Hominin Occupation of the North-Central Caucasus During the Middle Paleolithic: New Results from Saradj-Chuko Grotto and the State of Research

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ABSTRACT

The north-central Caucasus region—located between the highest Caucasian volcanic mountain peaks of Elbrus (5642m asl) and Kazbek (5034m asl)—is notable as the area producing the only obsidian source (called Baksan or Zayukovo) known in the Northern Caucasus. Only two stratified sites, however, provide evidence of the Middle Paleolithic (MP) occupation in the region. These are the Weasel Cave (Myshtulagty Lagat) in the east (Kazbek region) and the Saradj-Chuko Grotto in the west (Elbrus region) of the north-central Caucasus. Both sites are located in the Terek River basin (the Caspian Sea marine basin). In this paper, we report results of the 2017–2019 multidisciplinary research at Saradj-Chuko Grotto and summarize the latest information about the Neanderthal occupation of the north-central Caucasus in the broader MP cultural context.

INTRODUCTION

Important issues of human evolutionary research include the settlement of various regions and contacts between different groups of Middle Paleolithic (MP) hominins. Studies indicate that the dynamics of environmental conditions had a significant impact on hominin settlement of various regions during the MP, especially in mountain regions such as the Caucasus Mountains, and particularly in the Northern Caucasus (Doronicheva et al. 2023; Golovanova 2015; Golovanova and Doronichev 2003; Golovanova et al. 2022; Tselmovich et al. 2019). On current radiometric data, MP hominins were present in the Caucasus from ~260–210 thousand years (ka) ago (Asryan et al. 2020; Blackwell et al. 2020b; Mercier et al. 2010) to ~40 ka calibrated years ago (ka cal BP)(Golovanova and Doronichev 2020; Pinhasi et al. 2011, 2012). Several culturally different MP entities, represented by over 270 open-air and cave sites, are identified in the Caucasus. Most researchers working in the region tend to see basic technological and typological distinctions associating the MP sites in the north-western Caucasus with the Eastern Micoquian in Central and Eastern Europe, and the MP sites in the Southern and Lesser Caucasus, and the Armenian Highlands, with the Levantine Mousterian and Zagros Mousterian in south-western Asia (Adler and Tushabramishvili 2004; Bar-Yosef et al. 2005; Beliaeva and Lioubine 1998; Golovanova, 2015; Golovanova and Doronichev 2003, 2005; Doronicheva et al. 2020a; Gasparyan and Glauberman 2022; Ghasidian et al. 2023).

However, there is currently little understanding regarding the origins, geographic dispersion, and cultural development of various MP entities in the Caucasus, and the relationships between different MP hominin groups in this region and with other hominin groups in regions outside the Caucasus, as well as the important contributions made by Caucasian MP hominins to the dispersal and biocultural evolution of MP hominins in Europe and Asia. In this article, based on the results of recent multidisciplinary research at Saradj-Chuko Grotto and the published data about previous multidisciplinary research in Weasel Cave, the authors will summarize the latest information about hominin occupation of the north-central Caucasus during the MP. The evidence from the north-central Caucasus and comparative data from other MP sites allows us to discuss some general issues related to Neanderthal migrations and settlement, contacts between culturally diverse Neanderthal groups, and the origins and evolution of MP cultures in the Caucasus.

In the Caucasus, obsidian represented the most attractive stone raw material for MP hominins on both the northern (Doronicheva and Shackley 2014; Doronicheva et al. 2016; 2019a) and southern (Le Bourdonnec et al. 2012; Pleurdeau et al. 2016) slopes of the Greater Caucasus, such as in the Lesser Caucasus (Biagi et al. 2017) and Armenian Highlands (Frahm et al. 2016; Kandel et al. 2017). The north-central Caucasus region—located between the highest Caucasian volcanic mountain peaks of Elbrus (5642 m asl) and Kazbek (5034 m asl)—is notable as the area producing the only obsidian source (called Baksan or Zayukovo) known in the Northern Caucasus.

Recent studies indicate that the Zayukovo (Baksan) obsidian source was a center of attraction for MP hominins in both the north-central (Terek River basin) and north-western (Kuban River basin) Caucasus (Doronicheva and Shackley 2014; Doronicheva et al. 2016; 2019a). Only two stratified sites, however, provide evidence of MP hominin settlement in the area. These are the Weasel Cave in the eastern part (Kazbek region, Northern Ossetia-Alania Republic, Russia) and the Saradj-Chuko Grotto in the western part (Elbrus region, Kabardino-Balkaria Republic, Russia) of the north-central Caucasus (Figure 1A). Both sites are located in the Terek River basin (the Caspian Sea marine basin).

Weasel Cave (MyshtulagtyLagat in the Ossetinian language), located at 1125m asl in the Terek River valley, was discovered and excavated continuously by N. Hidjrati from 1981 to the present. Unfortunately, publications about research at Weasel Cave are either preliminary reports or focused on specific issues (Faulks et al. 2011; Hidjrati 1990; Hidjratiet al. 2003, 2010).

Saradj-Chuko Grotto, located at 934m asl in the Saradj-Chuko (Fanduko) River valley (a tributary of the Baksan River) (Figures 1B, 2A, B) and approximately 6km from the Zayukovo (Baksan) obsidian source, was discovered by E. Doronicheva in 2016 and multidisciplinary research at this site was conducted in 2017–2019 (Doronicheva et al. 2017, 2019a, 2019b, 2020a, 2020b, 2021). Also, in 2021 we discovered a new MP locality of Humalan in the Elbrus region (see Figure 1A, B). The site yielded a small collection of artifacts collected on the surface. They are made of silicified limestone and flint, and include typically Mousterian

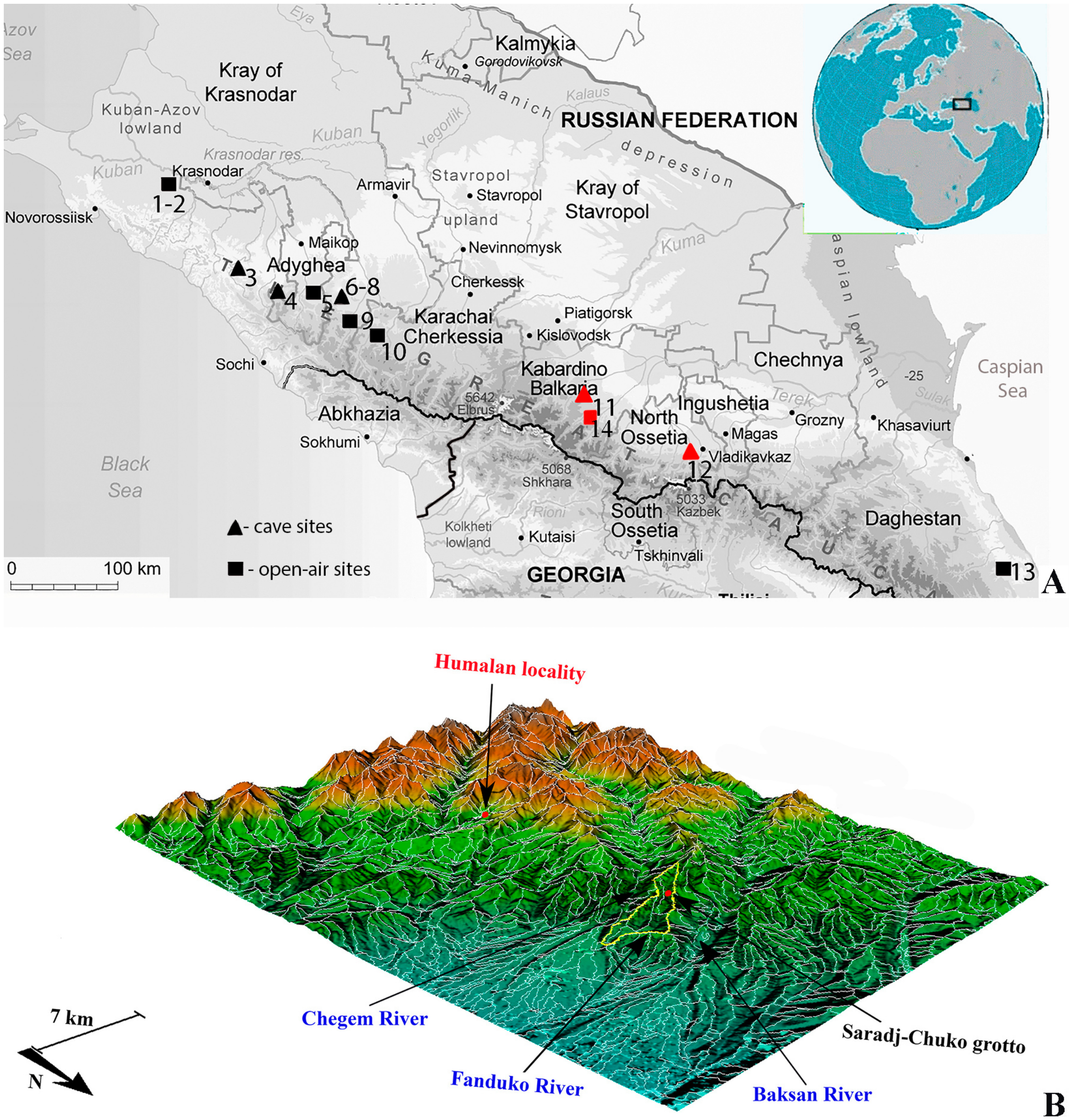

Figure 1. A) Simplified map showing main stratified MP sites in the Northern Caucasus. 1, 2: Il'skaya 1 and Il'skaya 2 sites; 3: Matuzka Cave; 4: Mezmaiskaya Cave, Hadjoh-2 site; 6–8: Monasheskaya and Barakaevskaya caves and Gubs 1 Rockshelter; 9: Besleneevskaya-1 site; 10: Baranakha-4 site; 11: Saradj-Chuko Grotto; 12: Weasel Cave; 13: Tinit-1 site; 14: Humalan locality. Red triangles indicate the MP stratified cave sites at Saradj-Chuko Grotto and Weasel Cave, and red square indicates the Humalan locality in the north-central Caucasus. After Doronicheva et al. (2019b: Figure 1), with modifications. B) The position of Saradj-Chuko Grotto and the Humalan locality. The relief visualization produced using DEM.

laminar and Levallois blanks, and several retouched tools. These recent discoveries show the potential of the Elbrus region to provide new data on MP occupation of the Northern Caucasus.

CHRONOLOGY AND PALEOGEOGRAPHY

WEASEL CAVE

To date, the oldest evidence of MP hominin settlement in the north-central Caucasus comes from Weasel Cave. The excavations revealed a stratigraphic sequence over 22 vertical meters, which comprises 36 distinct lithological strata, including over 10 volcanic ash horizons and about 40 Paleolithic occupation horizons in 23 layers (Hidjratiet al. 2003, 2010: Figure 1).

According to later estimates (Faulks et al. 2011), the upper MP layers 5–11, in which pollen spectra indicate fluctuations between interstadial and stadial conditions, are likely dated to oxygen isotope stage (OIS) 3. Two radiocarbon dates reported for Layer 5—32,980±1070 uncal BP and 34,288±1235 uncal BP—are much younger than the age of the end of the MP currently established by a robust series of radiometric estimates in both the Northern (Pinhasiet al. 2011) and Southern (Pinhasiet al. 2012) Caucasus. Ra-

