Special Issue: The Impact of Upper Pleistocene Climatic and Environmental Change on Hominin Occupations and Landscape Use, Part 1

Dynamics of Climate and Human Settlement During the Middle and Upper Paleolithic in the Northwestern Caucasus

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ABSTRACT

Recent studies of the Middle and Upper Paleolithic in the northwestern Caucasus are focused on the research of relations between natural (climate and environment) and social (behavior and adaptations) factors that governed settlement dynamics of Neanderthal and anatomically modern human populations in the region. The majority of Middle Paleolithic sites in the region show temporal changes within a local variant of the Eastern Micoquian industry between approximately 90 and 40 thousand years (ka) ago. The final stage of the Eastern Micoquian occupation in the northwestern Caucasus is notable in that the number of Neanderthal sites increases, and these sites show a higher variety and spread towards the eastern boundary of the region. The research provides new data indicating that ecology and subsistence of late Neanderthals were affected by a large, catastrophic volcanogenic event, which likely caused the Neanderthal extinction, and that was followed by a subsequent reoccupation of the region by Upper Paleolithic modern humans. In addition, recent genetic analyses indicate that a population turnover is likely to have occurred, either in the Caucasus or throughout Europe, towards the end of Neanderthal history.

In the northwestern Caucasus, Upper Paleolithic sites are found mostly in caves or rockshelters, and show two major periods of modern human occupation: (1) Upper Paleolithic, from ~39/38 ka to the onset of the Last Glacial Maximum; and, (2) Epipaleolithic, from the Last Glacial Maximum to ~11/10 ka. The Upper Paleolithic sites are rare, while the Epipaleolithic sites are quite numerous in the region. After the Last Glacial Maximum, milder conditions of the Late Glacial promoted an increase in the number of sites and mobility of the Epipaleolithic human groups. A high mobility is confirmed by the facts that similar Epipaleolithic industries are found in the Southern and Northern Caucasus and that the same obsidian sources were exploited in both regions. Results of recent studies indicate that the most crucial factors for hominin settlement during the entire Upper Pleistocene in the northwestern Caucasus were favorable climatic and environmental conditions.

In comparison to other regions, including the Levant, the Caucasus' archaeological record shows distinct regional peculiarities and a specific pathway of Upper Paleolithic development, which we identify as the "Caucasus Upper Paleolithic". In support of this view, the results of two recent palaeogenomic analyses of two human individuals from the Southern Caucasus indicate that the first modern humans in the Caucasus shared ancestry with Upper Paleolithic humans of Western Asia, and that the first Upper Paleolithic modern humans in the Caucasus belonged to a distinct ancient clade, which split from the European Upper Paleolithic populations about 45 ka ago, shortly after the expansion of modern humans into Europe.

This special issue is guest-edited by William Davies (Centre for the Archaeology of Human Origins, University of Southampton) and Philip R. Nigst (Department of Prehistoric and Historical Archaeology, University of Vienna).

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INTRODUCTION

A growing scope of scientific data indicates that cultural development of Neanderthal and anatomically modern human (AMH) groups was driven by major environmental changes (Banks et al. 2013; Bar-Yosef 2017; Berger and Guilaine 2009; Borrell et al. 2015; Dennell et al. 2011; Eren 2012; Moore and Hillman 1992; Premo and Kuhn 2010; Riede 2009; Torfstein et al. 2013; Weninger et al. 2009; Ziegler et al. 2013). The results obtained during the last 20 years provide more detail and abundant data for correlation between dynamics of environmental cycles and changes in the Middle Paleolithic (MP) and Upper Paleolithic (UP) industries, as well as suggest the larger environmental impact on movements of the Neanderthal and AMH groups and changes in their survival strategies. Especially during the coldest periods of environmental stress, such as the Campanian Ignimbrite (CI) eruption at about 40 ka and the Last Glacial Maximum (LGM) between approximately 25–20 ka, various studies suggest a substantial restructuring of natural environments, which likely affected human ecology and habitation areas (e.g., Banks et al. 2009; 2011; Black et al. 2015; Soffer and Fedele et al. 2008; Gamble 1990; Giaccio et al. 2017; Golovanova et al. 2010b).

The most significant periods of environmental stress during the Late Pleistocene are currently defined as Heinrich events (H), which are characterized by abrupt climate transitions towards cold climate (e.g., Clark et al. 2012; Seierstad et al. 2014). Some of the environmental stress periods correspond to well-defined periods of global cooling of the climate and establishment of glacial conditions over vast territories, such as the LGM (Clark et al. 2009).

The northwestern Caucasus (NWC) contains a rich archaeological record of MP Neanderthal and UP AMH occupation (Golovanova 2015; Golovanova and Doronichev 2003, 2012, 2017; Golovanova et al. 2014; 2017), and research in this region has implications for general issues of Eurasian prehistory (Bar-Yosef et al. 2006; Fu et al. 2016; Green et al. 2010; Golovanova and Doronichev 2012; Golovanova et al. 2010b, 2014; Gunz et al. 2012; Hajdinjak et al. 2018; Jones et al. 2015; Ponce de Leon et al. 2008; Weaver et al. 2016). In some multilayered Paleolithic sites in the NWC, breaks in human occupation during periods of climatic stress or marked changes in material culture after these periods are revealed. In the NWC, six major periods of environmental stress—characterized by abrupt climate change to cold Heinrich events—can be defined at present during the MP and UP (Table 1):

- Early Glacial Maximum (EGM), which corresponds to Marine Isotope Stage (MIS) 4 in the interval from approximately 70 to 59 thousand years ago (ka), including the H6 event;
- H5 event approximately 48–47 ka;
- H4 event approximately 40–38 ka, whose onset at 39.9 ka coincides with the CI super-eruption in Italy (Giaccio et al. 20017)—the largest volcanic eruption during the last 200,000 years;
- H3 event approximately 33–32.5 ka;
- Last Glacial Maximum between 26.5–19 ka, according to Clark et al. (2009), including the peaks of the H2 and H1 events; and,
- Younger Dryas or H0 event between 12.6–11.7 ka (Clark et al. 2012), which marks the end of the Pleistocene.

In the NWC, the impact that environmental stress stages had on populations and ecological niches of MP Neanderthals and UP modern humans is not well studied, and environmental information about many chronological periods is lacking. The research conducted in multilayered Mezmaiskaya cave, containing the richest records of MP and UP occupation, and other Paleolithic sites in the NWC, summarized in this paper, allows us to define environmental stress periods as the ones associated with abrupt climatic changes towards cold climate that caused either breaks in human occupation during these periods or marked changes in material culture that followed these periods. Below we present a summary of the data, which we have collected to date regarding the issue, focusing on environmental and climatic impacts on Neanderthal and modern human occupations and landscape use, and changes in material culture in the NWC region.

MIDDLE PALEOLITHIC

Almost all MP sites known at present in the NWC (Kuban River basin) represent a local variant of Eastern Micoquian industry, which was produced by Neanderthals (Golovanova 2015; Golovanova and Doronichev 2003, 2005, 2017; Golovanova et al. 2017; Figure 1A). In the region, there are known at present 12 sites that produced in total about 30 occupational layers with Eastern Micoquian assemblages. The Eastern Micoquian sites are spread from low foothills (Ilskaya-1 and Ilskaya-2, about 100masl) throughout middle mountain plateaus with elevations up to 1300–1500masl (Mezmaiskaya and Baranakha-4), as well as from the lower basin of the Kuban River through nearly the central part of the Northern Caucasus.

The MP sequence at Mezmaiskaya cave includes 7 layers and represents currently the most complete and longest succession of Eastern Micoquian in the region, demonstrating a local development of this cultural tradition from its early stage throughout the end of MP in the NWC. In Mezmaiskaya cave, the most robust series of radiometric (radiocarbon and ESR) dates for the regional Eastern Micoquian was obtained (Skinner et al. 2005; Pinhasi et al. 2011), which provided a background for assessing the chronological position of other, undated or poorly dated Eastern Micoquian sites in the region. Based on the MP sequence of Mezmaiskaya cave, it has become possible to link the regional Mousterian assemblages into one developmental lineage of a local Micoquian tradition and identify temporal trends and changes in the regional Micoquian industry during a long period of time from late MIS 5 throughout MIS 3, between ~90 and 40 ka ago (Golovanova 2015; Golovanova and Doronichev 2003, 2005, 2017; Golovanova et al. 1998, 1999, 2010b, 2017; see Table 1). Mezmaiskaya cave is also widely known as an MP site, in which two DNA analysed Neanderthal fossils, including an almost complete Neanderthal newborn skeleton, were found (Briggs et al. 2009;

Gunz et al. 2012; Hajdinjak et al. 2018; Ponce de Leon et al. 2008; Weaver et al. 2016). Based on the results of radiometric dating, palynological, and geoarchaeological studies in Mezmaiskaya cave, we can identify now three major stages of the Eastern Micoquian Neanderthal occupation of the NWC, which are separated by pronounced cold stages that we identify as periods of environmental stress (see Table 1):

