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Early Upper Paleolithic Serpentine Ornaments from Ust-Karakol, Northwestern Altai

We describe the spatial context, technology, and possible function of serpentine-antigorite artifacts discovered at the Ust-Karakol Early Upper Paleolithic site in the Altai Mountains. The ornaments were made locally, with a single manufacturing process. They were fragmented either at the preform stage or at the stage of final trimming. There are no use-wear traces. The chaîne opératoire included the preparation of blanks, biconical drilling, and polishing. Because the material is fragile, drilling of preforms preceded their polishing. This approach was also used with artifacts made of other fragile materials, such as ostrich eggshell, widely employed in the Paleolithic of North and Central Asia. Reconstructed techniques of manufacturing serpentine ornaments belong to the technological repertoire of the Early Upper Paleolithic Ust-Karakol tradition in the Altai. The petrographic analysis of magmatic rocks of the Bashchelak and Anuy mountain ranges suggests that serpentine could have been local. The potential sources include gabbroid deposits related to the Devonian and Permian magmatism of the region.

Keywords: *Altai Mountains, experimental use-wear analysis, technological analysis, spatial analysis, Early Upper Paleolithic, serpentines, stone ornaments.*

Introduction

Stratified archaeological sites of the Anuy River valley, such as Denisova Cave, Ust-Karakol, Anuy-1–3 in the northwestern Altai, are the keys for studying the formation and development processes of the material and intellectual culture of the first Upper Paleolithic inhabitants of the region (Derevianko, Shunkov, 2004; Derevianko, Shunkov, Markin, 2014: 69–99). The most ancient and representative collection of Upper Paleolithic ornaments in Northern Asia gives a particular significance to this group of sites. Its important part consists of items made of "soft" stones (class 1–4 in the Mohs scale of hardness): pendants made of green kaolinite agalmatolite, light talc, greenish-yellow, green and light-brown serpentine; beads of yellowish-white, milk-white talc and pyrophyllite; pendants and a ring of white marble; a bracelet of dark-green chloritolite (Derevianko, Shunkov, Volkov, 2008; Kulik, Shunkov, 2011; Shunkov et al., 2016; Shunkov, Fedorchenko, Kozlikin, 2017, 2018). Such raw material and typological variety of stone ornaments is always an abundant source for archaeological reconstructions (Bar-Yosef Mayer, Porat, 2008; Kulik, Shunkov, 2004, 2011; Cârciumaru et al., 2016; Zhitenev, 2017; Lbova et al., 2018; Fedorchenko et al., 2018). Analysis of spatial context plays a major role in determining the time of manufacture of ornamental stone items (White, Normand, 2015). The spatial analysis data also help to identify the

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special status of ornaments in the structure of habitable space and their meaning as elements of symbolic activity (Bader, 1998; Derevianko, Rybin, 2003; Grigoryeva, 2003–2004; Pitulko et al., 2012).

In the Paleolithic collections from the Anuy valley sites, items made of serpentine or, more precisely, of antigorite as its variety, form a series of 15 items, which amounts to no less than 30 % of the total number of stone ornaments. Visual and physical properties of this mineral, such as an impressive color, a compact cryptocrystalline constitution of its partings, the possibility of producing smooth and shiny surfaces, and a rather low hardness (class 3.5 in the Mohs scale), made it one of the most in-demand stones as raw material in the Upper Paleolithic. In its origin, serpentine-antigorite is a rock-forming mineral of serpentinites (hydrothermally altered ultrabasites) or magnesian carbonate rocks altered by contact (Godovikov, 1983: 363–364). Antigorite is formed by filling tectonic fractures in serpentinites; and regeneration of these fractures often results in its concealed fracturing and foliation accompanied by emergence of partings similar to laminar ones, with slickenside. All serpentines, including antigorite $Mg_6[Si_4O_{10}](OH)_8$, are characterized by $Mg^{+2} \leftarrow Fe^{+2}$ substitution, which is a factor determining the color of minerals: nonferrous varieties are commonly colorless or yellow-tinged, low-iron ones are greenish or, when having a high iron content, dark-green.

In the Altai Mountains, Paleolithic serpentine ornaments have only been discovered at the Anuy valley archaeological sites, such as Denisova Cave, Ust-Karakol, and Anuy-2 (Fig. 1). The most impressive evidence is recorded in the deposits of layer 11 of Denisova Cave (Derevianko et al., 2006; Shunkov et al., 2016; Shunkov, Fedorchenko, Kozlikin, 2017). According to data from radiocarbon AMS-dating of lithological layers 11.1–11.2 in the eastern gallery, layers 11.1–11.4 in the central hall, and layer 11 in the southern gallery, these assemblages are of an age from 27.8 to 51.3 thousand years (uncal) (Douka et al., 2019). These are possibly the most ancient examples of using serpentine to manufacture ornaments. At Anuy-2, a light gray-green serpentine pendant has been discovered in deposits of lithological layer 13.2 dated in the range of 28–27 ka BP (uncal) (Prirodnaya sreda…, 2003: 328–329).

Significant information about serpentine ornaments is carried by the Ust-Karakol materials (Ibid.: 235–236). The finds of 2016 supplementing the collection of serpentine items have opened up new prospects for their in-depth study. The objective of this study is to reconstruct the production technology and functions of Ust-Karakol serpentine artifacts, and to clarify their chronostratigraphic, cultural, and spatial context.

General archaeological context

The collection of items made of ornamental stones was obtained in excavation area 2 of the Ust-Karakol site (Ust-Kansky District, the Altai Republic), which was studied from 1993 to 1997 (Prirodnaya sreda…, 2003: 235–289). It is located in the lower part of a smooth slope of the northern exposition at the spit of the Anuy and Karakol rivers. The studied area covers about 250 m^2. During excavations, slope detritus with a total thickness up to 6.5 m was unearthed. Materials of the Early Upper Paleolithic united in the EUP-1 cultural complex are related to lithological layers 8–11 (Derevianko, Shunkov, 2004; Belousova, 2012). The radiocarbon age of the deposits is within 29.7–35.1 thousand years (uncal) (see *Table*).

