives of the Synya Khanty. During the ritual, they killed a white deer and took the skin with them. A spruce was cut down there. The stump of its trunk then lay for almost a year in a cult barn along with the dressed deerskin. Then, at the male sacred place in Vytvozhgort, during one day, Afanasy's uncle made a tambourine from the brought stump of the tree and skin (the tambourine was supposed to be made by the father, but he was already seriously ill). During the work, those present were surprised by the fact that the hoop bent easily, without cracks. After the tambourine was made, another deer was sacrificed (Synskiye khanty, 2005: 162–163).

The author of this study has collected information on 44 tambourines (see *Table*). The Table combines the data from collections by A. Ahlquist, A. Kannisto, I.N. Shukhov, V.N. Sokolova, I.N. Gemuev, A.M. Sagalaev, and A.V. Baulo, as well as exhibits from the collections of a number of Siberian museums, and presents some features of tambourines belonging to the northern Mansi (17 items) and Khanty (27 items) (Fig. 1). The shape of the tambourines is round (16 items) or oval (27 items). The handles are most often forked (26 items); 11 items have cross-shaped handles, of which eight are X-shaped; 5 handles are made in the form of the letter U; they are composite*. The handles of tambourines are usually abundantly wrapped with pieces of fabric: "The sorcerer and fortune teller are paid for their work. On the Upper Lozva, upon completion

*A *Yur* is a mythical beast often identified with a mammoth, etc., capable of causing landslides. On the Konda River, the *yur* was believed to be similar to a lizard. On the Northern Sosva River, it was represented as a fish; on the upper Lozva River, as a crayfish. The Voguls' songs collected by B. Munkácsi mention a "living", "crawling", "toothy", "winged", "legged", and "iron-bodied" *yur*. One of the songs says that many winged *yur* animals fly to the sacred tree of the spirit; if the upper wind shakes the branches, many *yur* fly up (Mifologiya mansi, 2001: 67).

*The tambourine of S. Eprin from the village of Lorovy (Shuryshkary District of the Yamal-Nenets Autonomous Okrug) stands out from the general series. All that remained of it was a rim; inside it, an arrow was stuck into the ring in two places, serving as a handle. It is known that on the Synya River, shaman tambourines had handles in the form of straight sticks (Synskiye khanty, 2005: 165).

Main features of shaman tambourines among the Northern Ob Ugrians

No.	Location	Owner	Date	Shape	Handle	Resonators	Additional information
1	2	3	4	5	6	7	8
			Mansi				
1	Rezimovo	S. Pakin	Late 19th century	Round	Forked	14	Handle designates the spirit of the tambourine
2	Vorsik-oyki sacred place	T. Puzin	1940–1950	"	"	14	–
3	"	"	1940–1950	Oval	"	14	Mask on the handle
4	Yasunt	I.K. Puzin	1940–1950	"	"	21	Tambourine as a patron spirit, two shirts
5	"	I. Nemdazin	Late 19th century	Round	"	12	–
6	"	"	First half of the 20th century	"	"	16	–
7	Shchekurya	A.I. Sainakhov	First quarter of the 20th century	"	"	21	Tambourine as a patron spirit, five shirts. Resonator in the shape of a joint
8	Saranpaul	…	Mid 20th century	"	"	14	–
9	Lombovozh	V. Albin	1940–1950	"	"	…	Mask of the spirit of the tambourine on the beater
10	"	P.E. Sheshkin	First half of the 20th century	Oval	Y-shaped, composite	16	Two masks of spirits carved on the handle
11	Khanglasam-paul	Puksikov	Early 20th century	Round	Forked	…	–
12	Yasunt	A. Tikhonov	Early 20th century	Oval	"	…	–
13	Upper reaches of the Northern Sosva River		1960s	…	"	14	–
14	Shomy	V.A. Adin	Early 20th century	"	Cross-shaped	21	Mask of a spirit carved on the handle
15	Menkv-ya-paul	Alkadyev	Early 20th century	"	"	15	Tambourine wrapped in a robe of brown color
16	Khulimsunt	T.I. Nomin	1970s	Round	Cross-shaped	9	–
17	Berezovsky District of the KhMAO–Yugra	…	First quarter of the 20th century	Oval	X-shaped	14	–
			Khanty				
18	Tutleim	Novyukhov	First half of the 20th century	"	Forked	14	“Dressed” in a large white shirt
19	"	"	First quarter of the 20th century	"	"	14	–
20	"	"	First half of the 20th century	"	Y-shaped, composite	14	Repair of the membrane with pieces of fish skin
21	Ishvary	Togochev	Early 20th century	"	X- shaped	9	–
22	Lorovy	S.G. Eprin	Early 20th century	"	Arrow	…	–
23	Khanty-Muzhi	N. Pastyrev	Mid 20th century	Round	Forked	27	–
24	"	…	Early 20th century	"	X-shaped	15	–
25	Kazym River basin	…	First third of the 20th century	Oval	"	27	–

Table (end)

1	2	3	4	5	6	7	8
26	Kazym-mys	…	Late 19th–early 20th century	"	"	…	–
27	"	…	Early 20th century	Oval	Forked	…	–
28	Lopkhari	…	Late 19th–early 20th century	Round	"	14	–
29	Evrigort	M. Longortov	First third of the 20th century	Oval	Y-shaped, composite	15	–
30	"	I. Rokhtymov	Mid 20th century	"	Not survived	…	Repair of the membrane
31	Tiltim	Longortov	First third of the 20th century	"	Forked	21	Three tambourines together
32	"	"	First third of the 20th century	"	"	14	Male and female figurines – spirits of the tambourine, husband and wife – inside; traces of blood on the clothing
33	"	"	First third of the 20th century	"	Y-shaped, composite	14	"Dressed" in a shirt made of thick woolen cloth of brown color
34	Loragort	E. Valgamov	Mid 20th century	Round	X-shaped	7	Used by father and son
35	Ovolyngort	Longortov	First third of the 20th century	Oval	Forked	21	Lay inside a black robe
36	Ovgort	A.N. Pyrysev	1970s	"	"	14	–
37	"	A.K. Kurtyamov	1980s	"	"	9	Wrapped in a men's shirt with traces of blood of a sacrificial deer. Male and female figurines (spirits of the tambourine, husband and wife) inside
38	Sacred place near the village of Khoryer	Murkin	Mid 20th century	"	"	11	Repair of the membrane; traces of blood thereon
39	"	"	Mid 20th century	Round	"	…	Traces of blood on the membrane
40	Yamgort	F.K. Pyrysev	1980s	Oval	"	12	–
41	Obdorsk	…	Second half of the 19th century	Round	Y-shaped, composite	14	–
42	Pashertsevy Yurty	…	Late 19th–early 20th century	Oval	X-shaped	…	–
43	Sacred place in the Polui River basin	V.I. Ataman	1960–1970s	Round	"	…	Seven masks carved on the handle. Handle and beater form an anthropomorphic figure
44	"	P.T. Rusmilenko	1960–1970s	Oval	Forked	…	–

of a shaman's work, people tie 15–20 kopecks into the corner of his scarf; then he ties the scarf with money to the handle of the tambourine" (Kannisto, 1958: 432). The number of resonating posts varies: 7 (1 item), 9 (3), 11 (1), 12 (2), 14 (14), 15 (3), 16 (2), 21 (5), and 27 (2). Since a tambourine was perceived as a shaman's riding deer, in two cases resonator posts made in the form of deer-joints were recorded.

Patron spirits and guardian spirits of tambourines

The handle of tambourine is referred to as "*koipyng pupyg*— the patron spirit of the magic tambourine. Its longer ends represent the legs of the patron spirit; the shorter ends, his head" (Kannisto, 1958: 411). The figure of the patron spirit is most clearly represented on the tambourine of the Khanty

Fig. 1. Shamanic tambourines with forked (*a*), composite (*b*), cross-shaped (*c*), and X-shaped (*d*) handles.
a – late 19th century, Mansi; *b* – second half of the 19th century, Khanty; *c* – early 20th century, Mansi; *d* – mid-20th century, Khanty.

man V. Ataman from the village of Zeleny Yar. The beater is tied to the sticks of the handle at the place where they intersect at the back. The upper part of the beater is covered with a piece of reindeer wool; the other end is egg-shaped. Thus, the crossed sticks and the beater form a semblance of an anthropomorphic figure wearing a hat and having a distinctively male feature—the genitals (Fig. 2).

"Among the lower Khanty, faces of seven spirits whom the shaman invoked during the shamanic ritual were sometimes carved on the …handle" (Rudenko, 1958: 296) (see also (Ivanov, 1970: 60)) (Fig. 3). "The handle is fork-shaped, with the image of a face in the fork. According to the shaman, this is St. Nicholas, who helps him with fortune-telling" (Shukhov, 1916b: 31–32). Anthropomorphic masks on the handle have also been observed on the tambourines of the Lyapin Mansi (Gemuev, Sagalaev, 1986: 25; Gemuev, 1990: 102).

The tambourine's beater has a narrow handle and wide striking surface covered with skin from a deer's forehead. Some items have anthropomorphic masks carved on them, representing the patron spirit of the tambourine. Shukhov described a birch beater among the Kazym Khanty that "had an image of St. Nicholas on the handle" (1916b: 31–32). The author of this study has observed masks on the handles of beaters among the Mansi Albins in the village of Lombovozh, the Khanty Artanzeevs in the village of Yamgort, and the Khanty Shiyanovs in the village of Lokhpodgort (Fig. 4).

Fig. 2. The figure of the patron spirit of the tambourine, composed of a handle and beater. Sacred place of the Khanty in the Polui River basin.

Fig. 3. Representations of seven spirits on the tambourine handle. The northern Khanty.

The Synya Khanty described a tradition of shaman patron spirits "living" inside the tambourine. The spirits formed a married couple and acted as shaman's servants during the ritual. The first such tambourine was kept in the attic of a house in the village of Tiltim. It contained the figures of two spirits, husband and wife (Fig. 5, *a*). Both were based on wooden anthropomorphic images. The male figurine was wearing several shirts and black coat buttoned with three buttons. A female figure wearing a white reindeer-fur coat was belted with a colorful kerchief. Under the coat, there were several shirts with coins of 5 kopecks from 1931, 10 kopecks from the 1930s, and a scrap of newspaper from 1942 inside. Traces of sacrificial blood were visible on some shirts. The second tambourine was kept in the village of Ovgort. It was wrapped in a man's shirt with traces of the blood of a sacrificial deer. Figurines of a man (*kho*) wearing a white deerskin parka and a woman (*ne*) wearing a fur coat and scarves (Fig. 5, *b*) were inside the tambourine. These were the spirits of the tambourine, husband and wife. The figures were made by the mother of the tambourine's owner.

The Lyapin Mansi have another tradition: tambourines are "guarded" by *koipyng-pupygs* ('tambourine spirits'), acting as protectors*. These are placed at the back wall of the attic, next to the tambourine (Fig. 6). The figure of *koiping-pupyg* usually consists of seven votive arrows wrapped in cloth, with several shirts and robes placed over it. The head is represented by a cone-shaped hat

Fig. 4. Beater with a mask of the patron spirit. The northern Khanty.

*These were recorded in the home shrines of the Mansi: Puzins and Khozumovs in the village of Yasunt, Sainakhovs in the village of Shchekurya, and Merova in the village of Khoshlog. In Yasunt, there were two tambourine guards at once—male and female.

Fig. 5. Tambourines with figures of patron spirits. The Synya Khanty.

Fig. 6. *Koipyng-pupyg* and shaman tambourine—family patron spirit. The Lyapin Mansi.

made of cloth; the plume is made of seven tassels. The length of the figures is 50–75 cm.

Shamanic rituals with tambourine

Unfortunately, there are no detailed descriptions of rites with the tambourine, and not so many fragmentary reports from eyewitnesses. The most complete description of the shamanic rite was left by N.L. Gondatti: "During the performance, the shamans… have… in their hands a tambourine, which they occasionally strike with a special stick covered with skin of some animal… all rattles make loud noise with strong and fast movements made by the shamans during the invocation of gods. The tambourine itself, when struck, makes a distinct sharp sound, especially if it is held over the fire for some time beforehand; these sounds are pleasing to the gods… Most often, Mir susne khum is invoked… for his invocation, people most often use nights, when he makes his rounds around the earth; to do this, the fire is extinguished in the dwelling where the fortune-telling takes place; the shaman beats the tambourine several times and then everything falls silent and a deathly silence ensues, in the midst of which the sound of horses' hooves can apparently be clearly heard, ending with a crack indicating the god's entrance into the dwelling; after which everything stops and the shaman, often stretched out on the floor, begins to report what the god has told him… <…> Once, during a smallpox outbreak, one Ostyak's entire family died, and finally he also fell ill. He called for the shaman, who began to beat the tambourine, whisper something to himself, and finally started to dance; he spun and whirled all night, and then announced that the Ostyak would die…" (1888: 11–16).

V.V. Bartenev, a revolutionary exiled to Obdorsk, was present at a shamanic session: "The shaman comes with an assistant who repeats his words, and with a penzyar (a tambourine made of reindeer skin, which is struck with a beater). The divination takes place in the following manner. After entering the chum, the shaman sits down next to his assistant, and all those present sit down as well. Then the tambourine is heated so that the skin stretches tighter: the sound becomes louder. The shaman begins to beat the tambourine, at first quietly and once in a while, then louder and more often, finally, with all his might. At times the beat weakens, and then these strange sounds intensify again, dully spreading across the tundra. At the same time, the shaman, and those present following him, shout in a drawn-out voice: 'ko-o-o-o! ko-o-o-o!' This is done to invoke the spirits. When the spirits flock to the shaman, he begins to question them and passes the answers on to those present" (1896: 87–88).

Feldsher L. Korikov described his trip to the village of Khurumpaul in December 1898 to see a sick Vogul. A small chest with a tambourine lying on it was in the yurt above the bunks. The sick man refused help and ordered a shaman to be called. A gray-haired old man entered, took the tambourine from the shelf, put on expensive brocade robe, and began healing. A sharp blow on the tambourine was heard; then more blows followed "accompanied by a trembling old man's voice". Finally, the sound of the tambourine died away. "Suddenly, a heavy sigh broke the grave silence. <…> At last, a quiet, distant, but impressive voice was heard. It was the shaman speaking. He finished communicating with Torm* and now announced the sacrifice required by the god" (Korikov, 2003: 59–62).

According to A. Kannisto, "on the Upper Lozva, the shaman uses a tambourine if someone falls ill. He sits in the room in front of the fireplace with burning fire, or in the chum near the hearth and warms the tambourine, singing a magic song (*pupyg kaisov*)… Singing of the *kai sov* is accompanied by eating fly agarics…" (Kannisto, 1958: 432–433). One of the invocatory songs recorded by Kannisto also mentions actions with tambourine:

A tambourine filled with seven *yurs*,
A tambourine filled with six *yurs*,
They tune (rock).
Appointed by the spiritual patron for the dark night,
Appointed by the *Torum* for the dark night
They tune (rock).
……………….
A tambourine filled with seven inserted (heads) *yurs*
I hear, they tune,
A tambourine filled with six inserted (heads) *yurs*
I hear, they tune

(Mansiyskaya… poeziya, 2017: 35).

V.N. Chernetsov described a ritual associated with the Mansi idea of a person's second soul, *urt*: "A man died. If someone he knew is in an open place or outside the house that night or the next night, the *urt* of the deceased attaches itself to that person in order to take him away with it. The person to whom the *urt* attached itself then feels unwell or heavy. In that case, a shaman is called… The shaman then takes the soul that attached itself to the living person. The shaman strikes a tambourine, rubs the tambourine against the person to whom the soul has attached itself, and then says: 'Well, now it has shaken itself out'" (1959: 131).

M.N. Gogoleva, a resident of the village of Aneevo, said: "One shaman in the dark at night in his house hits arrowheads against each other, and another shaman beats a tambourine, and all in tune. And then he speaks coherently, the one who beats the tambourine; he is the main one. And then he says: don't let the child out on the street or what to feed him" (Baulo, 2017: 82). Recalling how he performed a shamanic rite, informant P.F. Merov assumed a distinctive posture: a tambourine in his left hand skin side down, face raised up, gaze to the left not looking at the tambourine (Baulo, 2016b: 265).

The tambourine after the shaman's death

The fate of a tambourine after the death of its owner was not clear. Rudenko wrote about the northern Khanty that "upon the death of fortune tellers, their tambourines were placed near the grave, and tambourines of shamans were hung on a special tree at the sanctuary. Tambourines were passed down by inheritance" (1958: 297). Among the Kazym Khanty, "upon the death of a shaman, the tambourine is pierced and kept in a barn at the sacrificial site" (Shukhov, 1916b: 32). Informant A.D. Tarlin said that when his grandfather, a shaman, died, "they heated the tambourine strongly over a fire and hit it. The skin burst. Then they took everything to the forest, and left it for the gods. If you do not tear it up and take it to the forest, there will be misfortunes in the family" (FMA, 1998, village of Yuilsk). After the death of A. Pyrysev from the village of Yamgort, his tambourine was buried in the forest along with other sacred objects (Synskiye khanty, 2005: 176). Among the Sosva Mansi, "when a tambourine breaks through, the skin is hung on a tree in the place where it broke" (Istochniki…, 1987: 156). Their informants also mentioned that the shaman is buried separately, and "the tambourine is then chopped into pieces… and everything is thrown there, into the grave" (Snigirev, 2013: 524).

Tambourines of the northern Ob Ugrians could have a different fate: after the death of a shaman, these received the status of a family patron spirit whose anthropomorphic appearance was emphasized by "dressing" the tambourine in men's shirts. The author of this study first encountered this practice in 1999 in the village of Shchekurya among the Mansi. Here, in the attic of the house of A.P. Sainakhov, the tambourine of his grandfather A.I. Sainakhov (repressed in 1936) has survived, "dressed" in five specially sewn shirts with long sleeves (Fig. 6), and the owner was not even aware that a shaman tambourine was inside the clothes (Baulo, 2013: 186). In the attic of the house of I. Puzin in the village of Yasunt, his grandfather's tambourine was also kept, "dressed" in two shirts, and was revered as a family patron spirit (Fig. 7, *a*). In the village of Menkv-ya-paul, an old shaman tambourine of the Alkadyevs was in the attic, wrapped in a brown man's robe (Gemuev, Baulo, 1999: 101).

A similar tradition of transforming a tambourine that has fallen out of use into a family patron spirit has also been recorded among the Khanty. The Novyukhovs' tambourine in the village of Tutleim was "dressed" in a

*Torm—from Torum ('god, deity').

a b

Fig. 7. Shamanic tambourines that became family patron spirits of the Mansi Puzins (*a*) and the Khanty Longortovs (*b*).

large white shirt. Judging by the coins of 1874, 1931, and 1946, preserved in pieces of cloth, it was used in the first half of the 20th century, after which it became a part of the family household gods (Baulo, 2016a: 282, fig. 451). Among the Synya Khanty in the village of Vytvozhgort, a white men's shirt was put on the old tambourine of the Kurtyamovs, and a shirt made of brown woolen cloth with short sleeves was put on the tambourine of the Longortovs in the village of Tiltim; its lower part was tied with a cord—the figure was belted (Fig. 7, *b*) (Ibid.: 288).

Conclusions

The topic of shamanism is one of the most neglected roday, largely because the older generation still remembers the years of persecution that the adherents of traditional cults had to endure. Nevertheless, judging by the published sources and stories of informants, in the second half of the 20th century, shamans continued to perform their functions in a number of villages inhabited by the northern Khanty and Mansi. These functions were primarily limited to fortune telling and healing; more rarely, to leading rituals at sanctuaries. The word "shamanism" has been simplified to a certain extent. Today, turning to a patron spirit for a person means "to shamanize", sacred places are colloquially called "shamanic", and people who perform some kind of rite are often considered to be shamans.

Special clothing of shamans and fortune tellers among the northern Ob Ugrians in the 20th to early 21st centuries has not been observed; caftans, robes, and hats were multifunctional. They may rather be called ritualistic—for shamanic rites, bear festivals, and dressing the patron spirits. Almost the only attribute of a shaman is the tambourine.

Notably, the total number of tambourines described by predecessors and encountered the author's field works is not so large, amounting to 60–70 items. For example, the author of this article knows over 400 attributes of the cult of *Mir-susne-khum*—sacrificial covers, warrior belts, and helmets with the image of a galloping horseman. Modern data (20th to early 21st centuries) show the predominance of the attributes of the Heavenly Horseman in the religious and ritualistic realm over those of shamans and fortune tellers (even if we add cold weaponry used in fortune telling to tambourines). In fact, there are very few descriptions of shamanic rites with a tambourine.

The small number of tambourines and descriptions of rites with them tend to confirm the point of view on the underdeveloped shamanism among the northern Ob Ugrians, although the shamanic practices of these groups produced some original features.

1. Since the tambourine was understood as the shaman's riding deer, some tambourines had small resonating posts made in the form of deer joints.

2. Figures of spirits of the tambourine, usually husband and wife, are made together with tambourines. Masks on the handle or beater also represent spirits. Among the Lyapin Mansi, tambourines are accompanied by the figures of *koipyng-pupygs*, their guards.

3. During animal sacrifice in the course of a shamanic rite, the membrane of the tambourine, as well as the clothes of the figures of his spirits, were sprinkled with deer or horse blood.

4. There are rare examples of using a tambourine after its owner's death as a family patron spirit, which is confirmed by the clothing observed on it.

5. During shamanic rites and fortune telling, tambourines could be replaced by musical instruments (*sankvyltap*, *nars-yukh*) or sabers.

In the 20th to early 21st centuries, tambourines were common in the following main local areas: the Lyapin River basin for the Mansi, and the Synya River basin for the Khanty. The sources of these rivers are located close to each other, and in the 18th–19th centuries this territory was a contact zone of the Ob Ugrians and Nenets people. In general, we should speak about the influence of the Nenets traditions of making and using tambourines on the northern Khanty and Mansi.

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Principal Results of the Project Implemented by the Research and Educational Center for Altaic and Turkic Studies "Greater Altai"

We outline the result of collaboration by a team of more than sixty researchers from 22 Russian and 13 foreign institutions under the project implemented by the Research and Educational Center for Altaic and Turkic Studies "Greater Altai" in 2022–2023. Six archaeological and four ethnographic expeditions were carried out in the Russian Federation, the Republic of Kazakhstan, and the Kyrgyz Republic. Findings concern the origin of the Turkic ethno-cultural complex and its spread across Central Asia. Archaeological surveys revealed new sites, many of which were excavated, and some were included in the museum projects. Extensive photographic and volumetric documentation was conducted. In the course of ethnographic expeditions, Turkic epic texts were collected, many elements of traditional culture were revealed, showing parallels between Altaic and Kyrgyzian traditions. Also ethnographic parallels were documented between Slavic and Turkic cultures of the Greater Altai. These were used to elaborate the concept of Slavo-Turkic unity, which has both theoretical and practical implications.