- The first stage corresponds to the interval from late MIS 5 through the end of MIS 4, between about 90 to 60 ka. The earliest (in the region) Eastern Micoquian occupations are known from the lower MP levels (Layers 3, 2B4, and 2B3) at Mezmaiskaya cave, and in the lower layers at Ilskay-1 and Ilskay-2. Apparently, the Mousterian levels with evidence of a cold climate, such as Layer 3 at Barakaevkaya cave (Golovanova 2015) and Layers 6 and 7 at Khadjokh 2 (Hadjoh-2; Doronicheva et al. 2018) may also date to this stage. Additionally, an early MP industry with bifacial leaf points was found in Layer 2 at Sredniy Khadjokh (Hadjoh), which was dated preliminarily to MIS 5a-5b based on an IR-OSL date of 87.8±6.8 ka (Doronichev et al. 2018). According to multidisciplinary research at Mezmaiskaya cave (Baryshnikov et al. 1996; Golovanova and Doronichev 2003, 2017; Golovanova et al. 1998; 1999; Nesmeyanov

TABLE 1. CORRELATION OF ENVIRONMENTAL AND CLIMATE DATA FOR ARCHAEOLOGICAL PHASES CORRESPONDING TO MAIN CULTURE-CHRONOLOGICAL PERIODS OF MP AND UP OCCUPATION IN THE NWC.*

Greenland ice-core events, climatic phases, and their chronology	Archaeological phases in the NWC and their chronology	Archaeological assemblages in the NWC and their chronology
Start of Holocene 11.7		
GS-1 12.9–11.7 (**H0**) Younger Dryas (12.9–11.7 ka cal BP)	Epipaleolithic (~20–11 ka cal BP)	**Dvoinaya cave** Layers 5–6: 12.4–11.3 ka cal BP **Kasojskaya cave** Layer 4, Hor. 1: 12.6–11.6 ka cal BP **Mezmaiskaya cave** Layer 1-3 (Hor. 1): 12.5–12 ka cal BP **Gubs 5 (Chygai) rockshelter** Layers 5–8: 12.6–12 ka cal BP
GI-1a–GI-1e 14.7–12.9 Bølling-Allerød (14.7–12.9 ka cal BP)		**Kasojskaya cave** Layer 4, Hor. 4: 13.1–12.8 ka cal BP **Gubs 7 (Satanai) rockshelter** Hor. 3, 4: 13.3–12.9 ka cal BP **Dvoinaya cave** Layer 7: 14–13.5 ka cal BP
GS-2.1a 17.5–14.7 Oldest Dryas (17.5–14.7 ka cal BP) GS-2.1b (late phase) 19.7–17.5		**Mezmaiskaya cave** Layer 1-3 (Hor. 3-9**)**: 17.3–15.3 ka cal BP **Besleneevskaya site** Layer 2B: 16.7–15.3 ka cal BP **Gubs 5 (Chygai) rockshelter** Layer 9: 16.5–15 ka cal BP **Kasojskaya cave** Layer 4, Hor. 5: 17.5–17.1 ka cal BP **Mezmaiskaya cave** Layer 1-4: 19.7–19.1 ka cal BP
GS-2.1b (early phase) 20.9–19.7 (**H1**) GS-2.2–GS-2.1c 23.2–20.9 GI-2.2 23.3–23.2 Last Glacial Maximum GS-3 (late phase) 24.5–23.3 (**H2**) (26.5–19.0 ka cal BP)	no evidence of human occupation	
GS-3 (early phase) 27.5–24.5 GI-3 27.8–27.5 GS-5.2–GS-4 32.0–27.8 GI-5.2 32.5–32.0	Late Upper Paleolithic (~30–20 ka cal BP)	**Mezmaiskaya cave** Layer 1A-1: 25-24.5 ka cal BP; **Mezmaiskaya cave** Layer 1A-2: 28-27.5 ka cal BP **Korotkaya cave** Layer 2, Hor. 2: 30-29 ka cal BP **Mezmaiskaya cave** Layer 1B: 32-28 ka cal BP
GS-6 33.4–32.5 (**H3**)	Early Upper Paleolithic (~40–30 ka cal BP)	**Mezmaiskaya cave** Layer 1C top: 33-32 ka cal BP
GI-8c–GI-6 38.2–33.4		**Korotkaya cave** Layer 2, Hor. 8: 38-35 ka cal BP
GS-9 39.9–38.2 (**H4**)		**Mezmaiskaya cave** Layer 1C base: 39-36 ka cal BP
GI-11–GI-9 43.3–39.9 GS-12 44.3–43.3 GI-12a-c 46.9–44.3	Final Middle Paleolithic (~50–40 ka)	**Mezmaiskaya cave** Layer 2: 44.6–43 ka cal BP direct date for Mez2 Neanderthal individual **Mezmaiskaya cave** Layer 2: 48–40 ka cal BP **Mezmaiskaya cave** Layer 2A: 46.5–44 ka cal BP
GS-13 48.3–46.9 (**H5**)	Late Middle Paleolithic (~60–50 ka)	**Ilskaya-1 site** upper layer: 47±2 ka (U-series)
GI-13a-c – GI-14a-e 54.2–48.3		
GS-16.1–GS-15.1 56.5–54.2		
GI-17.2–GI-16.1a 59.4–56.5		

TABLE 1. CORRELATION OF ENVIRONMENTAL AND CLIMATE DATA FOR ARCHAEOLOGICAL PHASES CORRESPONDING TO MAIN CULTURE-CHRONOLOGICAL PERIODS OF MP AND UP OCCUPATION IN THE NWC (continued).*

Greenland ice-core events, climatic phases, and their chronology	Archaeological phases in the NWC and their chronology	Archaeological assemblages in the NWC and their chronology
GS-18 63.8–59.4 (**H6**) Early Glacial Maximum GI-18 64.1–63.8 MIS 4 (~70–59 ka) GS-19.2–GS-19.1 70.4–64.1		**Mezmaiskaya cave** Layer 2B3: 56.5±4.2 ka (mean ESR/LU) **Mezmaiskaya cave** L. 2B4 (H.2): 59.0±4.9 ka (mean ESR/LU)
GI-19.2 72.3–70.4 GS-20 74.1–72.3 (**H7a**) GI-20a-c 76.4–74.1 GS-21.1 77.8–76.4 (**H7b**) MIS 5a (~85–70 ka) GI-21.2–GI-21.1a 85.1–77.8	Early Middle Paleolithic (~90–60 ka)	**Mezmaiskaya cave** L. 2B4 (h.3)**:** 70.6±7.4 ka (mean ESR/LU) **Mezmaiskaya cave** Layer 3: 67.6±5.4 ka (mean ESR/LU)
GS-22 87.6–85.1 (**H8**) MIS 5b (~88–85 ka)		**Sredniy Khadjokh site** Layer 2: 87.8±6.8 ka (IR-OSL)
GI-23.1–GI-22a 104.0–87.6 MIS 5c (~108–88 ka) GS-24.1–GS-23.2 105.4–104.0 GI−24.2–GI−24.1a 108.3–105.4		**Mezmaiskaya cave** Layer 3 base: genetic age ~89 ka for Mez1 Neanderthal individual

The timing and duration of Greenland ice-core events, Greenland stadials (GS), and Greenland interstadials (GI), as defined by Rasmussen et al. (2014: Table 2, Figure 1). Correlation between the Greenland ice-core sequence and Heinrich events (H0-H6; in bold) following Clark et al. (2012: Figure 2) and Seierstad et al. (2014: Figure 8). Chronology of Marine Isotope Stage (MIS) 4, 5a, 5b, and 5c, according to Railsback et al. (2015: Figure 3). Chronology of the Last Glacial Maximum (LGM) and stages of the Late Glacial period, Oldest Dryas, Bølling-Allerød, and Younger Dryas, according to Clark et al. (2009; 2012).

*Based on non-radiocarbon dates, thousand years ago (ka) for the MP, and calibrated radiocarbon dates, thousand calibrated years ago (ka cal BP), for UP; the cold climatic phases that correspond to the periods of environmental stress dividing the archaeological phases are highlighted. For references see citations in the text).

1999), a relatively mild climate existed during Layers 3 and 2B4. Rodents typical of woods and sub-alpine meadows were found in both layers. In layer 2B4, grasses and bushes predominate, while arboreal flora is rare. Pollen spectra indicate cool and dry climatic conditions, lowering the tree line, and the spread of subalpine meadows in layer 2B3. In this layer, we also identified the highest concentrations of toxic elements (see below).