Archaeological materials of the EUP-1 cultural complex comprise 2248 artifacts, and pertain to the Early Upper Paleolithic Ust-Karakol industry in the Altai Mountains (Derevianko, Shunkov, 2004). The lithic assemblage is based on the blade production technology using volumetric parallel unidirectional or bidirectional reduction, with a relatively poor standardization of detachments (Fig. 2, *1*, *6*). The technology of producing bladelets with a straight or curved profile (Fig. 2, *3*, *4*, *7*, *8*), based on unidirectional, parallel, and convergent reduction of blanks along a pronounced smooth arch of edge-faceted (wedge-like) and wide-front volumetric cores (carinated items, including their specific bifrontal modifications) is of paramount importance (Fig. 2, *3*, *4*). Purposeful production of flakes from wide-front non-volumetric and arbitrary cores can be considered one of the special features of the assemblage (Fig. 2, *2*). The toolkit of the EUP-1 complex (Fig. 3) includes backed bladelets (Fig. 3, *8*); carinated end-scrapers, ogival end-scrapers, and end-scrapers on blades (Fig. 3, *1–4*, *10*, *14–16*); retouched blades (Fig. 3, *11–13*); flat-faceted, dihedral, and angle burins; and a fragment of a bifacial tool (Fig. 3, *9*). Noteworthy is a considerable number of massive items: side-scrapers with a high working edge on large flakes and pebbles, spur-like tools, etc. (Fig. 3, *18*, *19*).

The lithic assemblage of the EUP-1 cultural horizon was based on the local multiple raw materials resource of pebbles (Postnov, Anoikin, Kulik, 2000). The exception are wax-brown jasperoids, which are known in artifacts but absent in the river pebbles, as well as rock crystal and smoky quartz. Sources for these stone raw material could have been localities situated 30–60 km to the north and southwest of the site. The use of rare material is directly related to the selectivity in choosing raw materials, which is clearly manifested in analysis of the petrographic composition of stone artifacts in the complex. Large flakes were detached from the partings

Fig. 1. Location of the Ust-Karakol and other Paleolithic sites in the Altai Mountains.

Radiocarbon chronology of the Early Upper Paleolithic archaeological complex of the Ust-Karakol site

Layer	^{14}C-date, BP	±σ	Calibrated value, BP	±σ	Lab index	Method of dating
9.3	29,720	360	33,870	306	SOAN-3359	Conventional
9.3	29,860	355	33,978	297	SOAN-3358	"
9.3	31,580	470	35,480	480	AA-32670	AMS
9.3	33,400	1285	37,690	1507	SOAN-3257	Conventional
10	35,100	2850	39,563	3131	SOAN-3259	"

of aphyric effusives often of medium or low quality. Pebbles of sedimentary rocks, their weakly-hornfelsed varieties, biotite hornfels, showing splitting anisotropy caused by lamination, were used for preparing the cores for the production of blades. Bladelets were obtained from the partings of the highest quality and spalls from hornfels pebbles, dense weakly-hornfelsed sedimentary rocks, thinly crystallized aphyric effusives, and homogeneous siltstones, as well as jaspers, wax jasperoids, and rock crystal, which are stone materials of the highest quality in terms of technology.

Materials and methods of study

The serpentine-antigorite items form a small but rather informative element of the Ust-Karakol EUP-1 complex. One serpentine artifact we consider to be a pendant blank, fragmented at the final stage of drilling (Fig. 4, *1*). The second artifact represented by two small fragments was identified as an ornament with traces of polishing (Fig. 4, *2*, *3*).

A pendant blank made of pale-yellow serpentine-antigorite with a biconical hole (artifact No. 1, Fig. 4, *1*)

Fig. 2. Cores for flakes (*2*), blades (*1*, *6*), and bladelets (*3–5*, *7*, *8*) of the EUP-1 cultural complex. Ust-Karakol site.

has the shape of an irregular hexagon with a thin sub-rectangular cross-section and a straight profile. The dimensions are 19.0 × 14.0 × 3.5 mm. A drilled biconical hole (diameters of 3.0 and 5.5 mm), across which the blank was broken, is located at its center. One of the wide sides of the blank has a smooth shiny natural surface of slickenside, the other one shows traces of knapping, possibly of artificial origin. Features of the break can be observed on the upper, lower, right, and left side faces. In the last case, these are, obviously, traces of fragmentation in the course of the item's treatment. No use of polishing, planning, or scraping has been recorded on this artifact.

A large fragment of an ornament made of greenish-yellow serpentine-antigorite (artifact No. 2, Fig. 4, *2*) is composed of two appliquéd pieces of irregular rectangular