Keywords: *Greater Altai, international cooperation, expeditions, Turkic history, archaeology, ethnography, Slavo-Turkic unity.*

Introduction

The relevance of uniting the scientific community in the Eurasian space is conditioned by the logic of the development of historical science, the development of information technologies, and the modern international political realities. A comprehensive concept of the historical and cultural unity of the Slavic and Turkic peoples of Central Asia can only be created through the joint efforts of scientists from different countries. The Greater Altai area includes the territories of several polyethnic and multi-confessional states: Russia, Mongolia, Kazakhstan, China, and Kyrgyzstan. The population of the region is linked by the historical and cultural roots, as well as by the centuries-old traditions, all of which conditioning the specific features of the Turko-Slavic world. In order to study the cultural and historical heritage of the Slavic and Turkic peoples, the Research and Educational Center (REC) for Altaic and Turkic Studies "Greater Altai" was established in 2019. It happened on the initiative of Altai State University (Barnaul) and Gorno-Altaisk State University (Gorno-Altaisk) at the First International Altaic Forum. Both universities are located in the heart of the Greater Altai area. At present, it is an international team of scholars united by the idea of studying and preserving the cultural and historical unity of Slavic and Turkic peoples. The research process involves specialists from different scientific fields, which makes it possible to implement the interdisciplinary approach. The REC for Altaic and Turkic Studies "Greater Altai" integrates many leading researchers to form an objective and holistic view of the origin and the historical and cultural unity of Slavic and Turkic peoples, as well as to posit Altai as the historical homeland of the latter (Zemlyukov, Grushin, 2021). Some new aspects of the processes of formation and distribution of the Turkic cultural complex, as well as the interaction between Slavic and Turkic peoples in various historical periods, are revealed on the basis of major international interdisciplinary studies, including historical, archaeological, ethnographic, legal, and other reconstructions.

The main objectives of the project "The Turkic-Mongolian World of the Greater Altai" and of the Research and Educational Center (REC) were formulated as follows:

1) the establishment of a world-class international research center for Altaic and Turkic Studies on the basis of the REC;

2) the creation of a permanent research and educational team of scientists, teachers, postgraduates, and masters from the universities of Central Asian countries on the basis of the REC;

3) the development of the concept of Slavo-Turkic unity and its realization in the field of international research and educational cooperation;

4) the expansion of research and educational co-operation with the universities of Eurasian countries.

For the first time in modern history, an international team consisting of more than 60 researchers has been assembled within the framework of one research project. The team comprises leading scholars in the field of Turkic Studies from 22 Russian and 13 foreign research and educational centers. It includes scientists from Russia, Kazakhstan, Kyrgyzstan, and Uzbekistan. The REC "Greater Altai" has become a platform for the interaction and partnership between leading universities and research centers of Russia and Central Asian countries. More than 50 universities and research institutions in Eurasia have signed the co-operation agreements.

A qualitative step in the international cooperation was the opening in 2023 of the representative offices of the REC in Uzbekistan and Kyrgyzstan on the basis of Samarkand State University and Kyrgyz National University, respectively. Preparations are currently underway to open a similar center in Kazakhstan. The established system of international co-operation has already demonstrated its efficacy in the scientific, educational, and information spheres. At present, the research work of the REC "Greater Altai" is organized in five project groups headed by leading experts in the field of Altaic and Turkic Studies from the universities and research centers of Central Asian countries. The researchers concentrate their efforts on solving several principal scientific problems.

1. The identification of specific features of the formation and distribution of the Turkic ethno-cultural complex in Central Asia on the basis of archaeological, ethnographic, linguistic, and written sources.

2. The comprehensive analysis of political, legal, and confessional processes in the Turkic world of the Greater Altai area both in historical retrospective and in the modern period.

3. The formation of a holistic view of the historical and cultural interaction between Slavic and Turkic peoples, as well as the development of the concept of the Slavo-Turkic unity.

4. The assessment of modern perception of the history of Slavo-Turkic relations by Turkic peoples of Central Asia, and the assessment of its reflection in the world information space.

In the present article, we will review the main results of the Research and Educational Center activities aimed at identifying the specific features of the formation of the Turkic ethno-cultural complex and its spread in the Greater Altai area. Notably, the historiography on this scientific problem covers several centuries. Among the scientists who made a significant contribution to the development of the topic at the level of monographs are historians, ethnographers, linguists, and archaeologists, such as N.Y. Bichurin (1950), S.E. Malov (1951), A.N. Bernshtam (1952), L.N. Gumilev (1993), N.V. Kyuner (1961), A.A. Gavrilova (1965), L.R. Kyzlasov (1969), V.D. Kubarev (1984), V.I. Molodin (Baraba…, 1988), Y.S. Hudiakov (1991), K.S. Tabaldiev (1996), V.A. Mogilnikov (2002), A.M. Shcherbak (2001), S.G. Klyashtorny, D.G. Savinov (2005), G.V. Kubarev (2005), V.V. Gorbunov, A.A. Tishkin (2022), N.N. Seregin, S.A. Vasyutin (2021), and others. Among the summarizing fundamental publications of recent years, which include sections devoted to the medieval period, we can name "The History of Siberia" (Istoriya Sibiri, 2019: 287–534) and "The History of Altai" (Istoriya Altaya, 2019: 310–353). It is also appropriate to mention here the first volume "The Turkic World in the 6th–12th Centuries AD" of the collective monograph "Chronicle of the Turkic Civilization" (Letopis…, 2023) prepared by an international team of scholars under the project "Greater Altai". Despite the substantial historiography, many aspects of the Turkic Studies, especially the archaeological aspects, remain underexplored. This research continues the work of our predecessors.

Results of the activity of the REC for Altaic and Turkic Studies "Greater Altai"

The work on the formation of some new archaeological and ethnographic sources was carried out within the framework of the identified research issues. For that purpose, ten international expeditions were undertaken from 2021 to 2023: six archaeological, and four ethnographic. More than 70 scientists, postgraduates, and students from six research and educational institutions of Russia and Kazakhstan took part in the archaeological expeditions. The work was carried out in the Altai Territory, the Altai Republic, and Kazakhstan. During the expeditions, an extensive scientific program was implemented, including the identification of new sites, the photographic and 3D documentation of the structural features of sites, as well as the excavation and museumization of the archaeological sites of pre-Turkic and Turkic times. We shall focus on the main results of the archaeological research of the international expeditions "Greater Altai: the Turkic Heritage".

Sentelek – 2022–2023. The studies were conducted in the Charyshsky District of the Altai Territory. The excavations of the non-contemporaneous cemeteries of Ust-Teplaya, Urochishche Balchikova-3, and Malaya Tatarka-2 involved researchers from Altai and Kemerovo State Universities, the Institute of the History of Material Culture RAS, and Pavlodar State University of the Republic of Kazakhstan. Some undergraduate, graduate, and postgraduate students from those institutions also took part in the excavations.

The archaeological complex of Ust-Teplaya is located on the above-floodplain left-bank terrace where the Teplaya River flows into the Charysh River, 200 m to the east-northeast of the "Zazubra" Tourist Center. The site was discovered by P.I. Shulga in 1996. In 1999, the researcher recorded eight sites in the form of mounds and stone alignments of various sizes. In 2000, the Research and Development Center "Heritage" and the Barnaul Laboratory of Archaeology and Ethnography of Southern Siberia of the Institute of Archaeology and Ethnography of the Siberian Branch of the Russian Academy of Sciences (IAET SB RAS) and of Altai State University conducted emergency works under the direction of P.I. Shulga. In the course of the works, eight stone mounds were excavated (Grushin, Shulga, Fribus, 2022: 173).

During the international expeditions in 2022–2023, seven stone mounds and two altars were investigated at the site. The identified constructions, features of the burial rite, and the finds made it possible to establish the cultural and chronological affiliation of these objects. The earliest of the studied complexes (three mounds) was attributed to the Afanasyevo culture of the 31st–28th centuries BC (Ibid.). It was represented by small above-ground burial structures of rounded or oval shape, made of flagstone, one of them having a crepidoma made from stone slabs. The buried people were laid in shallow pits on their backs, with their heads to the west and their legs being bent with the knees up. Four excavated mounds were attributed to the Pazyryk culture of the Early Iron Age (6th–5th centuries BC). The rounded mounds, 6–10 m in diameter, were made of both flagstone and gravel. Burial chambers made of wood or stone slabs were built in the grave pits up to 1.8 m deep. The deceased were laid on their backs with their heads to the south-west. The features of the burial rite included the accompanying burials of horses, secondary burials, and sacrificial food (ram). The grave goods were represented by some ceramic vessels, a bronze dagger in a wooden scabbard, a bronze mirror, some iron knives, and some ornaments (torques, earrings, headdress details, etc.).

The cemetery of Malaya Tatarka-2 is located 7.2 km south-east of Sentelek village, on the left bank of the Charysh River, 200 m north-west of the confluence of the Malaya Tatarka River. The site was discovered by Shulga in 1991. In 2022–2023, three stone mounds were excavated, extended in a chain along the N–S line. The above-ground burial structures included enclosures of flat slabs laid flatwise on top of each other in two or three layers. In the center, there was a burial chamber of rounded shape, made of vertically imbedded stone slabs. The buried people were laid in shallow pits on their backs, with their heads to the west and their legs being bent with the knees up. The grave goods included ceramic vessels and bracelets made of stone and iron beads. The construction features of the mounds, the burial rite, and the finds allowed us to attribute the sites to the Afanasyevo culture of the 32nd–27th centuries BC.

Materials of the Turkic times were obtained during the excavation of burial mounds at the Urochishche Balchikova-3 cemetery, located on the left bank of the Sentelek River on the second above-floodplain terrace, 3.4 km upstream of the Sentelek village (Fig. 1). The site was discovered by Shulga in 1991. In the period from 1991 to 2000, the elite burial mound of the Pazyryk period was partially cleared, nineteen stone stelae were restored to the east of the mound, five medieval mounds were excavated to the north-east of the "royal" one, and four more burial mounds were cleared (Shulga, Demin, 2021).

The works in 2023 were a logical continuation of the excavations of the site carried out earlier. Their aim was to investigate the medieval burial mounds to the north-east of the "royal" mound. Three burial mounds were excavated; two of them turned out to be without burials; the third one was an unlooted burial of a man with a horse and a ram (Fig. 2). Details of the horse equipment were found—cheek-pieces, horse-bits, buckles, and plaques. According to the features of the burial rite and the grave goods, the burial can be attributed to the Turkic times and tentatively dated to the 8th–9th centuries.

Notably, more than 40 burial mounds were recorded at the Urochishche Balchikova-3 cemetery in 2023. Some of the mounds undoubtedly belonged to the Turkic times, as evidenced by the presence of the stelae near the eastern fringes of the mounds. This is the largest Turkic cemetery on the territory of Northern Altai, marking the northern border of the distribution of the ancient Turkic culture and the contacts with the nomads of the Altai steppes.

Fig. 1. The Urochishche Balchikova-3 cemetery (view of the "royal" burial mound and its periphery from the north-west).

Fig. 2. The burial of a man with a horse at Urochishche Balchikova-3 (taken from the north-west).

Fig. 3. Turkic funeral enclosure after the reconstruction. *Photo by S.P. Grushin*.

We can state that in the Charyshsky District of the Altai Territory there is a large number of burials of various historical periods, from the Chalcolithic to the Early Middle Ages. In this area, there is a necropolis with numerous burials from the Early Turkic period. Further archaeological excavations will make it possible to open new pages in the history of the Turkic peoples of the Greater Altai area. In order to preserve the cultural heritage, including the Turkic one, it is necessary to withdraw the territory of the site from the economic use and to create a cluster such as a "landmark site".

Kalmakkyrgan – 2022, Semiyarka – 2023. The surveys were carried out in the Maysky and Ust-Kamenogorsky districts of the Pavlodar Region of the Republic of Kazakhstan. There were 25 participants—scientists, undergraduate, graduate, and postgraduate students—from the Margulan Institute of Archaeology, as well as from Altai and Pavlodar State Universities. A total of five sites from the pre-Turkic and Turkic times were studied. Three Turkic funeral enclosures were discovered and studied (Fig. 3), a stone mound of the pre-Turkic time was excavated, and a stone sculpture was discovered (Merts V.K., Merts I.V., Demidkova, 2020). The complex of settlements in the Kalmakkyrgan Mountains was investigated for the first time. The obtained materials will provide reliable data for the reconstruction of the subsistence system of the early medieval nomads. The field data analysis is currently underway.

Ulagan – 2022, Kosh-Agach – 2023. The main task of the

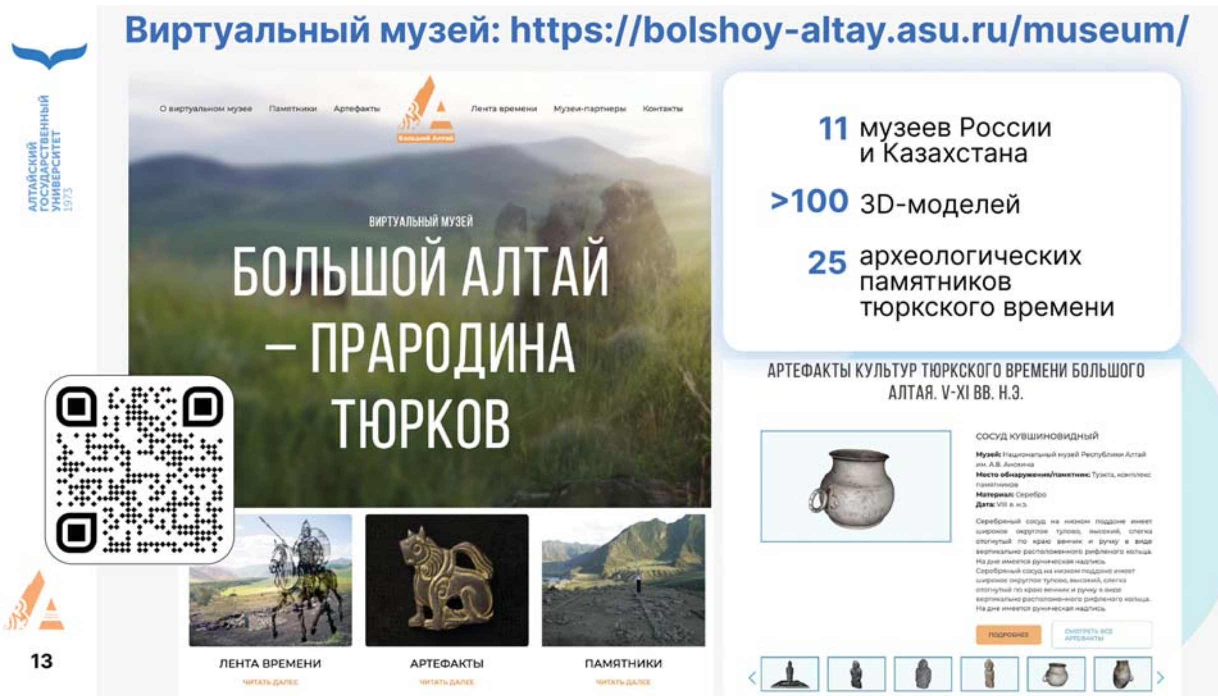

Fig. 4. The virtual museum "Greater Altai—the Ancestral Home of the Turks".

expeditions was recording and monitoring of the already known archaeological sites of the Turkic times in the Shebalinsky, Ongudaysky, Ulagansky, and Kosh-Agachsky districts of the Altai Republic. The archaeological survey was carried out by researchers from Altai, Kemerovo and Pavlodar State Universities. More than 40 sites were surveyed. The obtained materials were used to create a catalogue of the Turkic archaeological sites in the Altai. The first issue of the catalogue has already been published (Rannesrednevekoviye pamyatniki…, 2022), and the second issue is currently in preparation.

One of the tasks of the research activity of the REC is to create a virtual museum "Greater Altai—the Ancestral Home of the Turks" as a platform uniting the information resources of many institutions that are engaged in the preservation and representation of materials of the Turkic era of the Greater Altai area (Fig. 4). At present, the project includes 11 museums in Russia and Kazakhstan. During the two years of its implementation, over 100 3D-models have been created of the most outstanding exhibits and, importantly, of 25 archaeological sites of the Turkic times. Among the exhibits, there are stone sculptures, items of toreutics, items of armour, details of outfit, ornaments, horse harness, etc. All exhibits are publicly available on the website of the Research and Educational Center "Greater Altai".

The main section of the virtual museum integrates visual images of the most essential exhibits from the pre-Turkic and Turkic times. It contains 3D-models of the most impressive and significant objects of art and material culture of the medieval Turks. In addition to the main section, there are other units, presenting information about the archaeological sites of the Turkic times in the Greater Altai, as well as about the ancient and medieval history of the Turks (Frolov, Grushin, 2021).

The new materials obtained and the analysis of the already available archaeological data have confirmed the model of emergence and development of the ritual practice of the early medieval Turks of the Greater Altai. The results of excavations of the memorial and funeral sites demonstrate that the Turkic culture was formed on the basis of two main components: the local one, represented by the complexes of the Bulan-Koba culture of the Xianbei-Rouran time; and the alien one, associated with the population whose earlier history has not yet been provided with any archaeological materials (Tishkin, Seregin, 2011: 28). This is confirmed by the written sources—the Chinese chronicles (Tishin, 2023).

Another research task is to identify the ethnographic parallels between different Turkic peoples of the Greater Altai countries, in particular, to do a comparative study of various aspects of the material and spiritual culture of the Altaians and the Kyrgyz. Such research was carried out in 2021–2023 during four international ethnographic expeditions in the Republic of Altai and Kyrgyzstan. These are the places of residence of the Altai and Kyrgyz peoples, which preserve the main features of the traditional subsistence system (Oktyabrskaya et al., 2022; Nazarov, 2023; and others):

1) "Greater Altai: Russia – Kyrgyzstan – 2021", September 10–28, 2022, in the valley of Lake Issyk Kul;

2) "Greater Altai: From Altai to Chong-Alay", July 2022, in the Chong-Alaysky District of the Osh Region of the Kyrgyz Republic. The participants were 15 scientists from Russia and Kyrgyzstan (Altai State University, Osh State University, and Balasagyn Kyrgyz National University);

3) "Greater Altai: Turkic Heritage – 2022", August 2022, in the Republic of Altai. The participants were 15 researchers from Russia and Kyrgyzstan (Altai State University, Gorno-Altaisk State University, Jamgerchinov Institute of History, Archaeology and Ethnology of the National Academy of Sciences of the Kyrgyz Republic);

4) "Greater Altai: From Altai to Chatkal", July 1–10, 2023, in the Chatkalsky District of the Jalal-Abad Region of the Kyrgyz Republic.

The ethnographic expeditions and processing of the obtained materials have revealed parallels in the cultural phenomena of the compared ethnic groups (Fig. 5). These reflect the ethnogenetic and historical-cultural ties between the Altai and Kyrgyz peoples in ancient time and in the Middle Ages. Common stages in the ethnic history of these peoples, which had had common ancestors in the past, predetermined the presence of a large number of similar aspects in their modern culture. Notably, being ethnogenetic in nature, these aspects were adapted to the specific environmental, social, and cultural settings of different regions where the Altai and Kyrgyz peoples live today: the Altai-Sayan and Tien Shan mountain systems, respectively (Fig. 6). The expedition teams working both in Russia and Kyrgyzstan included the representatives of universities and research institutions from both countries, which ensured the effectiveness of the research in identifying the similarities and specific features of the compared cultures.

Fig. 5. Kyrgyz craftswoman making a shyrdak felt carpet. The Chatkalsky District of the Jalal-Abad Region of the Kyrgyz Republic. *Photo by I.I. Nazarov*.

In 2021–2023, within the framework of the research area "Ethnography and Cultural Studies of the Greater Altai", the ethnographic parallels between the Slavic and Turkic peoples of the Greater Altai countries were

Fig. 6. A summer camp of Kyrgyz cattle breeders (*jailoo*) in the Chong-Alaysky District of the Osh Region of the Kyrgyz Republic. *Photo by I.I. Nazarov*.

revealed, the material on the Turkic epic was collected, and the contextual analysis of Turkic lexical items was carried out on the basis of the epistolary heritage of the Altai Ecclesiastical Mission of the mid 19th to early 20th centuries. It has been proved that the key factors of the integration of Turkic and Slavic peoples are sacral values, which allow the identification of not only ethno-national cultural features of these peoples, but also substantive (common views, ideas, and traditions) and civilizational (common grounds for building and strengthening the world order) features. The ethnographic research of the REC includes projects aimed at studying Turkic vocabulary. More than 955 word forms of the appellative lexicon of the Turkic origin have been detected in the course of the works. The models involved in formation of these words have been identified (Dmitrieva, Sorokina, Titova, 2023). The study of the epic heritage of Slavic and Turkic peoples of Central Asia is aimed at identifying spiritual constants and cultural archetypes. In the study of the general and local aspects in the epic, the ideological-axiological approach has been applied, which has made it possible to analyze the initial universal spiritual archetypes in the epic texts and the worldview models.

Conclusions

The result of the multidisciplinary study carried out by the international project teams of the REC was the publication of the first volume “The Turkic World in the 6th–12th Centuries AD” of the monograph “Chronicle of the Turkic Civilization” (Letopis…, 2023). The authors of the project tried to embody a holistic picture reflecting all the historical stages and civilizational forms of coexistence of Slavic and Turkic peoples of Russia and Central Asian countries in the concept of their historical and cultural unity. This is a theoretically substantiated system of socio-cultural and worldview values and practices based on the historical and civilizational heritage of these peoples. It relies on their common history, taking into account the experience of co-habitation, the inter-ethnic interaction, and being part of the Turkic, Mongolian and Slavic state formations, namely the Turkic Khaganates, the Golden Horde, the Russian Empire, the USSR, and the CIS.

The concept has important theoretical and practical relevance. The millennial Turko-Slavic interaction is the foundation for integration between Russia and the countries of the Central Asia region, which is based on the ethnogenetic, historical, territorial, state-legal, and cultural backgrounds, and allows achieving greater results with lower social costs. The Slavo-Turkic unity is the main conceptual core of the integration and of its future development and strengthening. This is a Slavo-Turkic, Christian-Muslim, and socially unifying geopolitical project of the Eurasian Union. The fundamental principles of the concept are also relevant for strengthening the Russian state system, implying the Slavo-Turkic unity within the Russian Federation.

Under the assignment of the Ministry of Science and Higher Education of the Russian Federation, the Program of Development of the Research and Educational Center for Altaic and Turkic Studies “Greater Altai” for the years 2023–2030 has been developed, presenting the project of promoting the concept in question as an instrument of the Russian influence on the research and educational space of the Central Asian countries.

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Bony Labyrinth in Upper Paleolithic Individuals Buried at Sungir

The bony labyrinth of the Sungir individuals was studied using the computed tomography scanning on an industrial Phoenix X-ray device. Three-dimensional modeling and visualization were carried out with special software. Crania of an adult (Sungir 1) and two children (Sungir 2 and 3) were analyzed. Findings reveal that bilateral asymmetry is insignificant. Individual variation range suggests that the group is morphologically homogeneous. Comparison of averages with those of Neanderthals and anatomically modern humans demonstrates overall similarity with the latter and significant difference from the former in key traits. Based on results of the discriminant analysis, children unambiguously fall in the H. sapiens group, while the adult is halfway between the latter and the Neanderthal sample. But such a finding is neither exceptional nor even rare. A Neanderthal-like morphology of the bony labyrinth (large lateral semicircular canal and high sagittal index) occurs in a small number of Upper Paleolithic humans of the modern morphological type. The Sungir adult belongs to this group.