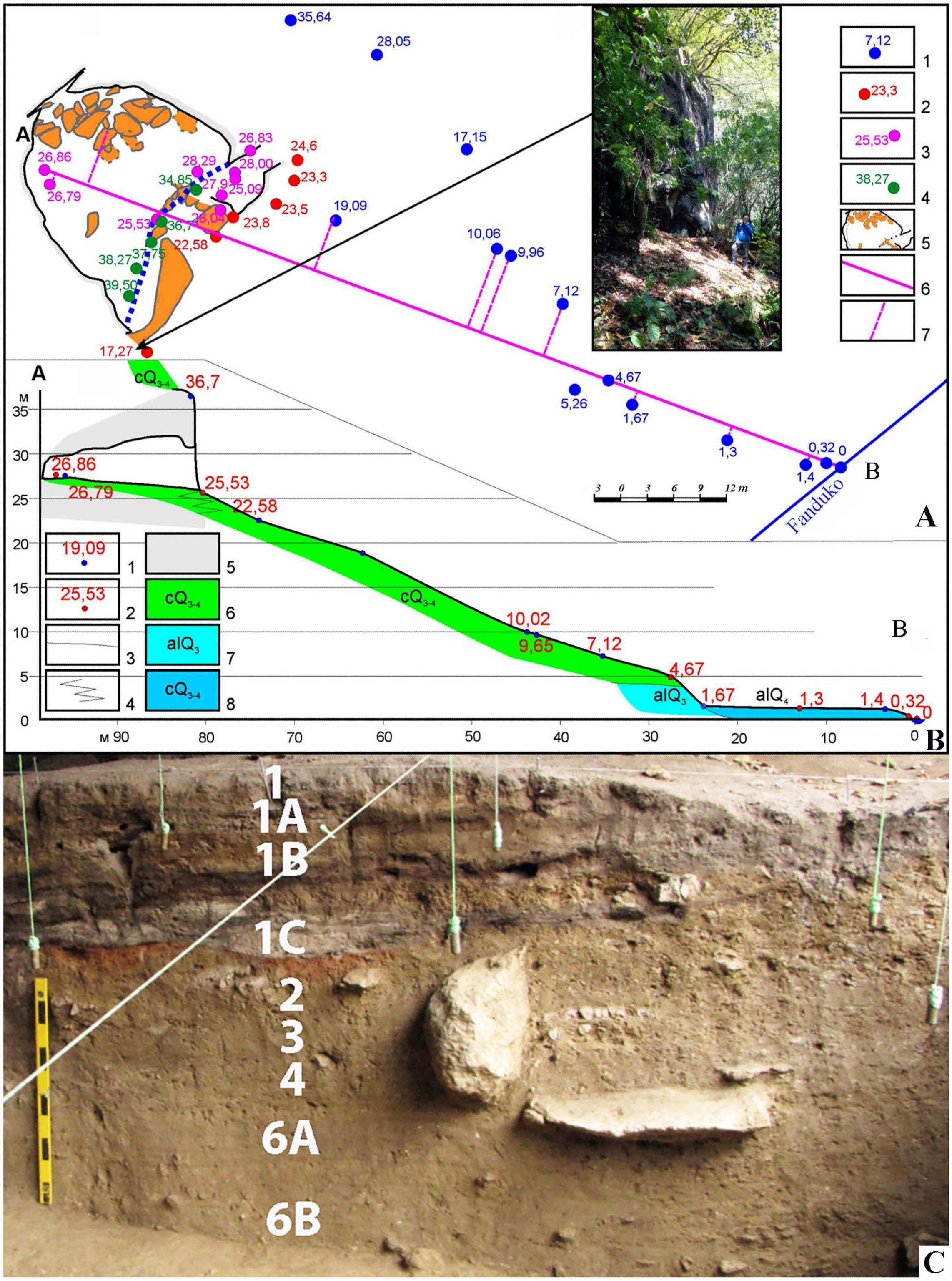

Figure 2. A) Schematic plan of the lower part of the left side of the Fanduko River valley in the area of Saradj-Chuko Grotto with geodetic measurements and photo of the entrance to the grotto, taken from the south, in the area of geodetic point 17.27. 1–4) points of geodetic measurements with depths: 1 – on the landslide cone and floodplain; 2 – at the entrance to the grotto; 3 – inside the grotto; 4 – on the rocky ledge above the grotto; 5) plan of Saradj-Chuko Grotto with collapsed blocks inside the grotto and at the entrance; 6) main geodetic profile AB; 7) lines of transferring the geodetic measurements to profile AB. B) Geodetic profile AB. 1, 2) points of geodetic measurements: 1 – transferred to the profile; 2 – measured on the profile; 3, 4) geological boundaries: 3 – conditional; 4 – possible facies substitution; 5–8) rock complexes: 5 – indigenous volcanic; 6 – landslide/talus; 7, 8) alluvial deposits: 7 – on the first terrace; 8 – on the floodplain. C) Photo of excavation profile showing a general stratigraphic sequence at Saradj-Chuko Grotto.

diocarbon dating on bone from layers 6–11 indicated the age to be >38 ka uncal BP. Earlier excavators suggested that warm pollen spectra identified for MP layers 12–14 testify to a climate typical for the Riss-Wurm Interglaciation (OIS 5e), in the range of 75–125 ka (Hidjrati 1990). The current estimate, however, suggests that layers 12 and 13 are dated to between 50–90 ka (OIS 3 – OIS 5c; Faulks et al. 2011). Layer 14 may also date to OIS 5c, based on the similarity of pollen spectra.

The excavators suggested similarity of the lithic assemblages found in the lower layers 15–21 to a laminar Mousterian industry from layers 12–14. Originally, layers 15–21 were presumed to date to the end of the Middle Pleistocene (~130–250 ka; Hidjrati 1990). An archaeologically sterile layer 18 is a volcanic ash horizon representing one eruption episode of Mt. Kazbek, located some 15km to the southeast; the stratum has an Ar^{39}-Ar^{40} date of >200 ka (Hidjratiet al. 2003). A small number of artifacts, however, were found in layers 15–21. They include some Levallois blades with faceted platforms in layers 15–17 and 19, but lack diagnostic Mousterian tools, such as retouched points or convergent scrapers that are well represented in the upper layers 12–14 (Hidjratiet al. 2003). These data suggest that only the lithic assemblages from layers 5–14 have definable MP characteristics in Weasel Cave, with the oldest MP assemblages from layers 13 and 14 presumably dating from late OIS 5.

The uppermost MP layer 5 includes numerous limestone *éboulis*, suggesting a cold environment. In layers 6–11, several forest rodent species indicate a warmer climate, and pollen data suggest two stadials with increased values of grasses and birch, and two interstadials with higher values of pine pollen. All the layers were formed during a period when environments fluctuated from subalpine meadows to birch- and fir-dominated forests. During the deposition of layers 12–14, the climate was very warm and humid, and the prevailing environment was a deciduous forested landscape with birch and chestnut mixed with hornbeam, oak, elm, walnut, and lime. In contrast, the pollen spectrum of Layer 15 indicates an alpine meadow environment, suggesting a cold climate. Layers 16–18 comprise a single pollen complex, indicating that pine and juniper forests prevailed in the cave vicinity. The spectrum from Layer 19 indicates a dry and warm climate, and deciduous forests composed of elm, beech, walnut, hornbeam, and oak (Hidjrati et al. 2010).

SARADJ-CHUKO GROTTO

The Saradj-Chuko Grotto Stratigraphic Sequence and Its Dating

The Saradj-Chuko Grotto stratigraphic sequence comprises 11 distinct lithological layers containing, from top to bottom, modern to MP cultural deposits, as described below (Doronicheva et al. 2017, 2019b, 2020a) (Figure 2C).

Layer 1 is a gray sandy loam with admixture of tuff fragments, 5–6cm thick. The archaeological material from layer 1 includes fragments of late Medieval ceramic, pieces of slag (brass with admixture of iron), several small fragments of obsidian, and a few animal bones.

Layers 1A, 1B, and 1C are three layers of yellow sandy loam with several charcoal and ash levels that were found only in a small area closer to the grotto entrance; each is 5–10cm thick. The material excavated from these layers comprises few obsidian and flint artifacts, animal bones, several pieces of slag, fragments of clay plaster, and fragments of ceramics. Earlier, a radiocarbon date of 2044±30 uncal BP (SPb-2536) obtained on bone from layer 1B defined the calendric age of 59±44 cal BC for this layer, and layers 1A–1C were presumably dated to the Roman period (Doronicheva et al. 2019b). However, two new radiocarbon dates and the enlarged set of archaeological material recovered from these layers indicate that layers 1A–1C are dated from the XIX to XVI centuries AD (Doronicheva et al. 2020a).

Layer 2 is a yellow sandy loam, 11–24cm thick. This is a nearly sterile stratum, which yielded only several animal bones and nine stone artifacts.

Layer 3 is yellow sandy loam with three thin levels of tuff *gruss*, 12–17cm thick. The layer yielded several animal bones and obsidian artifacts, including a typical MP unfinished bifacial tool. This is the top of the MP sequence.

Layer 4 is gray-brown loam, 14–30cm thick. The layer yielded several animal bones and a few MP artifacts.

Layer 5 was defined as a separate stratigraphic level in the 2016 test pit, but later research has shown that it is actually a thin (5–7cm) tectonic crack, running obliquely through several layers and filled by dark-brown, locally almost black humic sandy loam. Few animal bones and only two clearly redeposited small flake fragments were found in this layer.

Of the greatest interest is lower layer 6 (as defined in the 2016 test excavation), which was subdivided into two separate layers (6A and 6B) in the 2017–2019 excavations. Both layers have yielded abundant MP artifacts and fossilized animal bones, but only the lower part of layer 6B represents a level of active hominin occupation in the cave.

Layer 6A is a gray clay-rich sandy loam with a small amount of tuff fragments, 30–40cm thick.

Layer 6B (the main MP occupational horizon) is a dark brown to orangey-brown clay-rich sandy loam with rare small pebbles of ignimbrite and tuff, 30–40cm thick.

Layer 7 is the lowest, sterile stratum lying at the base of excavated deposits. The layer consists of bar-shaped fragments of ignimbrite and tuff that appear to make up the cave floor, and has a visible thickness up to 20–30cm, revealed in a test pit. The fragments of volcanic rocks are weakly cemented with iron hydroxides. No artifacts or bones were found in this layer.

At Saradj-Chuko Grotto, 10 radiocarbon dates were obtained in 2017–2020 (Doronicheva et al. 2020a). Young radiocarbon dates obtained for the upper MP layers 3, 4 and 6A are underestimates and require verification by other radiometric methods. All radiocarbon dates for layer 6B are >40 ka uncal BP, suggesting that the age of this lower MP layer is beyond the limit of radiocarbon dating.

Results of optically stimulated luminescence (OSL) dat-

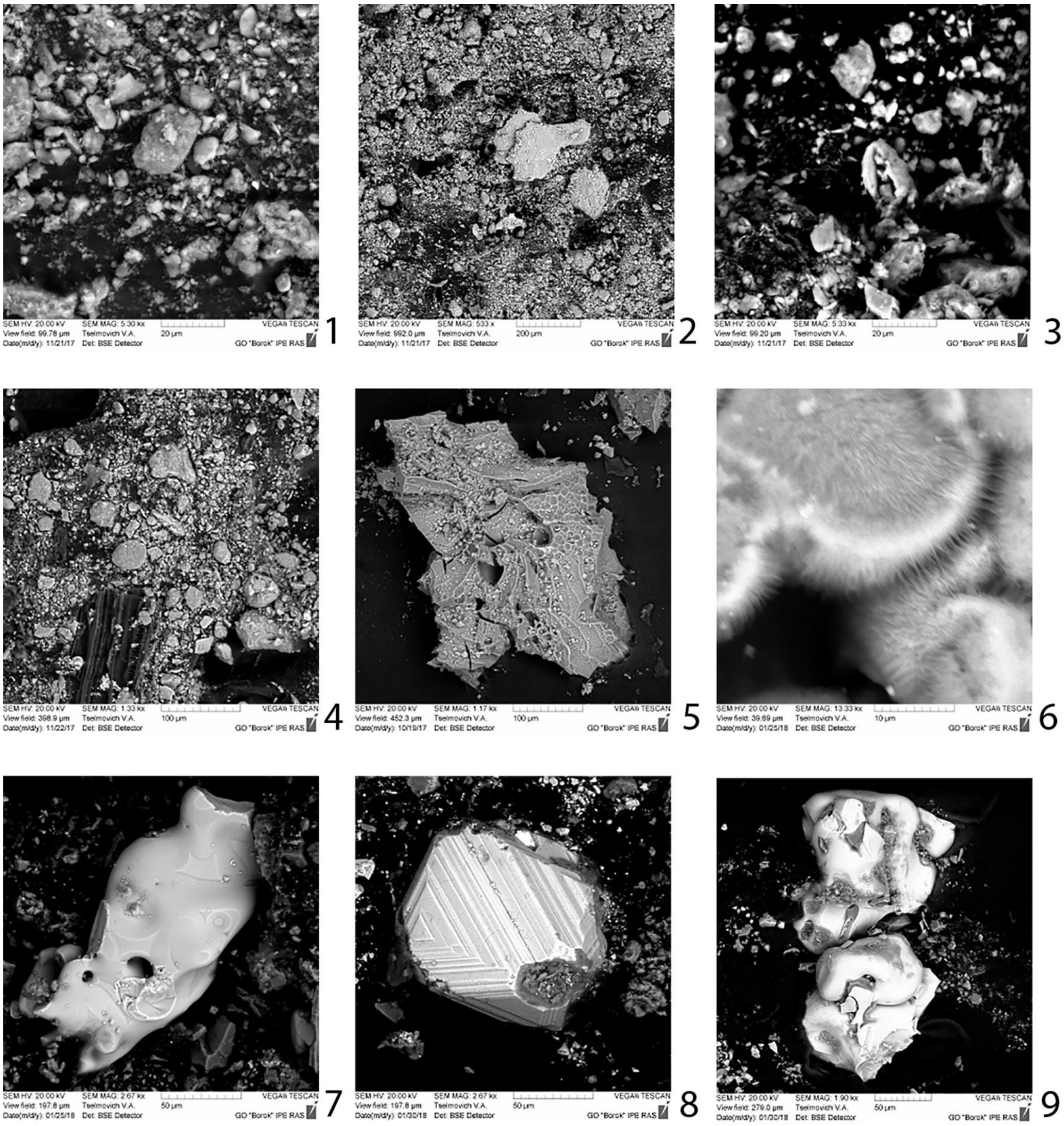

Figure 3. Saradj-Chuko Grotto. Microphotographs of the most characteristic mineral particles. Numbers indicate: 1) Layer 1. Hydromicas; 2) Layer 2. Hydromicas; 3) Layer 3. Spars; 4) Layer 4. Rounded particles and a volcanic ash particle (dark, in the lower left part); 5) Tectonic crack (layer 5). Volcanic ash particle; 6) Layer 6A. Spar needles; 7) Layer 6A. Melted ilmenite with signs of high temperature degassing; 8) Layer 6A. Titanomagnetite, a single crystal with growth steps; 9) Layer 6A. Melted ilmenite with degassing structures (rounded pores). After Doronicheva et al. (2020a: Figure 37).

ing on samples collected in 2018 and 2019 from MP deposits at Saradj-Chuko Grotto indicate that the lower MP layer 6B was deposited during OIS 5, between ca. 90/80 and ca. 70 ka. Layer 6A was accumulated during early OIS 3, between ca. 60–50 ka. The end of the grotto occupation by MP hominins in Layer 3 is dated to ca. 45–40 ka (Doronicheva et al. 2023b). ESR dating results for Saradj-Chuko Grotto are pending.