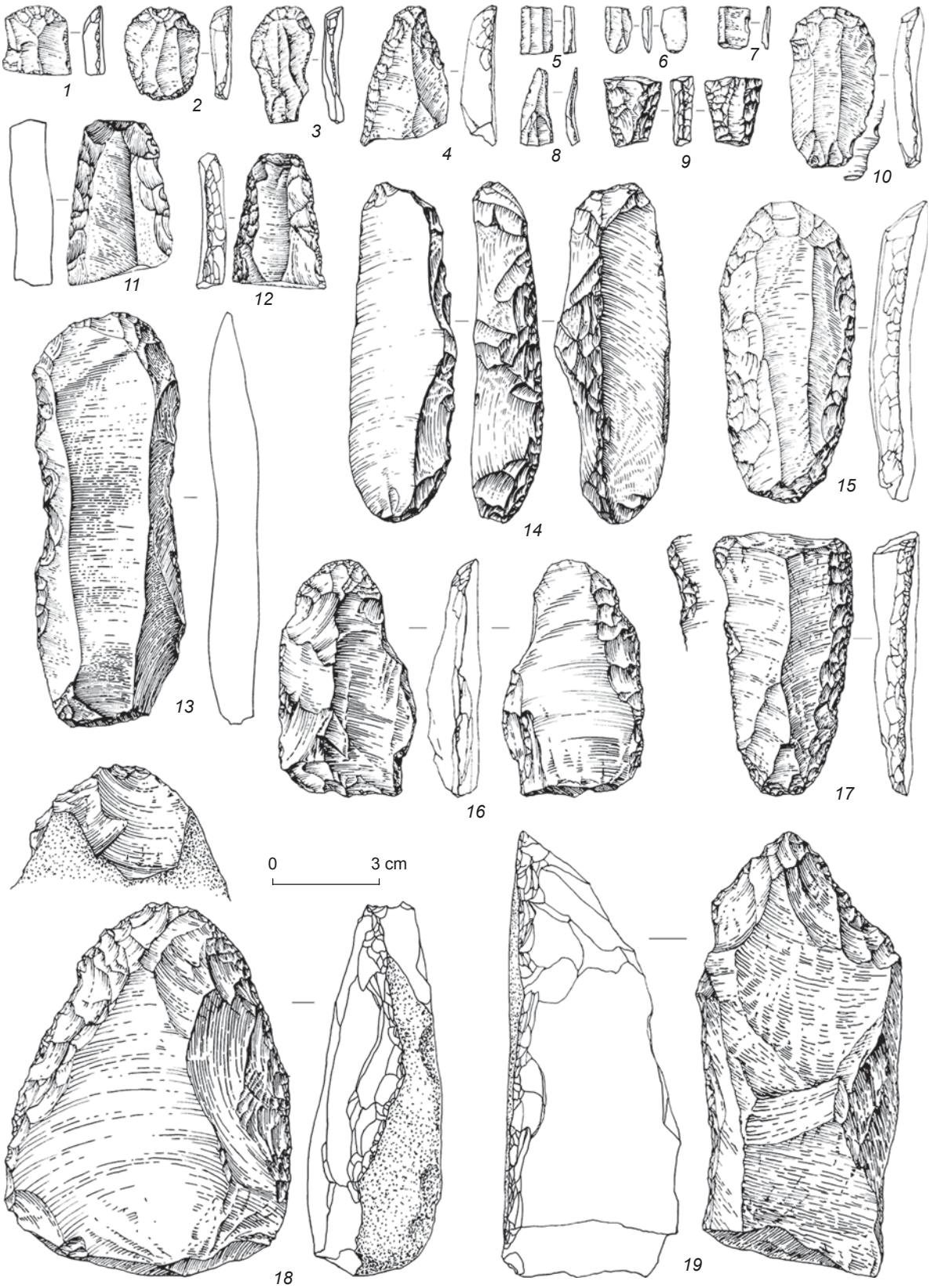

Fig. 3. Stone tools (*1–4*, *8–19*) and bladelets (*5–7*) of the EUP-1 cultural complex. Ust-Karakol site.

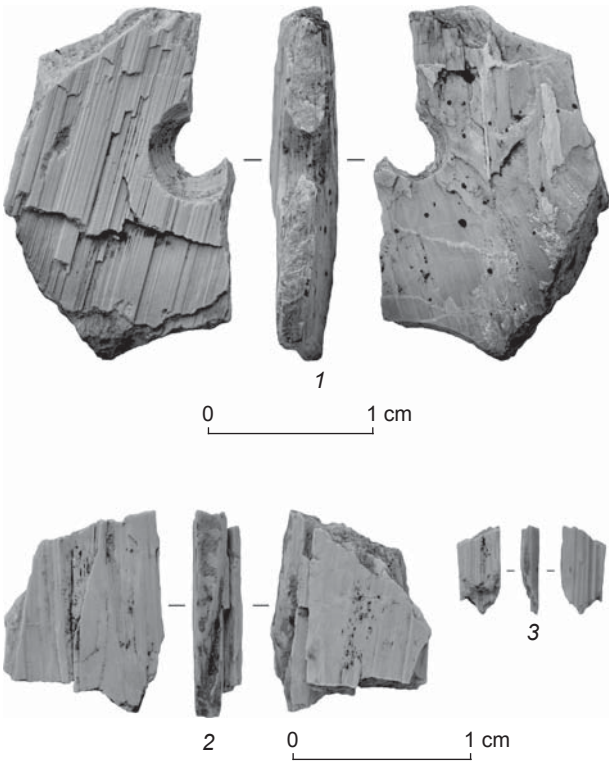

Fig. 4. Items made of serpentine. Canon EOS 7D + EF-S 60 mm f/2.8 Macro USM. Ust-Karakol site.
1 – a fragment of the ornament's blank with traces of biconical drilling; *2*, *3* – fragments of the ornament with traces of polishing.

shape. Traces of breaking are discernible over much of the artifact's perimeter. When assembled, the item has a sub-rectangular shape, plano-convex cross-section, straight profile, and dimensions of 11.0 × 9.5 × 3.5 mm. Flattened zones with traces of abrasive treatment can be seen on the flat side and on certain protrusions of the convex side (near the side faces).A face beveled at an angle of 45° to the longitudinal axis of the item is shaped on the convex side by means of abrasion.

A small fragment of an ornament made of greenish-yellow serpentine-antigorite (artifact No. 3, Fig. 4, *3*) has a sub-rectangular shape, flattened-lenticular cross-section, and dimensions of 4.7 × 2.0 × 1.5 mm. Like the previous one, it is a fragment of an indeterminate ornament. Traces of knapping are seen on both flat sides. The use-wear analysis has failed to reveal obvious traces of treatment. Since fragments of item No. 2 are appliquéd, and their color, texture, and other characteristics of the surface are identical to those of item No. 3, we suppose that they are parts of a single artifact.