- The second stage spans the interval between the H6 and H5 events, from about 60 to 50 ka ago. In Mezmaiskaya cave, the MP Layers 2B2 and 2B1 are dated to this period. The upper layer of Ilskaya 1 also has a date corresponding to this period (Golovanova 2015). In Layer 2B2, a warmer and dry climate, the spread of forest-steppe vegetation, and conditions of the upper boundary of the forest zone have been defined. Apparently, Layer 4 at Monasheskaya cave, which lacks dates, can be also dated to this stage. In Layer 2B1, dating to H5, a volcanic ash was identified. The paleoenvironmental and archaeological data indicate that this volcanic eruption resulted in significant deterioration of climate and the establishment of a cold and humid subalpine climatic condition in the vicinity of Mezmaiskaya cave, and Neanderthal occupation of the cave fell to its lowest intensity during this period.
- The third and final stage is represented by Layers 2 and 2A at Mezmaiskaya cave, Layers 2-3B at Monasheskaya cave, MP layers in Gubs rockshelter 1, upper MP layers at Khadjokh 2, Layers 3 and 4 at Besleneevskaya, and MP Layer 2-3 at Baranakha 4. The majority of Eastern Micoquian sites in the NWC are currently dated to this stage (Golovanova 2015). During this stage, the pollen record indicates a warmer and wetter climate, which, however, remained quite cool and dry, and the spread of subalpine meadows in the uppermost MP Layers 2A and 2 at Mezmaiskaya. This final stage of the Eastern Micoquian industry in the NWC coincides with Greenland interstadials GI-12c–GI-9, between ca. 47 and 40 ka ago, and the Eastern Micoquian Neanderthal occupation of this region ends with the onset of the cold H4 event and the CI eruption, which are dated at 39.9 ka ago by combined high-precision radiocarbon and $^{40}Ar/^{39}Ar$ dating results (Giaccio et al. 2017).

The presence of diverse bifacial tools is the main feature that distinguishes the Eastern Micoquian from other MP industries in the Caucasus. In the early Micoquian levels (Layers 3 and 2B-4) at Mezmaiskaya cave, these bifacial tools include small broad triangular handaxes (Figure 2: 3, 4), laurel-leaf-like projectile points (Figure 2: 1), various bifacial and partly bifacial scraper-knives (Figure 2: 5–9) and convergent tools (Figure 2: 2). The bifacial and partly bifacial scraper-knives from Mezmaiskaya cave have analogs in other Eastern Micoquian assemblages across Central and

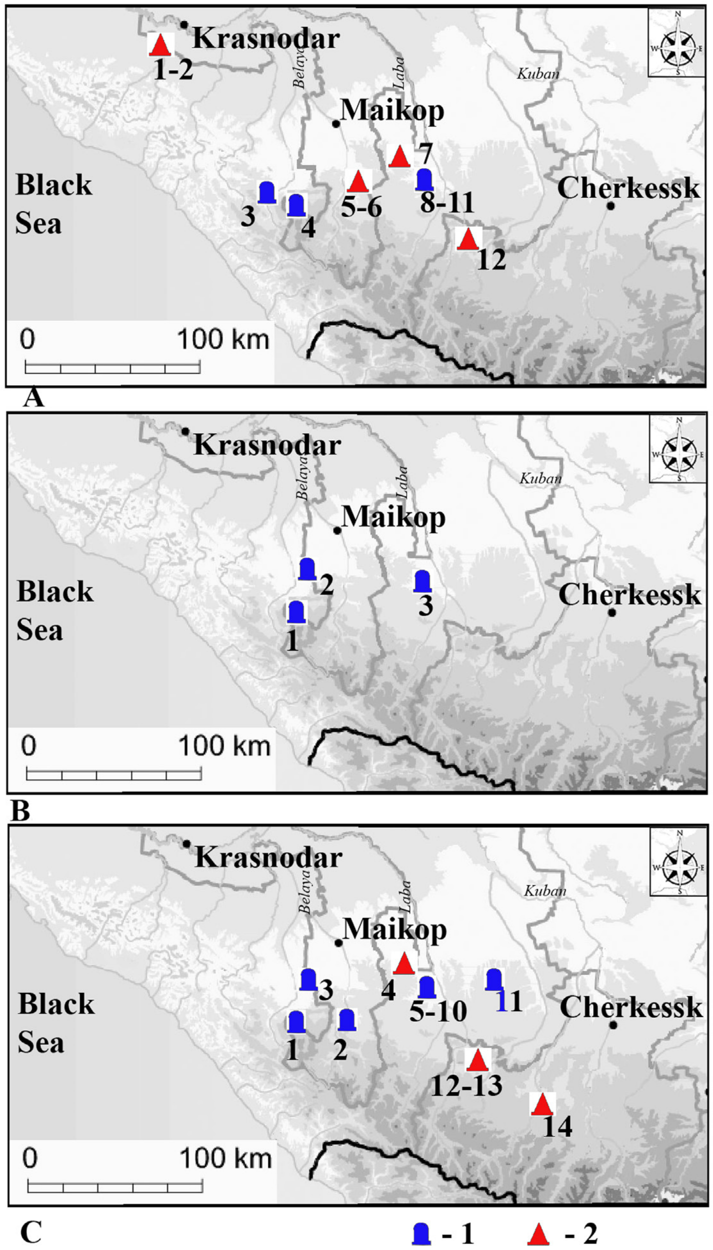

Figure 1. Legend: 1 – cave sites, 2 – open air sites. A) Map showing location of MP/Eastern Micoquian sites in the NWC: 1, 2) Ilskaya-1 and Ilskaya-2; 3) Matuzka Cave; 4) Mezmaiskaya Cave; 5, 6) Credniy Khadjoh, Layer 2, Khadjoh-2; 7) Besleneevskaya; 8–11) Monasheskaya and Barakaevskaya caves, Gubs Rockshelter-1, MP Layers 5–7, and Autlevskaya Cave; 12) Baranaha-4. B) *Map showing location of EUP and LUP sites in the NWC: 1) Mezmaiskaya cave, Layers 1C–1A1; 2) Korotkaya Cave; 3) Gubs Rockshelter-1, lower UP Layer 2. C) Map showing the location of Epipaleolithic sites in the NWC: 1) Mezmaiskaya Cave, Layer 1-3; 2) Dahovskaya-2 Cave; 3) Korotkaya-2 Cave; 4) Besleneevskaya; 5–10) Gubs Rockshelter 1 EP layer, Satanay (Gubs Rockshelter 7) Horizons 3, 4, Kasojskaya Cave, Chigay Rockshelter Layer 9, Dvoinaya Cave, Ruslanova Cave; 11) Il'ichevskaya Cave; 12, 13) Baranaha 4 Layer 1A, Baranakha 1; 14) Yavora.*

Eastern Europe (Golovanova et al. 2017). A characteristic feature of the early Micoquian industry is also the presence of numerous bone artifacts (Figure 3).

Throughout the Eastern Micoquian occupation of the NWC, this industry shows a quite clear development, with a decrease in bifacial tools from the earlier to later sites (Figure 4). In flaking technology, the Eastern Micoquian industry shows some increase in laminar products and a number of tools made on blades in the later Micoquian levels at Mezmaiskaya cave (Figure 5). These trends of a decrease in bifacial tools and a higher laminarity are particularly expressed in the final stage, after stadial H5, of the Eastern Micoquian industry in the NWC. The later Micoquian levels at Mezmaiskaya cave differ not only in having a lower percentage of bifacial tools but also a lower variety (see Golovanova 2015; Golovanova et al. 2017; see Figures