A Sedimentary Break and Volcanic Ash Identification

At Saradj-Chuko Grotto, 186 samples in total collected from layers 1–7 were used for the energy-dispersive X-ray spectroscopy (EDS), saturation isothermal remanent magnetization (SIRM) and x-ray phase analyses to identify minerals and their associations that may indicate volcanic activity and climatic variations (Doronicheva et al. 2019b, 2020a; Tselmovich et al. 2019, 2020). The SIRM analysis indicates that the most significant sedimentary break or low sedimentation phase corresponds to the boundary between layers 4 and 6A. The other two analyses indicated the presence of tephra (volcanic ash) in layers 6A and 4. The specific tephra particles identified in the analyzed samples (Figure 3) likely represent a non-acidic volcanic ash that resulted from volcanic activity in the region. The content of SiO_2 in the tephra particles is 56–64%wt, corresponding to the andesitic composition.

A comparison with explosive volcanic eruptions recorded in the central Greater Caucasus during the past 250,000 years (Lebedev and Vashakidze 2014) suggests that both the Elbrus and Kazbek volcanoes were active at that time, and could produce the non-acidic, andesitic volcanic ash identified at Saradj-Chuko Grotto. The Saradj-Chuko Grotto area falls within proximal fallout zones of pyroclastic and ash materials for both volcanoes. After the eruption recorded in layer 6A, MP hominins only occasionally visited Saradj-Chuko Grotto. Based on these data, we assume that the volcanic eruption likely seriously affected the hominin population in the Elbrus region, and probably the entire north-central Caucasus.

Sedimentary Dosimetry for Saradj-Chuko Grotto and Hominin Habitation

Saradj-Chuko Grotto is one of the few lava tube caves that have yielded Mousterian assemblages. In a lava tube such as Saradj-Chuko, the sediments lack or contain few carbonate deposits, while the more acidic sediments may destroy bone and carbonate fossils (see Saradj-Chuko Grotto in Faunal Assemblages and MP Hominin Hunting below). Lava tube sites have inhomogeneous ("lumpy") sediments with mineralogically and biologically distinct geochemistries. This generates inhomogeneous radiation dose fields. In Saradj-Chuko, 40 sediment samples were analyzed by neutron activation analysis to measure volumetrically averaged sedimentary dose rates. Water, U, Th, and K concentrations were measured for 16 different layers or horizons, from which Dsed,$\beta(t)$ and Dsed,$\gamma(t)$ were calculated (Blackwell et al. 2020a; Doronicheva et al. 2020a).

The grotto's rhyolitic ignimbrite walls produce very acidic clay-rich conglomeratic silts that retain 16–24%wt water today. Due to the high [Wsed(0)], and its igneous source rocks that weather into sediment with high acidity, the Saradj-Chuko sediments contained up to 40–50% clay in many horizons. Unlike in karst caves, most layers at Saradj-Chuko Grotto had sedimentary U concentrations >4ppm and Th >12ppm, but some samples from Layer 6B exceeded 20.8ppm uranium. The Saradj-Chuko sediment also contained high K concentrations. Such high concentrations emit dose rates averaging ~1.9–3.7mGy/y, but locally up to 4.1–5.0mGy/y. The hominins that repeatedly occupied the Saradj-Chuko Grotto might have begun to experience medical effects, within a few decades, from the high radiation rates.

Palynological Data

Results of pollen analyses (Doronicheva et al. 2019b; 2020a) allow us to characterize several stages of vegetation development in the Saradj-Chuko Grotto area during the Late Pleistocene and Holocene, as described below, from bottom to top.

The earliest stage defined in the lowermost sterile layer 7 and the base of the lower MP layer 6B is characterized by pollen zone I. All samples indicate a diversity of tree and shrub species, suggesting a warm, interglacial climate. The angiosperm species include *Betula* sect. *Albae, Alnus glutinosa et incana, Carpinus caucasica, Carya ovata, Juglans regia, Juglans cinerea, Corylus colurna, Ostyacarpinifolia, Ulmus campestris, Quercus* aff.*hartwissiana, Quercus ilex, Quercus pubescens, Fagus orientalis*, and *Castanea sativa*. Rare pine pollen of species *sula* and *strobus* may indicate mild winters, with temperatures not lower than -9°C and an annual rainfall value about 800–1500mm. Grassy vegetation includes rare pollen of *Salsola soda*, Compositae, Poaceaeae, Apiaceae, and Urticaceae. Among spores, Polypodiaceae predominates, including *Polypodium serratum* and *Cystopteris fragilis*, and rare *Pteridium tauricum* was found.

This pollen spectrum suggests that hazel-hornbeam-oak forests with admixture of gray hazel and walnut, oriental beech, and chestnut, and rare relict species currently growing in subtropical climates (hickory, Canadian hemlock, magnolia, and ephedra) were wide spread in the area. The grass cover was poorly developed.

Pollen zone II (Layer 6B, middle level) is arbitrarily defined because all samples contained very few spores and pollen grains and showed poor preservation of the latter. However, the composition of pollen spectra from the middle of layer 6B is similar to zone I and indicates the spread of hornbeam-elm forests with walnut, linden, and oriental hornbeam. Among herbaceous plants, Poaceae and sedge species (Cyperaceae) predominate. *Beckmannia erueformis* and *Juncellus pannonicus* suggest existence of swampy areas, and *Osmunda regalis* indicates the development of waterlogged ground and peatlands near the cave. Zone II apparently reflects the beginning of climate cooling and decrease of summer temperatures. At this stage, thermophilic trees existed in this area, but bore very few fruits.

In pollen zone III (Layer 6B, upper level), oak-hornbeam forests with an undergrowth of hazel and hornbeam developed.

The results of the pollen analysis indicate that Saradj-Chuko Grotto was located in the lower forest zone during the entire period of layer 6B accumulation. Forest associations were represented first (base of layer 6B, pollen zone I) by oak-hornbeam forests with admixture of gray hazel, walnut, oriental beech, chestnut, and hazel, and then (layer 6B, pollen zones II and III) by hornbeam-elm and oak-hornbeam forests with walnut, linden, and oriental hornbeam. The grass cover was poorly developed. The spectra indicate the predominance of a warm and humid climate, and that the environmental dynamics identified in layer 6B best correspond to the late stage of an interglacial period with deteriorating environmental conditions.

Also, the presence of *Beckmannia erueformis* and *Juncellus pannonicus* indicates swampy areas, and *Osmunda regalis* indicates the presence of waterlogged ground and peatlands near the cave. This suggests that Saradj-Chuko Grotto was located close to or on the river floodplain during the entire period of layer 6B. Coniferous tree associations, which are represented only by rare pollen, most likely grew in higher elevations in this region. Apparently, the higher mountain vegetation zone was composed by birch and pine forest with admixture of spruce.

Pollen zone IV (top of Layer 6B) is arbitrarily assigned

TABLE 1. ASSESSMENT OF SARADJ-CHUKO GROTTO SETTLEMENT ACTIVITY IN LAYERS 6B, 6A, AND 3 (Excavations 2017–2019).

Layer	Artifacts n total	Artifacts per m²	Artifacts per m³	Living structures, hearths	Faunal remains n total	Faunal remains per m²	Faunal remains per m³
6B	10,959	295	31,311	+	20,847	533.4	59,563
6A	610	14.5	1,743	-	4,398	78.8	12,566
3	80	2.2	471	-	961	13.7	5,653

to a cooling phase, because pollen is rare.

Pollen zone V (Layer 6A) reflects a warm interval.

In pollen zone VI (top of Layer 6A and bottom of Layer 4), the pollen spectrum indicates cool climatic conditions.

In pollen zone VII (Layer 4 and bottom of Layer 3), the increase in the percentage of small-leaved tree species (birch and alder) indicates warming and increased humidity.

Pollen zone VIII comprises subzones VIIIa (top of Layer 3 and bottom of Layer 2) and VIIIb (Holocene layers 1–1C and 2). The climate was predominantly moderately warm and humid, similar to the modern climate in this region.

Spatial and Microstratigraphic Analyses of Layer 6B

At Saradj-Chuko Grotto, the microstratigraphy and the lithic artifacts' spatial distribution in Layer 6B were analyzed by the method of Golovanova et al. (2014) (Table 1). The analyses show that the main concentration of artifacts coincides with the most bones (Figure 4). A large lithic assemblage excavated from Layer 6B (10,959 artifacts) in-

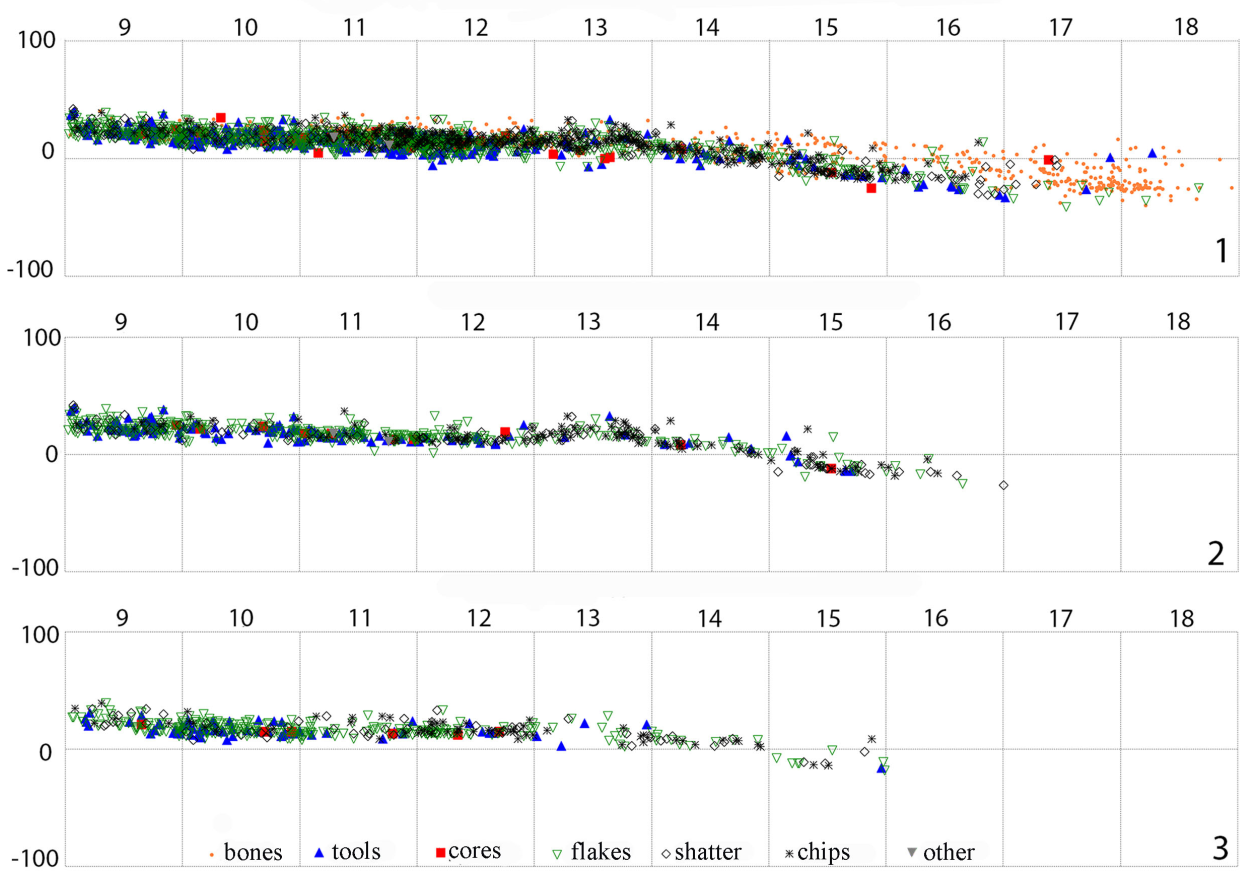

Figure 4. Saradj-Chuko Grotto. Layer 6B. Three microstratigraphic longitudinal profiles showing a vertical distribution of artifacts and bones within the layer. 1) Profile along grid lines P–S – 9–18; 2) Profile along grid line R9–R18; 3) Profile along grid line S9–S18. After Doronicheva et al. (2020a: Figure 51).

dicates that this layer represents the level of most intense (on average about 295 lithic artifacts per m^2) hominin occupation in Saradj-Chuko Grotto (Doronicheva et al. 2020a; 2021a, b). Artifact refitting results confirm on-site knapping of obsidian and that the area of obsidian knapping is related to the main concentration of artifacts (Figure 5). This zone is confined to the lower 20cm within Layer 6B , near the two hearths (Figure 6).