Studying the manufacturing technology and determining the functions of the personal ornaments under study were based on the data from technological and experimental use-wear methods (Girya, 1997: 58–79; White, 2007; Heckel, 2016). The primary use-wear analysis was carried out at medium and low (×7–×45) magnification, using the binocular microscope Altami CM0745-T with oblique illumination. Micro-examination (×100–×500) employed the metallographic microscope Olympus BHM equipped with a reflected light illuminator and differential interference contrast (DIC) lenses. Photo-fixation of materials was performed using the Canon EOS 7D and Canon EOS 5D Mark IV Digital SLR cameras with the EF-S 60 mm f/2.8 Macro USM, EF 100 mm f/2.8 Macro USM lenses and a tripod mount with manual focus-adjustment. Microlevel photographic recording was conducted using the Canon EOS 7D camera and the Olympus BHM optical system. High-quality photographs of the artifact surfaces, with focusing in the entire area of one frame, were obtained with the Helicon Focus program. Traces were studied with the involvement of a collection of comparative use-wear references obtained as a result of experiments, and published experimental data (Francis, 1982; Gurova, Bonsall, 2017).

The study of the spatial distribution of the ornaments, aimed mainly at clarification of their cultural and chronological context, was based upon the methods of spatial analysis, refitting and raw material units, and upon the data on stratigraphy of cultural deposits of the site. Mineral raw materials were diagnosed using the microscope MBS-10. Variability of physical properties (color, texture, etc.) of serpentine partings was determined by comparing with samples included in the reference mineralogical collection owned by the Department of Geology and Geophysics of the Novosibirsk State University.

Results of the study

Spatial context. The blank of a pendant was found during the 1995 field studies in lithological horizon 9.2, sq. 9/10. Three fragments of a polished item, two of which are appliquéd, were identified in 2016 when sorting out the 1995 collection of faunal materials, among small indeterminate bone remains recorded in lithological horizon 9.3, sq. 7/11 (Fig. 5, 6).

All artifacts were discovered in the downhill part of excavation area 2, in the immediate vicinity of the northern stratigraphic section of 1995. In this area, the lithological units of layer 9 lay subhorizontally, with a gentle westward gradient (Fig. 6). Being composed of light loess loams, these were a part of geological body, relatively homogeneous in color and composition—a pack of layers 8–11. Lithological horizon 9.3 has been recorded within the entire area of excavation 2. Its boundaries are indistinct, wavy-tongued and saw-toothed; the thickness varied from 0.1 to 0.3 m. Lithological horizon 9.2 was a dynamic formation rather than a sedimentary one (Prirodnaya sreda…, 2003:

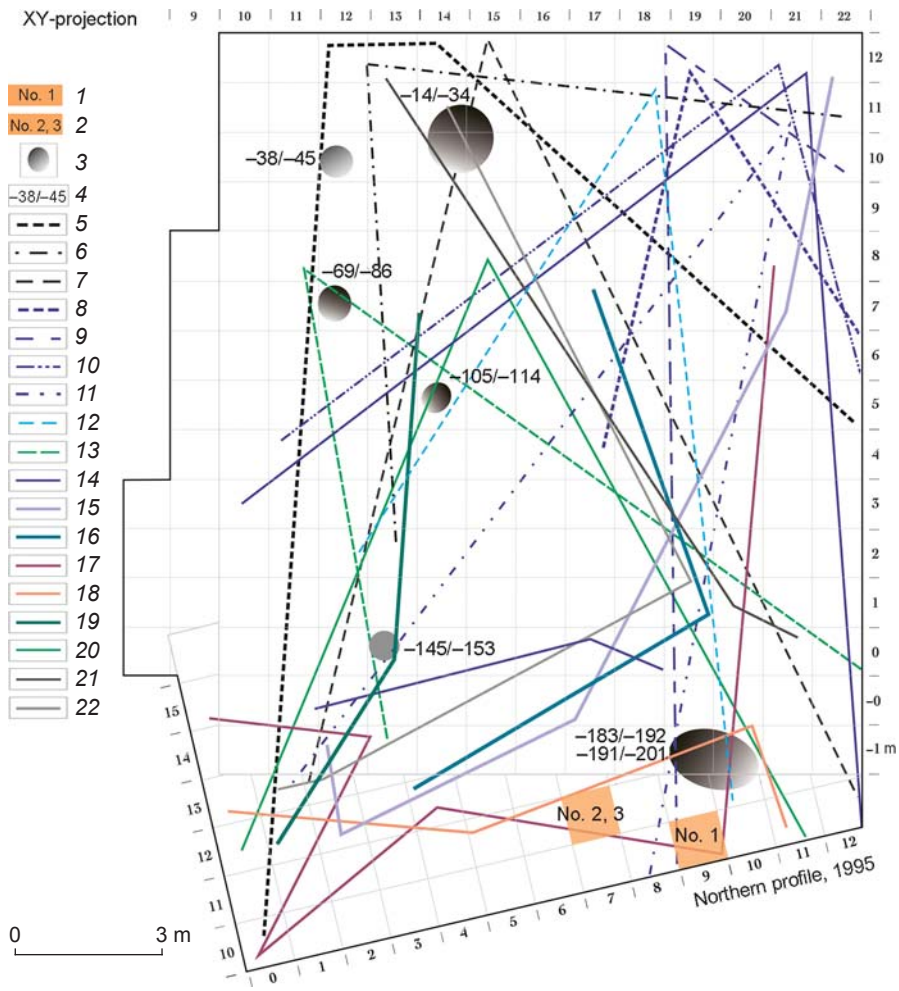

Fig. 5. Spatial context of serpentine items. Ust-Karakol site.

1 – location of a serpentine ornament blank with traces of drilling; *2* – location of fragments of a serpentine ornament with traces of polishing; *3* – coaly fireplace spots; *4* – bench marks; *5–13* – distribution zones of knapping products of individual blocks of raw materials (large groups of raw materials, including appliquéd fragments); *14–22* – spatial relations between elements of refitting and raw material groups.