Keywords: *Upper Paleolithic man from Sungir, bony labyrinth, computed tomography, semicircular canals, Neanderthals, humans of the modern morphological type.*

Introduction

The bony labyrinth is located in the stony part of the temporal bone. The pyramid is known as the best-preserved structure of the skull (Iscan, 2005: 108). It was retrieved intact even after cremation (Wahl, Graw, 2001). The labyrinth is a hollow bony shell protecting the organs of hearing and balance. It consists of three separate parts. The cochlea contains the organs of sound perception and auditory nerves (Spoor, Zonneveld, 1995; Miller, 2007). The nearby vestibule contains the otolith apparatus, which is one of the receptors for balance and spatial sense (Highstein, 2004; Rabbitt, Damiano, Grant, 2004). The end of the labyrinth furthest from the cochlea consists of the anterior, posterior, and lateral semicircular canals (named after their orientation in the skull), which are part of the vestibular system. These canals contain receptors that respond to head rotation and contribute to the coordination of body movements during locomotion (Rabbitt, Damiano, Grant, 2004). Given the prenatal formation, stability of labyrinth development, and minimal sex differences, it can be assumed that the morphology of the inner ear will reflect only one aspect of variability in the studied groups—that is genetic (Wu et al., 2014).

Material

Three-dimensional models of the bony labyrinths from three individuals were investigated: Sungir 1—male, aged 40–45 years, Sungir 2—boy, aged 11–13 years, Sungir 3—boy, aged 9–11 years.

Kinship ties. In 2017, a team from the University of Copenhagen's Laboratory for GeoGenetics determined that all three Sungirians belonged to the same species, *Homo sapiens*. The genetic analysis revealed that the individuals from the paired child burial were not close relatives. According to the results obtained by geneticists, the structure of the Sungir Upper Paleolithic group is characterized by a low level of intragroup kinship and inbreeding. The Sungirians exhibited a social organization similar to that of hunter-gatherers, characterized by a low level of inbreeding within groups that were embedded in a larger network of reproductive relations (Sikora et al., 2017).

Dating. A radiocarbon dating analysis was recently carried out at the Sungir funerary complex. The principal challenge was the contamination of the samples by fixatives employed in the extraction and restoration of human bones during the 1960s. As a consequence of incomplete cleaning, certain dates were found to be inaccurate. The AMS-dating of Sungir 1 by the amino acid fraction obtained on an XAD polymer column and by the individual acid hydroxyproline (HYP) showed statistically similar results, with a mean value of 29,780 ± 420 and 28,890 ± 430 BP, respectively. The four animal bones discovered in the cultural layer below exhibited dates within the range of 28,800–30,140 BP, thereby suggesting the possibility that both the layer and the burials can be assigned to approximately the same period. The further narrowing of the interval is hindered by the significant error of the radiocarbon method. The chronology and stratigraphy of Sungir do not contradict the correlation of lithic artifacts found there with the Streletskaya complex as an East European variant of the Final Streletskaya technocomplex (Early Upper Paleolithic) (Kuzmin et al., 2022).

Furthermore, recent computed tomography (CT) studies have demonstrated that the adult Sungirian possessed a cerebral volume of ca 1443 cm^3, with notable advancement of the occipital lobes, which indicates the development of visual cortex of the large hemispheres (Vasiliev et al., 2021). The use of CT has also been instrumental in resolving the enigma surrounding the death of an adult Sungirian individual (Vasiliev et al., 2022).

Methods

The inner ear structures of the right and left sides of each individual skull were measured. Models of the bony labyrinth were made from computed tomography. Scans were performed on a Phoenix v|tome|xc450 industrial X-ray computed tomography scanner (Baker Hughes), with a resolution on the order of 110 μm, at a source voltage of 400 keV, and a current strength of 250 mA. 3D-models and their visualization were performed with the software products CTan, CTvol (Bruker), and Avizo (FEI). Measurements were carried out using these models in the Cloud Compare program (https://www.danielgm.net/cc/). The primary data were eight linear dimensions (mutually perpendicular diameters of the semicircular canals and cochlea) and the sagittal labyrinthine index (SLI), used to express the percentage of the posterior canal that partly lies below the plane of the lateral canal (Table 1). These data formed the basis for the calculation of 11 indices. The method of F. Spoor and F. Zonneveld (1998) adapted to 3D-models was used (Fig. 1).

Table 1. **Standard deviation (*s*) and technical error (TEM) of the bony labyrinth measured traits**

Trait		*s*, mm	*s*, %	TEM, mm	TEM, %
ASCh.	Anterior semicircular canal (SC) height	0.06	1.1	0.20	3.4
ASCw.	Anterior SC width	0.05	0.8	0.09	1.4
PSCh.	Posterior SC height	0.05	0.8	0.17	2.8
PSCw.	Posterior SC width	0.06	1.1	0.11	1.8
LSCh.	Lateral SC height	0.05	1.1	0.18	4.0
LSCw.	Lateral SC width	0.09	1.8	0.15	3.2
COh.	Cochlear height	0.05	1.0	0.39	5.8
COw.	Cochlear width	0.12	3.0	0.27	4.5
SLI.	Sagittal labyrinth index	0.06	0.1	–	–

Note. TEM (after (Knapp, 1992)) for repeated measurements according to (Osipov et al., 2013) (corresponds to *s* for double measurements).

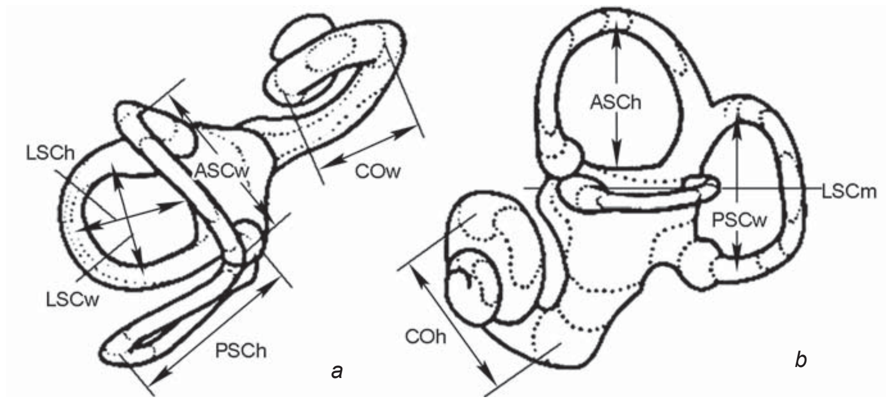

Fig. 1. Linear measurements of the bony labyrinth used in the paper (after (Spoor, Zonneveld, 1998)). The LSCm line determines the sagittal labyrinthine index (SLI).

The measurements were taken three times for each specimen. For intra- and inter-group comparisons, the dimensions of the inner ear structures on the two sides of the skull were averaged. The dimensions are presented in millimeters and rounded to the nearest hundredth. The error of our measurements does not exceed 3% and is comparable to that observed in the test work that evaluated the stability of the employed system for bone labyrinth measurements (Osipov et al., 2013).

Results

Left and right sides comparison. To identify bilateral asymmetry of the inner ear apparatus, the size of each trait of the left side was subtracted from the corresponding size of the right side, and the resulting differences were compared with similar indicators of a large sample (without pathologies) (Osipov et al., 2013) (Table 2). Differences between the sides are present for the vast majority of traits of all individuals. At the same time,

Table 2. **Differences between the left and right traits as compared to the bilateral symmetry data from (Osipov et al., 2013)**

Trait	S1	S2	S3	Mean differences	SD
ASCh	–0.20	–0.12	–0.17	0.08	0.25
ASCw	0.02	–0.03	0.01	0.06	0.22
ASCh/w	–0.05	0.00	–0.02	0.00	0.05
ASCR	0.00	0.00	0.00	0.03	0.08
PSCh	0.04	–0.18	0.44	–0.08	0.27
PSCw	–0.09	0.12	0.17	–0.01	0.25
PSCh/w	0.02	–0.05	0.03	–0.01	0.06
PSCR	0.00	–0.10	0.20	–0.01	0.10
LSCh	–0.49	–0.13	0.04	0.06	0.28
LSCw	–0.19	–0.01	0.10	0.01	0.24
LSCh/w	–0.05	–0.02	–0.02	0.01	0.07
LSCR	–0.20	0.00	0.10	0.02	0.11
COh	–0.19	–0.05	–0.03	–0.05	0.38
COw	–0.11	–0.49	0.01	0.07	0.28
COh/w	–0.02	0.14	–0.02	–0.02	0.06
COR	0.00	–0.10	0.00	0.07	0.27
SLI	–0.32	0.65	0.02	0.62	4.05

Note. SD – standard deviation; h/w are taken in fractions, as in (Osipov et al., 2013).

they fit within 95% (SD × 2) of the differences observed in the model group. Thus, we can assume that bilateral asymmetry in the three individuals from the Sungir burials is insignificant. In further analyses, we will consider the data averaged by sides in accordance with the accepted methodology (Spoor et al., 2003).

Intra-group analysis. The cochlea and semicircular canals reach their adult size and mature morphology between the 17th and 25th weeks of intrauterine development (Jeffery, Spoor, 2004; Richard et al., 2010). There is no further significant change in the size of these structures. Thus, all three presented bony labyrinths have already reached their definitive form and are morphologically "adult" (Fig. 2–4). This allows them to be treated as equals, without reservations or corrections.

The possibility of assigning the studied individuals to a homogeneous sample from the morphological point of view was considered. The F-criterion was employed to compare the variability indices in the Sungir group and the model population (Osipov et al., 2013) (Table 3). The results demonstrated that the F-criterion did not reach the critical value in any instance. Consequently, the diversity observed in the Sungir group can be attributed to normal variability, and individual data can be employed to calculate averages.

Intergroup analysis. The studies have demonstrated that the structure of the bony labyrinth is reliably distinct between the lineages of Neanderthals and humans of the modern morphological type (from the Middle Pleistocene to the present day). The differences in structure can be observed in the small size of the upper semicircular canal, the large lateral canal, and the low position of the posterior semicircular canal in relation to the plane of the lateral canal (Spoor et al., 2003; Bouchneb, Crevecoeur, 2009; Wu et al., 2014).

Samples of Neanderthals, people of the modern morphological type (MMT) of the Middle and Upper Paleolithic, and modern humans were used as a comparative reference for the Sungir group (Table 4). A comparison of diagnostically significant features, including the lateral semicircular canal radius (LSCR) and the position of the posterior canal relative to the lateral plane (sagittal index SLI), reveals that the Sungirians differ significantly and with statistical reliability from Neanderthals, and have no differences from people of the modern morphological type. According to the diagnostically significant anterior semicircular canal radius (ASCR), there are no reliable differences between the samples. In addition, the Sungirians exhibit significant differences in three features (PSCR%, LSCR%, PSCh/w)

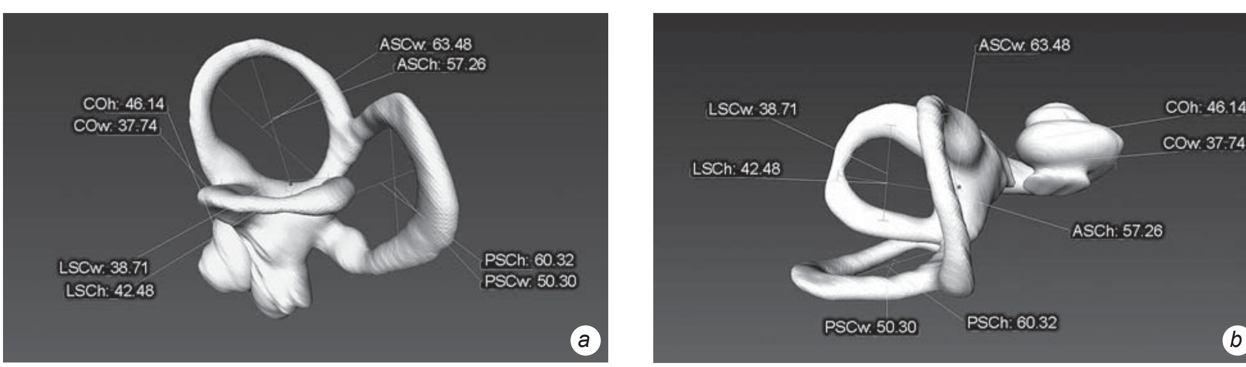

Fig. 2. Left bony labyrinth of individual Sungir 1.
a – lateral view; *b* – top view.

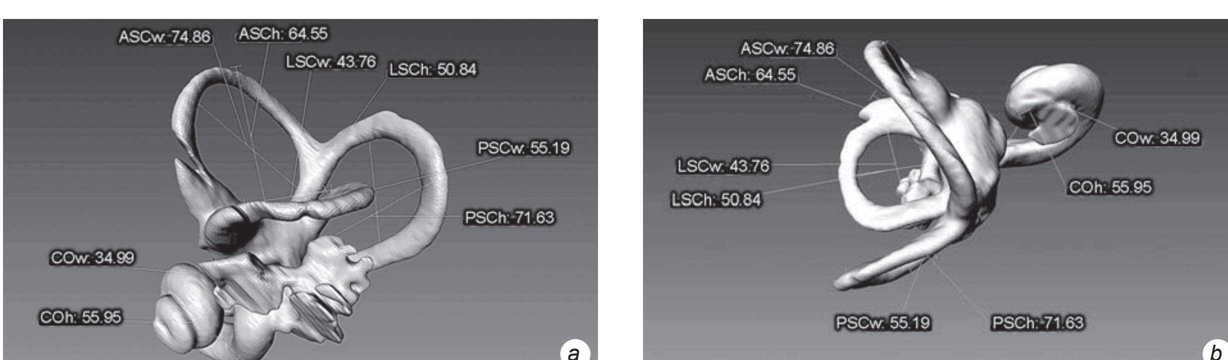

Fig. 3. Left bony labyrinth of individual Sungir 2.
a – lateral view; *b* – top view.

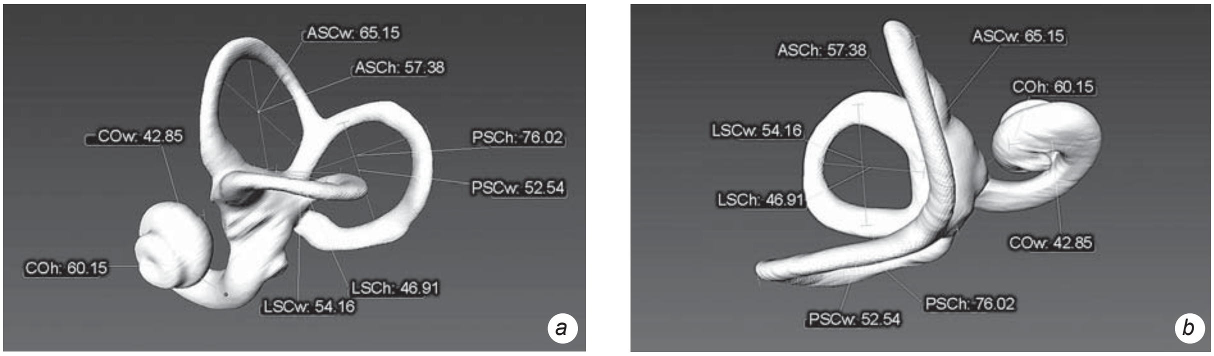

Fig. 4. Left bony labyrinth of individual Sungir 3.
a – lateral view; *b* – top view.

Table 3. **Sungir Group (SG) data and Model Population (MP) variability indicators**

Trait	S1	S2	S3	*m* SG	*s* SG	*s* MP	F
ASCh	5.60	6.15	5.85	5.87	0.28	0.45	0.37
ASCw	5.85	6.95	6.60	6.47	0.56	0.43	1.71
PSCh	5.85	6.60	6.30	6.25	0.38	0.45	0.70
PSCw	5.20	5.95	6.00	5.72	0.45	0.43	1.09
LSCh	4.40	4.85	4.30	4.52	0.29	0.42	0.49
LSCw	4.40	5.00	5.05	4.82	0.36	0.37	0.96
COh	5.10	5.60	5.75	5.48	0.33	0.35	0.90
COw	3.65	4.20	4.20	4.02	0.33	0.30	1.18
SLI	52.70	43.95	41.60	46.08	5.85	4.72	1.54
ASCh/w	95.75	88.49	88.64	90.96	4.15	5.34	0.60
ASCR	2.86	3.28	3.11	3.08	0.21	0.20	1.12
PSCh/w	112.50	110.95	104.97	109.47	3.98	4.94	0.65
PSCR	2.76	3.14	3.08	2.99	0.20	0.21	0.95
LSCh/w	99.95	97.00	85.16	94.04	7.83	5.77	1.84
LSCR	2.20	2.46	2.34	2.33	0.13	0.18	0.52
COh/w	139.73	131.23	136.90	135.95	4.33	4.38	0.98
COR	2.19	2.45	2.49	2.38	0.16	0.15	1.18

as compared to Neanderthals, and two features (ASCR%, PSCh/w) as compared to both the Middle Paleolithic and modern humans.

In terms of the bony labyrinth morphology, the Sungir group can be considered to occupy a place in the lineage of people of the modern morphological type. The identified features, namely, the large relative size of the anterior canal (ASCR%) and the narrower posterior canal (PSCh/w), distinguish Sungirians among the MMT humans. However, further confirmation is required because of the small sample size.

Another mathematical procedure, discriminant analysis, was employed to ascertain the proximity of the Sungirians to Neanderthals and Upper Paleolithic humans. For the purposes of this study, published individual measurements were included. The application of this approach resulted in a notable reduction in the number of analyzed features and the composition of the compared samples (Table 5). A stepwise analysis was carried out, with the inclusion of various variants. However, other alternative methods yielded inconclusive results. As anticipated, two variables were found to be involved in the discriminant function: the sagittal labyrinthine index (SLI) and the relative size of the lateral canal radius (LSCR%). The Wilks' lambda statistic was calculated to be 0.27, indicating that the samples could be effectively distinguished.

The results of the analysis do not contradict the previous conclusion on the t-criterion; rather, they clarify it. The probabilities of belonging to the classification

Table 4. **Comparison of the Sungir Group with other anthropological samples (Student's t-test)**

Trait	Sungir (n = 3)		Neanderthals (n = 30)		t	Middle Paleolithic humans (n = 11)		t	Upper Paleolithic humans (n = 10)		t	Modern humans (n = 180)		t
	m	*s*	*m*	s		m	s		m	s		m	s	
ASCR	3.1	0.2	3.0	0.2	0.62	3.3	0.2	–1.62	3.3	0.2	–1.61	3.2	0.2	–0.98
PSCR	3.0	0.2	2.8	0.2	1.54	3.0	0.2	–0.08	3.1	0.3	–0.74	3.1	0.3	–0.94
LSCR	**2.3**	0.1	**2.6**	0.2	**–3.13**	2.4	0.2	–0.73	2.5	0.2	–1.73	2.3	0.2	0.39
SLI	**46.1**	5.9	**63.5**	5.8	**–4.84**	53.0	6.2	–1.79	43.7	9.4	0.53	50.7	6.8	–1.35
ASCR, %	**36.7**	0.5	35.9	1.5	1.94	**38.1**	1.3	**–2.98**	37.2	1.4	–0.97	**37.3**	1.3	**–2.16**
PSCR, %	35.6	0.5	33.6	1.6	**4.66**	34.7	1.6	1.64	34.5	1.7	1.84	36.0	1.8	–1.37
LSCR, %	27.7	0.9	30.5	1.1	**–5.15**	27.2	1.6	0.73	28.3	0.9	–1.06	26.8	1.8	1.77
ASCh/w	91.0	4.2	92.6	5.0	–0.63	88.5	6.9	0.78	89.5	6.7	0.46	89.8	5.1	0.48
PSCh/w	**109.5**	4.0	**100.7**	8.0	**3.06**	**100.0**	7.9	**2.86**	106.7	7.6	0.83	**104.1**	8.8	**2.25**
LSCh/w	94.0	7.8	92.7	6.7	0.28	83.4	9.7	1.98	94.0	6.2	0.01	90.8	7.0	0.71
COR	2.4	0.2	2.3	0.1	0.84	2.5	0.1	–1.23	2.4	0.1	–0.20	2.3	0.1	0.86
COh/w	136.0	4.3	132.5	11.4	0.99	129.7	7.7	1.83	141.5	8.7	–1.49	132.7	9.1	1.25

Notes. Bold text highlights diagnostically significant traits and reliably different values.

Neanderthals: Amud 1, 7, Arcy-Sur-Cure C7.1544, Dederiyeh 1, Devil's Tower 1, La Chapelle-aux-Saints 1, Engis 2, La Ferrassie 1–3, Forbes' Quarry 1, Kebara 1, Krapina 38.1, 38.12, 38.13, 39.1, 39.4, 39.8, 39.13, 39. 18, Marillac LP01-H02, Le Moustier 1, Obi-Rakhmat 1, Pech de l'Azé 1, Petit Puymoyen 5, La Quina 5, 27, Spy 1, 2, Tabun 1; Middle Paleolithic MMT humans: Qafzeh 3, 6, 7, 9, 11–13, 15, 21, Skhul 1, 5; Upper Paleolithic MMT humans: Cro-Magnon 1, Lagar Velho 1, Laugerie-Basse 1, Malori 1, Nazlet-Khater 2, Muierii 2, Oase 2, Abri Pataud 1, 3, Rosherel 1; modern humans: China (n = 26), Belgium (n = 100), sample from around the world (n = 54).

Samples of Neanderthals and MMT humans after (Wu et al., 2014).

Table 5. **Means of groups used in the discriminant analysis, and individual data of Sungirians**

Trait	Neanderthals (n = 22)		Upper Paleolithic MMT humans (n = 7)		Sungir		S1	S2	S3
	m	*s*	*m*	*s*	*m*	*s*			
ASCR	3.04	0.16	3.30	0.17	3.08	0.21	2.9	3.3	3.1
PSCR	2.84	0.26	3.09	0.18	2.99	0.20	2.8	3.1	3.1
LSCR	2.56	0.17	2.50	0.10	2.33	0.13	2.2	2.5	2.3
ASCR, %	36.2	1.6	37.4	1.4	36.7	0.25	36.6	36.9	36.5
PSCR, %	33.6	1.8	34.5	1.4	35.6	0.45	35.3	35.4	36.1
LSCR, %	**30.2**	**1.1**	**28.1**	**0.7**	**27.7**	**0.35**	**28.1**	**27.7**	**27.4**
ASCh/w	93.1	5.7	90.9	8.9	91.0	4.2	95.8	88.5	88.6
PSCh/w	102.4	7.8	107.5	8.1	109.5	4.0	112.5	111.0	105.0
LSCh/w	92.6	5.7	93.7	5.5	94.0	7.8	100.0	97.0	85.2
SLI	**62.3**	**4.8**	**44.5**	**8.2**	**46.1**	**5.9**	**52.7**	**44.0**	**41.6**

Notes. Bold text highlights reliably different traits.