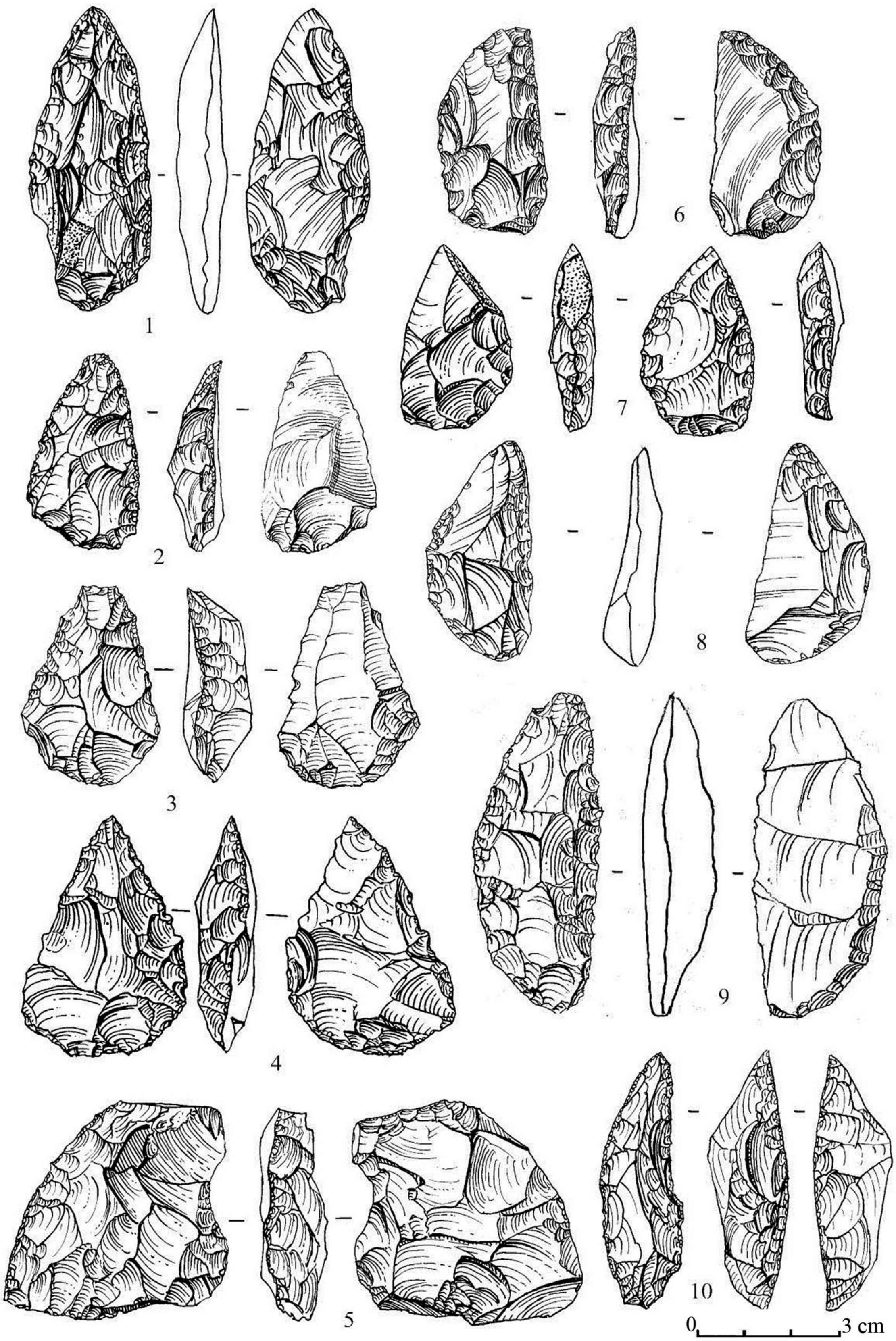

Figure 2. Bifacial and partial bifacial scraper-knives from the early Micoquian Layers 3 and 2B4 at Mezmaiskaya Cave. 1) laurel-leaf-like projectile point; 2) convergent tool; 3, 4) small broad triangular handaxes; 5–9) bifacial and partly bifacial scraper-knives; 10) limace.

Figure 3. Bone artifacts from the early Micoquian Layers 3 and 2B4 at Mezmaiskaya Cave. 1) bone point; 2–3) bone retouchers; 4–5) bone flakes; 6–7) bone scrapers; 8) modified bone retoucher.

2, 4; Figure 6).

One of approaches allowing reconstruction of paleoecological conditions is a chemical analysis of mineral elements in deposits and bones, using the X-ray fluorescence (XRF) method (see Aleksandrovskaya and Aleksandrovskiy 2003). For the first time in the Caucasus, this study has been conducted at Mezmaiskaya Cave (Aleksandrovskiy et al. 2015). We analyzed 6 bone fragments of the Mez 1 Neanderthal infant from the earliest MP Layer 3 (70–60 ka) and a skull fragment of the Mez 2 Neanderthal child (1–2

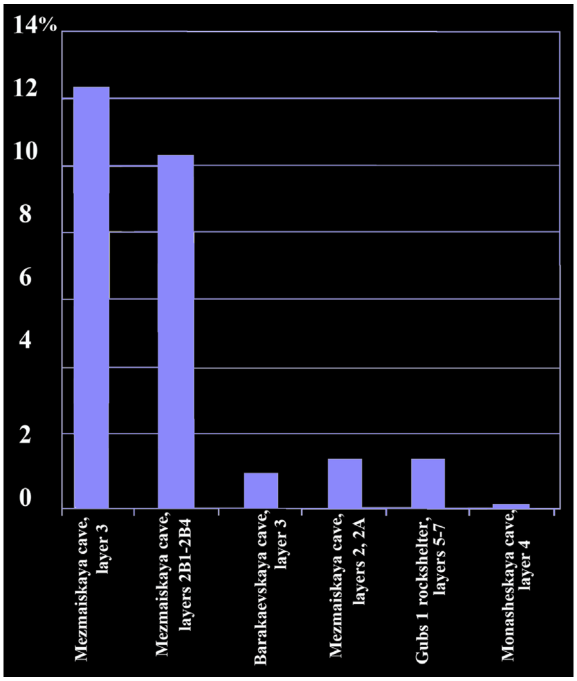

Figure 4. Graph showing decrease of the Biface Index (the ratio of bifacial and partial bifacial tools to the total tools, in percent) from the earlier to the later Eastern Micoquian assemblages in the Northwestern Caucasus.

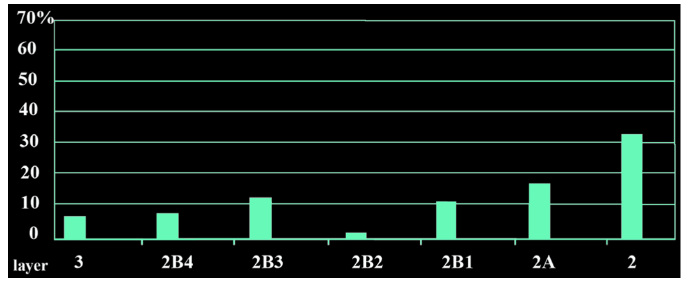

Figure 5. Graph showing increase of the percentage of laminar products and tools made on blades from the earlier to the later Eastern Micoquian layers at Mezmaiskaya cave (1987–1995, 2001, 2003, and 2005 excavations).

years old) from the latest MP Layer 2 (40–42 ka) (Figure 7), as well as sediment samples, and bone samples of ungulates and some predators from all MP layers. In total, 29 specimens were examined. We documented that the Mez 1 Neanderthal newborn from Layer 3 shows low concentrations of harmful elements, while the Mez 2 specimen from Layer 2 shows a very high concentration of manganese, as well as toxic chemical elements such as copper, zinc, and nickel (Table 2). The increase of manganese content in the older Neanderthal child may be related to typical conditions of living near fire in caves, while a high concentration of toxic chemical elements may have another explanation (see below).

Our study also indicated that the highest concentrations of toxic elements in bulk sediment samples were found in Layers 2B-3, 2B-1, and 1D. Two of these layers (2B-1 and 1D) also contained volcanic ash and formed during periods of ecological stress caused by regional volcanic eruptions. All three layers have increased concentrations of toxic chemical elements such as potassium, copper, zinc, arsenic, and lead. These results suggest that volcanic activity, which was recorded in Layer 2B-1, may have resulted in increased concentration of toxic elements in bones of late Neanderthals, as it is indicated by the study of the Mez 2 specimen (see Table 2). In comparison to Layer 3, Mez 2 (Figure 8-1), animal bones (Figure 8-2), and a sediment sample (Figure 8-3) from Layer 2 indicate a more unfavorable chemical environment at the end of the late Neanderthal occupation of Mezmayskaya cave. The increased concentration of toxic elements in bones of late Neanderthals could adversely affect Neanderthal health.

In addition, a recent genetic analysis (Hajdinjak et al. 2018) indicates that the Mez 2 specimen from the uppermost MP Layer 2 at Mezmaiskaya is more similar to other late Neanderthals in Europe than to the older Mez 1 specimen. This suggests that there was a population turnover, either in the Caucasus or throughout Europe, towards the end of Neanderthal history. This turnover may have been the result of a population related to western Neanderthals replacing earlier Neanderthals in the Caucasus, or the replacement of Neanderthals in western Europe by a population related to Mezmaiskaya 2. The timing of this turnover coincides with pronounced climatic fluctuations during MIS 3. Also, our new data (reported here) indicate that a volcanic eruption during the period of Layer 2B-1 and cold and humid subalpine climatic conditions separate the earlier Neanderthals from Layer 3 and the later Neanderthals from Layer 2 at Mezmaiskaya.

In Mezmaiskaya Cave, we conducted multidisciplinary research (Golovanova et al. 2010b) which indicated that the disappearance of Neanderthals in the NWC is marked by a regional volcanic eruption—in a sterile Layer 1D lying between the MP and UP levels—the age of which likely coincides with the CI super-eruption at about 40 ka ago. Golovanova et al. (2010b) suggested that the coeval volcanic eruptions (from a large CI eruption in Italy to a smaller-scale regional eruption in the Caucasus) forced the fast and extreme climate deterioration (a so-called "volcanic winter" using the term of Fedele et al. 2008) of the Northern Hemisphere at the beginning of the H4 event and this had an unusually sudden and devastating effect on the ecology of late Neanderthal populations. Given the data from Mezmaiskaya cave and supporting evidence from other sites in Europe, we offered hypothesis that the Neanderthal lineage truncated abruptly after the CI eruption in most of its range and that the MP to UP transition in western Eurasia was the result of this volcanogenic cataclysm.