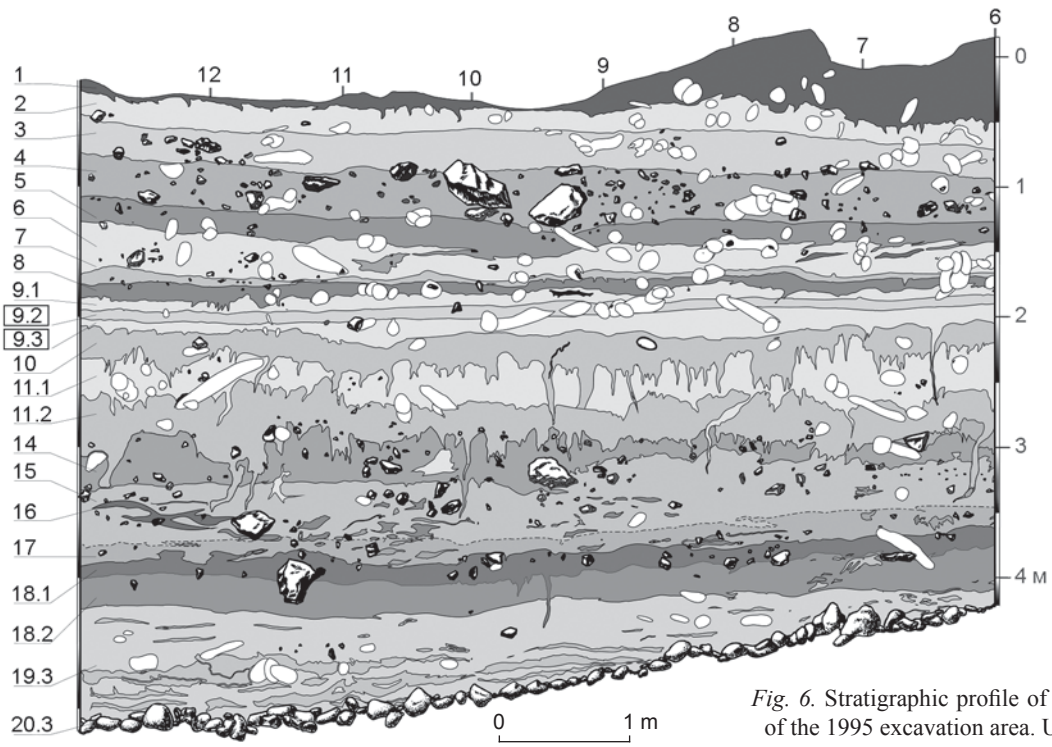

Fig. 6. Stratigraphic profile of the northern part of the 1995 excavation area. Ust-Karakol site.

240–243). In the area where the pendant blank lay, it was traced locally, in the form of an albic strip with indistinct boundaries. The horizon's thickness varied from 0.01 to 0.12 m. The stratigraphic situation in the area where ornaments have been discovered, and the data of spatial analysis, suggest severe post-sedimentary disturbances of deposits, which had a biogenic origin (Shunkov, Belousova, 2015).

The results of spatial reconstructions testify that all serpentine-antigorite items are a part of one of four large spatial structures of the EUP-1 complex, recorded during the study of technological accumulations and fireplace spots (see Fig. 5). Three of them have been revealed in the southern part of excavation area 2, in the most elevated areas of the slope. Judging by the shapes of accumulations and the distribution of their elements, active displacement of lithic artifacts from these zones was due to gravitational drifting along the slope. A zone of technological accumulations related to ornaments is located downhill, in the northwestern part of the excavation area, and confined to a large fireplace spot. The pendant blank has been found at a distance of 0.5–1.5 m from the fireplace, and other antigorite items 1.5–2.5 m from it. Such inclusion of artifacts, some of which can be appliquéd to each other, in the spatial structures of the complex suggests that slope processes probably had no noticeable influence on the distribution of ornaments; and in the post-sedimentary period, these were also not affected by burrowing animals.

Sources of raw materials and technological context. Being typical for serpentine and talc, their formation in ultrabasites, which are absent in the northwestern Altai, earlier provided reasons to associate sources of these minerals with the ultrabasite occurrence in the southern part of the Altai Mountains, closest to the Anuy valley sites (Kulik, Shunkov, 2011). These are apoharzburgite serpentenites, serpentized pyroxenites, and gabbro ($\Sigma V–Є_1$) of the Terekta Ophiolitic Mélange Belt, accompanying the Terekta fault (Fedak et al., 2011: 139). At the same time, the light color of serpentine in the Ust-Karakol ornaments also permitted its formation in magnesian carbonate rocks altered by contact. However, the latter are absent in the aureole of granitoids of the Bashchelak mountain range, neighboring upon the Anuy group of sites. This fact, along with the presence of items made from dark green serpentine and talc with magnetite inclusions in Denisova Cave, made the version about association of serpentines (including antigorites) with ultrabasites from southern Altai more relevant.

Meanwhile, the considerable remoteness of raw materials locations in the Terekta fault, and also the specific yellow color of Ust-Karakol ornaments, indicative of a nonferrous material, push for searching for other sources of serpentine. Detailed studies of the petrographic composition of magmatic rocks of the Bashchelak and Anuy mountain ranges (Ibid.: 175–176) have shown that Devonian and Permian magmatism occurrences of main composition, widely developed in this territory, are often represented by gabbroids, including gabbronorites, norites, and even olivine-norites, i.e. varieties containing Mg-Fe-pyroxenes and olivine—the original minerals in serpentinization. These minerals do not form large accumulations, and their content in rock of not more than 10 % is quite in line with a relatively rare use of serpentine as a fabricating material and the small sizes of items (in contrast, serpentines formed in ultrabasites are characterized by the formation of massive accumulations). Closest to the Anuy valley sites, such occurrences are the Butachikha mass of the Topolnoye complex in the interfluve of the Chernovoy Anuy and Shchepeta rivers (≈ 20–25 km), a mass of gabbroids of the same complex on the Pleshivaya mountain in the Anuy ridge (≈ 20–25 km), and dikes of gabbroids to the south of the Topolnoye village (≈ 15 km).