Neanderthals: Dederiyeh 1, La Chapelle-aux-Saints 1, La Ferrassie 1-3, La Quina 5, 27, Le Moustier 1, Pech de l'Azé 1, Petit Puymoyen 5, Spy 1, 2, Tabun 1 (Spoor et al., 2003), Obi-Rakhmat 1 (Glantz et al, 2008), Krapina 38.1, 38.12, 38.13, 39.13, 39.18, 39.20, 39.4, 39.8 (Hill, Radovčić, Frayer, 2014); Upper Palaeolithic MMT humans: Abri Pataud 1, 3, Cro-Magnon 1, Laugerie-Basse 1 (Spoor et al, 2003), Nazlet-Khater 2 (Bouchneb, Crevecoeur, 2009), Muierii 2 (Ponce de León, Zollikofer, 2010), Oase 2 (Ponce de León, Zollikofer, 2013).

groups of the Sungirians clearly place the adolescents S2 and S3 in the group of MMT humans, while the adult male S1 has about the same chance of being assigned to both groups, with a slightly higher attraction to Neanderthals (Table 6). The two-trait classification showed that all the Neanderthals clearly fell into the Neanderthal group, whereas ~29% (two individuals) of the MMT individuals fell outside their titled group and were assigned to the Neanderthal group (Table 7). These "outliers" were individuals Abri-Pato 1 and Oase 2. Their a posteriori probabilities of belonging to the Neanderthal group were 0.734 and 0.847, respectively, and 0.266 and 0.153 for the MMT group.

A similar situation is described for Xujiayao 15 (Northern China), a late Pleistocene individual (Wu et al., 2014). According to the skull morphology, it is fully consistent with the lineage of MMT humans. According to the bony labyrinth structure, it is classified with a very high probability (0.95%) as Neanderthal (Table 8). On this basis, the authors of the paper make a broad generalization. Irrespective of the population position of Xujiayao 15, the implication is that a "Neanderthal" configuration of the bony labyrinth could have been present in humans of modern morphological type throughout Eurasia during the Late Pleistocene. This makes the feature less of a "Neanderthal" marker and more relevant to the paleobiology of Late Pleistocene *Homo*, whether it is discrete in itself or a consequence of other aspects of cranial morphology (Ibid.).

Conclusions

Because of its protection, the bony labyrinth is one of the best-preserved structures of the human skull. During the intrauterine period, it takes on its final form. There is minimal bilateral and sexual variability in the morphology of the bony labyrinth. Therefore, its structural characteristics seem the most suitable for analyzing intergroup variability.

Studying the structural characteristics of the inner ear of ancient and modern humans has revealed two morphological types in Eurasia that differ significantly

Table 6. **The Sungir people's posterior probabilities of classification group membership**

Sungir	Neanderthals	Upper Paleolithic MMT humans
S1	**0.573**	**0.427**
S2	0.004	0.996
S3	0.001	0.999

Table 7. **Discriminant analysis classification results (by individuals)**

Individuals	Percentage	Neanderthals	Upper Paleolithic MMT humans
Neanderthals	100.0	22	0
Upper Paleolithic MMT humans	71.4	2	5
Total	93.1	24	5

Table 8. **Comparison of means for classification groups and indicators of individuals other than MMT humans**

Trait	Neanderthals		Upper Paleolithic MMT humans		Sungir 1	Abri Pataud 1	Oase 2	Xujiayao 15
	m	*s*	*m*	*s*				
ASCR	3.0	0.2	3.3	0.2	2.9	3.2	3.2	2.9
PSCR	2.8	0.2	3.1	0.3	2.8	2.8	3.3 (?)	2.8
LSCR	**2.6**	**0.2**	**2.5**	**0.2**	**2.2**	**2.4**	**2.5**	**2.7**
ASCR, %	35.9	1.5	37.2	1.4	36.6	39	36	34.6
PSCR, %	33.6	1.6	34.5	1.7	35.3	33	36	33.7
LSCR, %	**30.5**	**1.1**	**28.3**	**0.9**	**28.1**	**28**	**28**	**31.7**
ASCh/w	92.6	5.0	89.5	6.7	95.8	84	103	87.1
PSCh/w	100.7	8.0	106.7	7.6	112.5	106	–	98.3
LSCh/w	92.7	6.7	94.0	6.2	100.0	92	94.1	82.8
SLI	**63.5**	**5.8**	**43.7**	**9.4**	**52.7**	**54**	**55.1**	**61.4**

Note. Bold text highlights diagnostically significant traits.

in their structure. One belongs to the line of modern morphological type from the Middle Paleolithic, while the other belongs to the Neanderthal line.

The absence of increased bilateral asymmetry of the bony labyrinth was observed in individuals from the Sungir burials. The Sungirians can be considered a morphologically homogeneous group owing to the inter-individual variability in the size of the inner ear parts. The comparison of the mean values of the bony labyrinth characteristics in this group with the corresponding indicators of Neanderthals and anatomically modern humans of various chronological associations revealed their undoubted belonging to the latter and reliable differences from the former. Discriminant analysis made it possible to specify this conclusion. It has shown that, according to the bony labyrinth structure, the two young individuals are clearly defined as belonging to the modern morphological type, whereas the adult can be attributed with equal probability to both classification groups. For humans of the modern morphological type, such a situation is not exceptional and even rare. The "Neanderthaloid" features of the structure of the inner ear (the large size of the lateral semicircular canal and the high sagittal index) occur in a small but significant number of people from the Upper Paleolithic. Such representatives include the adult male from the Sungir burials.

Therefore, when diagnosing an individual, it should be taken into account that the "modern" morphology of the bony labyrinth almost unambiguously identifies an individual as belonging to a modern anatomical type, whereas "Neanderthaloid" is not such an obvious marker, since it is found not only in Neanderthals.

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The Structure of the Late Bronze Age Population of Western Siberia: Craniometric Evidence

To assess the sources of population differentiation in Late Bronze Age Western Siberia, measurements of 68 cranial samples of this and earlier periods were processed with multivariate statistical methods. Results support the idea of at least two post-Afanasyevo migrations to Siberia from the west—pre-Andronovo and Andronovo. The former was represented by Chaa-Khol, Yelunino, and Samus people. Those associated with Karakol culture partly resemble the above and partly both autochthonous populations—that of Baraba ("Northern Eurasian formation") and that of Okunev culture ("Southern Eurasian formation"), which appear to be two extremes of a single continuum. Differences between the two Andronovo traditions, Fedorovka and Alakul, are likely due to the local substratum in the former rather than to various origins. The Karasuk group arose through admixture between Okunev and Andronovo. People associated with the classic Karasuk culture are closer to the former, while those of the Kamenny Log stage tend toward the latter. People of the Upper Irtysh and the Mongun-Taiga people from Baidag III resemble those of Karasuk. Two pooled groups, Irmen and Mongun-Taiga, and the Pakhomovskaya sample indicate a possible admixture between both autochthonous formations, Northern and Southern, as well as Andronovo and Karasuk. Among the so-called Andronoid groups, only Yelovka and Pakhomovskaya, as well as a sample from Yelovka I, suggest admixture between Andronovans and Western Siberian natives, while Cherkaskul and Korchazhka, like the Late Krotovo groups from Sopka and Cherno-Ozerye and the Begazy-Dandybai group of Baraba, deviate from the Northern Eurasian formation toward Okunev rather than Andronovo. Among the two Eurasian formations, the Southern one (i.e., Okunev) was more affected by admixture between the autochthones and the immigrants.

Keywords: *Western Siberia, Bronze Age, Northern Eurasian formation, Southern Eurasian formation, Okunev culture, Andronovo culture, Karasuk culture.*

Introduction

It is unanimously believed that the principal factor underlying the differentiation of the Late Bronze Age population of Western Siberia was the contact between the aborigines of that territory and the Andronovo immigrants. In the course of this process, a number of cultures known as Andronoid arose*. Andronoid cultures usually include Cherkaskul in the southern forest zone of the Urals (Kosarev, 1981: 132–141), Yelovka in

*To avoid confusion, I will use this term with reference to cultures rather than physical types of people associated with them.

the Tomsk-Narym stretch of the Ob (Ibid.: 145–162), Korchazhka in the Ob area of the Altai (Kiryushin, Shamshin, 1992), and Pakhomovskaya in the Tobol-Irtysh forest-steppe (Korochkova, 2009).

Despite the facts suggesting a large role of both Andronovo and autochthonous components in the Irmen culture of the Ob-Irtysh forest-steppe, specialists did not term it Andronoid, because it was believed to be relatively late. New radiocarbon dates, however, attest to the appearance of the Irmen people at Chicha as early as 15th–14th centuries BC (Schneeweiss et al., 2018). One of the key problems relating to the Irmen concerns the role of the Karasuk people in its origin (for a review, see (Kovalevsky, 2011)). The same question arises with regard to the Late Bronze Age culture of the Upper Irtysh at the time when the Andronovo tradition was being replaced by the Karasuk tradition (Chernikov, 1960: 74, 98).

Karasuk origins are likewise enigmatic. Certain archaeologists believe that both the Andronovo immigrants and the Okunev natives had taken part in this process (Vadetskaya, 1986: 61–63). Others ascribe the main role in Karasuk origins to Andronovans, while considering Okunev contribution minimal (Poliakov, 2022: 211, 226, 245, 249, 290, 316).

A separate issue is the participation of the Begazy-Dandybai component in the origins of Western Siberian cultures. It is traceable, specifically, in Late Bronze Age cemeteries of Stary Sad and Preobrazhenka-3 in Baraba (Molodin, Neskorov, 1992) and Yelovka I in the Tomsk stretch of the Ob (Kiryushin, 2004: 95). Some think that this component had contributed to the origin of the Yelovka culture at Yelovka II (Ibid.).

Craniometric evidence is highly relevant to all those issues. Several important summarizing studies in this field have appeared in the recent decades (Alekseyev, Gokhman, 1984; Dremov, 1997; Chikisheva, 2012; Zubova, 2014; Bagashev, 2017). The present article, continuing this direction of studies, aims at testing the hypotheses outlined above using a new material and a new graphic method of representing the data.

Material and methods

Measurements of 68 male cranial samples were used, representing the following cultures, periods, and territories*:

1. Okunev culture, Khakas-Minusinsk Basin, Tas-Khazaa.
2. Same, Uybat.
3. Same, Chernovaya.
4. Same, Verkh-Askiz.
5. Karakol culture, Gorny Altai.
6. Chaa-Khol culture, Tuva.
7. Yelunino culture, Upper Ob.
8. Samus culture, Tomsk-Narym stretch of the Ob.
9. Ust-Tartas culture, Baraba forest-steppe, Sopka-2/3.
10. Same, Sopka-2/3A.
11. Odino culture, Sopka-2/4A.
12. Same, Baraba forest-steppe, Tartas-1.
13. Same, Preobrazhenka-6.
14. Krotovo culture, classic stage, Sopka-2/4B, C.
15. Late Krotovo (Cherno-Ozerye) culture, Sopka-2/5.
16. Same, Omsk stretch of the Irtysh, Cherno-Ozerye-1.
17. Andronovo (Fedorovka) culture, Central, Northern, and Eastern Kazakhstan.
18. Same, Baraba forest-steppe.
19. Same, Southwestern Altai.
20. Same, Barnaul stretch of the Ob, Firsovo XIV.
21. Same, Barnaul-Novosibirsk stretch of the Ob.
22. Same, Chumysh River.
23. Same, Tomsk stretch of the Ob, Yelovka II.
24. Same, Kuznetsk Basin.
25. Same, Minusinsk Basin.

25a. Andronovo (Fedorovka) culture, pooled (No. 17–25).

26. Andronovo (Alakul-Kozhumberdy) culture, Southern Urals and Western Kazakhstan.
27. Andronovo (Alakul) culture, Central, Northern, and Eastern Kazakhstan.
28. Same, Omsk stretch of the Irtysh, Yermak IV.

28a. Andronovo (Alakul) culture, pooled (No. 26–28).

29. Cherkaskul culture, Bashkiria, Krasnogorskoye (Shevchenko, 1980); Chelyabinsk Region, Berezki Vg (Dremov, 1997: 153, 157)*.
30. Pakhomovskaya culture, Tyumen Region, Novo-Shadrino VII (Solodovnikov, Rykun, 2011).
31. Korchazhka culture, Kuznetsk Basin, Tanay-1 and -12 (Zubova, 2014: 183–184).
32. Yelovka culture, Tomsk stretch of the Ob, Yelovka II (Solodovnikov, Rykun, 2011).
33. Late Bronze Age culture, possibly Begazy-Dandybai (Kiryushin, 2004: 95); Tomsk stretch of the Ob, Yelovka I (Solodovnikov, Rykun, 2011).
34. Late Bronze Age culture, affected by Begazy-Dandybai (Molodin, 1985: 140–142; Molodin, Neskorov,

*The sources of information are indicated only for the samples that I used for the first time (No. 29–42). Information on other samples can be found in my previous articles (Kozintsev, 2009, 2020, 2021, 2023a, b, 2024).

*Materials from Tartysh (Akimova, 1968: 9–11) and Taktalachuk (Rud, 1981) in the Volga-Kama region, sometimes included in the Cherkaskul sample (Dremov, 1997: 153–154; Bagashev, 2017: 118), were not used because of uncertain cultural attribution (Shevchenko, 1980; Solodovnikov, Rykun, 2011).

1992), Baraba forest-steppe, Preobrazhenka-3, Stary Sad (Chikisheva, 2012: 388–390).

35. Late Bronze Age culture of the Upper Irtysh (Solodovnikov, 2009).

36. Irmen culture, Baraba forest-steppe, Preobrazhenka-3 (Chikisheva, 2012: 372–375).

37. Same, Novosibirsk stretch of the Ob (Zubova, 2014: 129).

38. Same, forest-steppe Altai (Ibid.: 134).

39. Same, Tomsk stretch of the Ob (Ibid.: 125).

40. Same, Kuznetsk Basin, Zhuravlevo-1, -3, -4 (Chikisheva, 2012: 372–375).

41. Same, Zarechnoye-1 (Zubova, 2014: 109).

42. Same, Vaganovo-2 (Ibid.: 117).

42a. Irmen culture, pooled*.

43. Karasuk culture proper (“classic stage”).

44. Karasuk culture, Kamenny Log stage.

45. Atypical Karasuk (groups No. 46–49 pooled).

46. Same, Northern group—Kamenny Log burials on the Karasuk River.

47. Same, Malye Kopeny III.

48. Same, Fedorov Ulus.

49. Same, Eastern Minusinsk group—Lugavskoye (Beya) burials on the right bank of the Yenisei, south of the Tuba.

50. Karasuk culture, Northern group.

51. Same, Southern group.

52. Same, Yerba group.

53. Same, Left-bank group.

54. Same, Right-bank group.

55. Same, Khara-Khaya.

56. Same, Tagarsky Ostrov IV.

57. Same, Kyurgenner I.

58. Same, Kyurgenner II.

59. Same, Karasuk I.

60. Same, Severny Bereg Varchi I.

61. Same, Sukhoye Ozero II.

62. Same, Arban I.

63. Same, Beloye Ozero.

64. Same, Sabinka II.

65. Same, Tert-Arba.

66. Same, Yesinskaya MTS.

67. Mongun-Taiga culture, Tuva, pooled.

68. Same, Tuva, Baidag III.

The trait battery includes 14 measurements: cranial length, breadth, and height, minimal frontal breadth, bizygomatic breadth, upper facial height, nasal height, nasal breadth, orbital breadth, orbital height, nasomalar angle, zygo-maxillary angle, simotic index, and nasal protrusion angle. Data were processed using the multiple discriminant (canonical) analysis, and Mahalanobis’ D^2 distances corrected for sample size were calculated. The distance matrix was subjected to nonmetric multidimensional scaling and cluster analysis*. A new graphic device aimed at combining the results of both analyses was employed.

*Samples No. 36–42 were supplemented by the Irmen sample from Tanay-2 and -7 in the Kuznetsk Basin, which was not used separately because of its small size (Zubova, 2014: 113).

*Boris Kozintsev’s CANON program and Øyvind Hammer’s software package PAST version 4.05 were used.

Results

The analysis with small groups resulted in four principal clusters (Fig. 1). The most isolated one is A, which is opposed to three others. It consists of six samples, including three cranially “westernmost” populations—Samus (No. 8) and two Andronovo groups with cranially Mediterranean features: a Fedorovka sample from Firsovo XIV (No. 20) and the Alakul-Kozhumberdy sample (No. 26), as well as three more Andronovo series from Northern, Central, and Eastern Kazakhstan (No. 17), Southwestern Altai (No. 19), and Minusinsk Basin (No. 25).

Among the three remaining clusters, the most isolated one is B. It includes four samples, markedly differing in the expression of western and eastern features: Chaa-Khol (No. 6) and Yelunino (No. 7) being more “western”, and Lugavskoye (Beya) variety of Atypical Karasuk (No. 49) and Karakol (No. 5), more “eastern”. This cluster is opposed to two larger ones, C and D, which include all the remaining samples.

Cluster C, displaying the “easternmost” trait combination, consists of 14 samples: eight from Baraba, representing the Northern Eurasian formation (after (Chikisheva, 2012: 6, 56, 59, 123–124, 179–180)) (No. 9–14) and those close to them (No. 15 and 16), the Andronovo sample from Yelovka II in the Tomsk stretch of the Ob (No. 23), Andronoids of Cherkaskul (No. 29) and Korchazhka (No. 31), Irmen samples from the Novosibirsk stretch of the Ob (No. 37) and from Zarechnoye in the Kuznetsk Basin (No. 41), and a Karasuk group from Arban I (No. 62).

Cluster D is the largest. It takes a central position, being surrounded by three others. It includes 44 samples: all four Okunev (No. 1–4), a half of Andronovo (No. 18, 21, 22, 24, 27, and 28), two Andronoid—Pakhomovskaya (No. 30) and Yelovka (No. 32), Late Bronze Age samples from Yelovka I (No. 33), Baraba (No. 34), and Upper Irtysh (No. 35), most of Irmen (No. 36, 38–40, and 42), all Karasuk except two (No. 43–48, 50–61, 63–66), and both Mongun-Taiga (No. 67 and 68). The Karasuk grouping (III) is distinctly intermediate between Okunev (I) and Andronovo (II).

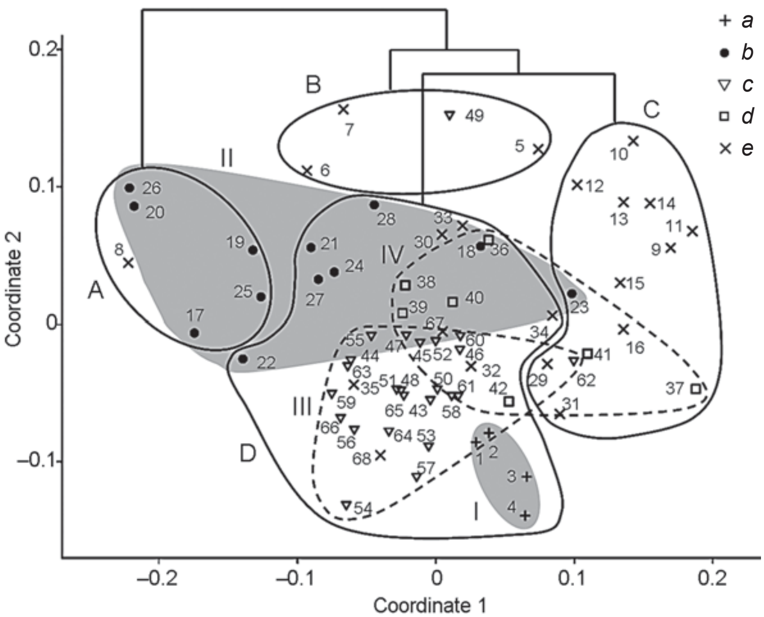

Fig. 1. Position of group centroids on the plane of the nonmetrical multidimensional scaling in the analysis with small groups (the dendrogram shows the hierarchical relationship between four major clusters A–D).
a – Okunev; *b* – Andronovo; *c* – Karasuk; *d* – Irmen; *e* – others. Groups are numbered as in the list (see above). Distribution areas of Okunev and Andronovo groups are shown by spots (I and II), those of Karasuk and Irmen, by dashed contours (III and IV).

As we see, the agreement between clusters and archaeological groupings is far from complete. Only Okunev (entirely) and Karasuk (with two exceptions, see above), fall within a single cluster D. The most notable disagreement concerns Andronovo samples, which are distributed between three clusters: A, C, and D. The Andronovo grouping (II) is markedly stretched along the direction that can be tentatively described as west to east: from morphologically Mediterranean samples of cluster A—Fedorovka from Firsovo XIV (No. 20) and Alakul-Kozhumberdy (No. 26)—to Yelovka II (No. 23), which belongs to the same cluster C as the autochthonous groups of Baraba (Northern Eurasian formation)*.

Likewise stretched along the west to east axis is the Irmen grouping. Most of its members fall within cluster D, together with Andronovo (No. 36, 38–40) and one Karasuk (No. 42) group, but two Irmen samples—from Zarechnoye-1 in the Kuznetsk Basin (No. 41) and the Novosibirsk stretch of the Ob (No. 37)—are in cluster C, the latter sample displaying the "easternmost" morphology. Two of the remaining samples—Cherkaskul (No. 29) and Korchazhka (No. 31)—are in the opposite, "western" part of that cluster, whereas five—Pakhomovskaya (No. 30), Yelovka (No. 32), and Late Bronze Age samples from Yelovka I (No. 33), Baraba (No. 34), and the Upper Irtysh (No. 35)—are in cluster D.

Because of numerous small samples, the cluster analysis is sometimes inefficient. Large clusters can be rather amorphous, which in this case mostly concerns the "central" and the most culturally heterogeneous cluster D.

Let us try to reduce the statistical noise and make the picture more informative by merging the groups. Thus, only two pooled Andronovo samples, Fedorovka (No. 25a) and Alakul (No. 28a), will be left; two pooled Karasuk samples—"classic" (No. 43) and Kamenny Log (No. 44), as well as a single pooled Irmen group (No. 42a). This does not mean that we consider all the variation within the pooled samples random (results outlined above disagree with this idea). However, because separating signal from noise is difficult when the samples are small, it makes sense to analyze central tendencies.

Results of analysis with pooled groups (Fig. 2) generally agree with those outlined above, but certain discrepancies are present. Instead of four major clusters, we see three. The former cluster B, which included three pre-Andronovo groups, Karakol (No. 5), Chaa-Khol (No. 6), and Yelunino (No. 7), is no longer present. Now, the latter two samples have joined Samus (No. 8) and Alakul (No. 28a) within the most isolated cluster A, which is morphologically "westernmost", as in the preceding analysis. The fourth pre-Andronovo group, Karakol (No. 5), which apparently includes a marked "eastern" admixture, has joined the Northern Eurasian formation (subcluster C1), taking, however, the "westernmost" place within it.

Cluster B, which, in terms of composition, largely coincides with the former cluster D, is now structured and consists of two subclusters. The first (B1) includes all Okunev samples (No. 1–4), and that of Yelovka culture (No. 32). The second (B2) consists of two subclusters of a lower rank: B2a—Fedorovka (No. 25a), both Karasuk (No. 43 and 44), Late Bronze Age group from the Upper Irtysh (No. 35), and Mongun-Taiga group from Baidag III (No. 68). Members of subcluster B2b are Pakhomovskaya (No. 30), pooled Irmen

*The "eastern" extreme in this continuum is represented not by Mongoloids in the traditional sense, who are not present among the samples used here, but by evolutionarily conservative groups displaying a plesiomorphic trait combination that is rather neutral on the west to east vector and likely precedes the major split between western and eastern populations of Northern Eurasia (Chikisheva, 2012: 6, 56, 57, 153, 169, 123–124, 179–180; Kozintsev, 2021).