Evidence of volcanic activity and ash deposition in deposits lying on the border between the Late Middle Paleolithic (LMP) to Upper Paleolithic was revealed by XRD analyses not only in Mezmaiskaya cave, but also more recently in two other sites in the NWC, the open-air sites of

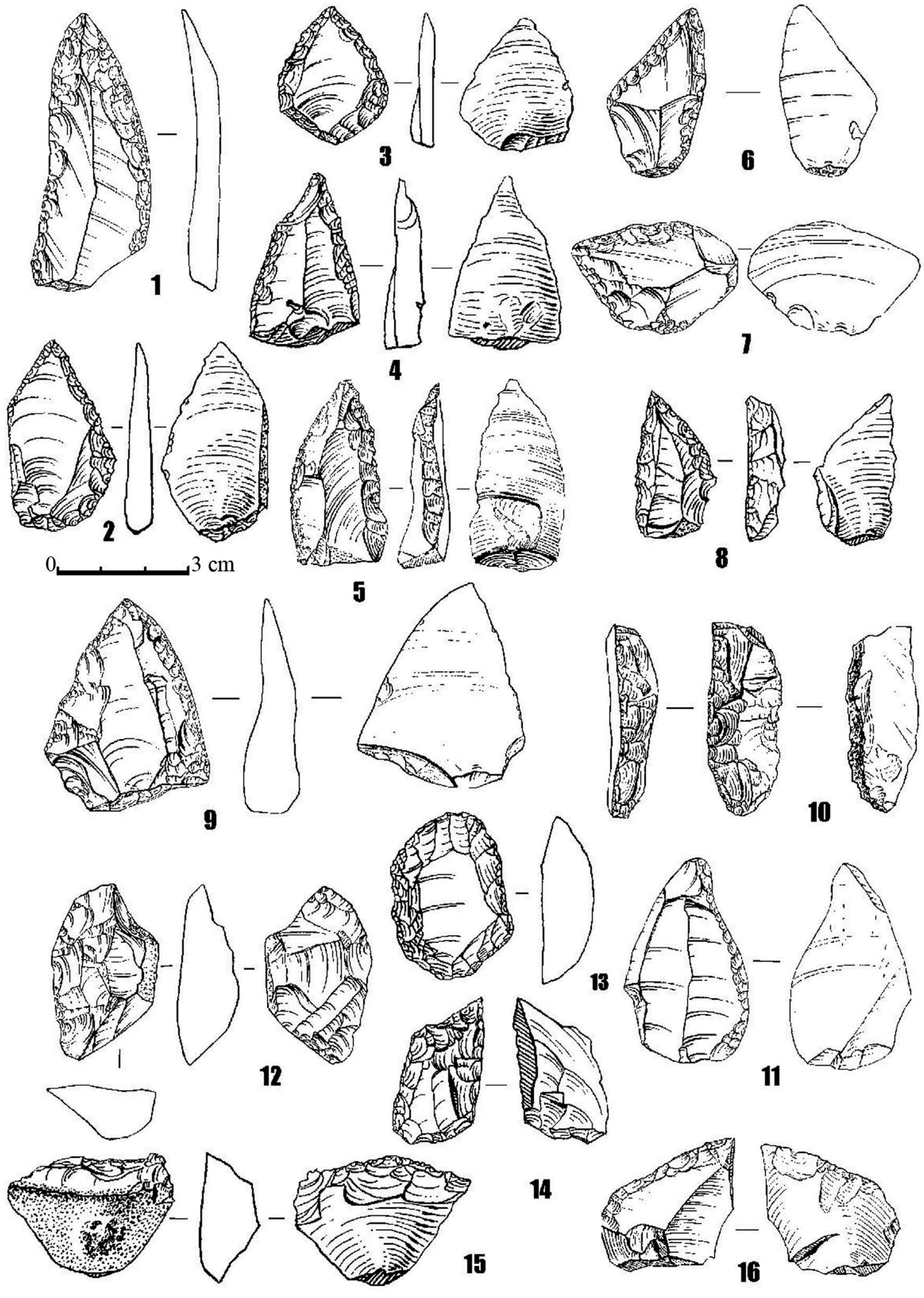

Figure 6. Unifacial and partial bifacial tools from the late Micoquian Layers 2 and 2A at Mezmaiskaya Cave. 1–5, 9) convergent tools; 6–8) angled (déjéte) scrapers; 10, 11) simple side-scrapers; 12) bifacial scraper; 13) end-scraper; 14) scraper with ventral retouch; 15) bifacial transversal scraper; 16) diagonal scraper.

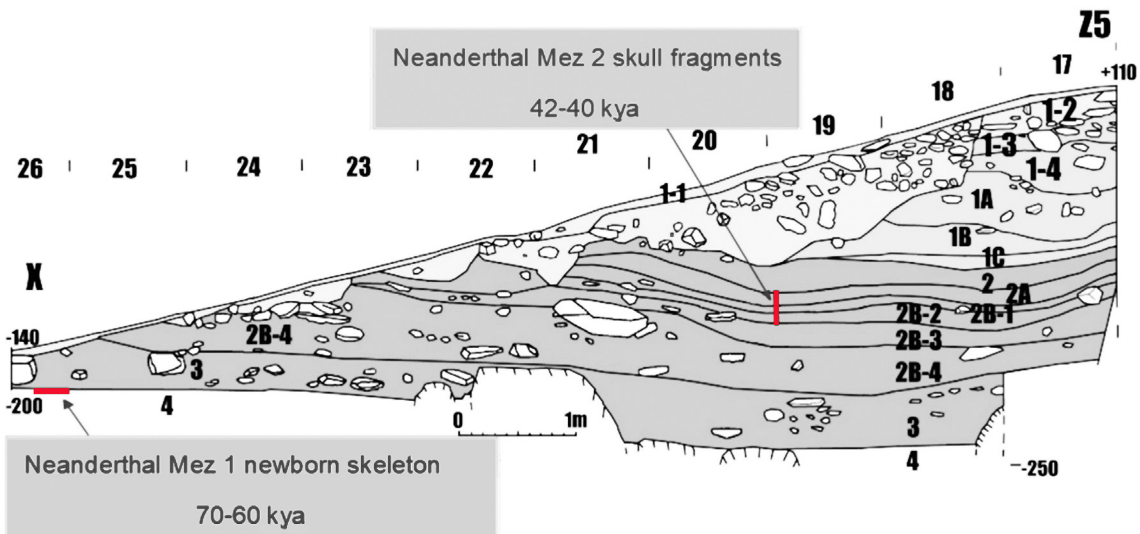

Figure 7. Stratigraphic position of Mez 1 and Mez 2 Neanderthal fossils at Mezmaiskaya cave. The sequence of MP Eastern Micoquian layers is colored in dark-gray; the sequence of Upper Palaeolithic layers is colored in gray. Modern erosional layers are colored in light-gray.

TABLE 2. RESULTS OF XRF ANALYSIS OF CHEMICAL COMPOSITION OF MEZ 1 (M1) and MEZ 2 (M2) NEANDERTHAL FOSSILS, ANIMAL BONES, AND SEDIMENT SAMPLES FROM MP LAYERS IN MEZMAISKAYA CAVE (method and protocol following Aleksandrovskaya and Aleksandrovskiy [2003]).

Samples	Kali (K)	Calcium (Ca)	Manganese (Mn)	Ferric (Fe)	Nickel (Ni)	Copper (Cu)	Zinc (Zn)	Brome (Br)	Rubidium (Rb)	Strontium (Sr)	Yttrium (Y)	Zirconium (Zr)
Neanderthal fossils (mg/100g)												
Average values in bones of living humans*	1.7	1.5	10.0	1.5	0.7	1.8	14.0	0.7	2.5	8.5	0.7	0.01
Mezmaiskaya M2 Neanderthal skull fragment; Layer 2	n/i	n/i	35.0	1.2	4.0	3.0	54.0	0.7	n/i	4.0	n/i	n/i
Mezmaiskaya 75, M1 Neanderthal rib; Layer 3	1.3	87.1	8.1	5.0	0.0	0.9	5.1	0.3	0.1	1.7	0.1	0.01
Mezmaiskaya 76, M1 Neanderthal longbone; Layer 3	0.6	85.5	6.9	6.5	0.0	0.3	4.2	0.1	0.1	2.4	0.4	0.06
Mezmaiskaya 77, M1 Neanderthal longbone; Layer 3	0.7	95.2	9.5	1.6	0.0	0.3	4.1	0.1	0.1	1.9	0.3	0.03
Mezmaiskaya 73, M1 Neanderthal vertebra; Layer 3	0.6	96.7	0.0	1.4	0.0	0.3	3.5	0.1	0.1	1.4	0.2	0.01
Mezmaiskaya 74, M1 Neanderthal vertebra; Layer 3	0.8	94.1	1.2	2.3	0.0	0.4	3.7	0.2	0.1	1.7	0.0	0.01
Mezmaiskaya 72, M1 Neanderthal tooth; Layer 3	0.8	94.8	4.0	1.7	0.0	0.3	2.8	0.1	0.2	1.3	0.4	0.03

TABLE 2. RESULTS OF XRF ANALYSIS OF CHEMICAL COMPOSITION OF MEZ 1 (M1) and MEZ 2 (M2) NEANDERTHAL FOSSILS, ANIMAL BONES, AND SEDIMENT SAMPLES FROM MP LAYERS IN MEZMAISKAYA CAVE (continued)
(method and protocol following Aleksandrovskaya and Aleksandrovskiy [2003]).