The technological context of manufacturing personal ornaments of serpentine-antigorite at Ust-Karakol and other sites of the Anuy group is incomplete, since it lacks initial nodules of raw material, primary flakes, chatters, or chips, which could testify to the transportation of small blanks and preforms to the site. This assumption is also supported by the data on consumer properties of antigorite: its untreated partings are rarely large and massive; these are more often fragile and split into small chatters owing to a high intensity of rock fracturing and foliation; i.e. primary approbation of this stone raw material should have been made at the place of its discovery.

Studying serpentine items from Ust-Karakol has demonstrated that fabricating materials for all ornaments are almost identical in texture, structure, and color, and only minor differences in tones are observed. The results of studying untreated serpentine-antigorite fragments from the reference collection testify that the recorded differences in the colors of ornaments derive from normal color variations typical for a single parting (Fig. 7). Consequently, all ornaments could have been made from one fragment of stone raw material brought to the site.

Manufacture of blanks. Analysis of the morphology of Ust-Karakol ornaments, data from petrography and experimental simulation suggest that the blanks of the items under consideration were produced by the knapping of serpentine partings by percussion technique, with the use of a stone hammer, or as a result of purposeful fragmentation in the hands of an artisan. Low hardness and pronounced lamination of serpentine (the result of foliation) made knapping of partings along the foliation directions the most suitable method for producing thin angular laminar blanks. The use of primary and secondary flakes as blanks at the Ust-Karakol site is evidenced by the morphology of the

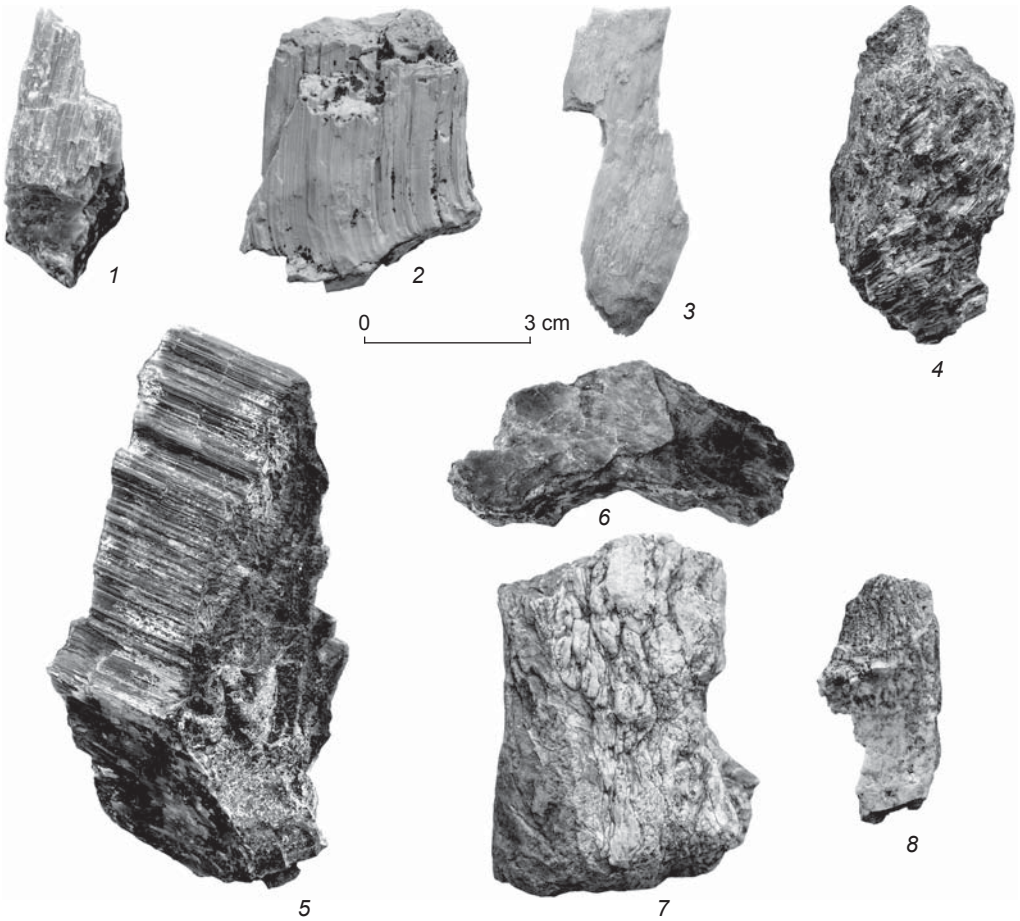

Fig. 7. Collection of serpentines and serpentinites from localities of the southern Urals (*1*, *3–8*) and western Chukotka (*2*). Canon EOS 5D Mark IV + EF 100 mm f/2.8 Macro USM.

ornaments: sub-rectangular cross-section, remains of a natural surface of slickenside, and traces of knapping along the lamination (Fig. 8, *c*).

Production of preforms. The serpentine-antigorite blank of a pendant has one hole, inside which several tiers of concentric grooves are preserved (Fig. 8, *a*). It is characterized by a regular circumference shape and biconical profile. There are no use-wear traces either inside or around the hole. The hole's morphology points to the smoothness of drilling, using a stone tool with a relatively wide symmetric working portion with a triangular shape, and the diameter of a circumscribed circle up to 6 mm. At the initial stage of drilling, a through-hole in the form of a wide truncated cone was formed on the item's surface, bearing traces of knapping along the lamination. Then, it was drilled out in the reverse direction from the opposite side, obviously by the same tool. There are no traces of leveling the passage by boring (Fig. 8, *b*). The blank's morphology is indicative of its deformation at the final stage of drilling, which may point to the manufacture of the ornament directly at the site. Heterogeneity (fracturing, lamination) of the initial parting of serpentine-antigorite was obviously the main reason for uncontrolled delamination and fragmentation of the blank when drilling perpendicularly to the lamination.