(No. 42a), and pooled Mongun-Taiga (No. 67).

The new cluster C, like the former one with the same designation, is cranially the "easternmost". It consists of two subclusters, C1 and C2. The first of them includes, apart from Karakol mentioned above (No. 5), six Baraba groups of the Northern Eurasian formation (No. 9–14). The second subcluster includes Late Krotovo (Cherno-Ozerye) samples from Sopka-2/5 (No. 15) and Cherno-Ozerye proper (No. 16), those from burials with Begazy-Dandybai traits in the Tomsk stretch of the Ob (Yelovka I, No. 33) and in the Baraba forest-steppe (No. 34), as well as two Andronoid groups: Cherkaskul (No. 29) and Korchazhka (No. 31). Yelovka I takes an isolated position within this subcluster, tending toward Fedorovka Andronovans (No. 25a). However, both Late Krotovo (Cherno-Ozerye) samples (No. 15 and 16) deviate from the Northern Eurasian formation in a different direction—not toward Andronovans but toward Andronoids of Cherkaskul (No. 29) and Korchazhka (No. 31), as well as toward a sample from burials exhibiting Begazy-Dandybai cultural traits in Baraba (No. 34).

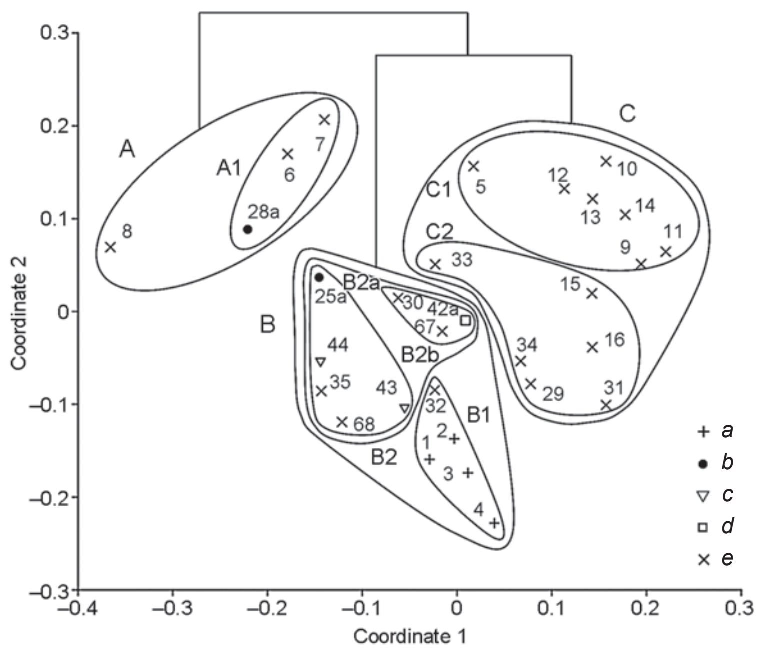

Fig. 2. Position of group centroids on the plane of the nonmetrical multidimensional scaling in the analysis with pooled groups (the dendrogram shows the hierarchical relationship between three major clusters A–C).

a – Okunev; *b* – Andronovo; *c* – Karasuk; *d* – Irmen; *e* – others. Groups are numbered as in the list (see above). Closed contours show clusters and subclusters.

Discussion

In the first analysis, three pre-Andronovo groups—Karakol (No. 5), Chaa-Khol (No. 6), and Yelunino (No. 7)—formed a separate cluster B, opposed to cluster A, which included morphologically "westernmost" Andronovans and the Samus sample (No. 8). This suggests that there were at least two post-Afanasyevo migrations to Siberia from the west, pre-Andronovo and Andronovo. Results of the second analysis do not contradict this despite the disappearance of the former cluster B, because three of the four members of the new cluster A precede Andronovo. Admittedly, the neighbor of Chaa-Khol and Yelunino in the second analysis is Samus rather than Karakol, whereas the Karakol people appear to have originated from a mixture between migrants from the west (Chaa-Khol and Yelunino), on the one hand, and autochthonous members of the Northern Eurasian formation, on the other*.

The two pooled Andronovo samples in the second analysis became members of different clusters: cluster A in the case of Alakul (No. 28a) and subcluster B2a in the case of Fedorovka (No. 25a). However, the distance separating them is small, especially as compared to a large between-group variation within these archaeological groupings (see Fig. 1). Findings of a special study (Kozintsev, 2023b) suggest that Fedorovka and Alakul have had a common origin, and the differences between them are secondary. Specifically, the "eastern" tendency of Fedorovka as compared to Alakul is likely caused by admixture between certain Fedorovka populations and Siberian autochthones.

The neighbors of Fedorovka within subcluster B2a in the second analysis are both pooled Karasuk groups: the earlier "classic" (No. 43) and the later Kamenny Log (No. 44). The apparent reason, apart from the Andronovo component in the Karasuk population, is the fact that the probable ancestors of Andronovans—the Catacomb people of Northern Caucasus, as well as those of Poltavka, Abashevo, and Sintashta—were not used in the present analysis (Ibid.). In both analyses, as in the earlier studies (Kozintsev, 2023a, 2024),

*This seems to disagree with the fact that the Karakol group—the most isolated of all—is closer to the Okunev-like (i.e., "Southern Eurasian") sample from Yelovka II than to any "Northern Eurasian" samples from Baraba. I thank Tatyana Chikisheva, who, in a personal communication, drew my attention to the "Southern Eurasian" tendency displayed by the Karakol people.

Karasuk groups are intermediate between Okunev and Andronovo, "classic" Karasuk being closer to the former, and Kamenny Log deviating toward the latter. This supports both the hypothesis of Karasuk origin through admixture (Vadetskaya, 1986: 61–63; Rykushina, 2007: 15, 20; Kozintsev, 2023a, 2024), and the idea that the transition between Karasuk proper and Kamenny Log was caused by another Andronovo migration, this time from Xinjiang via Mongolia down the Upper Yenisei (Poliakov, 2022: 311).

Apart from Fedorovka and Karasuk samples, subcluster B2a includes a Late Bronze Age group from the Upper Irtysh (No. 35) and a Mongun-Taiga sample from Baidag III in Tuva (No. 68). Both these groups, which are close to one another, take an intermediate position between Andronovo and Okunev. In this respect, they resemble Karasuk. Possibly, they too should be viewed in the context of admixture between Andronovans, on the one hand, and Okunev people or their relatives belonging to the Southern Eurasian formation, on the other (Kozintsev, 2023a, 2024).

The same may concern the Yelovka group (No. 32)—the only non-Okunev member of subcluster B1. It is intermediate between Okunev and Fedorovka, much closer to the former. Although archaeologists speak of an "extremely strong Andronovo component" in the Yelovka culture (Korochkova, 2013: 343), results of the first analysis in the present study indicate only the affinity between Yelovka and the cranially "easternmost" Andronovo groups—one from the same cemetery (No. 23)*, the other from the Baraba forest-steppe (No. 18), i.e., precisely those which, to all appearances, represent Siberian natives subjected to acculturation.

However, the closest affinity to Yelovka is displayed by its neighbors in subcluster B1—the Okunevans, especially the early ones, those from Tas-Khazaa (No. 1) and Uybat (No. 2). The D^2_c values in those cases are negative, which means that the crude D^2 is less than its statistical error. Chronological considerations suggest that what we see here is a similar proportion of two components, native and immigrant (European), rather than direct relationship. The share of the latter was higher in early Okunevans than in the later ones (Poliakov, 2022: 131–132; Gromov, 1997), which, apparently, accounts for the observed result.

Among all the groups used, only that associated with the Yelovka culture can be regarded as a possible direct descendant of the Okunev population or a related one. If so, it likely included a slight Andronovo admixture. The fact that the Yelovka culture is separated from Okunev in both time and space does not contradict the idea of continuity, because the Southern Eurasian formation included not only Okunevans (Chikisheva, 2012: 57–58; Kozintsev, 2021). Evidently, what we observe here is acculturation, whereby Siberian natives—descendants of Okunevans or their relatives—borrowed the elements of Andronovo culture without mating with the immigrants on a large scale.

Because subcluster B2b takes a central position, it is difficult to assess its status. One of its members is the pooled Irmen group (No. 42a), whose closest parallel is the pooled Mongun-Taiga sample (No. 67). The latter is even closer to Irmen than to the other Mongun-Taiga group—Baidag III (No. 68). Archaeologists wrote about the continuity between Irmen and the Yelovka culture preceding it (see especially (Matyushchenko, 1974: 4–5)). While the cranial resemblance between them does exist, the parallel between Irmen and Mongun-Taiga is even more marked. It is especially prominent in the southernmost Irmen population—that from the forest-steppe Altai (No. 38). Whether or not this is accidental is hard to say. Regarding the relative resemblance of Irmen to Andronovo versus Karasuk, the two-dimensional space occupied by centroids of separate Irmen samples in the analysis with small samples overlaps with both, being shifted in the morphologically "eastern" direction relative to both, especially to Andronovo. In the second analysis, the pooled Irmen group (No. № 42a) is equally distant from pooled Fedorovka (No. 25a), and both pooled Karasuk groups (No. 43 and 44). Its position, like that of the entire subcluster B2b, including Pakhomovskaya and Mongun-Taiga, agrees with the idea of admixture between Fedorovka immigrants and Siberian autochthones similar to those of Late Krotovo (Cherno-Ozerye) stage. Possibly, the agreement would be even better if we assume that Karasuk people, too, were engaged in the admixture. However, Pakhomovskaya (No. 30) is closer to another Andronoid group, Yelovka, than to other members of subcluster B2b. Both groups, despite the impression that the two-dimensional projection conveys (see Fig. 2), are equally removed from Fedorovka, although archaeological facts indicate the predominance of the Andronovo component in Yelovka and the mostly local roots of Pakhomovskaya (Korochkova, 2013).

Representatives of the Late Krotovo (Cherno-Ozerye) stage at Sopka-2 (No. 15) and especially at Cherno-Ozerye proper (No. 16)—members of subcluster C2—deviate from the Baraba groups of the Northern Eurasian formation (subcluster C1) not toward Andronovans but toward the Southern Eurasian formation, specifically the Okunev-Yelovka subcluster B1. This was noted also by T.A. Chikisheva (2012: 123). To an even greater degree, this concerns other members of subcluster C2: possible relatives of the Begazy-Dandybai people in the Baraba forest-steppe (No. 34) and Andronoids associated with the Korchazhka (No. 31) and Cherkaskul (No. 29) cultures.

*This is hardly incidental, given the territorial coincidence of both these groups.

The position of the second presumably Begazy-Dandybai sample, from Yelovka I (No. 33), is rather peculiar; unlike other members of subcluster C2, it really shows a marked Andronovo tendency, compatible with the idea of admixture between aborigines of the Northern Eurasian formation and Andronovans*.

The status of other members of subcluster C2—Late Krotovo (No. 15 and 16), Cherkaskul (No. 29), Korchazhka (No. 31), and cultural relatives of the Begazy-Dandybai people in Baraba (No. 34)—is hardly reconcilable with the above hypothesis. They are far not only from Andronovans but also from an imaginary line connecting them with members of the Northern Eurasian formation (see Fig. 2). Meanwhile, according to a common view, admixed populations are normally intermediate between parental ones in terms of measurements and their combinations. Nor are there any indications that subcluster C2 evidences admixture between Andronovans and Okunev people or their relatives belonging to the Southern Eurasian formation. To all appearances, members of subsluster C2 are Western Siberian autochthones, who, rather than mixing with Andronovans, had undergone acculturation. But which of the two known Eurasian formations did they belong to?

Late Krotovo (No. 15 and 16) is clearly an offshoot of the Northern Eurasian formation, to which people of the classic Krotovo stage belong (No. 14). Cherkaskul people (No. 29) are closest to a Late Krotovo group from Cherno-Ozerye (No. 16), but they also resemble people associated with Yelovka culture (No. 32), who belong to the Southern Eurasian formation. The cultural relatives of Begazy-Dandybai people in Baraba (No. 34) are similar to both Late Krotovo (Cherno-Ozerye) samples and to Yelovka. The Korchazhka people (No. 31), too, are similar to those of Cherno-Ozerye, but also, like the pooled Irmen group (No. 42a), to Mongun-Taiga (No. 67). The latter, in turn, resemble classic Karasuk (No. 43; Chikisheva (2012: 8) attributes both latter groups to the Southern Eurasian formation).

Samples from cemeteries with Begazy-Dandybai features at Yelovka I (No. 33) and in the Baraba forest-steppe (No. 34), according to the results of the first analysis, are situated in the right, i.e., cranially "eastern", part of the Andronovo grouping. Although in the second analysis they both are members of the same subcluster C2, no particular resemblance between them is seen, and the only group deviating toward Andronovans is Yelovka I, which, like Irmen, is closest to Mongun-Taiga (No. 67). As to supposed cultural relatives of the Begazy-Dandybai people in Baraba (No. 34), this was the group that Chikisheva used to describe the Southern Eurasian formation for the first time (Ibid.: 57). However, as the statistical analysis demonstrates, this group is closest to Late Krotovo (Cherno-Ozerye) samples (No. 15 and 16), which are affiliated with the Northern Eurasian formation, but, like Cherkaskul (No. 29) and Korchazhka (No. 31), displays an even stronger Southern Eurasian tendency. It appears that both Eurasian formations, so far rather vaguely demarcated, are extremes of the same continuum. The group associated with the Yelovka culture (No. 32), which, too, was possibly influenced by the Begazy-Dandybai culture (Kiryushin, 2004: 95), definitely belongs to the Southern Formation, since it is part of the Okunev cluster. Because samples from cemeteries showing elements of Begazy-Dandybai culture are not close cranially, and the Begazy-Dandybai culture proper is not represented by cranial material, these findings can hardly be interpreted in a historically meaningful way. The four Andronoid groups, too, do not display a single physical type. In the second analysis, the two cranially more "western" ones, Pakhomovskaya (No. 30) and Yelovka (No. 32), are members of cluster B, the latter group differing from the former by a distinctly "Okunev" tendency. The more "eastern" samples, Cherkaskul (No. 29) and Korchazhka (No. 31), fall within subcluster C2, together with groups from the Late Krotovo (Cherno-Ozerye) cemeteries (No. 15 and 16).

*It is closest to the Mongun-Taiga group (No. 67), although the latter belongs to another cluster.

Conclusions

1. Yelunino, Chaa-Khol, and Samus belonged to the second (post-Afanasyevo) migration to Siberia from the west, whereas Andronovans represented the third migration. The Karakol people display contradictory affinities: with pre-Andronovo migrants such as Yelunino and Chaa-Khol, with autochthones of Baraba, and with Andronoids of Yelovka.

2. The small "eastern" tendency of Fedorovka relative to Alakul is likely caused by the native substratum absorbed by the former rather than by various origins.

3. The Karasuk population evidently emerged by admixture between Okunev and Andronovo people. Representatives of the "classic" Karasuk stage are closer to the former, while those of the Kamenny Log stage deviate toward the latter. Late Bronze Age people of the Upper Irtysh and the Mongun-Taiga people of Baidag III resemble those of Karasuk in appearance. They all may have had a common origin.

4. Andronoids of Yelovka II resemble Okunev people, but probably have a small Andronovo admixture.

5. The Late Krotovo (Cherno-Ozerye) groups from Sopka and Cherno-Ozerye proper deviate from the Baraba natives of the Northern Eurasian formation toward Okunev rather than Andronovo. The same applies to Andronoids of Cherkaskul and Korchazhka and to a group

from Late Bronze Age cemeteries with Begazy-Dandybai cultural features in Baraba. Yelovka I, which is culturally close to the latter, is intermediate between the Baraba autochthones and Andronovans.

6. Results suggest that both Eurasian formations, Northern and Southern, are extremes of the same continuum.

7. The pooled Irmen group, the pooled Mongun-Taiga group, and the Andronoids of the Pakhomovskaya culture take a central position in the analysis, which agrees with the idea that they originated through admixture of several components—both Eurasian formations, Andronovo, and Karasuk.

8. Only two of the four Andronoid groups, Yelovka and Pakhomovskaya, display traces of admixture between the aborigines and Andronovans. Two other Andronoid groups, Cherkaskul and Korchazhka, show no such traces, and the same is true of Late Krotovo people. The Southern Eurasian formation was more affected by the admixture between the autochthones and the Andronovo immigrants than was the Northern Eurasian formation.

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Affinities of the Sargat Population in the Baraba Forest-Steppe

Within-group, between-group, and comparative analysis of craniometric data relating to local and chronological samples of the Sargat population (5th century BC to late 3rd / 4th century AD) was carried out. The study focuses on sample from the Baraba forest-steppe. Comparative analysis, performed with the principal component method, included Early Iron Age samples from adjacent territories. No discontinuity was found in the spatio-temporal cranial variation among the Sargat groups. Despite differences between the three Sargat samples (Baraba, Irtysh, and Trans-Ural), they all represent one and the same Caucasoid physical type, characterized by meso-brachycrany, medium-high braincase, wide low, and somewhat flattened face, moderately inclined frontal bone, and protruding nasal bones. The Baraba group differs from two others by a wider face, larger pyriform aperture, and largest dacryal width. Comparative statistical analysis indicates affinities of the male part of Sargat groups with nomads of the Urals and Kazakhstan—Saka, Sauromatians, and Sarmats. Possibly, military campaigns by the Achaemenid state against the nomadic tribal unions of Central Asia in the second half of the 6th century BC triggered the migration process. Initially, migrants moved to the Irtysh basin, and thence to the western (Trans-Ural) and eastern (Baraba) peripheries of the emerging Sargat culture. The female part of the population was less affected by migratory processes. Female samples of the Sargat reveal an autochthonous cranial complex.

Keywords: *Sargat culture, cranial complexes, West Siberian forest-steppe, Ural and Kazakhstan steppes, nomadic tribes.*

Introduction

The similarities in the ceramics, house-building techniques, and funerary rites observed across the forest-steppes of the Irtysh and Ishim regions led to the formation of the concept and the term "Sargat culture" in the late 1960s (Koryakova, 1982: 115). The accepted boundaries of the Sargat archaeological sites area are as follows: the northern boundary is determined by the Tobol River's mouth, while the eastern boundary is delineated by the western part of the Baraba Lowland, extending to the middle of the Om River. The southern boundary is demarcated by the Kazakh steppes at approximately 55° N, the western boundary by the lower Tobol, Pyshma, Tavda, and the middles of the Iset and Miass rivers. Consequently, this area covers mainly the forest-steppe zone, and at its edge spreads to the northern sections of the steppe and southern forest zones (Koryakova, 1988: 6). The Sargat culture is represented by four local variations: Tobol, Ishim, Irtysh, and Baraba, which are geographically associated with the basins of the major rivers in Western Siberia (Ibid.; Matveeva, 2018).

Radiocarbon dating carried out by N.P. Matveeva on 118 samples from various objects, settlements, and burial mounds provided the results that placed the Sargat culture's primary area of existence (in the Tobol-Irtysh interfluvial region) in the period from the 5th century BC to the first half of the 4th century AD (2017). In accordance with the findings of S.V. Sharapova, the upper chronological boundary does not extend beyond the middle/second half of the 3rd century AD (2020). N.V. Polosmak, who conducted research on the Sargat culture in the Baraba forest-steppe (bordering the eastern edge of the Sargat area), posits that cultural formation began in the late 7th century BC, with its final stage dating from the 1st century BC to the 1st century AD (1987a: 96). Her evidence for this period includes analogs of grave goods, local features of the funerary rite, ceramics, and settlement structures. Nevertheless, dating in accordance with analogy provides a subjective assessment, which might lead to the wider intervals, as evidenced by the Baraba local variant. Therefore, it is imperative to conduct research into the anthropological characteristics of the ancient inhabitants of Baraba belonging to the Sargat culture, with a particular focus on morphology. A comparative analysis of Early Iron Age Sargat groups from different areas has been conducted. In addition, this article presents paleoanthropological studies on ancient people of the Baraba variant of the Sargat culture, which have not been previously published.

Material and methods

The paleoanthropological materials of the Sargat culture from the Baraba forest-steppe, which were obtained by 2000, were published by A.N. Bagashev (2000: 80–88; 338–349). During the last two decades, new data have been collected; thus, the present study has been supplemented by new materials from several cemeteries: Ust-Tartasskiye Kurgany, mound 51 (Mylnikova et al., 2022), Pogorelka-2 (Molodin et al., 2009), Gosudarevo Ozero (Molodin et al., 2017), Yashkino-1 (mounds 1 and 2 were excavated in 1982 by A.N. Neskorov, who discovered the site (Molodin, Novikov, 1998: 64), mound 5, in 2013 (Kobeleva et al., 2013)), and Protoka, barrow of mound 1 (Polosmak, 1987b).

The following comparative craniological material from the Early Iron Age of Western Siberia has been compiled from several publications: Sargat samples from the above-mentioned monograph by Bagashev (2000: 260–355)*, the pooled sample of the Kamen culture from the publication by M.P. Rykun (2013: 88–90), and that of the Bolshaya Rechka culture from the dissertation of M.S. Kishkurno (2023a: App. 2, pp. 22–61).

Multivariate exploratory techniques are designed to characterize a vast array of data. These techniques were applied for a thorough investigation of the craniological characteristics of contemporaneous populations inhabiting the regions of Eurasia neighboring the Sargat area. The data were also utilized in a monographic study where the provenance and archaeological context of the anthropological materials could be observed (Chikisheva, 2012: 13–16). The exceptions are two series stored at Jilin University (Changchun, China), which were analyzed by me but not included in this study. These are from the cemeteries of Nilki (Northeast Xinjiang, northern spurs of the Tien Shan, excavations of 2001) and Yanghai (Central Xinjiang, southern foothills of the Tien Shan, excavations of 1988) (Zhang Tienan, 1995).

To ensure the continued relevance and currency of the anthropological collections and the bibliographic list of sources, it is necessary to replenish them with new individual and average data. The adjustments affected the groups of the Sako-Usun period in Central Asia, and craniological materials of the Uyuk-Sagly culture (6th–4th centuries BC) from the Sagly cemetery in Tyva (Kozintsev, Selezneva, 2011). Furthermore, the pooled series of Usuns from Semirechye (4th century BC to 3rd century AD) (Ismagulov, 1962) was augmented with skulls from burials dating to the 4th–2nd centuries BC (Kitov, Tur, Ivanov, 2019: 195–196, 203–208). I considered it possible to combine these data with the very sparse material from the Zhaosu cemetery (5th–1st centuries BC) (Han Kangxin, Pan Qifeng, 1987), since all the archaeological sites are in one geographical area—the Ili River basin. A series from Korgantas-type burials, dating to the 4th–2nd centuries BC was included in the analysis along with groups of Central Kazakhstan (Beisenov et al., 2015: 181–184). A pooled series from Western Kazakhstan of the 4th century BC to the turn of the eras was formed (Kitov, Mamedov, 2014: 304–349). The quantity of published craniological material from Kyrgyzstan has increased significantly in recent years. In light of the revised dating of the majority of archaeological sites and the attribution of their entire array to the Saka culture (Kitov, Tur, Ivanov, 2019: 68), in the comparative analysis I applied the craniometric data on the newly unified series spanning the 5th–2nd centuries BC from the valleys of Tien Shan (western and central parts) (Ibid.: 69–71, 82–83, 91–92, 209–235) and Pamir-Alai (Ibid.: 82–83, 94–95, 99–100, 106–107, 235–242). The Sauromatian series from the Southern Urals was compiled from the materials of M.S. Akimova (1968) and T.S. Konduktorova (1962), while the Sarmat series combined the data of M.S. Akimova (1968), V.V. Ginsburg and B.V. Firshtein (1958).