Samples	Kali (K)	Calcium (Ca)	Manganese (Mn)	Ferric (Fe)	Nickel (Ni)	Copper (Cu)	Zinc (Zn)	Brome (Br)	Rubidium (Rb)	Strontium (Sr)	Yttrium (Y)	Zirconium (Zr)
Animal fossilised bones (mg/100g)												
Average values in bones of living animals*	1.7	1.5	10.0	1.5	0.7	1.8	14.0	0.7	2.5	8.5	0.7	0.01
Mezmaiskaya 82; Layer 2	0.2	86.0	2.3	11.4	0.0	0.0	4.6	n/i	0.0	0.4	0.2	0.04
Mezmaiskaya 83; Layer 2	2.9	65.7	13.0	15.9	0.6	0.0	7.0	n/i	0.0	0.2	0.1	0.03
Mezmaiskaya 84; Layer 2	0.2	96.6	1.5	1.0	0.0	0.0	4.3	n/i	0.0	0.2	0.3	0.02
Mezmaiskaya 9; Layer 2A	3.0	76.1	2.4	16.7	0.0	0.0	0.5	n/i	0.0	0.3	0.2	0.02
Mezmaiskaya 5; Layer 2B2	1.8	79.6	14.0	14.9	0.0	0.1	6.0	0.0	0.2	0.3	0.2	0.04
Mezmaiskaya 10; Layer 2B3	2.3	77.6	19.9	15.3	0.0	0.0	8.3	0.0	0.2	0.3	0.2	0.03
Mezmaiskaya 19; Layer 2B3	1.0	88.4	10.7	8.8	0.0	0.0	4.7	0.0	0.1	0.3	0.2	0.01
Mezmaiskaya 20; Layer 2B3	1.5	85.4	6.1	11.1	0.0	0.0	3.8	0.0	0.1	0.3	0.1	0.01
Mezmaiskaya 24; Layer 2B4	0.5	91.5	21.6	5.1	0.0	0.0	4.6	0.0	0.1	0.3	0.1	0.02
Mezmaiskaya 40; Layer 2B4	0.4	92.0	19.9	4.5	0.0	0.0	8.5	0.0	0.1	0.2	0.2	0.02
Mezmaiskaya 78; Layer 3	0.2	98.5	0.1	1.0	0.0	0.0	0.7	n/i	0.0	0.2	0.1	0.01
Mezmaiskaya 79; Layer 3	0.5	94.9	2.3	3.5	0.0	0.0	4.4	n/i	0.0	0.3	0.3	0.02
Mezmaiskaya 80; Layer 3	0.4	98.4	0.1	0.9	0.0	0.0	1.3	n/i	0.0	0.1	0.1	0.01
Mezmaiskaya 81; Layer 3	0.8	91.3	4.6	6.2	0.0	0.0	9.9	n/i	0.0	0.2	0.2	0.02
Sediment samples (mg/1kg)												
Mezmaiskaya, Layer 1D (with volcanic ash)	3.1	17.7	70	7.7	10	40	100	n/i	10	20	n/i	20
Mezmaiskaya, Layer 2	2.8	19.5	140	6.6	10	30	90	n/i	n/i	20	n/i	20
Mezmaiskaya, Layer 2A	2.8	19.2	480	9.9	40	80	70	n/i	10	10	n/i	30
Mezmaiskaya, Layer 2B1 (with volcanic ash)	3.1	9.8	70	7.3	n/i	20	30	n/i	10	10	n/i	40
Mezmaiskaya, Layer 2B3	2.6	28.0	200	7.7	n/i	30	80	n/i	10	20	n/i	40
Mezmaiskaya, Layer 2B4	2.9	22.1	80	8.0	n/i	30	80	n/i	10	10	n/i	30
Mezmaiskaya, Layer 3	2.0	29.7	100	4.4	n/i	20	90	n/i	n/i	20	n/i	170
Mezmaiskaya, Layer 3	1.7	45.5	230	5.2	n/i	30	160	n/i	n/i	30	n/i	n/i

Notes: n/i, not identified; increased values of chemical elements are highlighted: in blue = the highest values among sediment samples; in yellow = increased values among animal bone samples relative to average values for living animals; in pink = increased values among Neanderthal samples relative to average values for living humans; see discussion in the text.
*Reference: Aleksandrovskaya and Aleksandrovskiy (2003).

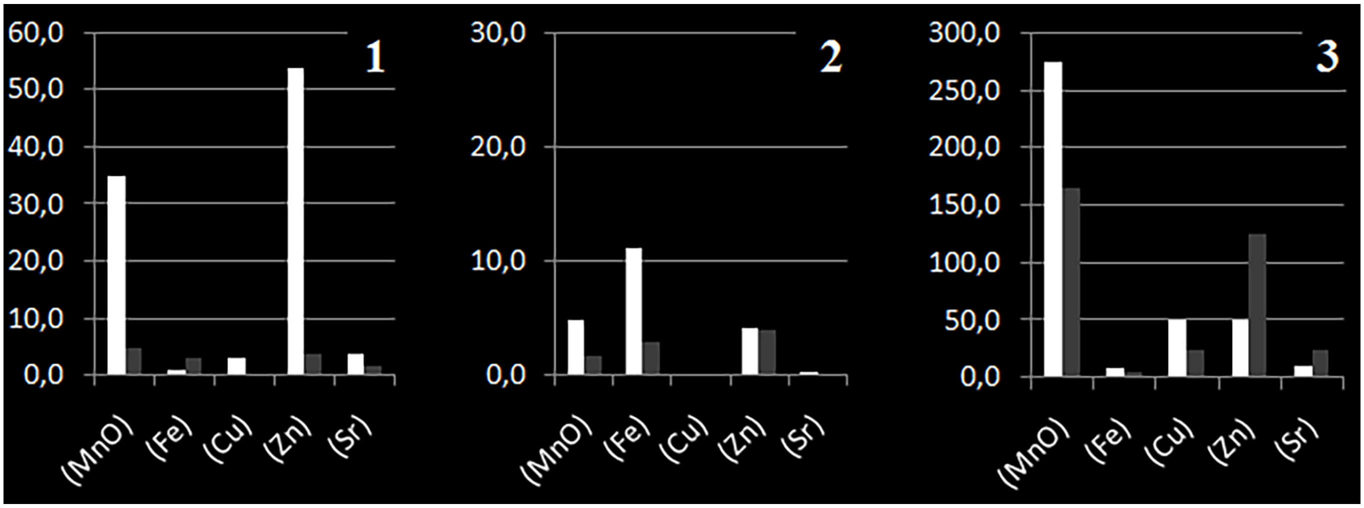

Figure 8. A comparison of chemical elements composition between Layer 2 and Layer 3 in Mezmaiskaya cave. Colors: white = Layer 2, gray = Layer 3. The vertical axes show percentage of the chemical element, indicated in Table 2. 1) Mez 1 (M1) and Mez 2 (M2) Neanderthal fossils; 2) animal bones from MP Layers 2 and 3; 3) sediment samples from MP Layers 2 and 3.

Baranakha 4 and Besleneevskaya (Table 3). These results provide confirmation for the scenario of the Middle to Upper Paleolithic transition mentioned above.

UPPER PALEOLITHIC

Based on a long stratigraphic sequence from Mezmaiskaya cave, in the NWC, as well as the combined record from this and other sites in the Caucasus, the UP of Caucasus can be subdivided into three distinct chrono-cultural stages (see Table 1):

- Early Upper Paleolithic (EUP, ~39/38–32 ka cal BP);
- Late Upper Paleolithic (LUP, ~30–20 ka cal BP); and
- Epipaleolithic (~20–12/11 ka cal BP).

EARLY AND LATE UPPER PALEOLITHIC

In the Caucasus, the well-dated UP sequences from Mezmaiskaya, Dzudzuana, Ortvale Klde, Aghitu-3, and a few other cave sites suggest that the first Early Upper Paleolithic (EUP) modern humans entered this region during a cold H4 event (Adler et al. 2008; Golovanova and Doronichev 2012; 2020; Golovanova et al. 2010a; Kandel et al. 2017). At present, only two EUP sites have been found in the NWC (Mezmaiskaya, Layer 1C; Korotkaya, Layer 2/horizons 6–8; see Figure 1B). The earliest EUP assemblage from Mezmaiskaya cave, which is at 1310m asl, Layer 1C is from an age where a cold and dry climate prevailed. In Korotkaya cave, located at a lower elevation (550m asl), in Layer 2/horizon 8, dating from ca. 38–35 ka cal BP, the more comfortable conditions of a warm and humid climate have been determined.

The Caucasian EUP is generally characterized by a highly developed blade and bladelet technology, distinguishing by the predominance of bladelets (width 12–5mm) and microbladelets (width <5mm), as well as variable bladelet tools. The bladelet tools show the predominance of backed pieces (Figure 9: 17–19) and various points made on bladelets and microbladelets: needle-like (Figure 9: 1–4), Gravette (Figure 9: 12–14, 15), microgravette (Figure 9: 5), and symmetrical retouched (Figure 9: 6–10). Also, there are well represented backed pieces with oblique truncation (Figure 9: 11, 16), bladelets with fine retouch (Figure 9: 20), backed microbladelets (Figure 9: 21), and bladelets with denticulate retouch (Figure 9: 22).

The Caucasian EUP includes a wide assortment of bone implements, mostly awls (Figure 10: 5, 6) and points with rounded cross-sections (Figure 10: 9–11). In Mezmaiskaya Layer 1C the oldest bone needle fragment in Europe was found (Figure 10: 8). Also, personal ornaments made from marine gastropod shells (Figure 10: 3, 4) and pendants made from caprid incisors with cut holes (Figure 10: 1, 2) are found in the EUP Layer 1C at Mezmaiskaya.