The absence of traces of preliminary abrasive or other treatment shows that the perforating stage preceded polishing in the *chaîne opératoire*. This is typical for the preparation of preforms from other fragile fabricating materials widely employed in the Paleolithic of North and Central Asia—for example, for making beads from ostrich eggshell (Tashak, 2002; Volkov, Gladyshev, Nokhrina, 2015). Notably, the *chaîne opératoire* of manufacturing Paleolithic ornaments from agalmatolite, chloritolite, and marble, known in North Asia, is dominated by the reverse operation sequence at the stage of preform preparation: first, the blank surface was treated by planing and/or polishing, and then, it was perforated using a drill or a reamer.

The final stage of manufacturing antigorite ornaments. This consisted in abrasive treatment of the surface. The technological features of this stage were reconstructed when analyzing a large ornament fragment composed of two appliquéd parts. The preserved traces of polishing are

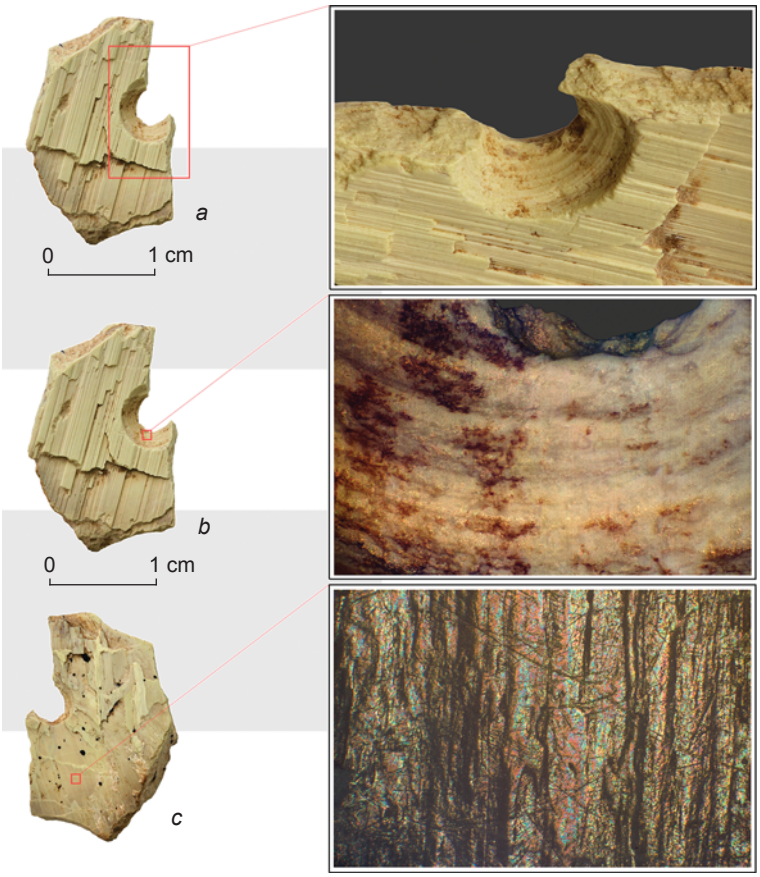

Fig. 8. Serpentine ornament-blank with traces of biconical drilling. Ust-Karakol site, the EUP-1 cultural complex. Canon EOS 7D, Olympus BHM, EF-S 60 mm f/2.8 Macro USM, processing in the Helicon Focus program.
a, *b* – traces of biconical drilling: *a* – ×3 magnification, *b* – ×40 magnification; *c* – remains of natural surface of slickenside (×40).

confined to the protruding areas of the wide surface and the adjoining side face (Fig. 9, *a*). At ×100 magnification, it has been established that they have appearance of parallel rows of long, thin incised striations. Abrasive treatment was employed to level surface irregularities (Fig. 9, *b*) and smooth side faces of preforms in order to produce items of preset shapes (Fig. 9, *c*). Use-wear analysis has not identified any explicit wear characteristics:

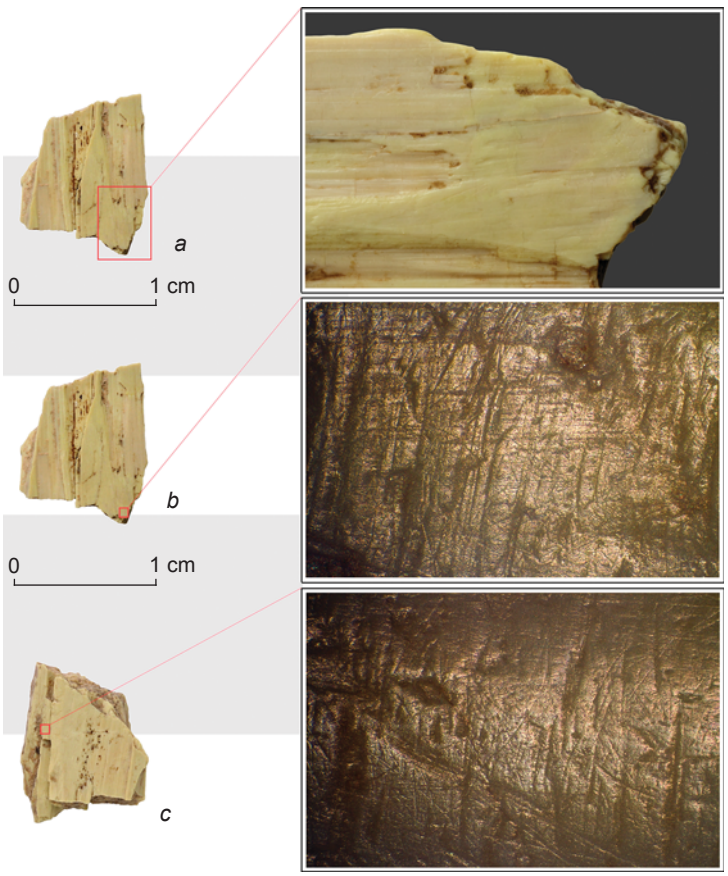

Fig. 9. Fragment of ornament with traces of polishing. Ust-Karakol site, the EUP-1 cultural complex. Canon EOS 5D Mark IV, Olympus BHM, EF 100 mm f/2.8 Macro USM, processing in the Helicon Focus program.
a – pendant's surface leveled by polishing; *b*, *c* – traces of polishing (×100).