Found in 2018 *in situ* in Layer 6B, the two, well preserved hearths were simple, distinct, flat, oval hearths that lacked stone rims (Doronicheva et al. 2019b; 2020a; 2021a, b; see Figure 5; Figure 7). Oriented southeast-northwest, the larger hearth 1 has an oval shape, 180x140cm, and is 5–7cm thick. The smaller oval hearth 2, 40x30cm, is about 2cm thick. Macroscopically, both hearths exhibited a similarly diagenetically altered internal stratigraphy, lacking the ash horizons (see Figure 6: 3). Both were associated with similar archaeological material. The black (char-rich) horizons in both hearths had almost black sandy silt, which mainly contained scarce, scattered black wood charcoal fragments. The maximum firing temperature measured by magnetic susceptibility analyses using burnt clay samples collected from both hearths within Layer 6B was defined as averaging ~530-600ºC.

Our results show that in Layer 6B hominins were engaged in intensive knapping of obsidian, and production and use of tools made mostly from obsidian for butchering and consumption of hunted prey that was represented mainly by ungulate animals.

The collection from layer 6A includes only 610 artifacts (see Table 1). The data indicate that during the accumulation of Layer 6A only short-term sites existed in the cave. Here hominins were engaged in making tools from obsidian and butchering hunted prey. Volcanic ash was recorded in Layer 6A, and environmental conditions in the region were unfavourable. There is a significant decline in the settlement of the region during this period.

Volcanic ash was also recorded in the overlying Layer 4, during the accumulation of which the site was probably not visited at all.

In Layer 3, there are single artifacts per square meter—only two pieces. Our analyses indicate that during the formation of Layer 3, hominins also did not stay in the cave for a long time, but used it as a short-term shelter, where the butchering of hunted prey took place.

FAUNAL ASSEMBLAGES AND MP HOMININ HUNTING

WEASEL CAVE

Faunal remains are well preserved at Weasel Cave. In the total faunal assemblage from MP layers, red deer (*Cervus elaphus*), Caucasian mountain goat (*Capra caucasica*), and cave bear (*Ursus spelaeus*) are well represented, followed by wild horse (*Equus caballus*), roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*), and bison (*Bison priscus*). Caucasian mountain goat dominates the fauna from the upper MP layers 5–11, and red deer and cave bear dominate in the fauna from the lower MP layers 12–14 (Hidjrati 1990; Hidjrati et al. 2003, 2010). Unfortunately, the researchers did not provide a description of MP hunting strategies at this site.

SARADJ-CHUKO GROTTO

In total, more than 27.6 thousand bones or fragments were discovered in Saradj-Chuko grotto during 2017–2019 excavation seasons. Most of the bones are highly fragmented, so the percentage of the defined bones to species, genus, or class was 7.7%. A significant part of the fragments had various degrees of burning, ranging from traces of heat treatment to clear and complete charring. On average, the proportion of burned fragments was 40–45%.

Faunal remains from MP layers 6B, 6A, and 3 are the most interesting and diverse of these remains (Figure 8D, E). Most intact bones had been broken or cracked by hominins. In Layer 3, the total number of bones and fragments is 961, of which 95 bones or fragments of large mammals were identified (Figure 8A). Among them, the remains of adult individuals of the Caucasian goat predominate (63%), the second most common were fragments of bison (25%). The ungulates and carnivores averaged about 3%. Of the predatory mammals in this layer, the first discovery of a fragment of the skeleton of a leopard (*Panthera pardus*) was recorded.

Layer 6A produced 4,398 bones and fragments, among them 300 bones and their fragments were identified to adult individuals of large mammals. The ratio of identified remains shows almost complete dominance of Caucasian goat (92%), the share of other ungulates and carnivores averaged 1–2% (Figure 8B).

Layer 6B was the richest in faunal remains (20,947 bones and fragments in total). In layer 6B, more than 500 bones and fragments of adult large mammals were identified (Figure 8C). Among them were many definable bone fragments, particularly those representing remains of ungulates that show traces of thermal impact by fire. The evidence of fire impact on many bones indicates that the bone assemblages represent mainly remains of animals that were hunted and consumed as food by hominins. In layer 6B, ungulate species are represented by Caucasian mountain goat (tur, C*apra caucasica*; predominates in all MP layers), bison (wisent, *Bison* sp.), roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), wild boar (*Sus scrofa*) and wild horse (*Equus* sp.) (see Figure 8A–C). Among carnivores, isolated fragments of the skeleton of a forest cat (*Felis silvestris*), a fox (*Vulpes vulpes*), and a small representative of the family of martens (*Mustelidae*) were found.

The general species composition and the ratio of animal remains in Layer 6B shows that the grotto in this period, according to zoogeographic zoning of the Caucasus in the Upper Pleistocene epoch (Vereshchagin, 1959), was located on the border of two districts—the Caucasian mountain and the pre-Caucasian forest-steppe or the border of these districts was relatively close to the location of the grotto. This can be confirmed also by the discovery of bison and horse remains in the layer at the same time.

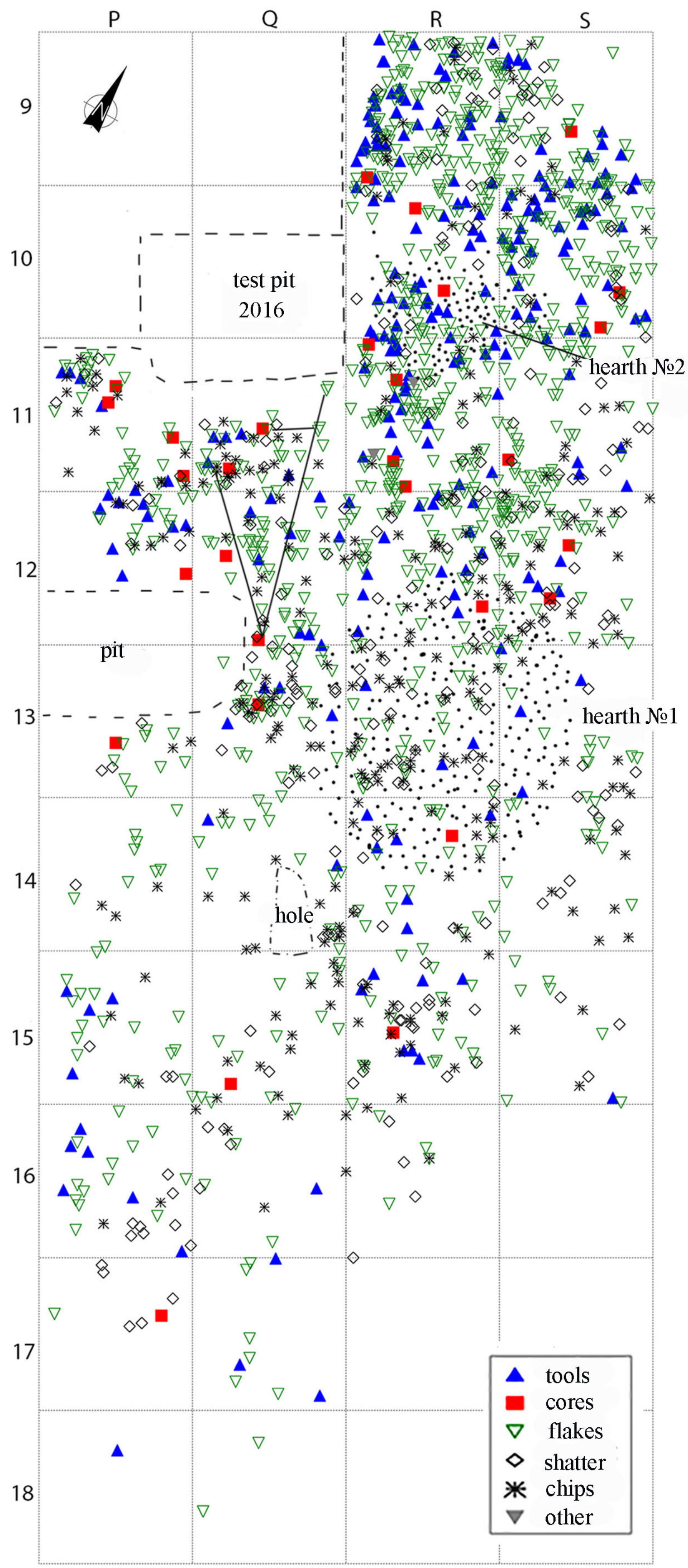

Figure 5. Saradj-Chuko Grotto. Layer 6B. Plan showing the distribution of artifacts in the excavation, by artifact category. After Doronicheva et al. (2020a: Figure 54).

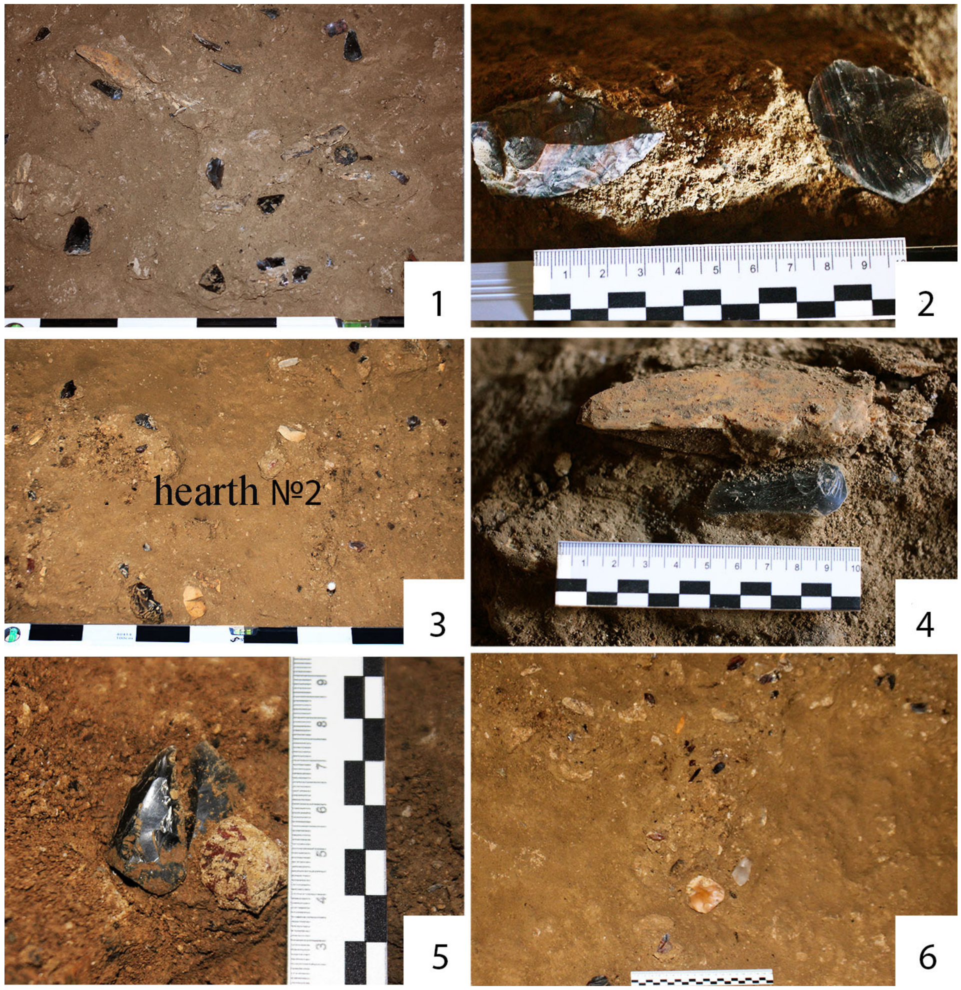

Figure 6. Saradj-Chuko Grotto. Photos of artifacts and bones in layer 6B. Numbers indicate: 1) The distribution of artifacts and bones on squares R–S-10. View from the southeast; 2) Two obsidian artifacts on square R-10. View from the southwest; 3) Hearth No. 2 on squares of R–S-10. View from the southeast; 4) Obsidian artifact and animal bone on square S-10. View from the southwest; 5) Obsidian point on square S-11. View from the northwest; 6) The distribution of artifacts and bones on squares R–S-12. View from the southeast. After Doronicheva et al. (2020a: Figure 56).

RAW MATERIAL EXPLOITATION

WEASEL CAVE

In Weasel Cave, the vast majority of lithic artifacts are made from fine- or medium-grained gray flint, for which the nearest sources are 20–30km west and south from the cave (Faulks et al. 2011). Other rocks (andesite, quartzite, etc.) were rarely used. No artifacts made from obsidian are reported in this site, located <100km from the Zayukovo obsidian source.

SARADJ-CHUKO GROTTO

Up to 96.7–98% of artifacts in layer 6B are made from obsidian, including all cores. All artifact categories are represented. All cores, core trimming elements, and primary (100% dorsal surface cortex) flakes are made from obsidian. Results of the x-ray fluorescence (XRF) analysis indicate that the obsidian artifacts are made exclusively of obsidian originating from the Zayukovo source, located 5–7km to the west of Saradj-Chuko Grotto (Doronicheva and Shackley 2014; Doronicheva et al. 2016; 2017; 2019a; 2019b; 2020a; 2021b; Shackey et al. 2018).