The EUP and LUP stages are divided by the cold H3 event between 33.5–32.5 ka ago (see Table 1). In Mezmaiskaya Cave, the LUP stage is characterized by a warm and dry climate and expansion of forest vegetation, with an increase of humidity towards the end of this stage. The LUP lithic industry in the NWC has certain peculiar features. The LUP assemblages at Mezmaiskaya show increased numbers of end-scrapers and burins made on blades.

In the lower LUP Layers 1B-2 and 1B-1 at Mezmaiskaya Cave, tools are not numerous, especially in Layer 1B-2, in comparison with Layer 1C. Backed bladelets and bladelets with fine retouch predominate among the tools (Figure 11: 3, 6, 7). Gravette (Figure 11: 4, 5) and microgravette points (Figure 11: 9–11) are well represented, and there are other types of points (Figure 11: 1, 2), some similar to Font-Yves, Krems or Arjeneh points. End-scrapers are not numerous and are mostly made on blades (Figure 11: 8, 13, 14). There are also rare burins (Figure 11: 12), *pièces esquillées*, and retouched flakes.

In the uppermost LUP Layer 1A-1 at Mezmaiskaya Cave, backed pieces (Figure 12: 16–18) prevail (30.7%).

TABLE 3. CHEMICAL COMPOSITION (wt.%) OF VOLCANIC ASHES IDENTIFIED FOR MP AND BETWEEN MP AND UP IN THE NWC, BASED ON XRD ANALYSIS OF VOLCANIC ASH SAMPLES FROM MEZMAISKAYA CAVE AND TWO OTHER SITES CONTAINING BOTH MP AND UP ARCHAEOLOGICAL LEVELS.

Sample	Radiometric results	Volcanic glass composition	SiO_2	Na_2O	K_2O	Reference
MP-UP Transition						
Besleneevskaya						
Layer 3, top (MP level)		(+) basaltic andesite	56.9	0.7	2.0	
Baranakha 4						
Layer 2-2 (UP level)		(++) basaltic andesite	54.2	0.8	2.4	
Layer 2-3, top (MP level)		(++) basaltic andesite	54.7	0.8	2.3	
Mezmaiskaya cave						
Layer 1C (EUP level)		no evidence of volcanic glass				
Layer 1D (sterile)		(+) basaltic	47.6	0.6	2.5	Golovanova et al. 2010: Table 2
Layer 2 (top MP level 1)	48–40 ka calBP 39.6±2.3 ka (ESR/LU)	(+-) picro-basaltic	43.1	0.5	2.2	
Layer 2A (MP level 2)	46.5–44 ka calBP 40.8±1.3 ka (ESR/LU)	(+) basaltic	50.3	0.5	2.6	
Middle Palaeolithic						
Mezmaiskaya cave						
Layer 2B-1 (MP level 3)	38.4±3.1 ka (ESR/LU)	(++) andesite-dacitic	62.2	<0.05	2.6	Golovanova et al. 2010: Table 2
Layer 2B-2 (MP level 4)		no evidence of volcanic glass				

Notes: Concentrations of volcanic glass in samples from archaeological sites identified by XRD analysis as (++) high, (+) medium, and (+–) small. In Besleneevskaya and Baranakha 4, volcanic ash was found in the contact between MP and UP levels; in Mezmayskaya cave, a sterile Layer 1D with volcanic ash lies between MP and UP levels. The three different volcanic eruptions defined basing on the composition of volcanic glass are highlighted in color.

There are also double-backed bladelets, end-scrapers on backed bladelets, blades and bladelets with oblique retouch (Figure 12: 14, 15), truncated bladelets, and blades and bladelets with fine retouch (Figure 12: 13). Retouched points are quite numerous (16.7% of all tools). Among the points, Gravette points (Figure 12: 2, 10, 12) predominate. There are also microgravette points made on very thin microbladelets (Figure 12: 5, 6, 8) and several point types

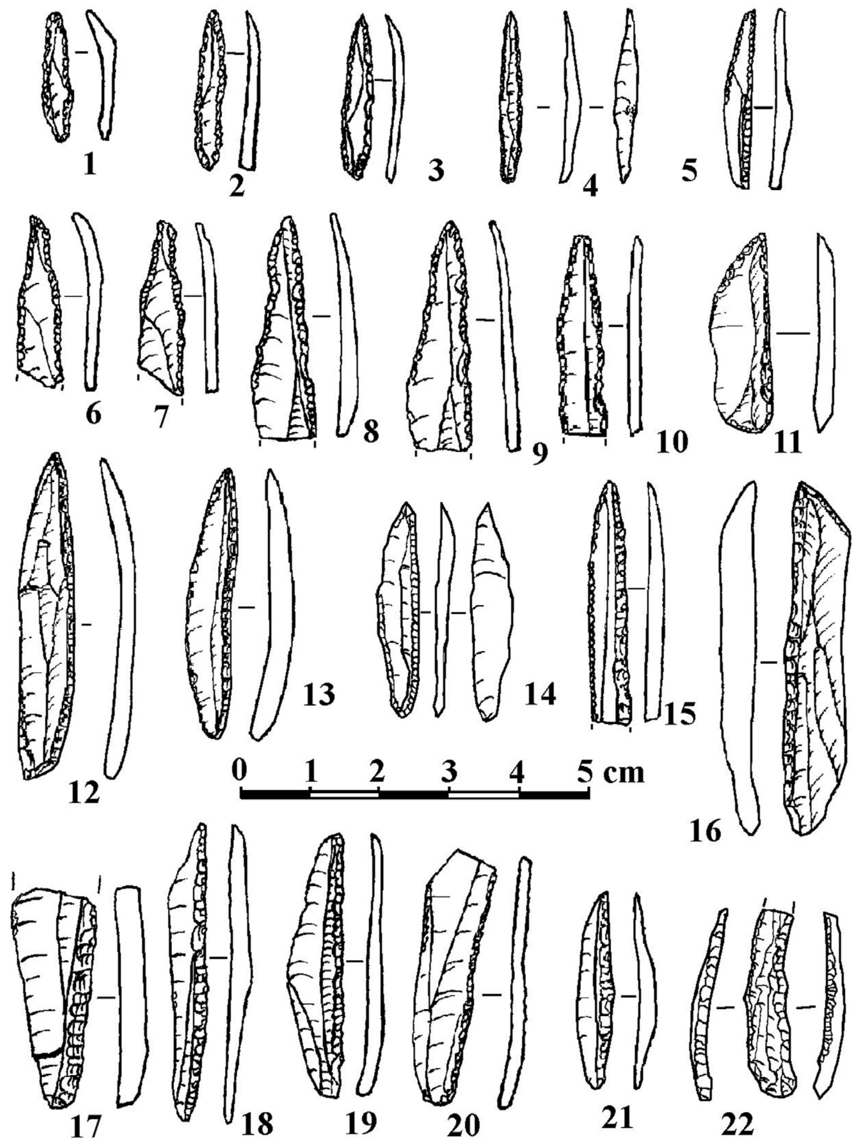

Figure 9. Bladelet tools from the EUP Layer 1C at Mezmaiskaya cave. 1–4) needle-like points; 5) microgravette point; 6–10) symmetrical retouched points on bladelets; 11, 16) backed pieces with oblique truncation; 12–14) Gravette points; 15) fragment of Gravette point; 17–19) backed pieces; 20) bladelet with fine retouch; 21) backed microbladelet; 22) bladelet with denticulate retouch.

on bladelets, such as symmetrically retouched points (Figure 12: 3), points with oblique retouch (Figure 12: 11), and points with retouched curved backs (Figure 12: 4, 7). It is necessary to note a complete shouldered point and a basal fragment of shouldered point (Figure 12: 1, 9) found in Layer 1A-1, which are the oldest shouldered points known in the UP of the Caucasus. These points have a long tang and a short nib and are made on narrow blades. It is worth noting that the shouldered points from Mezmaiskaya have analogues in some Eastern Gravettian sites on the Russian plain—namely, among the assemblages of the Kostenki-Avdeevo industry (see Sinitsyn 2013).

A morphometric study of laminar blanks from the UP layers at Mezmaiskaya (Nedomolkin 2019) indicates a gradual decrease in the relative thickness of bladelets and microbladelets during the Upper Paleolithic–Epipaleolithic sequence. This trend can be interpreted as reflecting the gradual development in the flaking technique aimed at the production of bladelets/microbladelets. However, blades basically kept their parameters unchanged during the entire period and were produced by the direct percussion technique, which continued to be used to produce large blades until the end of the Epipaleolithic. Also, the analysis suggests that direct percussion, probably using a soft hammer, was applied in the EUP.