there are neither attrition marks inside the blank's hole, nor signs of marco- and microdeformations on the fragment of the item with the traces of polishing.

Conclusions

Studying the spatial context of ornaments at the Ust-Karakol site has made it possible to establish that they lay in a relatively undisturbed condition and were not subjected to a substantial displacement due to slope and bioturbation processes. The ornaments were located within a single lithological layer in the northwestern part of the excavation area, near a large fireplace spot and several vague technological accumulations. Considering the rarity of serpentine-antigorite items, the occurrence of the pendant blank and several fragments of one ornament in a single spatial context is, most probably, evidence of one-time production activity. This conclusion is supported by the data on the variability of physical properties of raw materials similar to those employed for ornaments.

It has been established that the fabricating material for both items is identical in terms of petrography, while the differences in color derive from color shades of a single serpentine-antigorite parting.

According to the results of studies, operations for the manufacture of serpentine-antigorite ornaments were performed directly at the Ust-Karakol site. The artifacts were fragmented either at the preform stage, or at the stage of final trimming. No use-wear traces have been revealed. The *chaîne opératoire* for production of serpentine items included selection and transportation of raw materials and producing of blanks. For blanks, small angular laminar fragments were employed. Owing to the fragility of the serpentine-antigorite in use, perforation of preforms preceded the abrasive treatment of their surfaces. Such a sequence reduced the risk of breaking an item.

Reconstructed techniques of manufacturing serpentine ornaments belong to the technological repertoire of the Early Upper Paleolithic Ust-Karakol cultural tradition in the Altai. The age of the items under study corresponds to the range of values obtained for layer 9 (see *Table*), 29.7–33.1 thousand years (uncal). Lithic industries of this tradition demonstrate a good knowledge of the local raw material resource base and the high mobility of early humans. Thus, they could afford to be selective in choosing raw materials for manufacturing tools of various types. The petrographic analysis of magmatic rocks of the Bashchelak and Anuy mountain ranges showed that serpentine for Ust-Karakol ornaments could have been local. Potential sources were most probably gabbroid deposits related to Devonian and Permian magmatism of the region.

The technology of the treatment of serpentine, represented at Ust-Karakol, finds a wide range of parallels in the archaeological complexes of the Late Pleistocene and Early Holocene of North and Central Asia. Generally, the collection of artifacts made of serpentine and serpentinite consists of at least 75 items from 12 archaeological sites. Beyond the Altai Mountains, the most ancient examples of the manufacture of items from serpentine and its varieties in the form of single pendants have been recorded in the EUP complexes of the sites of Malaya Syya (34–29 ka BP) in southern Siberia (Lbova et al., 2018) and Tolbor-21 (34–26 ka BP) in Northern Mongolia (Rybin et al., 2017). An impressive collection of items made of this material (pendants, "fasteners", and a female figurine unique for the Siberian Paleolithic) was obtained at the Middle Upper Paleolithic sites of Malta and Buret (21–19 ka BP), in the southern Angara Region (Abramova, 1967). Informative ornaments in the form of flat round beads and blanks are present in the Final Paleolithic assemblages of Afontova Gora II (15–11 ka BP) (Derevianko et al., 2017) and Maltat (14.5–13.6 or 10.6–9.5 ka BP) (Paleolit…, 2018: 141), in the Yenisei region. A series of volumetric beads and pebbles, as well as a unique serpentinite bowl, have been discovered in the Paleolithic layer (16.0–13.9 ka BP) of Capova Cave, in the southern Urals (Zhitenev, 2017). Single pendants from similar raw materials have been found in Early Holocene complexes of Central Asia: in the Chikhen-Agui rock shelter (11.5–7.8 ka BP) in Central Mongolia (Derevianko et al., 2008) and at the Obishir-5 site (9.4–7.4 ka BP) in the Fergana Valley (Fedorchenko et al., 2018).

Comparison of the production technology and morphology of serpentine artifacts from Ust-Karakol and similar items from the Paleolithic sites of North and Central Asia has allowed several observations to be made. In this region, in the Early Upper Paleolithic, a rather stable set of techniques was applied to treat serpentine: biconical drilling, abrasive treatment, and polishing. Among these, the key technique was polishing, which allowed substantial changes in a blank's shape, creation of items with a thin and straight profile, and repair or reshaping. These technological solutions were used to manufacture pendants with relatively simple geometric shapes, including triangular, rectangular, or polyangular. The absence of drilling, grinding, and polishing in the Middle Paleolithic industries of the region suggests that these techniques were innovated in the Early Upper Paleolithic.

At the middle and late stages of the Upper Paleolithic, more sophisticated items are recorded. At that time, the following items were manufactured from serpentine: miniature beads (Maltat and Afontova Gora II), "buttons" and annular grooved pendants (Maltat and Buret), and, in certain instances, peculiar prestige and ritual items (a bowl from Capova Cave and an anthropomorphic figurine from Buret). The creation of more technically sophisticated shapes suggested a longer *chaîne opératoire* and strict stadiality. In the Late Upper Paleolithic, there appeared seriality and standardization in the production of certain categories of ornaments, for example flat round beads.

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