Only 352 artifacts are made from flint, including chips, flakes, shatter and tools. Results of petrographic and geochemical analyses indicate a local origin of flint from sources located about 5–7km to the north-west (Hana-Haku-1 and Shtauchukua-1 sources) and south-east (Kamenka source) from the site (Doronicheva et al. 2019a; 2020a; 2021b). The Jurassic and Cretaceous limestones are the primary source of these flints. We found primary outcrops of light gray flint in the Hana-Haku and Shtauchukua river valleys (small tributaries of the Baksan River), and primary outcrops of dark gray and black flint near the village of Bedyk in the Baksan river valley. Primary outcrops of black flint were also found in the Chegem river valley, and pink flint of different colors was found in alluvium of the Kamenka River.

The results of a petroarchaeological study of obsidian and much rarer flint artifacts indicate that MP hominins exploited raw material sources located within a radius

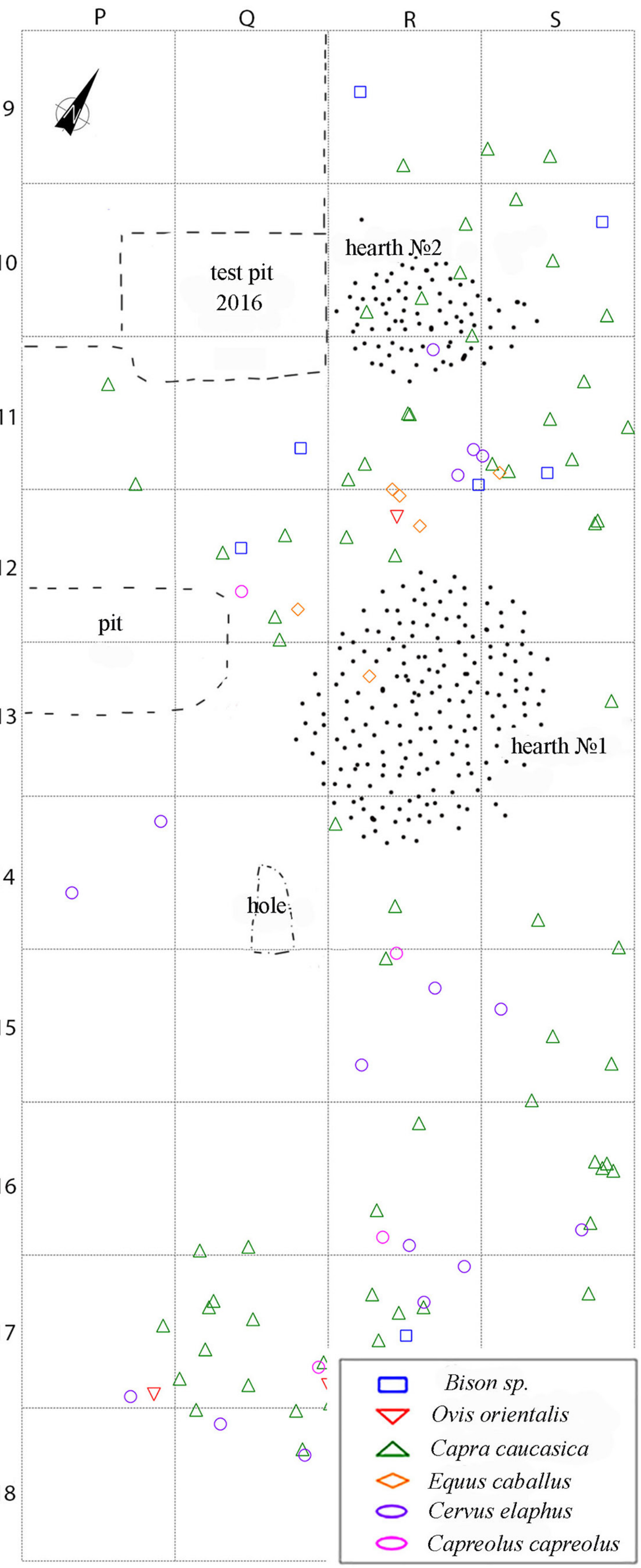

Figure 7. Saradj-Chuko Grotto. Layer 6B. Plan showing the distribution of identified bones, by animal species. After Doronicheva et al. (2020a: Figure 57).

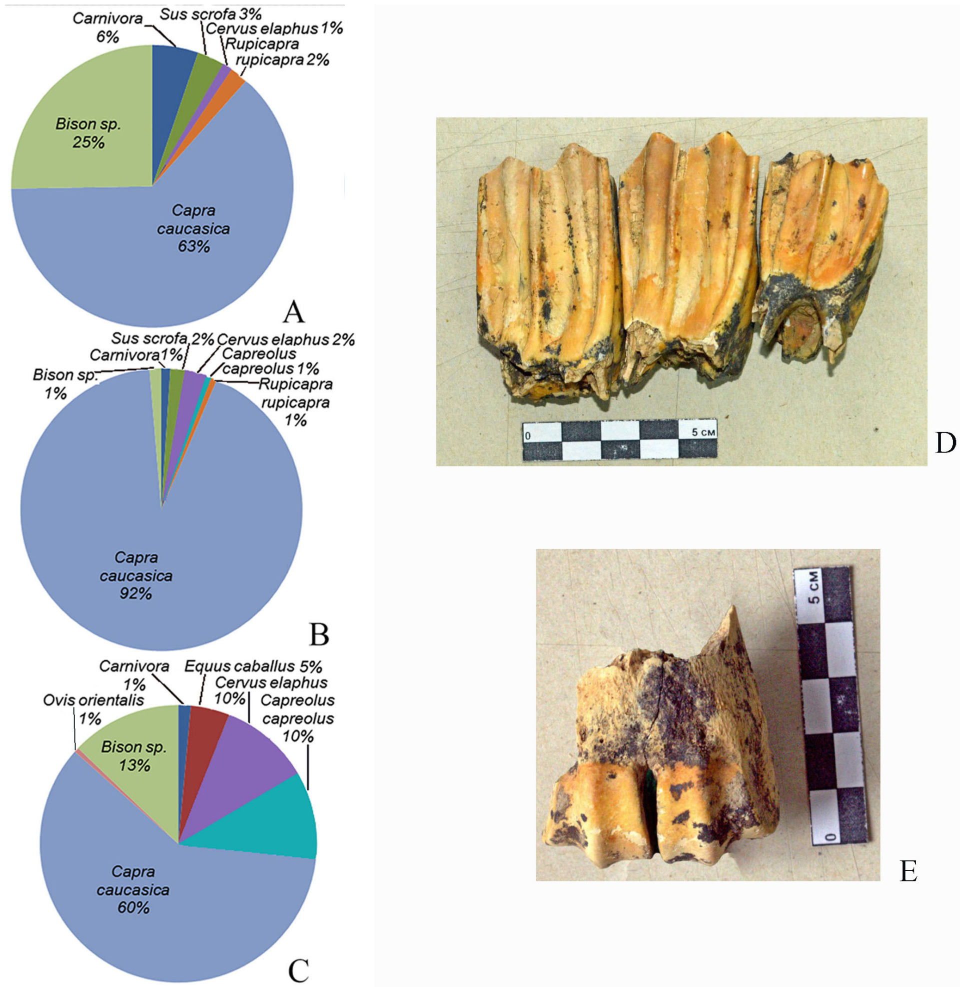

Figure 8. Saradj-Chuko Grotto. A) Ratio of identified large mammal remains in layer 3 (95 bone specimens in total); B) Ratio of identified large mammal remains in layer 6A (294 bone specimens in total); C) The ratio of identified large mammal remains in layer 6B (551 bone specimens in total). After Doronicheva et al. (2020a: Figure 180). D, E) Photos of two identified large mammal remains.

of 7km to the west and north-west (Baksan river valley), and south-east (Kamenka river valley) from the site. Many obsidian flakes have cortex areas on dorsal surfaces. This indicates that obsidian was brought to the cave as cobbles or pebbles that were knapped on the site. On the contrary, flint artifacts include only chips, flakes, shatter, and tools, with no cores or primary flakes. The composition of flint artifacts indicates that flint was brought as ready-to-use flakes and retouched tools that were rejuvenated or modified in the cave.

In the Zayukovo area, obsidian occurs only in deposits of the late Gelasian Baksan-ges formation composed of thick strata of coarse lacustrine-alluvial and proluvial-lacustrine deposits, 50–60m in total thickness, which filled a paleo-lake within the Zayukovo depression during the late Gelasian stage (Lower Pleistocene). At present, the obsidian-bearing Baksan-ges formation is preserved on both banks of the Baksan River only in the Zayukovo area. In 2016–2018, we undertook field survey in the Zayukovo (Baksan) obsidian source area, as well as along the Baksan River valley and valleys of its small tributaries in order to collect new information about the geology and geomorphology of obsidian- and flint-bearing deposits in the region. As a result, four different obsidian outcrops (named Zayukovo-1–4) were identified, sampled, and studied within the Zayukovo (Baksan) source area (Shackley et al. 2018).

The Zayukovo obsidian is mainly uniform aphyric black or brownish-red (mahogany), sometimes black with rare very small (<0.01mm) sanidine phenocrysts, banded black and brownish-red. In thin section, the obsidian shows alternation of brown, reddish-brown, and colorless bands, each divided into smaller thin bands. Although Zayukovo obsidian is highly variable in color, trace element analyses suggest a single homogeneous composition of all obsidian samples from the area and their distinction from other obsidian sources known in the Southern and Lesser Caucasus (Shackley et al. 2018). In the Zayukovo source, obsidian is found as cobbles and pebbles in secondary contexts on high river terraces along the banks of the Baksan River, and the largest quantity of obsidian and especially larger-sized cobbles (maximum length up to 20cm) is confined to the outcrops near the town of Zayukovo. These results indi-

TABLE 2. LITHIC COLLECTIONS FROM SARADJ-CHUKO GROTTO, LAYERS 6B, 6A AND 3 (Excavations 2017-2019).

Layer	Cores	Chips	Shatter	Flakes	Tools	Other	Total
6B	35	4,286	4,052	2,234	350	2	10,959
6A	2	205	210	170	23	-	610
3	1	17	15	38	9	-	80

cate that the Zayukovo (Baksan) source is a single obsidian source area, which has a total length of about 10km along the Baksan River.

LITHIC ASSEMBLAGES

WEASEL CAVE

Based on the published data (Hidjrati 1990; Hidjrati et al. 2003; 2010), Golovanova and Doronichev (2003; Golovanova 2015) suggested that the Mousterian industry from the lower MP layers 12–14 is similar to the Zagros Mousterian. The industry is based on Levallois technology, contains many Levallois and laminar blanks, including unretouched Levallois points, and is characterized by a high value of convergent tools (8–27% of the total artifacts) that include retouched Levallois points, Mousterian points, elongated Mousterian points made on blades, angular scrapers, and other convergent pieces. There are also knives with retouched backs, narrow and thick (bar-like) double side-scrapers (or "rods"), and a few truncated-faceted pieces (Golovanova 2015: Figure 23). These technological features and tool types are characteristic for Zagros Mousterian assemblages in the Zagros, Lesser Caucasus, and Armenian Highlands.

SARADJ-CHUKO GROTTO

At Saradj-Chuko Grotto, 12,225 artifacts were found in total during the 2017–2019 excavations (Doronicheva et al. 2020a). Most of them originate from MP layer 6B (10,959 pieces; Table 2). Also, a significant assemblage was found in MP layer 6A (610 pieces), while rare artifacts (80 pieces in total) were found in the top MP layer 3 (Figure 9). Additionally, a small collection of stone artifacts (152 pieces) comes from the Holocene layers (1, 1A–1C) and layer 2, as well as from the surface and collapsed or disturbed sediments. For the lithic analysis, we employed a standard Paleolithic typology using terms and definitions from Debénath and Dibble (1994).

The assemblage from Layer 6A includes mostly shatter and chips, rare flakes, including laminar flakes or bladey flakes, whose length (*L*) is between 1.5 and 2 times their width (*m*), after Debénath and Dibble (1994), and no cores (Figure 10). Tools are few and include mainly side-scrapers and convergent tools. Most of the artifacts are made from obsidian, and only some are made from flint or silicified limestone.

Layer 6B is the richest MP level (on average about 295 artifacts per m^2 or 31,311 artifacts per m^3 at Saradj-Chuko Grotto). The artifacts exhibit good preservation, are not damaged, and only rarely show patina or evidence of abrasion. The assemblage includes cores (0.3% of the total assemblage), flakes (20.3%), shatter (37.0%), chips (39.1%), and retouched tools (3.2%).