*The craniological series of the Ishim variant of the Sargat culture has been excluded from the statistical analysis owing to its paucity and poor preservation. Materials from burials in the Tobol valley and its tributaries have been grouped by Bagashev into the "Trans-Ural" category and will be referred to under this name here.

A total of 34 craniological series were included in the comparative analysis: Sargat culture of the Baraba forest-steppe (1), Trans-Urals (2), and Irtysh basin (3); Bolshaya Rechka culture of the Novosibirsk stretch of the Ob (4); Kamen culture of the Upper Ob (5); Pazyryk culture of the Altai Mountains (6); Tagar culture of the Minusinsk Basin (7); early stage of the Aldy-Bel culture of Tyva, Arzhan-2 (8); final stage of the Aldy-Bel culture of Tyva, Kopto (9); Uyuk-Sagly culture of Tyva, Dogee-Baary-2 (10), Sagly (11); 5th–3rd centuries BC, pooled series from different cemeteries of Tyva (12); Ulangom cemetery in Western Mongolia (13); Saka (14) and Wusun (15) of Eastern Kazakhstan (Irtysh valley); Wusun from the Ili River basin (16); Saka (17), Tasmola culture (18), burials of Korgantas type (19) of Central Kazakhstan; Saka of Northern Kazakhstan (20), Western Kazakhstan (21), Central Tien Shan (22), Alai (23); Saka of Xinjiang—Nilki (24), Yanghai (25), Alagou (26); Dzhetyasar culture (Saka-Tokhar) (27), Chirikrabat culture (Saka-Apasiak) (28), pooled series of 7th–5th centuries BC (Saka-Sakaravak) (29) of the Eastern Aral Sea region; male series of the Kuyusai culture of the Southern Aral Sea region (30); the Sauromatians (31) and Early Sarmats (32) of the Southern Urals; the Sauromatians (33) and Early Sarmats (34) of the Volga-Don interfluve.

A principal component analysis, conducted with Statistica 8 software, was used to facilitate comparative intergroup analysis. The craniometric program comprised 20 features, including the diameters of the cerebral and facial parts of the skull, angular parameters of vertical and horizontal profiles, the orbits and nasal aperture sizes, the width and height of the nose bridge, and the angle of nasal bone protrusion.

Results and discussion

The skeletal remains of the Sargat culture examined by me are poorly preserved. As a result, it is rarely possible to reconstruct the complete morphological type of an individual, characterized by the features of facial and cerebral sections. This does not lend itself to multivariate statistical analyses. At the same time, the craniological materials described by Bagashev, including those from the Baraba forest-steppe, are in a better state of preservation. The pooled series from Baraba provides increasing possibilities to study its craniometric variability. The individual measurement data of the new specimens (Tables 1, 2) don't include calculations of the cranial shape indices. However, these can be calculated, if necessary. The variability of these features will be the subject of discussion in the text.

An analysis of the individual values of craniometric traits in the total Baraba series has shown that nearly all of the craniometric measurements exhibit a normal distribution. This result was obtained through the Shapiro-Wilk test assessment. Among the male subjects, a distribution different from the normal was observed only for the zygomatic diameter ($p = 0.0015$). In this small group, there is an individual (Pogorelka-2, burial 3), whose face was reconstructed after severe deformation; this may have affected the distribution of variation series for this trait, given a very large zygomatic width (159 mm, see Table 1). However, even with this individual excluded, the test demonstrated a significant difference ($p = 0.0356$). In the male series from the Trans-Urals, a similar situation is observed for the length of the skull base ($p = 0.0239$). In the Irtysh series, however, no irregularities in the distribution of traits were observed. Furthermore, in the female Baraba group, the additional trait of upper facial height ($p = 0.0405$) is added to zygomatic diameter ($p = 0.0194$); in the Trans-Urals group, cranial index ($p = 0.0133$) is added; and in the Irtysh group, nose height ($p = 0.0399$).

Thereafter, the morphological differences between the three Sargat variants were examined. The analysis was carried out using Student's criterion for intergroup comparison of trait mean values and Fisher's criterion for sample variance comparison. In the groups under study, almost all traits, with the exception of a few, exhibited normal intragroup distribution. These data also exhibited unimodality, which is typically observed in anthropological data, and the characteristics of both criteria remained intact (Deryabin, 2004: 43, 53).

The results of the tests demonstrate that the differences in the mean values for a greater number of traits in the male Sargat samples were less than the critical level ($p \leq 0.05$) as compared to the female samples. Nevertheless, in the latter, there are considerable differences in dispersion for numerous traits.

The male Baraba group differs from the Irtysh one in cranial index ($p = 0.0357$), height ($p = 0.0234$), and width ($p = 0.0099$) of the pyriform aperture, nasal index ($p = 0.0009$), and dacryal width ($p = 0.0020$). The latter parameter also shows a difference in variance ($p = 0.0387$). The Baraba group differs from the Trans-Ural group in zygomatic width ($p = 0.0504$) and frontal-maxillary index ($p = 0.0276$). The longitudinal diameter of the skull ($p = 0.0458$) and cranial index ($p = 0.0298$) reveal differences between the Trans-Ural and Irtysh series. Consequently, the composition of craniometric features differentiating male Sargat samples is relatively limited. In comparison to other groups, the Baraba one is distinguished by moderate brachycrany (the largest value of cranial index is observed in the Trans-Ural group, while the smallest, belonging to the category of mesocranial, is in the Irtysh group), widest faces and largest dacryal width, and largest pyriform aperture.

The Baraba females differ from the Irtysh and Trans-Ural groups by a smaller naso-malar angle, indicating

Table 1. **Individual dimensions of male skulls from the Sargat cemeteries (Baraba forest-steppe)**

Trait	Ust-Tartasskiye Kurgany, mound 51, burial 23	Yashkino-1, mound 5, burial 1	Gosudarevo Ozero-1		Pogorelka-2			*X*/*N*/*S*
			Mound 1, burial 4	Object 65, burial 10?	Burial 3	Burial 4	Burial 5	
1	2	3	4	5	6	7	8	9
Age	40–45	40–45	20–25	30–35	40–45	40–45	35–40	–
1. Cranial length	188	170	175	176	190	198	…	182.8/6/10.8
8. Cranial breadth	150	158	138	138	146	149	…	146.5/6/7.7
8 : 1. Cranial index	79.8	92.9	78.9	78.4	76.8	75.3	…	80.4/6/6.4
17. Cranial height (from basion)	137	137	129	135	139	146	…	137.2/6/5.5
20. Cranial height (from porion)	116	121	113	118	-	128	…	119.2/5/5.7
5. Cranial base length	108	102	97	102	104	114	…	104.5/6/5.9
9. Minimal frontal breadth	94.2	101.1	90.2	82.3	101	102.4	96	95.3/7/7.2
10. Maximal frontal breadth	117	122	119	109	126	127?	…	120.0/6/6.6
11. Cranial base breadth	132	145	127	127	…	127	…	131.6/5/7.8
12. Occipital breadth	119	118	106	113	…	111	…	113.4/5/5.3
29. Frontal chord	110.8	109	103.6	110.2	131	121.2	…	114.3/6/10.0
30. Parietal chord	106	111	111	107	110	115	…	110/6/3.2
31. Occipital chord	97.5	92.2	94	90.3	87.9	93.7	…	92.6/6/3.3
26. Frontal arc	128	123	118	127	151	141	…	131.3/6/12.3
27. Parietal arc	118	126	127	119	124	126	…	123.3/6/3.9
28. Occipital arc	126	108	118	111	103	119	…	114.2/6/8.4
29 : 26. Frontal curvature index	86.6	88.6	87.8	86.8	86.8	86	…	87.1/6/0.94
Transverse frontal curvature angle (TFCA)	140.4	148.3	143.3	142	133.3	133.5	139.8	140.1/7/5.3
Sub.NB. Longitudinal frontal curvature subtense	24.6	20	18.8	23	33	24.6	…	24.0/6/5.0
Occipital curvature height (OCH)	27	19.7	26.3	24.3	16.1	25.8	…	23.2/6/4.4
45. Bizygomatic breadth	142	150	137	134	159?!	138	…	143.3/6/9.5
40. Facial base length	…	106	98	98	…	112	…	103.5/4/6.8
48. Upper facial height	…	71	65	66	…	70	…	68.0/4/2.9
47. Full facial height	…	120	…	…	…	118	…	119.0/2
43. Upper facial breadth	…	119	104	101	115	113	…	110.4/5/7.6
46. Midfacial breadth	…	108	100	…	…	102	…	103.3/3
60. Alveolar length	…	57	56	46	…	60	53	54.4/5/5.3
61. Alveolar breadth	…	69	66	63	…	67	64	65.8/5/2.4
62. Palate length	…	49.3	46.3	42	…	49	44.6	46.2/5/3.1
63. Palate breadth	…	41	37.8	37.4	…	37.5	39	38.5/5/1.5
55. Nasal height	…	54.1	48.6	47.6	…	54	…	51.1/4/3.5
54. Nasal breadth	…	28.5	27.7	27	…	24.3	…	26.9/4/1.8
51. Orbital breadth from mf.	…	47.3	43.4 (r.)	44.8 (r.)	…	47.2	…	43.4/4/1.9
51a. Orbital breadth from d.	…	43.1	40.7 (r.)	40.2 (r.)	…	45.2	…	42.3/4/2.3
52. Orbital height	…	35	32.5 (r.)	34.6 (r.)	…	34	…	34.0/4/1.1

Table 1 (end)

1	2	3	4	5	6	7	8	9
Bimalar breadth (BB)	…	108.2	98.1	95.5	108.9	105.6	…	103.3/5/6.1
Subtense from nasion to bimalar breadth (SN)	…	15.3	15.7	12.6	23.7	18.2	…	17.1/5/4.2
Zygomaxillary breadth (ZB)	…	111.4	98.6	…	…	100	…	103.3/3
Subtense from subspinale to the zygomaxillary breadth (SS)	…	27.9	22	…	…	22.2	…	24.0/3
77. Nasomalar angle	…	148.5	144.5	150.6	133.1	142	…	143.7/5/6.8
ZM. Zygomaxillary angle	…	126.9	131.9	…	…	132.1	…	130.3/3
SC. Simotic chord	…	9.5	8	7.1	…	6.8	9.5	8.2/5/1.28
SS. Simotic subtense	…	…	5.6	4.2	…	1.7	4.1	3.9/4/1.61
MC. Maxillofrontal chord	…	21.4	17.2	17	…	18.2	…	18.5/4/2.04
MS. Maxillofrontal subtense	…	…	8.2	5.6	…	6.2	…	6.7/3
DC. Dacrial chord	…	25.3	20	23.5	…	20.1	…	22.2/4/2.6
DS. Dacrial subtense	…	…	10.8	11.6	…	10	…	10.8/3
FC. Canine fossa depth (mm)	…	4.1	3.8 (r.)	4.7 (r.)	…	4.6 (r.)	…	4.3/4/0.42
Zygomatic bone curvature height (ZCH)	…	11.6	11.2 (r.)	10.1 (r.)	8.2 (r.)	15.5	…	11.3/5/2.7
Zygomatic bone breadth (ZB)	…	56.5	56.8 (r.)	51.5 (r.)	56.7 (r.)	61.5	…	56.6/5/3.5
32. Frontal profile angle from nasion	…	79	75	76	…	68	…	74.5/4/4.7
GM\FH. Frontal profile angle from glabella	…	70	67	69	…	68	…	68.5/4/1.3
72. General facial angle	…	78	77	85	…	79	…	79.8/4/3.6
73. Mid-facial angle	…	86	80	87	…	83	…	84.0/4/3.2
74. Alveolar angle	…	57	55	73	…	67	…	63.0/4/8.5
75. Nasal bones inclination index	…	…	53	62	…	54	…	56.3/3
75 (1). Nasal protrusion angle	…	…	24	23	…	25	…	24.0/3
68 (1). Mandibular length from condyles	…	121	…	…	101	…	104	108.7/3
79. Mandibular ramus angle	…	124	…	…	106	121	129	120.0/4/9.9
68. Mandibular length from angles	…	86	…	…	84	83	75	82.0/4/4.8
70. Ramus height	…	60	…	…	68	…	56	61.3/3
71a. Minimum ramus breadth	…	37	…	…	36	38	35	36.5/4/1.3
65. Condylar width	…	121	…	…	134	…	128	127.7/3
66. Angular width	…	107	…	…	118	98	118	110.3/4/9.7
67. Anterior width	…	51	…	…	48	47	51	49.3/4/2.1
69. Symphyseal height	…	35	…	…	34	34	35	34.5/4/0.58
69 (1). Corpus height	…	…	…	…	30 (r.)	31	32	31.0/3
69 (3). Corpus breadth	…	14	…	…	12 (r.)	13	15	13.5/4/1.3
C'. Mental protrusion angle	…	65	…	…	…	…	70	67.5/2
Intercilium (IC 1–6)	4	4	3	4	5	5	4	4.1/7/0.69
Browridges (BR 1–3)	2	2	1	2	2	2	2	1.9/7/0.38
External occipital tuber (EOT 0–5)	3	4	2	0	5	0	…	2.3/6/2.2
Mastoid process (MP 1–3)	3	2	2	2	3	3	2	2.4/7/0.53
Inferior margin of the piriform aperture (IMPA)	Anthr.	Anthr.	F. pr.	Anthr.	…	Anthr.	F. pr.	…
Anterior nasal spine (ANS 1–5)	…	3	…	3	…	3	3	3.0/4/0

Table 2. **Individual dimensions of female skulls from the Sargat cemeteries (Baraba forest-steppe)**

Trait*	Ust-Tartasskiye Kurgany				Yashkino-1			Gosudarevo Ozero-1					Pogorelka-2, burial 2	Protoka, mound 1, burial 1 (in the tumulus)	*X*/*N*/*S*
	Mound 51, burial 5 (from the trench wall)	Mound 51, burial 7, sk. 2	Mound 51, burial 13	Mound 51, burial 17	Mound 1, looting pit	Mound 1, burial 1	Mound 2, burial 2	Burial 3	Burial 6	Burial 7	Burial 9	Tumulus			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Age	> 50	25–30	> 50	40–50	40–45	25–30	35–40	20–25	50–60	18–20	35–40	30–35	35–40	25–30	–
1	…	174	…	181	173	…	170	…	…	…	…	172	176	172	174.0/7/3.6
8	…	136	…	131	137	…	135	…	152?	142	149?	132	138	136	138.8/10/6.9
8 : 1	…	78.2	…	72.4	79.1	…	79.4	…	…	…	…	76.7	78.4	79.1	77.6/7/2.5
17	…	132	…	131	133	…	128	…	…	…	…	128	134	130	130.9/7/2.3
20	…	115	…	110	115	…	112	…	…	…	…	113	113	…	113.0/6/1.9
5	…	100	…	102	102	…	95	…	…	…	…	98	102	101	100.0/7/2.6
9	…	88.2	96.6	92.3	98	…	84.5	…	100.8	116	…	86.5	97	90	95.0/10/9.1
10	…	109	…	101	117	…	111	…	125	…	…	111	116	115	113.1/8/7.0
11	…	123	…	124	125	…	121	…	144?	…	132	121	125	126	126.8/9/7.2
12	…	114	…	102	112	…	112	…	…	…	101	101	112	107	107.6/8/5.6
29	…	111.5	114.6	101.5	103.2	…	105.8	…	113.6	…	…	107.3	108.2	108.8	108.3/9/4.4
30	…	96	…	113	107	…	108	…	113	94	…	103	114	106	106.0/9/7.2
31	…	92.8	…	92.6	94.6	…	95.8	…	…	93	96.5	…	88.2	92	93.2/8/2.5
26	…	126	126	136	118	…	119	…	132	…	…	122	121	132	125.8/9/6.4
27	…	110	…	133	118	…	118	…	128	102	120	118	126	126	119.9/10/9.1
28	…	115	…	113	115	…	121	…	…	100	114	…	103	114	111.9/8/6.9
29 : 26	…	91.3	91	74.6	87.5	…	88.9	…	86.1	…	…	88	89.4	82.4	86.6/9/5.2
TFCA	…	135.6	129.1	129.1	141.6	…	140	…	135.8	…	…	138	131.7	…	135.1/8/4.8
Sub. NB	…	20.2	22.7	21	23.1	…	22.5	…	27.7	…	…	23.3	24	22.6	23.0/9/2.1
OCH	…	25.4	…	22	24.8	…	28.2	…	…	21.8	20.7	…	23	22.7	23.6/8/2.4
45	…	133	126?	127	133	…	124	…	152?	…	140?	126	135	133	132.9/10/8.4
40	…	…	…	…	102	…	97	…	…	…	…	92	94	93	95.6/5/4.0
48	…	…	66?	…	73	…	66	…	…	…	…	70	64	65	67.3/6/3.4
47	…	…	116?	…	117	…	106	…	…	…	…	…	…	109	112.0/4/5.4
43	…	101	105	102	108	…	102	…	110	…	…	100	110	100	104.2/9/4.1
46	…	…	90	…	98	…	91	…	…	…	…	…	99	88	93.2/5/5.0
60	…	…	…	…	56	…	51	…	…	…	…	…	52	52	52.8/4/2.2
61	…	…	62.5	…	65	…	58	…	…	…	…	…	67	54	61.3/5/5.3
62	…	…	…	…	43	…	45	…	…	…	…	…	41.7	44.2	43.5/4/1.4
63	…	…	34.3	…	35.6	…	33.6	…	…	…	…	…	39.7	35.6	35.8/5/2.4
55	…	…	51.7	…	52.2	…	51	…	…	…	…	…	51.5	47.5	50.8/5/1.9
54	…	…	28.2	…	26.3	…	24.2	…	…	…	…	…	25.8	23.7	25.6/5/1.8
51	…	…	45	…	46.2	…	40.6	…	…	…	…	43.4 (r.)	47.3	41.4	44.0/6/2.7
51a	…	…	41.5	…	44.8	…	39.8	…	…	…	…	42 (r.)	44.5	40.3	42.1/6/2.3

Table 2 (end)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
52	…	…	34.4	32.7	33.2	…	31.7	…	…	…	…	33.3 (r.)	37.2	35?	33.8/6/1.9
BB	…	93.2	97.1	95.5	98.9	…	94.5	…	101.1	…	…	95.2	105	93.2	97.1/9/3.9
SN	…	18.8	20	20	17	…	17.4	…	16.7	…	…	14.8	22.7	18.2	18.4/9/2.3
ZB	…	…	94.5	…	99.8	…	92.9	…	…	…	…	…	99.4	88	94.9/5/4.9
SS	…	…	23.5	…	23.2	…	21.1	…	…	…	…	…	24.2	19.2	22.2/5/2.1
77	…	136.2	135.2	134.6	142	…	139.6	…	143.5	…	…	145.6	133.3	137.4	138.6/9/4.3
ZM	…	…	127.1	…	130.2	…	131.2	…	…	…	…	…	128.2	132.9	129.9/5/2.3
SC	…	…	10.2	…	4.7	…	8.8	…	8.9	…	…	8	7.4	6.2	7.7/7/1.8
SS	…	…	5.6	…	1.6	…	4	…	3	…	…	3.2	2.3	2.5	3.2/7/1.3
MC	…	…	17.5	…	14.6	…	18	…	…	…	…	18.5	18.6	16.2	17.2/6/1.6
MS	…	…	7	…	6.3	…	7.2	…	…	…	…	6.4	5	7.2	6.5/6/5.0
DC	…	…	21.3	…	17	…	20.2	…	…	…	…	18	24	18.3	19.8/6/2.6
DS	…	…	10.5	…	10	…	10.3	…	…	…	…	7.6	10	9.7	9.7/6/1.1
FC	…	…	4	…	2.5	…	2	…	…	…	…	3.1 (r.)	2.5	5.3?	3.2/6/1.2
ZCH	…	…	11	10.6	9.5	…	10.5	…	…	…	…	11.3	10.5	11.1	10.6/7/0.59
ZB	…	…	53	51.4	53.6	…	52.2	…	…	…	…	51.2	56.2	51	52.7/7/1.8
32	…	…	…	…	83	…	82	…	…	…	…	76	78	80	79.8/5/2.9
GM\FH	…	…	…	…	77	…	74	…	…	…	…	73	75	76	75.0/5/1.6
72	…	…	…	…	82	…	81	…	…	…	…	86	80	88	83.4/5/3.4
73	…	…	…	…	85	…	90	…	…	…	…	93	83	88	87.8/5/4.0
74	…	…	…	…	70	…	65	…	…	…	…	69	75	88	73.4/5/8.9
75	…	…	…	…	59	…	56	…	…	…	…	…	…	67	60.7/3/5.7
75 (1)	…	…	25	…	23	…	25	…	…	…	…	…	…	21	23.5/4/1.9
68 (1)	106	…	…	…	110	100	103	97	104	…	…	…	…	…	103.3/6/4.5
79	113	…	124	…	122	126	118	108	112	…	118	…	…	…	117.6/8/6.3
68	82	…	80	…	81	70	78	81	82	…	82	…	…	…	79.5/8/4.1
70	61	…	61 (r.)	…	55	51 (r.)	58	60	66	…	…	…	…	…	58.9/7/4.8
71a	37	…	37 (r.)	…	35	32 (r.)	36	35	36	…	38 (r.)	…	…	32	35.3/9/2.1
65	123	…	…	…	112	99	112	112	119	…	…	…	…	126	114.7/7/9.0
66	103	…	109	…	99	95	94	93	66	…	113	…	…	85	95.2/9/13.9
67	45	…	49	…	46	47	46	48	67	…	44	…	…	40.6	48.1/9/7.5
69	27	…	32	…	…	30	30	25	69	…	…	…	…	27	34.3/7/15.5
69 (1)	29	…	32	…	29	30	27	25	27	…	30	…	…	28	28.6/9/2.1
69 (3)	14	…	14	…	12	14	12	13	12	…	10	…	…	11	12.4/9/1.4
C'	62	…	70	…	…	61	63	59	-	…	…	…	…	…	63.0/5/4.1
IC	…	3	2	3	2	…	1	…	3	…	…	2	2	2	2.2/9/0.67
BR	…	1	1	2	2	…	1	…	2	1	1	1	1	1	1.3/11/0.47
EOT	…	0	1	1	0	…	0	…	-	…	0	0	0	…	0.25/8/0.46
MP	…	2	2	2	2	3	2	…	2	2	2	1	2	2	2.0/12/0.43
IMPA	…	…	Anthr.	…	Anthr.	…	Anthr.	…	…	…	…	Anthr.	Anthr.	Anthr.	…
ANS	…	…	3?	…	4	…	3	5	…	…	…	…	3	3	3.6/5/0.89

*See traits in Table 1.

a sharper profile at the upper level. Furthermore, there is a significant difference between the Baraba and Trans-Ural group ($p = 0.0444$). There is no statistical difference in the average of intragroup series features among Baraba women. Nevertheless, it is advisable to highlight these characteristics, since they can serve as a means of differentiation. In comparison to the aforementioned groups, the Baraba group shows a larger longitudinal diameter, a smaller (mesocranial) transverse-longitudinal index, and a larger width of facial region.