The obsidian cores found in layer 6B are small (4–9cm) and reduced, have mainly parallel removals and rarer single ones, and weakly convex surfaces (Figure 11). Core platforms are minimally prepared, mostly by a series of small flake removals, and no preliminary preparation of production surfaces was identified. The prevalence of the unidirectional, parallel flaking method is also indicated by knapping products, among which flakes with unidirectional, parallel removals are most abundant. The predominance of single-platform cores also indicates that core reduction mainly ended at this stage, after which most cores were discarded. The rare two- and three-platform cores reflect a more prolonged reduction of some cores, using mainly bipolar (from two opposite platforms) or orthogonal (from two perpendicular platforms) flaking methods (see Figure 11). The rarity of bipolar and orthogonal cores correlates with a low number of flakes with orthogonal, transversal, or bipolar removals on dorsal surfaces.

The single refitting sample of a single platform core and five flakes (Figure 12) allows us to reconstruct the succession of removals that was typical for the laminar technology in layer 6B. This refitting shows that a sequential removal of pebble cortex occurred in the process of parallel flaking, i.e., the final decortication of cores occurred in the course of their reduction. As noted above, 46.2% of obsidian flakes have cortical areas on dorsal surfaces, which confirms this conclusion. As the result of the parallel flaking method and laminar technology, the produced flakes consistently acquired the morphology of laminar flakes and elongated blades. For example, the refitting shows that three of five flakes are laminar flakes (L=1.5–2 m), and two of them are narrow blades (L> 2 m).

An indicative feature of the stone knapping technology in layer 6B is the large number of laminar flakes (16.5% of total flakes), although true blades (5.0%) and typical Levallois triangular flakes or points (1.3%) are rare. Most flakes with an identifiable striking platform have prepared striking platforms (Faceting Index, IF=42.7), among which faceted platforms predominate (Strict Faceting Index, IFs=37), especially among laminar flakes (IFs=46–56 in various assemblages from the 2017–2019 excavations). These techno-

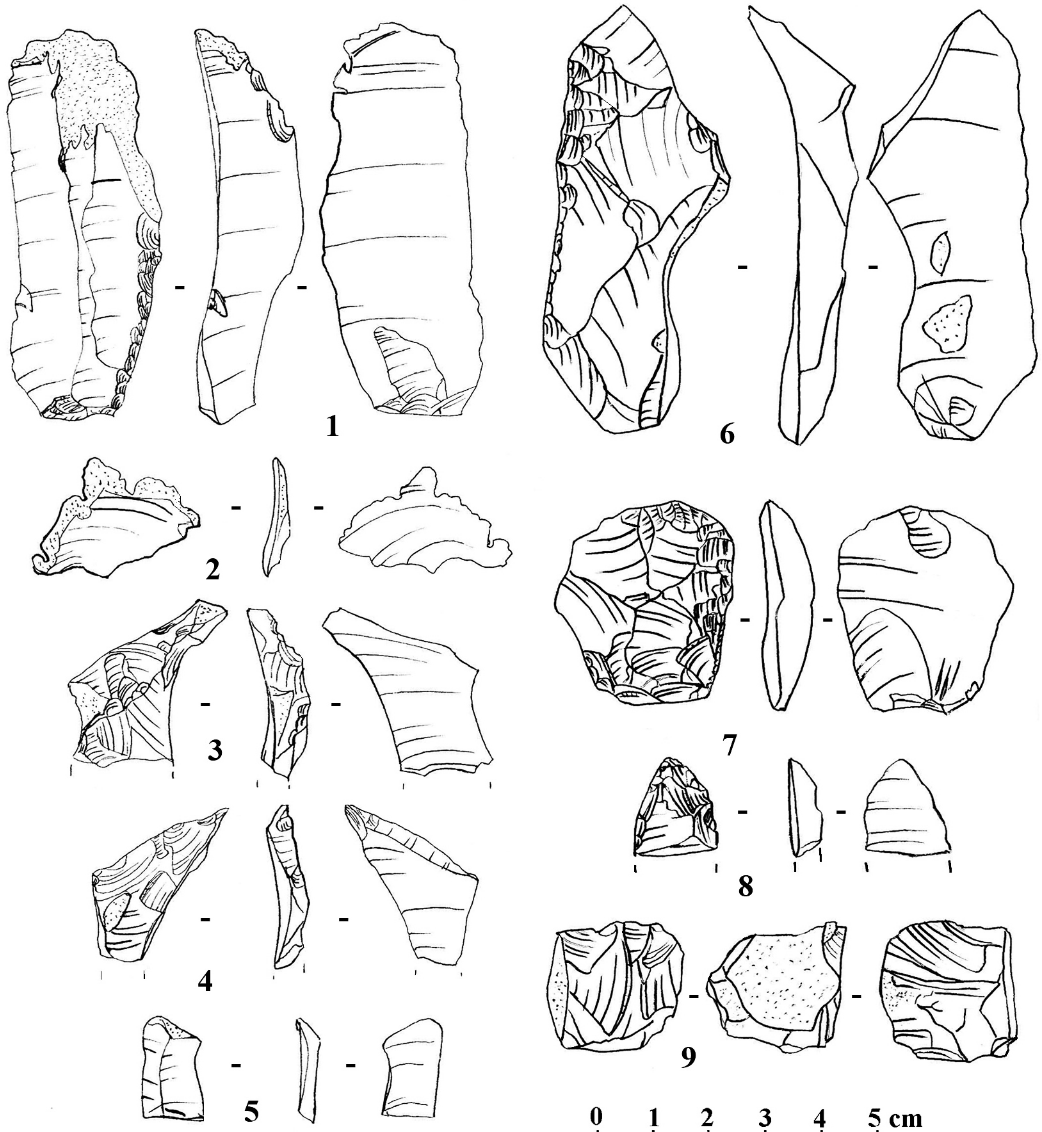

Figure 9. Saradj-Chuko Grotto. Lithic artifacts from layer 3 (2018 excavation). Numbers indicate: 1) retouched blade; 2, 4) flakes; 3) technical flake; 5) blade fragment; 6) side-scraper on technical flake; 7) end-scraper on flake; 8) tool fragment; 9) exhausted core.

logical indices are consistent with Bordes's (1961) definition of the "laminar faceting Mousterian," and allow us to define the MP industry from layer 6B as laminar Mousterian.

The retouched tools in layer 6B are represented by 350 pieces (3.2% of the total assemblage), and a large number of chips (39.1%) suggesting that many of the tools were manufactured inside the cave. Among tools, simple side-scrapers prevail. Also, diagonal, convergent, double, and angular scrapers, tools with thinning retouch from the ventral surface, and Levallois retouched and Mousterian points were identified (Figure 13). All these tool types are typical for Mousterian industries known in the Southern Caucasus (Golovanova and Doronichev 2003, 2005). Also, a few truncated-faceted pieces typical of the Zagros Mousterian were found in layer 6B.

In general, the recent research in Saradj-Chuko Grotto indicates that the MP lithic assemblages recovered from layers 6A and 6B at this site represent a non-Levallois, laminar, and faceted Mousterian industry. The laminar character of the knapping technology, indicated by the large number of laminar flakes (about 27–45 % and about 36–45 % of the total flakes in layers 6B and 6A, respectively), and especially the high indices of prepared (IF) and faceted (IFs) platforms differentiate the MP industry from Saradj-Chuko Grotto from the Eastern Micoquian industry in the northwestern Caucasus. The predominance of unifacial tools, represented mainly by various side-scrapers and convergent tools, many of which are made on laminar blanks, and the presence of truncated–faceted scrapers, which are typical for the Zagros Mousterian and absent in the Eastern Micoquian, are the typological features also indicating a similarity of the MP assemblages from Saradj-Chuko Grotto with the Zagros Mousterian industry (Doronicheva et al. 2023b).

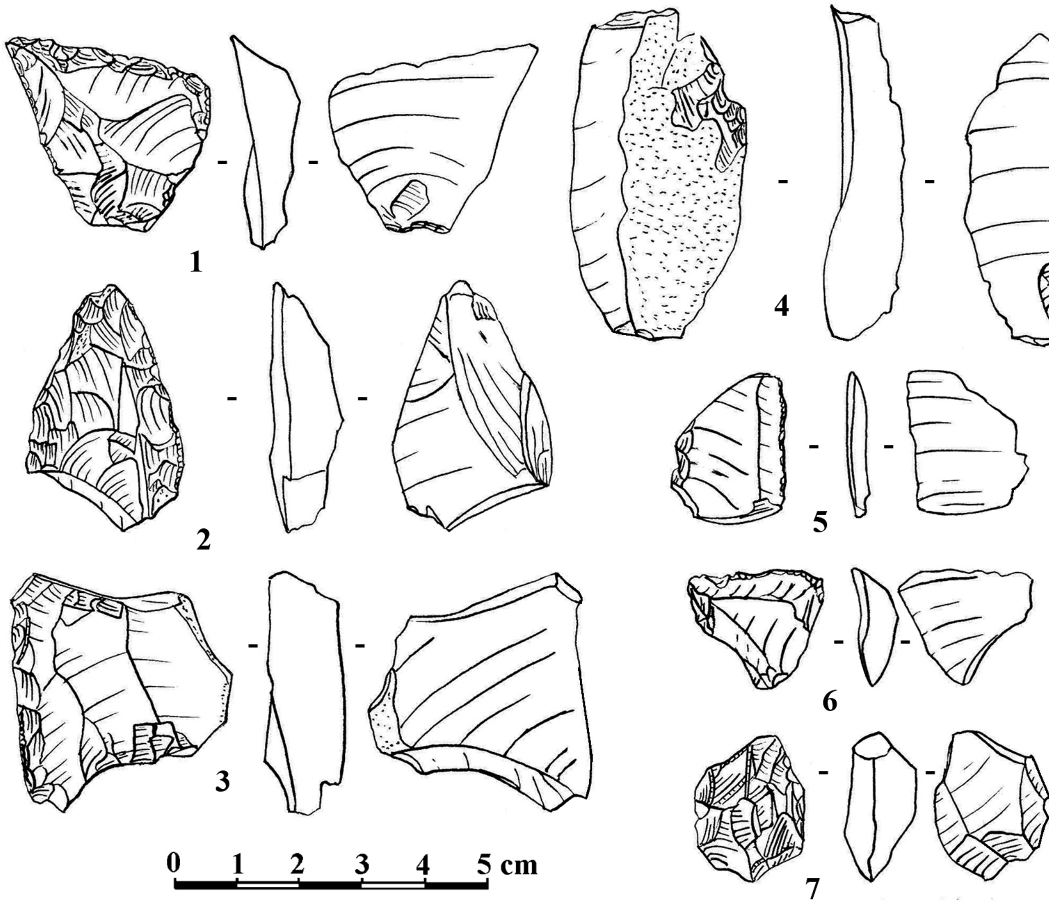

*Figure 10. Saradj-Chuko Grotto. Lithic artifacts from layer 6A (2018 excavations). Numbers indicate: 1) angled (*déjeté*) scraper; 2) distal fragment of partial bifacial point; 3) truncated-faceted side-scraper; 4) laminar flake; 5, 6) flakes with fine retouch; 7) exhausted core.*

USE OF FIRE AND SUBSISTENCE ACTIVITIES

WEASEL CAVE

In Weasel Cave, hearths and wood charcoal pieces were found in many MP layers. The microwear polishes research on a selection of 14 lithic tools indicates that MP hominins used both retouched tools and unretouched flakes for wood-working, butchery (including slicing of meat), and scraping of fresh or dry hides, in rank order. Also, hafting polish is common (Faulks et al. 2011; Kimball et al. 2017). However, no tools used as hunting weapons were identified.

SARADJ-CHUKO GROTTO

In Saradj-Chuko Grotto, two hearths were found in 2018 in layer 6B (Doronicheva et al. 2019b; 2020a; 2021; see Figures 5 and 7). Refitting results confirm on-site knapping of obsidian and that the area of obsidian knapping is related to the main concentration of artifacts and the two hearths. Both hearths show macroscopically similar diagenetically altered internal stratigraphy, lack ash levels, and are similar in the associated archaeological material. The black levels (BLs) in both hearths are sedimentary substrates representing a dark loam, which mainly contain scarce, scattered black particles, representing unidentified wood charcoal fragments, rather than a distinct level of fuel residues.

The determination of the maximum firing temperature (Tfire) of hearths in layer 6B was performed using the magnetic susceptibility method (Rasmussen et al. 2012). The burnt autochthonous clay samples collected from both hearths in layer 6B were used for this analysis. The Tfire of both hearths was determined in the range between ~530–600°C (Doronicheva et al. 2020a).

We conducted microscope use-wear analyses of 62 lithic tools made of obsidian (52) and flint (10) from the MP layer 6B at Saradj-Chuko Grotto (Doronicheva et al. 2020a; 2020b). The results indicate that the tools were used in a variety of activities, including as hunting weapons (spearheads), meat knives for butchering hunting prey, perforators, or awls for hide-working, scrapers on wood or bone/antler, and stone retouchers.

Among the 13 tools that we functionally identified as spearheads, most have been typologically defined as convergent tools and convergent scrapers, and one as a Mousterian point. The identification of MP stone-tipped hunting spears thus has been made for the first time in the Caucasus. These tools have characteristic impact fractures, such as transverse bending fractures with small spin-offs, and

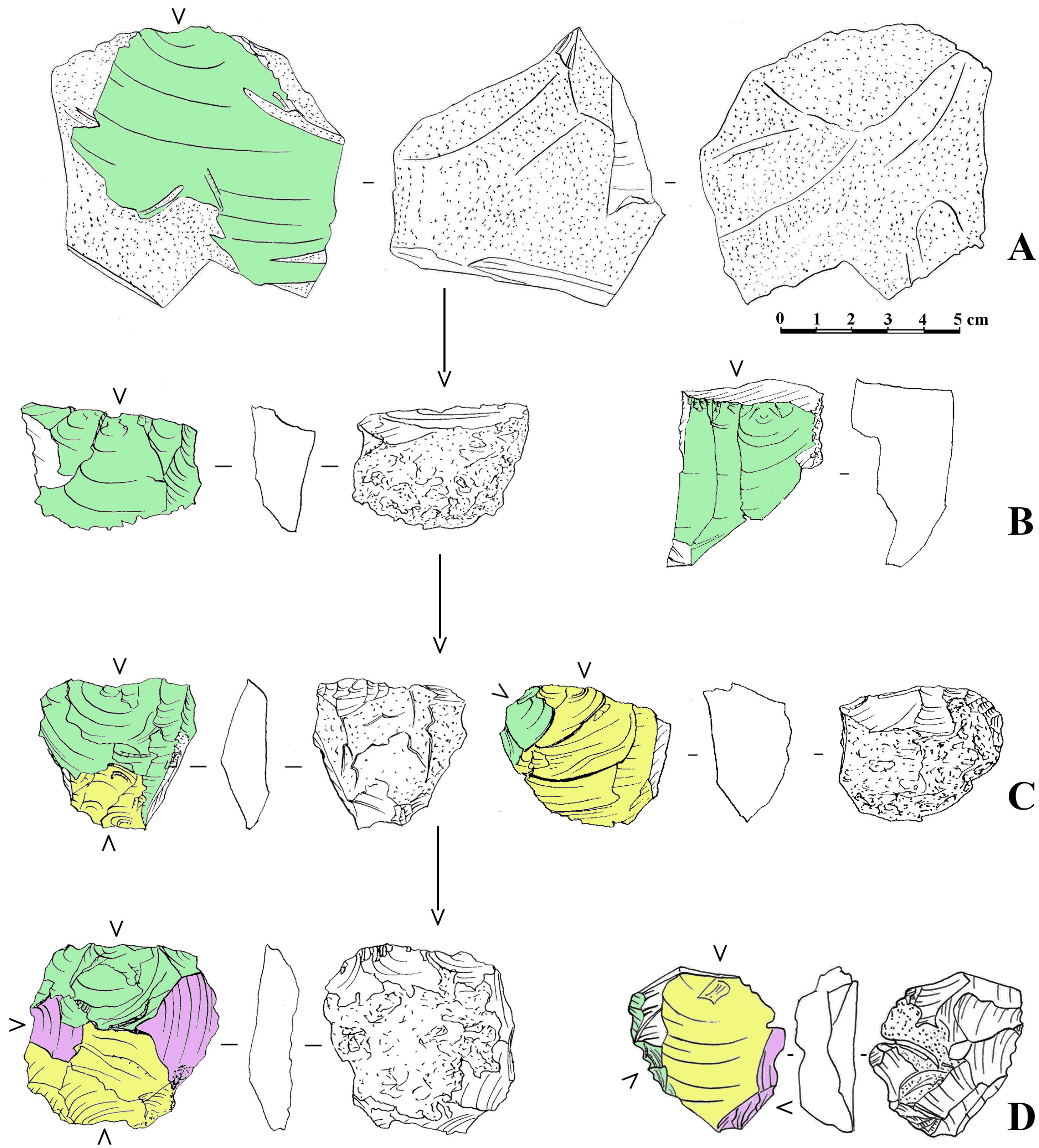

Figure 11. Saradj-Chuko Grotto. The reconstruction of unifacial core reduction technology in layer 6B. Letters indicate stages of unifacial core reduction: A) test flaking; B) one-platform parallel flaking; C) two-platforms bipolar or orthogonal flaking; D) three-platform unifacial flaking. Colors indicate the succession of removals: green – the initial (1st stage) removals; yellow – the 2nd stage removals overlapping the 1st stage removals, pink – the 3rd stage removals overlapping the 2nd stage removals. Drawings of cores are given in one scale. After Doronicheva et al. (2020a: Figure 71).

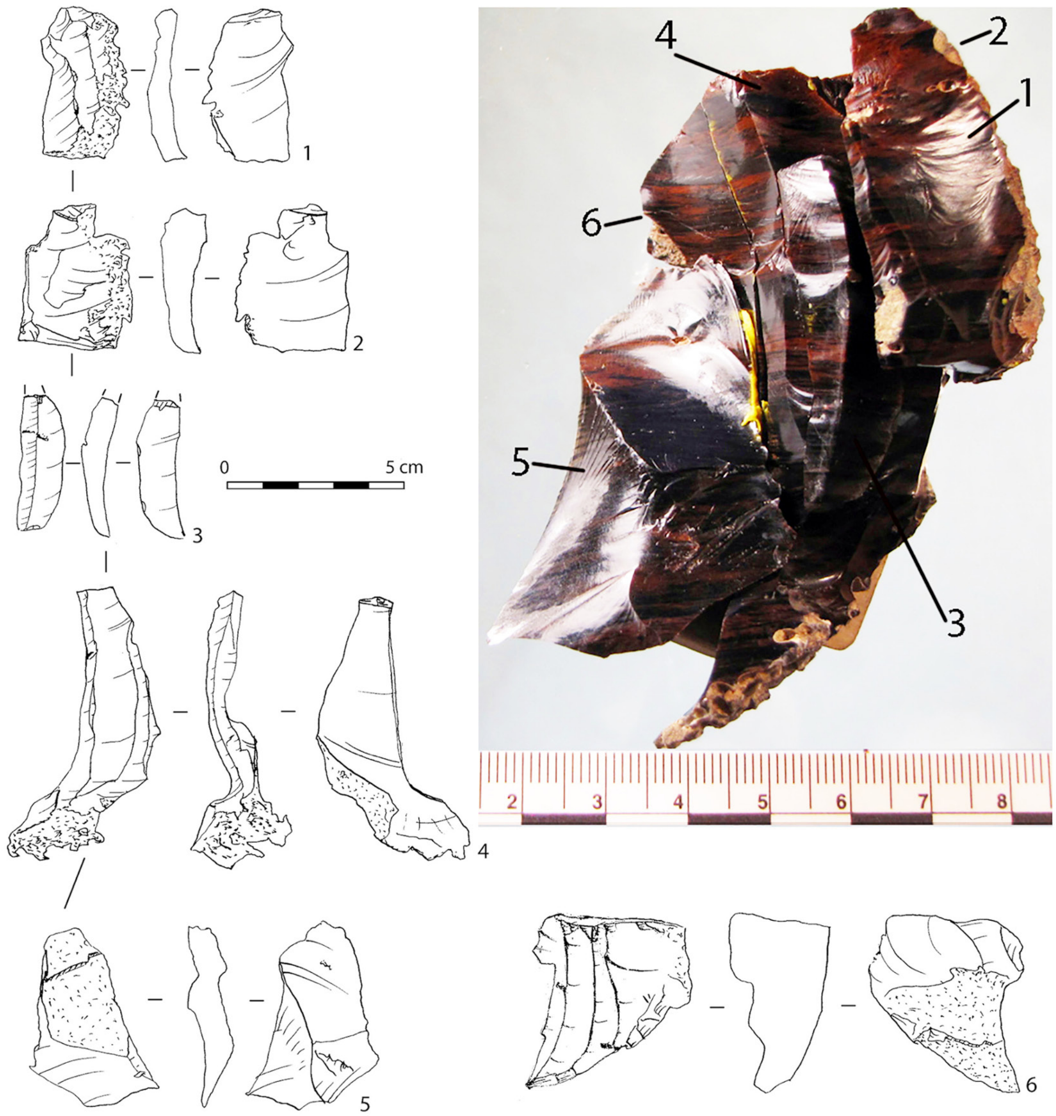

Figure 12. Saradj-Chuko Grotto. Layer 6B (2017 excavation). Drawings and photo of refitting of a core and five flakes. Numbers on drawings and photo indicate the sequence of removals (1–5) and the resulting exhausted, one-platform core with parallel removals (6).

some have identifiable microtraces of wear (smoothing and abrasion) resulting from hafting of the tool base in a wood shaft. We also defined a frequent supplementary use of the tools as bulb retouchers (seven of the thirteen pieces). Also, microresidues of a dark-brown or black substance, visually similar to birch bark pitch or bitumen, were found on basal parts of almost all of the tools.

In addition, a use-wear and residue analysis of four lithic tools from layers 6A (truncated-faceted side-scraper) and 6B (elongated Mousterian point, convergent scraper with a truncated-faceted base, and convergent scraper with the base thinned by ventral retouch) at Saradj-Chuko Grotto indicated that the tools were used as meat knife, projectile tip, and projectile tip/meat knife, respectively (Doronicheva et al. 2022). Three of the tools are made from flint and one (elongated Mousterian point) is made from obsidian. Lithic residue analysis, using scanning electron microscopy with energy dispersive spectroscopy (SEM-EDS), Fourier transform infrared (FTIR) spectroscopy and Raman spectroscopy, indicated the presence of specific bitumen absorption bands. This study for the first time unequivocally indicated the use of bitumen for hafting stone tools in the MP of the Caucasus.

DISCUSSION AND CONCLUSIONS

The discovery of the Saradj-Chuko Grotto in 2016 and multidisciplinary research in 2017–2020 at this site close a large gap in our knowledge about the MP hominin occupation of the Northern Caucasus. The evidence from Saradj-Chuko Grotto and comparative data from other sites allows us to discuss Neanderthal migrations and settlement, contacts between culturally diverse hominin groups, and the origins and evolution of MP culture in the Caucasus.

Previous studies demonstrated that almost all stratified MP sites in the north-western Caucasus (Kuban River basin) represent a regional variant of the Eastern Mico-

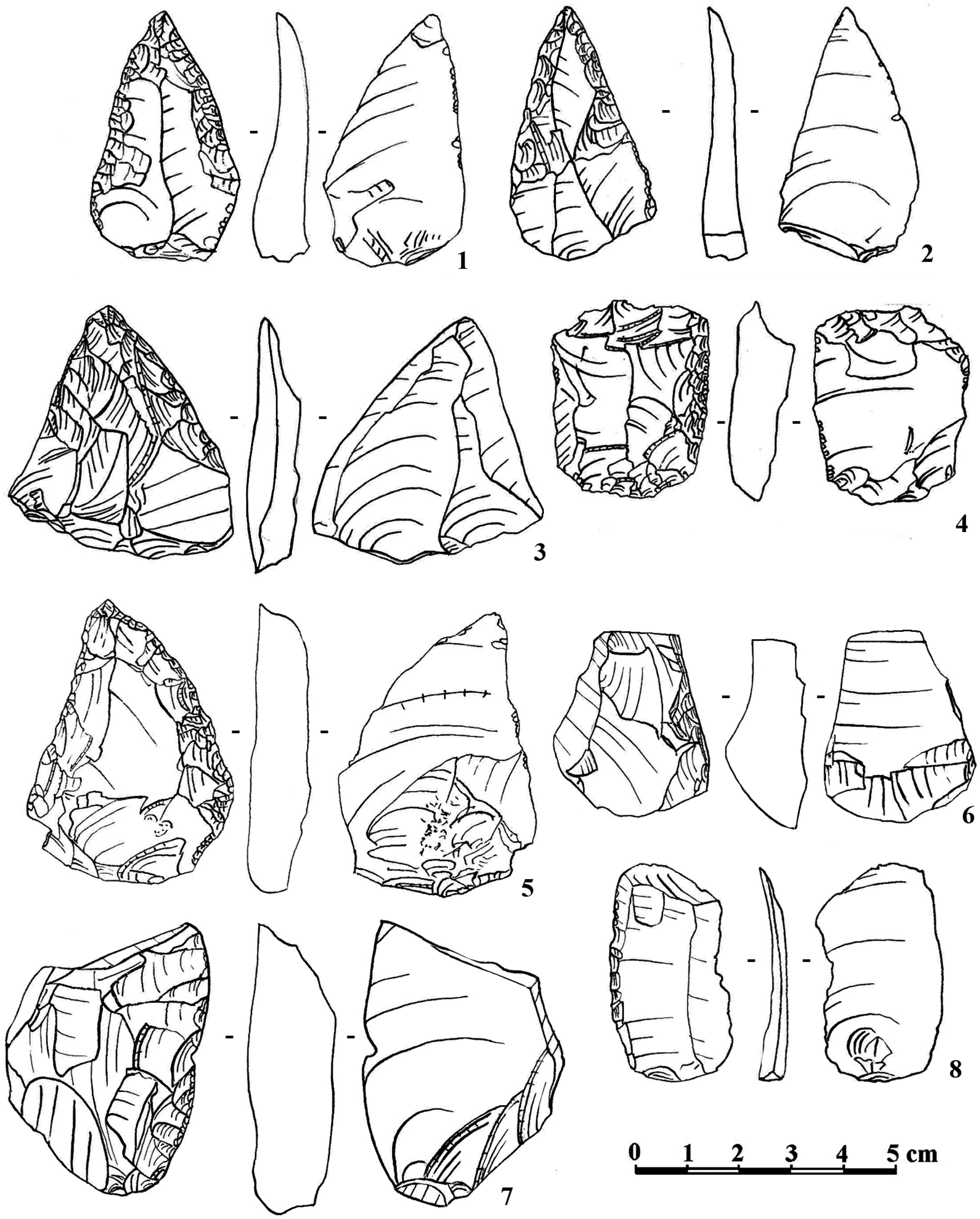

*Figure 13. Saradj-Chuko Grotto. Retouched tools from layer 6B (2018 excavations). Numbers indicate: 1, 2) elongated Mousterian points; 3) convergent scraper with a truncated-faceted base; 4) truncated-faceted side-scraper; 5) angled (*déjeté*) scraper; 6) tool fragment with ventral thinning retouch; 7) side-scraper with thinned back; 8) retouched blade.*