The morphological features of the Sargat craniological series exhibit intergroup differences that remain within the boundaries of a Caucasoid anthropological type. The following craniometric characteristics can be identified: meso-brachycrany, medium-high braincase, wide low, and somewhat flattened face, moderately inclined frontal bone, and protruding nasal bones. In other words, the local discreteness of the craniological complexes of the Sargat population has not been identified. Bagashev's craniological study of samples of local variants of the Sargat culture led him to the conclusion that population history was unified and that the groups were closely related (2000: 114, 120). The slight polymorphism observed in the Sargat people's anthropological composition can be attributed to a number of factors. Among these, the introduction of a nomadic population into the West Siberian forest-steppe from the Saka-Sauromatian-Sarmat environment is of particular significance.

There is a substantial range of craniological characteristics and craniometric data from contemporaneous cultures of Eurasian regions adjacent to the Sargat culture, which might have been involved in the process of its formation. This process is believed to have commenced in the late 7th century BC, but indisputably from the 5th century BC, and continued until the first half of the 4th to the second half of the 3rd century AD. The principal component method was utilized in order to identify the relevant groups. The analysis did not include those belonging to previous stages of cultural evolution, dating back to the Late Bronze Age and the transition between the Bronze and Iron Ages. The analysis of morphological space was limited to the chronological framework of the Saka period in order to identify intergroup connections that can be explained by migrations with a specific historical context.

The male Baraba sample of the Sargat culture is located in the coordinates of the first two principal components in the same space as the Trans-Ural and Irtysh samples (Fig. 1). The high factor loadings (approximately above 0.500) in these coordinates fall on several cranial parameters, including the width of the forehead, the symotic and dacryal parameters of the nose, the height of the nose, and the transverse diameter of the skull (Table 3). The Baraba sample exhibits a greater affinity with the Trans-Ural one than with the Irtysh, and the latter forms part of a concentrated population including a series of Saka, Sauromatians, and early Sarmats inhabiting the Ural-Kazakh steppes* and Eastern Aral Sea region (Fig. 1).

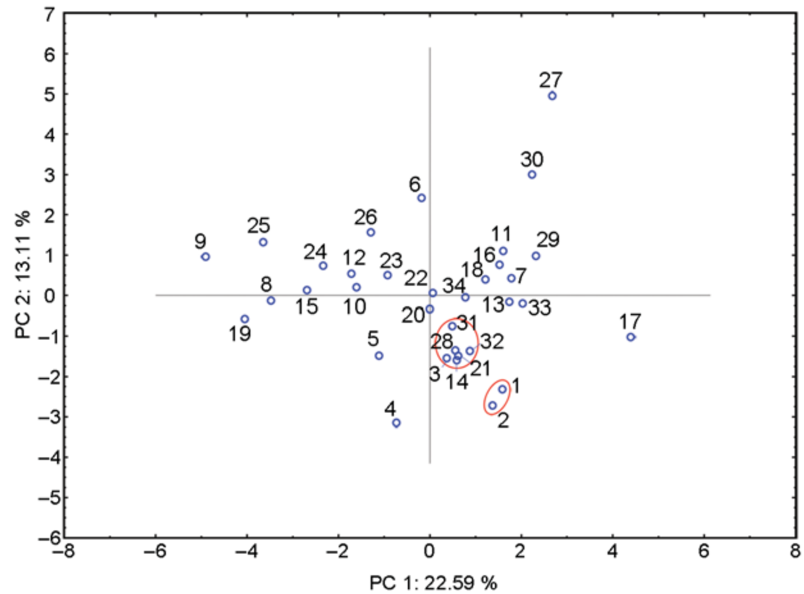

Fig. 1. Graphical result of the statistical analysis of the Early Iron Age craniometry series of West Siberian and Central Asian males (principal component method)
Numbers correspond to serial numbers of series listed in the text. The ellipses indicate the sets of groups with the highest degree of morphological similarity.

A previous study by Bagashev (2000: 122) established a similar pattern of local Sargat groups in craniometric similarity: male samples from geographically more distant regions, including Tobol and Baraba, were

*The concept of "Ural-Kazakh steppes" is derived from A.D. Tairov, who, relying on physical-geographical and archaeological evidence, outlines this region as extending "from the eastern spurs of the Southern Urals and Mugodzhar mountains in the west to the Irtysh valley in the east, from the forest-steppe zone of the Trans-Urals and Western Siberia in the north to Lake Balkhash and the right banks of the Chu and Syrdarya rivers in the south", dividing it into three large regions: Southern Trans-Urals, Northern Kazakhstan, and Central Kazakhstan (2019: 13). In terms of geographical classification, he distinguishes between two subregions within the Southern Urals: the western subregion, which includes Western Kazakhstan, and the eastern subregion, which encompasses the Southern Trans-Urals, both sharing a common border that is delineated by the central ridges of the Urals and Mugodzhar (Ibid.: 14).

Table 3. **Factor loadings on traits**

Trait	Males		Females	
	Factor 1	Factor 2	Factor 1	Factor 2
1. Cranial length	0.287	0.146	0.464	–0.068
8. Cranial breadth from basion	0.333	–0.562	–0.356	–0.267
17. Cranial height	0.122	0.444	0.463	0.232
5. Cranial base length	0.475	–0.139	0.559	0.246
9. Minimal frontal breadth	0.797	–0.245	0.340	0.132
45. Bizygomatic breadth	0.302	–0.241	0.042	–0.270
48. Upper facial height	–0.051	0.688	0.549	–0.545
55. Nasal height	–0.149	0.757	0.586	–0.581
54. Nasal breadth	0.203	0.116	0.637	–0.617
51. Orbital breadth from mf.	0.317	–0.418	0.148	–0.435
52. Orbital height	0.065	0.369	0.071	0.238
77. Nasomalar angle	–0.573	–0.477	–0.206	–0.501
ZM. Zygomaxillary angle	–0.505	–0.412	–0.380	–0.641
SC. Simotic chord	0.617	0.201	0.783	0.066
SS. Simotic subtense	0.829	0.164	0.401	0.526
DC. Dacrial chord	0.531	0.013	0.663	–0.166
DS. Dacrial subtense	0.768	–0.151	0.495	0.572
32. Frontal profile angle from nasion	–0.550	–0.130	–0.551	–0.016
72. General facial angle	–0.069	0.266	–0.169	–0.229
75 (1). Nasal protrusion angle	0.597	–0.047	–0.140	0.649

closer to each other than to a series from the Irtysh region, which was equidistant from both. The researcher attributes this phenomenon to the more pronounced influence of Mongoloid populations in the western and eastern peripheries of the Sargat area. In contrast, the anthropological appearance of the tribes in the Irtysh region was to a lesser extent "deformed by crossbreeding processes, aligning closely with the generalized characteristics of the entire Sargat population" (Ibid.: 124).

The way the Sargat population evolved differs slightly in its interpretation according to the statistical analysis. The discovered characteristics traditionally attributed to the Mongoloid complex, including a higher level of facial skull flattening, do not necessarily indicate the participation of Mongolian groups in the genesis of the population, as this complex is not exclusive to them. The consequence of taxonomically significant individual characteristics spreading to the group as a whole can be attributed to the limited number of the series and the suboptimal state of preservation of the facial skeleton for measurement, in addition to the relatedness of the individuals interred. Notably, among the components that contributed to the anthropological composition of the Sargat people, the autochthonous one of the forest-steppe zone of Western Siberia belongs to the protomorphic anthropological types. These are distinguished by an imbalanced combination of signs that are significant for differentiation between Caucasoids and Mongoloids, namely heteroprosopia of a horizontal profile with a high (Southern Eurasian formation) or low (Northern Eurasian formation) projection of the nose. Bagashev's assumption that the diachronic connections of the Sargat populations can be traced back to the carriers of the Late Bronze Age cultures of the Andronovo (Fedorovka) lineage (Ibid.: 193) is justified and beyond doubt.

Statistical analysis indicates that the connections of the male Sargat population, which are rooted in the nomadic tribes of the Ural-Kazakh steppes and the Eastern Aral Sea region, belong primarily to the Irtysh group. Furthermore, the anthropological type introduced by migrants spread throughout the western and eastern peripheries of the area encompassing the emerging Sargat culture. The migration of certain nomadic and semi-nomadic groups from Central Asia to the West Siberian forest-steppe can be attributed to a multitude of factors, both environmental and historical. The latter include the events of the second half of the 6th century BC associated with the military campaigns of the Achaemenid state against the nomadic associations of Central Asia (Tairov, 2019: 154–155).

The female Baraba sample from the Sargat culture, in coordinates of the first two main components, is situated in the same area as are series from the 5th to

3rd centuries BC from the territory of the Altai Mountains and Tyva. The high factor loadings (approximately above 0.500) associated with these coordinates include the length of the skull base, height of the face, height and width of nasal opening, width of nose, and angles of horizontal profile of face (Table 3). At first glance, this pattern differs from that observed in male populations of these groups. Nevertheless, all samples falling within the general area of the two main components (Fig. 2) are united by the presence of a morphological layer with Southern Eurasian origins. This complex is autochthonous to the Altai-Sayan Highlands and is represented among the earliest nomadic groups in the intermountain basins of this region and the foothills of Dzungaria and the Tien Shan (Kitov, Tur, Ivanov, 2019: 156; Chikisheva, 2008; 2012: 180). This craniological component was also recorded by M.S. Kishkurno among the Early Iron Age population of the forest-steppe Novosibirsk stretch of the Ob (2023b: 12). As shown in the plot (Fig. 2), the Bolshaya Rechka sample (4) is situated in close proximity to the group in question, and may be considered a potential addition. This indicates that the female component of the substratum population demonstrated resilience to the impact of migration, likely due to the influx of male migrants. The peripheral position of the Baraba variant within the Sargat culture area might have served to reduce the intensity of migration infiltration.

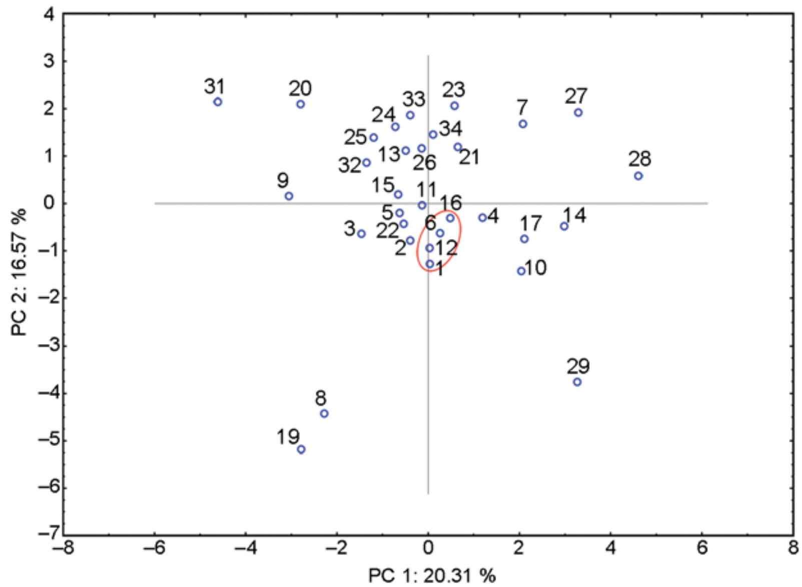

Fig. 2. Graphical result of the statistical analysis of the Early Iron Age craniometry series of West Siberian and Central Asian females (principal component method) Legend same as on Fig. 1.

The Trans-Ural and Irtysh local groups, according to PC1, separated from the Baraba Sargat people and formed a compact population within its negative field. This population consisted of samples from the Saka of Central Tien Shan (22), carriers of the Kamen culture from the forest-steppe Altai (5), and the Uyuk-Saglyn culture from Tyva (11). The distinctive feature (factor loadings greater than 0.500) in this context is the timing of the forehead formation. In terms of ethnoculture, the factor for this group association is Saka origin. However, it is presented in an anthropological form, with the involvement of a morphological complex from the Southern Eurasian formation.

The resulting picture of intra- and intergroup variability of craniometric parameters of samples from three populations of the Sargat culture-bearers and their comparative analysis in the morphological space of the early nomads of Southern Siberia and Central Asia allows us to formulate several conclusions about the factors forming the anthropological composition of this culture. First of all, the quantitative increase of the Baraba craniological series did not change the characteristics given by Bagashev, which emphasizes its insignificant specificity among other Sargat groups (2000: 114)*. The Baraba Sargat people differ from them, according to statistical criteria, in a wider face, a larger pyriform aperture, and largest dacryal width. However, this combination of features doesn't go beyond the overall morphology of the Sargat population. No significant evidence supports the assumption that the Baraba Sargat people included a Mongoloid component "associated in its origin with the inhabitants of the inner taiga regions of Western Siberia" (Ibid.: 126). So far, there are no specific representative craniometric data on the anthropological type of the autochthonous population of the West Siberian forest-steppe, which directly participated in the ethnocultural genesis of the Sargat people. However, the material available in scientific circulation, although not always grouped in adequately dated series, allows the assumption to be made that its peculiarity was a protomorphic combination of the most important diagnostic features, unbalanced in the context of the great Mongoloid and Caucasoid races.

Migration has played an important role in shaping the anthropological composition of the West Siberian population. Tribal associations of nomads from the western part of Central Asia, the Ural-Kazakh steppe—

*Publication of craniometric parameters of new finds, replenishing the known craniological series, is in itself significant, because it allows us to clarify the characteristics of these series, and increases the empirical database for comparative studies.

Saka, Sauromatians, and Sarmats—were the donors. No noticeable changes in the appearance of the people were caused by interbreeding at the level of two phenotypically close anthropological types (the morphological complex of the Southern Eurasian formation is one of the components in some Saka groups). However, using statistical methods based on correlations between craniometric features in series, it was possible to identify their aggregates on the basis of morphological similarity.

Conclusions

The territory of the Sargat culture was constantly infiltrated by nomadic groups during the long period of its genesis. The most intense infiltration came from the southwestern regions of Central Asia. Migration processes had a greater effect on the males, according to anthropological data. Probably, most of them moved to the territory of the West Siberian forest-steppe during the wars. It is likely that the necessary number of generations had not yet elapsed for the effects of interbreeding between the newcomers and the indigenous population to have an equal effect on the female population.

A comparative study of the craniological series of the Sargat culture revealed no significant differences in morphological features. Nevertheless, minor specifics were identified according to local affiliations. To elucidate the anthropological characteristics of the Sargat culture, further studies are required to ascertain the precise nature of the local variants. Specifically, the identification of an indigenous substrate dating to the Late Bronze Age and the transition to the Early Iron Age is essential. This can be achieved through the analysis of craniological material. Therefore, anthropological research should be conducted on paleoanthropological finds at archaeological sites exhibiting complex stratigraphic characteristics of the West Siberian forest-steppe, including burials from a range of historical periods.

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Application of the Decision Tree Method for Differentiating Human Groups

One of the tasks of modern biological anthropology is to develop a system that could objectively classify humanity on the basis of measurements. Here, the decision tree algorithm was chosen to create a classification of groups. The method helps to evaluate the differentiating power of specific dimensions for separating samples and to assess the composition of clusters at each step of the analysis. Standard cranial measurements were used, and the entropy index was chosen as a heterogeneity measure. Classification units were 39 ethno-territorial groups from 13 major regions of the Old World. At the first step, differentiation is made between broad-faced and narrow-faced groups, demonstrating the classificatory value of this trait. The first cluster includes only Mongoloids, admixed Southern Siberian populations, and Ainu. The second cluster is heterogeneous, but its further subdivision is more in line with the traditional classification. Traits underlying the branching of the tree may be the same in different branches, evidencing their taxonomic importance. Capabilities of the decision tree method proved sufficient to construct a system largely similar to the traditional one. Certain traits separate large groups of populations, while others are efficient at the regional level. The method, therefore, can be recommended as a supplementary tool at the intraspecific level.

Keywords: *Biological anthropology, polymorphism, craniology, biostatistics, decision trees.*

Introduction

Humanity classifications at various taxonomic levels could be developed owing to the high phenotypic polymorphism of the *Homo sapiens* species. Nowadays, numerous classification systems exist, each based on a different set of anthropological traits. The differences between underlying principles and selected fundamental and subordinate features are the key to such plethora and wide diversity of classifications. The main and basic requirement to such systems is their phylogenetic significance. This means that the structure devised must reflect the common ancestry of the entities in question. Nevertheless, this approach presents intractable challenges. The level of typological similarity is not necessarily indicative of kinship; therefore, in the construction of many classifications, both the geographical distribution of traits and the intrapopulation diversity of these traits are taken into account. This is reflected in the system of intragroup correlation coefficients. The features selection, as well as the interpretation of morphological similarity with consideration of the historical development of populations, trigger humanity classifications subjectivity, even at the level of major population groups.

The advancement of mathematical techniques has given rise to a new avenue in the pursuit of objective classification—numerical taxonomy. This methodology entails the comprehensive consideration of as much traits as possible and the assumption of their taxonomic equivalence. The latter is both an advantage and a significant disadvantage of any numerical classification. Nevertheless, this approach is widely employed across a range of biological research areas (Sokal, Sneath, 1963: 4; Cartmill, 2018; Hugenholtz et al., 2021).

The search for ways of objective numerical classification of human populations was first provided in the works of E.M. Tschepourkowsky (1905), and was also developed by foreign authors (Morant, 1928; Woo, Morant, 1932; Howells, 1973: 149–155; 1990: 71–79; Hanihara, 1996, 2000). In Russian anthropology, V.V. Bunak (1922) developed a numerical classification based on craniofacial features. His proposal was the use of three main diameters of the cerebral part of skull. Further work in this direction continued, involving new statistical methods (Alekseev, Trubnikova, 1984: 1–8, 115–116; Pestryakov, Grigoryeva, 2013). However, the problems of determining the taxonomic significance of different skull sizes, searching for new traits, and applying various mathematical approaches to solving this issue has not lost its relevance yet.

In order to construct a numerical classification according to skull size, correlation methods are mainly used, integrating the features into more complex structures (Alekseev, Trubnikova, 1984: 1–8, 115–116; Howells, 1990: 71–79). At the same time, there are few non-correlative methods in anthropology. Thus, the question of their applicability to the construction of anthropological classifications and the comparison of the results obtained by different methods is important.

In the present work, we use decision trees, also known as classifiers or regression trees (Breiman et al., 1984: 17; Quinlan, 1986). These names are synonymous; their use depends on the problem to be solved, since decision trees can be used either to classify objects or to construct regressions. Unlike canonical discriminant analysis, decision tree algorithm is not correlative. At the same time, unlike cluster analysis or multidimensional scaling, its mathematical apparatus does not involve the calculation of distances between objects. The possibility of using variables of different types (quantitative and categorical) in one set is also a peculiarity of the algorithm. The method's results are simple and clear.

In general, a tree represents branches, which are dichotomously separated at a certain point (node). Leaves are the final elements of branching. This means that branches will never merge, but will be divided into smaller and smaller sub-sets. This will produce a graph showing a multi-nodal classification tree and the final results from the classification, the leaves.

In every step of the analytical process, we can assess the discriminatory power of each dimension and the composition of the resulting linkages. It is clear that the highest differentiation occurs at the base of the tree. This allows us to understand the morphological similarity of the groups and to identify the features that make them similar. In addition, the marginal values of these features are also reflected. This method and the "random forest" algorithm generalizing it are widely used in various biological and medical studies (Wong et al., 2004; Djuris J., Ibric, Djuric Z., 2013; Feldman, 2020; Al Mamun, Keikhosrokiani, 2022).

Material and methods

The mathematical approach used in the classification tree algorithm is based on the stepwise splitting of samples with the maximum reduction of the measure of their heterogeneity. In other words, the probability of combining samples of different types is reduced. The splitting (branching) is carried out until there are no more objects of the same type left in the leaf of the tree. Thus, the criterion of sample heterogeneity at each point determines the need for further splitting. Therefore, the entropy and Gini indices are used. In this research, the former was chosen.

Shannon entropy calculation formula:

$$H = \sum_{k=1}^{m} p_k \log_2\left(\frac{1}{p_k}\right),$$

where k is the number of types; p_k is the probability that an object belongs to type k.

The first branching is done on the features that distinguish the largest number of samples, the second step separates two group associations, and so on until homogeneous sets of samples remain. As a result, it is possible to get an idea of which of the features used are the most important for differentiating certain objects. Separation is based on the discreteness of the mean variation series.

The decision tree algorithm forms part of a broader methodological approach, known as random forest. Its fundamental principle is the construction of classification or predictive trees. The random forest algorithm is predicated on the preliminary stage of machine learning, whereby training and test samples are constructed. Notably, there are certain limitations to the construction of a single tree; there is no guarantee that the algorithm has chosen the optimal path. However, this method is suitable for differentiating groups based on the average values of traits. In this case, the predictive value of classification is not the key consideration, and the result obtained is clear and easily interpretable. The classification tree algorithm was implemented using the scikit-learn library in Python (Pedregosa et al., 2011).

There are several differentiation parameters (Fig. 1) at each node (leaf) of the tree:

1) the absolute value of the feature that separates the two populations at a given level; the groups located to the left of the node in the figure have a lower value, those to the right of the node have a higher value;

2) the value of the Shannon entropy (*H*) for the samples divided at a given level;

3) the number of groups (*y*) constituting the populations at this level of segregation (samples = = *n* (*y*));

4) the number of samples in each class—the regional group we formed (value = [n_1, n_2, n_3, ... n_k]);

5) the dominant class at this stage of differentiation, i.e. the one with the most groups (class = macro-regional group).

Fifteen craniometric traits according to the standard methodology (Martin, 1928: 625–660; Alekseev, Debets, 1964: 52–74) were used in this work (designated according to the numbering in R. Martin's program): cranial length (M.1), cranial breadth (M.8), cranial height (M.17), skull base length (M.5), minimum frontal breadth (M.9), frontal arc (M.26), parietal arc (M.27), occipital arc (M.28), bizygomatic breadth (M.45), midfacial breadth (M.46), facial length (M.40), upper facial height (M.48), nasal height (M.55), nasal breadth (M.54), orbital height (M.52).

The mean values for 39 ethno-territorial groups from 13 macro-regions of the Old World were used for the construction of the classification (see *Table*). The data were taken from literature sources. Some of the skulls from collections of the Research Institute and Museum of Anthropology (Moscow State University) and the Peter the Great Museum of Anthropology and Ethnography were measured by one of the authors. Only male skulls were included.

Results

In the initial stage of analysis, differentiation is based on bizygomatic breadth (M.45) (Fig. 1), which represents a linear dimension. The samples from Middle East, North and Central Asia, in addition to the Ainu and Khanty populations, exhibited higher values for this trait, exceeding 136.74 mm. A total of 12 samples were grouped together and designated as the "North Asia" category at this stage. The samples from Southeast, South, and East Asia, Europe, Africa, Melanesia, and Polynesia are characterized by narrower faces; this mixed group is named in accordance with the most numerous, "Southeast Asia". The sample set consists of 27 samples.