quian industry that was present in the region from at least OIS 5d (~119–108 ka), or even OIS 5e (~130–120 ka), to ~40 ka, and was clearly produced by the Neanderthals, whose fossils were well studied in Mezmaiskaya Cave and found in several other sites (Doronicheva et al. 2023b; Gasparyan and Glauberman 2022; Golovanova 2015; Golovanova and Doronichev 2003, 2005; Golovanova et al. 2022). The most indicative feature of the north-western Caucasian Micoquian industry is the presence of quite numerous and variable bifacial and partial bifacial tools, including triangular, wide small bifaces, bifacial leaf-points, and bifacial, often asymmetric, and backed scraper-knives, as well as various partially bifacial and unifacial convergent tools and side-scrapers, and non-Levallois, non-laminar recurrent flaking technology with low indices of prepared (IF) and especially faceted (IFs) platforms; these are characteristic to the Eastern Micoquian assemblages in this region. Paleogenetic analyses of the Neanderthal specimens from Mezmaiskaya Cave indicate that the Eastern Micoquian Neanderthal population from the north-western Caucasus belongs to a group of European Neanderthals who diverged from other European Neanderthals during OIS 5, after ~110 ka (Briggs et al. 2009), or between 100 and 80 ka (Andreeva et al. 2022; Hajdinjak et al. 2018).

The MP industry from layer 6B at Saradj-Chuko Grotto shows similarity with MP industries known in neighboring areas, especially with the MP industry from layers 12–14 in Weasel Cave (Doronicheva et al. 2019b; 2020a). In Weasel Cave, pollen spectra from layers 12–14, which are presumably dated to early OIS 3 – late OIS 5 (between 50–90 ka), indicate a warm and humid climate, and the prevalence of deciduous forests with a variety of thermophilic tree species (Faulks et al. 2011; Hidjratiet al. 2003, 2010). Pollen data suggest that layer 6B in Saradj-Chuko Grotto was deposited during an interglacial period when the cave was surrounded by deciduous forests with a variety of thermophilic tree species, and the climate was warm and humid. This similarity of environmental conditions suggests a temporal affinity of the MP assemblages in these two sites located in the north-central Caucasus at close elevation, Saradj-Chuko Grotto (940m asl) and Weasel Cave (1125m asl). Based on comparative paleogeographic data, we tentatively dated layer 6B in Saradj-Chuko to OIS 5, in the range approximately from 120 to 70 ka (Doronicheva et al. 2019b; 2020a). OSL dating results are now available and indicate that MP deposits at Saradj-Chuko Grotto are dated from late OIS 5 (90–70 ka; Layer 6B), and early (60–50 ka; Layer 6A) and late (45–40 ka; Layer 3) OIS 3 (Doronicheva et al. 2023b).

The laminar technology differentiates the MP industry of the north-central Caucasus, represented by Saradj-Chuko Grotto and Weasel Cave, from the Micoquian industry widespread in the north-western Caucasus, for which low indices of laminarity and faceted platforms are typical. The absence of bifacial tools also distinguishes the MP industry of the north-central Caucasus from the Micoquian industry of the north-western Caucasus.

Considering the assemblage from layer 6B at Saradj-Chuko Grotto in the context of MP industries of the Caucasus, it should be emphasized that the high indices of laminarity and faceted platforms characteristic of this assemblage are most typical for Zagros Mousterian industries in the Lesser Caucasus and Zagros. The abundance of unifacial convergent tools, such as *déjeté* scrapers, convergent scrapers, Mousterian points, and Levallois retouched points, many of which are made on laminar blanks, and the presence of rare truncated-faceted tools, which are unknown in the Eastern Micoquian industry in the north-western Caucasus, also point to a similarity of the MP industry in the north-central Caucasus with the MP industries defined in the Southern Caucasus, and especially with the Zagros Mousterian in the Lesser Caucasus and Armenian Highlands.

Although fossils of MP hominins were not found yet at Saradj-Chuko Grotto, Weasel Cave, and a few other MP sites known at present in the eastern half of the Northern Caucasus, only Neanderthal remains are associated with the Zagros Mousterian distribution area, from the Lesser Caucasus (King et al. 2016) to Zagros Mountains (Heydari-Guran et al. 2021; Pomeroy et al. 2017; Solecki 1972). This strongly suggests that the Zagros Mousterian assemblages in the Northern Caucasus were produced by Neanderthals. Moreover, recent study suggests that the Neanderthal groups from the Caucasus, particularly those associated with the Zagros Mousterian and Levantine Mousterian, could have provided a source population for the dispersion of Neandertals towards Central Asia and southern Siberia (Ghasidian et al. 2023).

Earlier, Liubin and Beliaeva (2009) suggested that the rarity of MP sites in the north-central Caucasus may be explained by an almost complete lack of high-quality flint sources in this region. However, our field surveys in 2016–2017 allowed us to discover several primary (in limestone rocks) and secondary (in river alluvium) sources of high-quality, gray, pink, and black flint in the Baksan, Chegem, and Kamenka river valleys in the region (Doronicheva et al. 2017; 2019b; 2020a). A petroarchaeological study of obsidian and flint artifacts indicates that at Saradj-Chuko Grotto, MP hominins exploited obsidian and flint sources located within a radius of 5–7km from the site.

Many petroarchaeological studies indicate that obsidian represented the most attractive stone raw material for MP hominins in both the Northern (Doronicheva and Shackley 2014; Doronicheva et al. 2016; 2019a) and Southern (Le Bourdonnec et al. 2012; Pleurdeau et al. 2016) Caucasus and Armenian Highlands (Frahm et al. 2016; Kandel et al. 2017). Recent studies indicate that the Zayukovo (Baksan) obsidian source —the only obsidian source known in the Northern Caucasus—was a center of attraction for MP hominins in both the north-central Caucasus (Saradj-Chuko Grotto) and the north-western Caucasus (Doronicheva and Shackley 2014; Doronicheva et al. 2016; 2019a). In the MP layers at Mezmaiskaya Cave, located ~250km to the west of the Zayukovo obsidian source, rare artifacts (< 0.2% of the total MP lithics) made of Zayukovo obsidian were found. This is the first evidence defined for the MP of the Caucasus of obsidian transport over a linear distance of >200km. This example of obsidian transport over a long distance allowed us to assume the possibility of contacts between the Eastern Micoquian Neanderthal population in the north-western Caucasus and the MP population in the north-central Caucasus.

Some researchers (e.g., Golovanova and Doronichev 2005) assumed a possible association of such long-distance stone raw material transportation with interregional movements of Neanderthal mobile hunting groups. In the north-western Caucasus, the area of lithic raw materials procurement is defined within a 100km radius from Mezmaiskaya Cave and outlines the habitation area (i.e. the territory, within which the population regularly exploited resources) of the Eastern Micoquian Neanderthal population in the region (Doronicheva et al. 2016). However, the findings of rare artifacts made from Zayukovo obsidian in MP layers at Mezmaiskaya allowed us to suggest a higher mobility range of the Eastern Micoquian Neanderthals towards the east, within the Northern Caucasus.

Also, in layer 2B4 at Mezmaiskaya Cave, we identified a small concentration of several Levallois blanks and a flake made from exotic raw material (probably slate or volcanic rock) that are not characteristic for the Eastern Micoquian industry in the north-western Caucasus (Golovanova 2015; Golovanova et al. 2014). We interpreted them as intrusive objects that likely entered Mezmaiskaya Cave from another cultural context.

The evidence in support of contacts between the Eastern Micoquian Neanderthal populations in the north-western Caucasus and the culturally different hominin population that settled the region near the Zayukovo (Baksan) obsidian source in the north-central Caucasus was found recently at Saradj-Chuko Grotto. In layer 6B in this site, five bifacial tools were found that are not characteristic of the Zagros Mousterian, but instead are typical of the Eastern Micoquian in the north-western Caucasus (Doronicheva et al. 2019b; 2020a).

These data, combined with the obsidian transport results, suggest cultural contacts and probable other relations between the Neanderthal population of the north-western Caucasus and the MP populations inhabiting the north-central Caucasus. Moreover, all the typical Micoquian tools found at Saradj-Chuko Grotto are artifacts that could potentially have served as a hunting mobile inventory, which hunters could use as weapons for hunting animals or butchering prey. Two of them were functionally identified, based on the study of use-wear traces, as a hunting projectile tip and a meat knife (Doronicheva et al. 2020a; 2022). This evidence confirms that small, mobile hunting groups of Eastern Micoquian Neanderthals from the north-western Caucasus could sporadically enter the cultural area of the Zagros Mousterian Neanderthals in the north-eastern Caucasus, moving as far south-east as the Saradj-Chuko Grotto, located at the currently defined western boundary of the Zagros Mousterian distribution area in the Northern Caucasus. The distances of obsidian artifact transport and moving of hunting groups (linear distances of ~250km between Mezmaiskaya Cave and Saradj-Chuko Grotto) are consistent with those documented now for the MP hominins in the Lesser Caucasus and Armenian Highlands (Asryan et al. 2020; Gasparyan and Glauberman 2022).

Moreover, the characteristics of MP assemblages from Weasel Cave and Saradj-Chuko Grotto, indicating the similarity of these assemblages with the Zagros Mousterian, also suggest possible cultural contacts and probable other relations between the MP population of the north-central Caucasus and the MP populations that inhabited the Southern and Lesser Caucasus, and the Armenian Highlands. However, the nature of these proposed contacts remains to be studied and defined. At present, no evidence of raw material transport is identified between these regions. As we noted above, no artifacts made from obsidian are reported at Weasel Cave, located <100km linearly to the south-east from the Zayukovo obsidian source.

Other stratified MP sites known in the eastern part of the Northern Caucasus, in which MP artifacts were found *in situ*, include only the Tinit-1, and Darvagchay-Zaliv-1and Darvagchay-Zaliv-4 open-air sites located in the Caspian Sea coastal region in Dagestan. Darvagchay-Zaliv-1 and Darvagchay-Zaliv-4 are dated from early OIS 5 (probably OIS 5e), and produced small lithic assemblages that represent flint-knapping workshops, in which mostly exhausted cores and other stone knapping products (mainly flakes) were found, but retouched tools were rare (Rybalko et al. 2020). The Tinit-1 site has yielded a finely stratified succession of eight or eleven MP occupational horizons with *in situ* artifacts that are dated from the late MP, based on mean AMS radiocarbon ages between 43 and 51 ka cal BP (Anoykin et al. 2013). The lithic assemblages represent short-term stone knapping workshops and, probably, hunting camps. Typologically definable retouched tools are few and comprise only unifacial tools, including side-scrapers, Mousterian and retouched Levallois points, atypical endscrapers, and a single truncated-faceted piece.

Both the absence of bifacial tools and Levallois/laminar technology differentiate the MP assemblages from these sites from the Eastern Micoquian industry in the north-western Caucasus. The MP assemblages from the Tinit-1 sites show many features of similarity, including the laminar technology and the tool types typical for Zagros Mousterian, with the MP assemblages from Saradj-Chuko Grotto and Weasel Cave.

In conclusion, we note that the modern archaeological record on MP occupation of the North Caucasus indicates that the MP Neanderthal groups in the north-western Caucasus (Kuban River basin) produced a regional variant of the Eastern Micoquian industry, and were closely related culturally to the Neanderthal populations bearing the Micoquian (or *Keilmesser*-group) Mousterian tradition in Eastern and Central Europe. On the contrary, the MP Neanderthal groups that inhabited the eastern half of the Northern Caucasus (Terek River basin) produced a laminar/Levallois Mousterian industry and were culturally similar to the Neanderthal populations producing laminar and Levallois Mousterian industries in the Southern and Lesser Caucasus, as well as in the Levant and Zagros, and especially with the Zagros Mousterian industry in the Lesser Caucasus and Armenian Highlands (Doronicheva et al. 2023b).

Further excavation and research at Saradj-Chuko Grotto will allow us to better clarify the chronology and cultural peculiarities of the MP assemblages in the north-central Caucasus. Saradj-Chuko Grotto has great potential to provide significant new results that illuminate cultural variability, differences in subsistence, characteristics of obsidian and other lithic raw material exchange, and inter-regional contacts among MP hominin groups in the Northern Caucasus, as well as within the broader MP cultural context, including the south of the Russian Plain, Southern and Lesser Caucasus, Armenian Highlands, Levant, and Zagros.

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DATA AVAILABILITY STATEMENT

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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