Let us consider further differentiation within a subgroup characterized by a broader face (Fig. 2). The subsequent differentiation is based on the facial length (M.40). Four subgroups with smaller values of this trait (the class "Central Asia" plus one subgroup from Middle East) are distinguished from the remaining eight subgroups forming the class "North Asia". The latter also encompasses the Khanty of Western Siberia and the Ainu.

The zero value of the entropy index for the class "Central Asia" is reached at the subsequent step; however, to divide the class "North Asia" into homogeneous groups, three additional steps were required, in which the values of traits M.52 (orbital height), M.28 (occipital arc), and M.9 (minimum frontal breadth) were used. As a result, we obtained

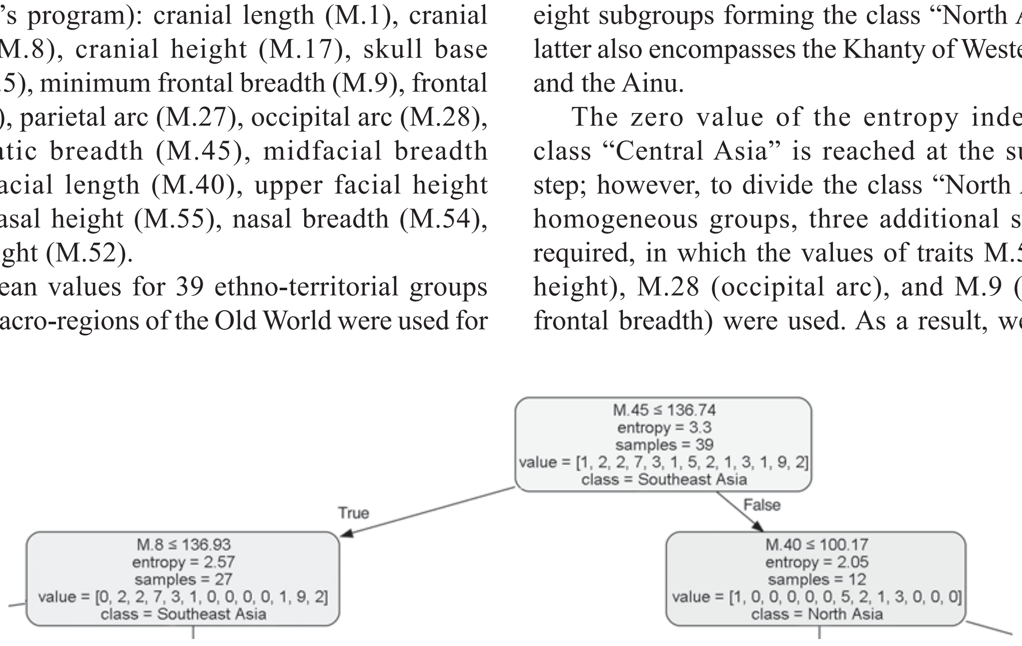


Fig. 1. The initial stage of the analysis (differentiating by linear measurements).
The initial set of 39 groups was designated "Southeast Asia" owing to the fact that these samples constituted the majority.
The content of each node is described in the text.

Groups analyzed and their origin

№	*n*	Group	Reference	Region
1	11	Teita	(Kitson, 1931)	East Africa
2	39	Tigre	(Sergi, 1912)	
3	88	Cameroon	(Drontschilow, 1913)	Central Africa
4	24	Basques	(Morant, 1929)	Europe
5	10	Bulgarians	Data by O.A. Fedorchuk	
6	14	Italians	"	
7	63	Armenians	(Bunak, 1927)	
8	9	Irani	Data by O.A. Fedorchuk	
9	15	Latvians	"	
10	56	Ossetians	"	
11	11	Chukchi	"	North Asia
12	18	Eskimos of Chukotka	"	
13	11	Aleuts	"	
14	93	Eskimos of Alaska	(Debets, 1986)	
15	11	Yakuts	Data by O.A. Fedorchuk	
16	109	Kazakhs	(Ismagulov, 1970)	Middle East
17	9	Kirghiz	Data by O.A. Fedorchuk	
18	61	Khanty	"	Western Siberia
19	26	Telengits	"	Central Asia
20	154	Buryats	Archival data by N.N. Mamonova (provided by D.V. Pezhemsky)	
21	17	Mongols	Data by O.A. Fedorchuk	
22	7	Ainu	"	Far East
23	36	Nepalese	(Morant, 1924)	East Asia
24	32	Tibetans	(Ibid.)	
25	22	Aeta	(Bonin, 1931a)	Southeast Asia
26	19	Bantam	(Ibid.)	
27	25	Jakarta	"	
28	28	Dayaks	"	
29	14	Madura	"	
30	28	Javanese	"	
31	15	Tagalogs	"	
32	32	Central Java (pooled)	"	
33	44	Burmese	(Tildesley, 1921)	
34	15	Andamans	(Bonin, 1931a)	South Asia
35	35	Tamils	(Harrower, 1924)	
36	49	New Britain	(Bonin, 1936)	Melanesia
37	72	North New Guinea	(Hambly, 1940)	
38	25	South New Guinea	(Ibid.)	
39	24	Easter Island	(Bonin, 1931b)	Polynesia

Note. Macro-regional groups are formed on the basis of geographical criteria only.

tree leaves—homogeneous classes, comprising samples from a single macroregion: "Central Asia" (three samples), "Western Siberia" (one sample), "Ainu", and "North Asia" (five samples). The Kazakh and Kyrgyz samples, which were initially assigned to the "Middle East" region, were subsequently divided into two distinct clusters. Interestingly, at the final stage of analysis, both samples diverged from those considered “similar” due to a larger frontal breadth (M.9). The differentiation of Middle East samples into distinct branches is attributed to variations in the facial length.

Following the initial dichotomy, additional groups exhibited increasingly narrower faces and greater entropy. This indicated a higher level of differentiation, necessitating more complex steps for classification (Fig. 3). In the second step, the differentiating feature for this group is the cranial breadth (M.8). Then, for one of the branches, frontal breadth (M.9) proves to be a significant differentiating factor. This particular trait serves to distinguish the Asian samples from the union of European and Central African samples. The formation of homogeneous classes at the final stage is based on the measurements of height of the facial features: M.48 (upper facial height) and M.55 (nasal height). The final differentiation of populations of different macroregions of the leftmost branch of the

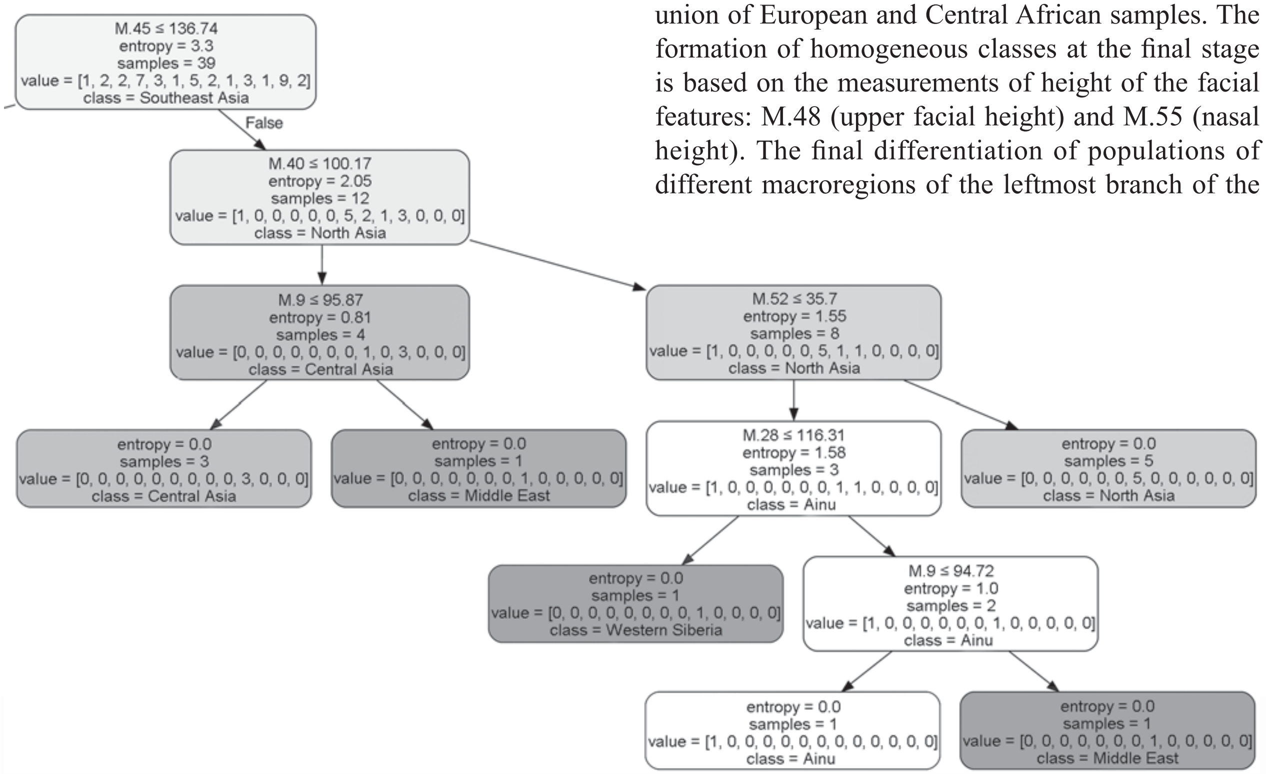


Fig. 2. The tree branch for groups with a large zygomatic diameter, after the first dichotomy (illustrated in gray to indicate the prevalence of groups from a specific macro-regional group within a node or leaf).

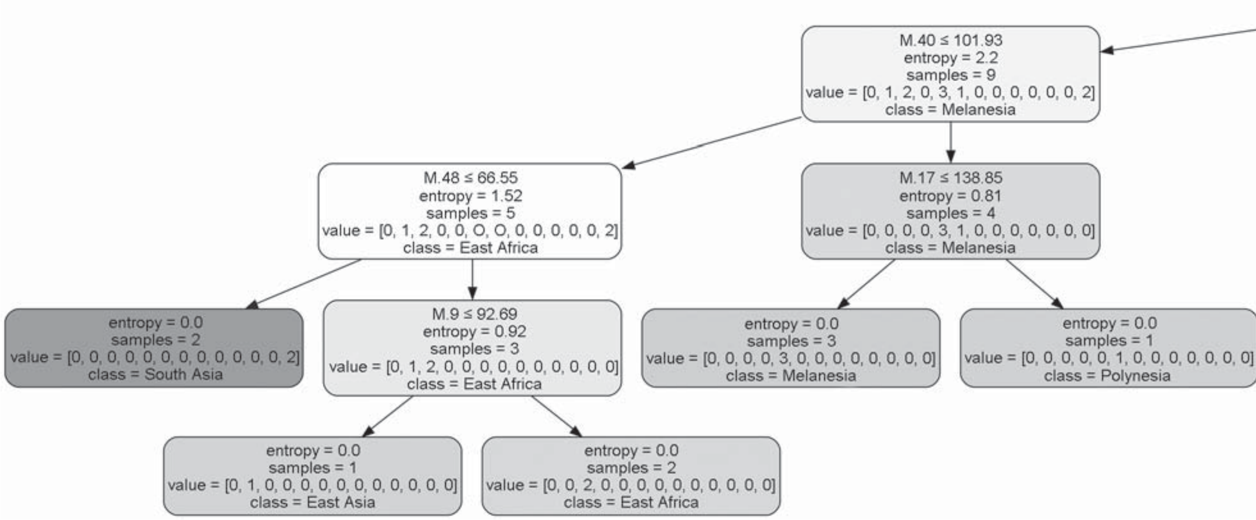


Fig. 3. Distribution of groups with a smaller

tree (Fig. 3) is conducted using a highly similar set of traits: facial length (M.40), cranial height (M.17), upper facial height (M.48), and minimum frontal breadth (M.9).

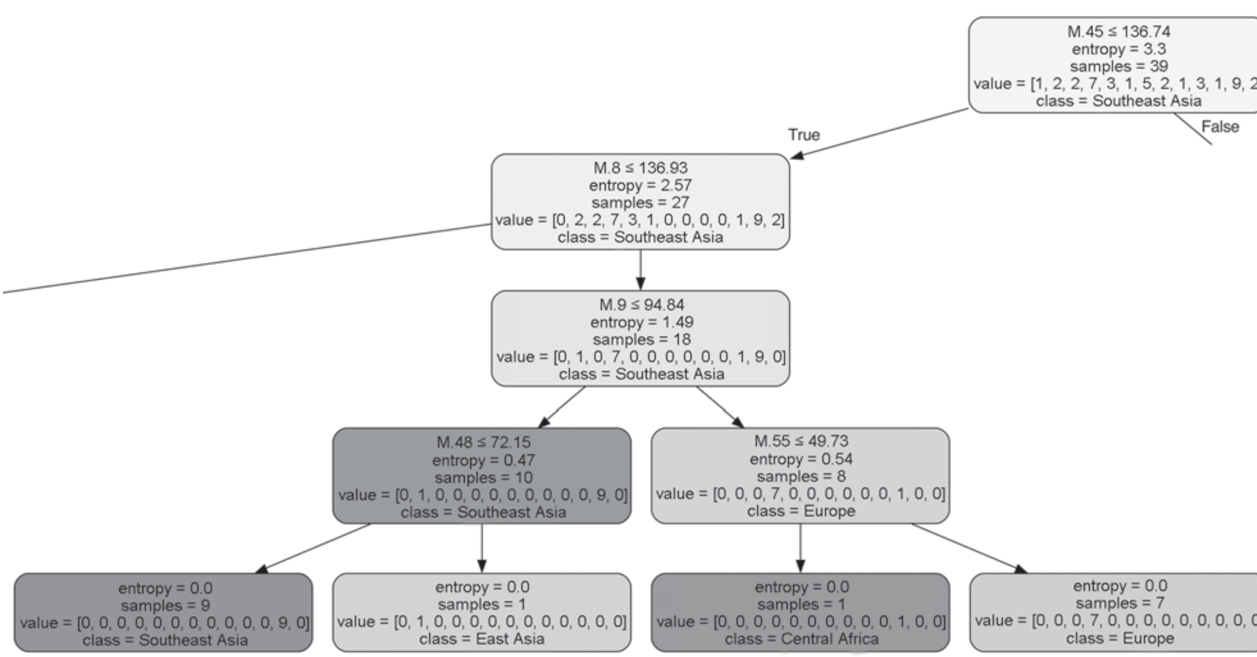
Discussion

The initial query is to ascertain to what extent the differentiation delineated by the decision tree aligns with an anthropological classification. The second, to identify the specific characteristics that were employed as the basis for the division of the total set into homogeneous groups.

The initial branching point along the bizygomatic breadth aligns with the prevailing notions regarding the importance of this feature for classification purposes. Indeed, the majority of North Asian groups within the Mongoloid lineage exhibit elevated values of facial breadth. Consequently, the initial dichotomy is a logical separation of northern and southern, more gracile Mongoloid populations. The latter are united with other samples exhibiting minimal facial breadths—those belonging to the African, European, East and South Asian, and Oceania groups. This second cluster comprises a heterogeneous array of groups. However, its further fragmentation results in an increasingly precise alignment with the anthropological classification, which is an expected outcome given that any system considers the distribution areas of populations, too. It is of interest to consider the regional associations that have diverged along different branches of the tree. Two such groups are the Middle East and the East Asian (Nepalese, Tibetan). Notably, both cases are associated with the differentiation of samples, which distribution areas fall within the contact zone of different subdivisions of humanity. The Middle East groups are of the admixed Southern Siberian lineage, while the East Asian groups originate from the region at the junction of the territories of distribution of small races belonging to the large Mongoloid lineage.

The traits that give rise to the formation of dichotomous divisions are replicated in nodes at various levels of the classification hierarchy, thus underscoring their inherent importance. The majority of these traits are typically employed for the purpose of population classification. However, there are certain traits whose significance is not immediately apparent, such as facial length (M.40) or frontal breadth (M.9).

The results obtained using the decision tree algorithm and the widely used multidimensional



zygomatic diameter, after the first dichotomy.

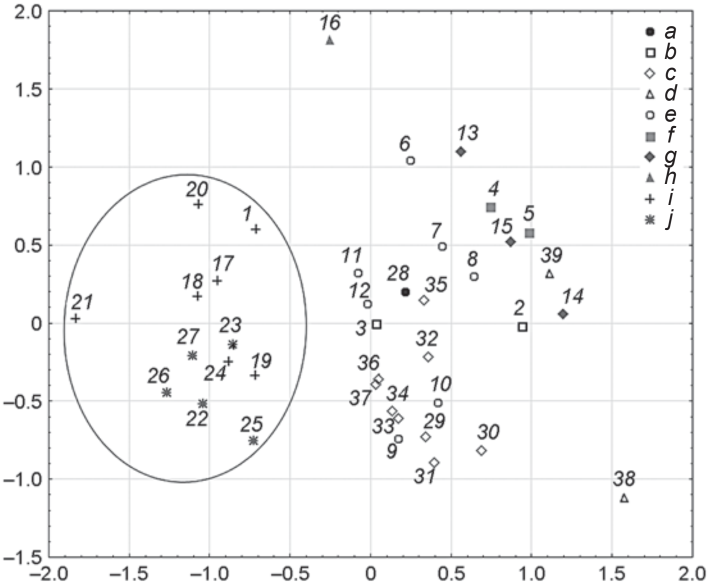


Fig. 4. The differentiation of groups on the basis of the results of multidimensional scaling.
1 – Ainu; *2* – Nepalese; *3* – Tibetans; *4* – Taita; *5* – Tigre; *6* – Basques; *7* – Bulgarians; *8* – Italians; *9* – Armenians; *10* – Irani; *11* – Latvians; *12* – Ossetians; *13* – New Britain; *14* – North New Guinea; *15* – South New Guinea; *16* – Easter Island; *17* – Chukchi; *18* – Eskimos of Chukotka; *19* – Aleuts; *20* – Eskimos of Alaska; *21* – Yakuts; *22* – Kazakhs; *23* – Kyrgyz; *24* – Khanty; *25* – Telengits; *26* – Buryats; *27* – Mongols; *28* – Cameroon; *29* – Aeta; *30* – Bantam; *31* – Jakarta; *32* – Dayaks; *33* – Madura; *34* – Javanese; *35* – Tagals; *36* – Central Java (pooled); *37* – Burmese; *38* – Andamanese; *39* – Tamils.
a – Central Africa; *b* – East Asia; *c* – Southeast Asia; *d* – South Asia; *e* – Europe; *f* – East Africa; *g* – Melanesia; *h* – Polynesia; *i* – North Asia; *j* – Middle East and Central Asia.

scaling method (Fig. 4) will now be compared. In this case, a Euclidean distance matrix is used. The alienation and stress coefficients were found to be 0.117 and 0.108, respectively.

The configuration of the groups within the coordinate system aligns with the classification derived from the decision tree method. It is evident that a subset of the samples from Middle East, North and Central Asia (encircled) exhibits notable separation from the remainder. Given the results of the classification tree analysis, it may be posited that the augmented distance between this cluster and all other groups was a consequence of disparities in bizygomatic breadth (M.45). The Ainu sample is also situated at the periphery of the cluster. Overall, the sample's composition aligns precisely with that of the right branch of the classification tree (see Fig. 2).

The second, somewhat informal grouping of samples is equally indicative. The composition of this subset coincides with the left branch of the decision tree (see Fig. 3). Furthermore, the samples from Europe, Southeast Asia, and the craniological series from East Asia and Central Africa were also identified as a distinct subset. The results of the classification tree analysis allow us to conclude with a high degree of confidence that this artificial population is situated on a background of similarity in the cranial breadth (M.8). The differentiation of these disparate groups can be achieved through the utilization of minimum frontal breadth (M.9), a phenomenon that is clearly discernible within the decision tree. Furthermore, this approach permits the complete separation of these groups, whereas in the multidimensional scaling plot, two samples from Southern Europe (Irani and Armenians) fall within the Southeast Asian cluster.

Finally, at the periphery of the multidimensional scaling field, we find the groups that, within the classification tree, constituted the leftmost branch and unified the samples from Melanesia, Polynesia (Easter Island), East Africa, South Asia, and one additional sample from East Asia (Nepalese). The positioning of these clusters on the graph indicates that, in fact, they are quite disparate. For example, the samples from the Andamanese and Easter Island aborigines are situated at a considerable distance from the primary cluster, which is reflective of their uniquely distinct anthropological status.

Conclusions

The differentiation of humanity into discrete categories based on the linear measurements of skull size alone is inherently constrained by the existence of divergent differentiating characteristics across distinct geographical regions. It can thus be surmised that an attempt to divide a significant sample array using a limited set of features may not yield the desired result in all instances. Nevertheless, the capabilities of the decision tree method have proven sufficient to construct a classification that is consistent with classic notions of human differentiation. Notably, this method does not allow us to estimate the magnitude of distances between individual groups. However, it does enable us to identify the features by which samples are dichotomized up to the final stage.

Canonical discriminant analysis can be employed to ascertain the directions of intergroup morphological variability. However, it belongs to the class of correlation methods, which entails restrictions on the utilization of initial features and indices based on them, as well as categorical features, across a single set. A key advantage of classification trees is that they permit the analysis of data comprising both categorical features and indices. In conclusion, the toolkit of anthropological classification techniques has been expanded to include a further method that facilitates the acquisition of novel data and the use of disparate sets of features. Therefore, the decision tree algorithm should be proposed as an independent method of systematic classification at the intraspecific level.

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AN SSSR – USSR Academy of Sciences

BAR – British Archaeological Reports

CIK SSSR – Central Executive Committee of the USSR

ERAUL – Etudes et Recherches Archéologiques de l'Université de Liège

GIM – State Historical Museum (Moscow)

IA RAN – Institute of Archaeology, Russian Academy of Sciences (Moscow)

IAET SO RAN – Institute of Archaeology and Ethnography, Siberian Branch, Russian Academy of Sciences (Novosibirsk)

IEA RAN – Institute of Ethnography and Anthropology, Russian Academy of Sciences (Moscow)

IIMK RAN – Institute for the History of Material Culture, Russian Academy of Sciences (St. Petersburg)

ISME – International Society for Microbial Ecology

KSIA – Brief Communications of the Institute of Archaeology, Russian Academy of Sciences

KSIE – Brief Communications of the Institute of Ethnography of the USSR Academy of Sciences (Moscow)

MAE RAN – Peter the Great Museum of Anthropology and Ethnography (Kunstkamera), Russian Academy of Sciences (St. Petersburg)

MGU – Lomonosov Moscow State University

MIA – Materials and Investigations on Archaeology in the USSR

PFA RAN – Archive of the Russian Academy of Sciences, St. Petersburg Branch

PNAS – Proceedings of the National Academy of Sciences

SO AN SSSR – USSR Academy of Sciences, Siberian Branch

TIE – Transactions of the Institute of Ethnography

UrO RAN – Ural Branch of the Russian Academy of Sciences

VINITI – Russian Institute for Scientific and Technical Information (Moscow)

VSEGEI – Karpinsky Russian Geological Research Institute (St. Petersburg)

YuNC RAN – Southern Scientific Center, Russian Academy of Sciences (Rostov-on-Don)

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