The LUP assemblages demonstrate a wider assortment of organic artefacts and decorations, including a richer inventory of bone tools and more variable personal ornaments, in comparison to the EUP assemblages, as well as the first appearance of ornamented bone artifacts. In the Caucasus, organic artifacts and personal ornaments are especially abundant and diverse in the LUP layers at Mez-

Figure 10. Organic artifacts from the EUP Layer 1C at Mezmaiskaya cave. 1, 2) pendants from caprid incisors; 3, 4) marine gastropod shells; 5, 6) bone awls; 7) fragment of a flat bone point; 8) fragment of bone needle with eye; 9–11) fragments of bone points with rounded cross-sections.

maiskaya (Golovanova et al. 2010a) and Unit C at Dzudzuana (Bar-Yosef et al. 2011).

In Mezmaiskaya cave, they include double-pointed bone points (Figure 13: 17), awls, and needles with holes drilled from one side (Figure 13: 18, 19); all these artifacts are similar to those found in the EUP Layer 1C. There are teardrop-like pendants made from red deer milk teeth (Figure 13: 1–4) or made of bone and imitating a teardrop shape (Figure 13: 5). Pendants from marine shells are also represented (Figure 13: 15, 16). Also, unique for the Caucasus, UP flat stripe-beads made of ivory (Figure 13: 6–8) and bone (Figure 13: 9, 10) are found. They have a roughly

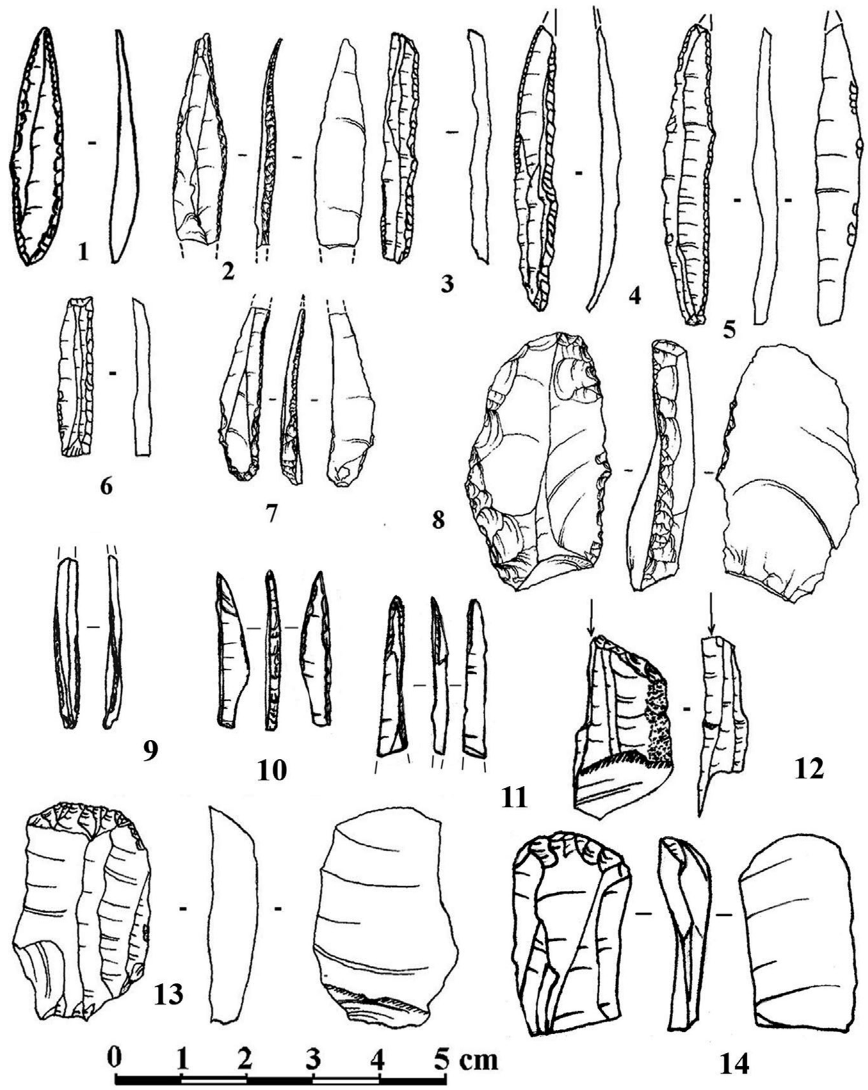

Figure 11. Retouched tools from the oldest LUP Layer 1B-2 at Mezmaiskaya cave. 1, 2) points similar to Font-Yves, Krems or Arjeneh points; 4, 5) Gravette points: 3, 7) retouched bladelets; 6) backed bladelet; 9–11) microgravette points; 8, 13, 14) end-scrapers; 12) burins.

square shape, with three rounded sides and one straight side, and holes drilled from one side (Figure 13: 6–10). Of particular note are the small stripe-beads with a hole, made from ivory, and having a geometric design in the form of dots arranged in line and traces of ocher (Figure 13: 11), a fragmented stripe-bead (Figure 13: 12), and a bead made of a tubular bone of a bird (Figure 13: 13) from the LUP layers in Mezmaiskaya. These artifacts have no analogues in the UP of the Caucasus but are similar to artifacts made from bone and ivory found at Sungir, on the Russian plain (Bader 1978: Figure 113). A needle case with fine geometric design found in the LUP layers at Mezmaiskaya is a unique find for the Caucasian UP, having no analogues (Figure 13: 14).

The latest analyses of lithic and organic artifacts from the LUP Layers 1A2–1A1 (ca. 33/27–25 ka BP) at Mezmaiskaya cave point to new analogues between these layers and the UP sites on the Russian plain. These analogues include shouldered points with long tangs and short distal parts made from blades, and artifacts made from bone and mammoth tusk. These data may indicate either the intensification of contacts between the UP population of the NWC and the more northern UP populations of the Russian plain, or the spread of some Eastern Gravettian groups into the more southern regions before the LGM, dated ca. 25/24–20/19 ka BP in the Caucasus.

EPIPALEOLITHIC

The cold maximum of the LGM period, dated in the Caucasus to about 25-–20 ka BP represents a global ecological crisis, which had a crucial impact on populations of modern humans in many regions of Eurasia (see Table 1). In the NWC, a new Epipaleolithic industry appears after the LGM, and occupies the time period between ~20 ka cal BP and the early Holocene at ~10 ka cal BP. In the NWC, a major concentration of about 14 Epipaleolithic sites post-

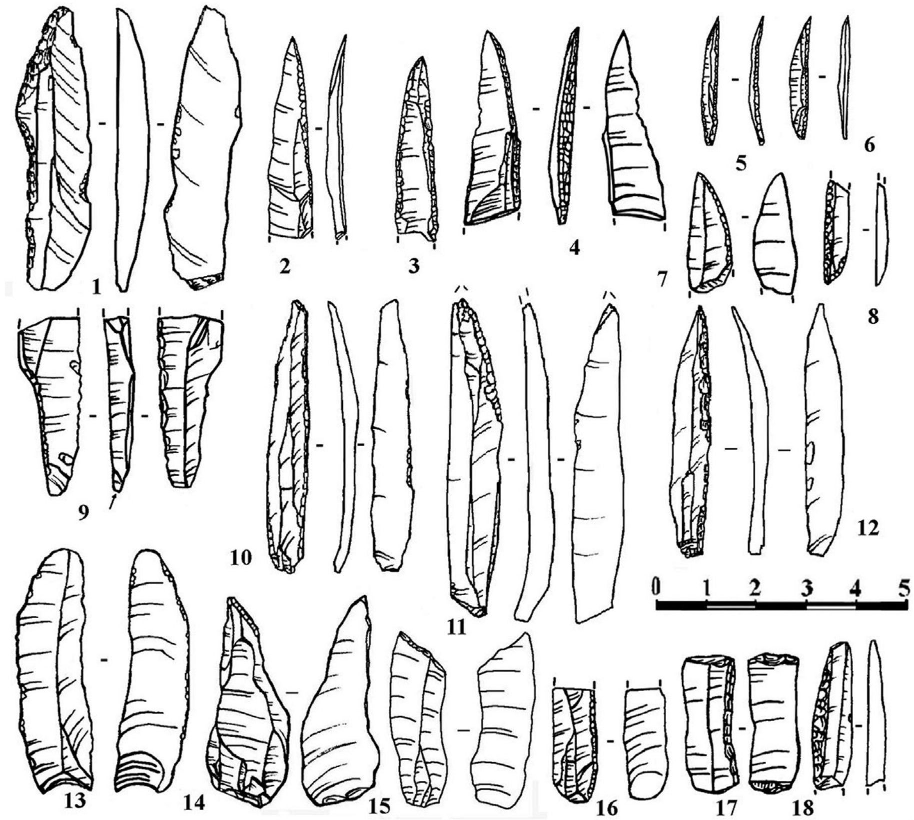

Figure 12. Points and other tools on laminar blanks from the latest LUP Layer 1A-1 at Mezmaiskaya cave. 1) shouldered point; 9) fragment of shouldered point; 3) symmetrically retouched point; 2, 10, 12) Gravette points; 11) point with oblique retouch; 4, 7) points with retouched curved backs; 5, 6, 8) microgravette points; 13) bladelet with fine retouch; 14, 15) blades and bladelets with oblique retouch; 16–18) backed pieces.

dating the LGM (see Figure 1C) is known from the Kuban River basin (Golovanova et al. 2014; Golovanova and Doronichev 2020). However, in this region, there are only nine known Epipaleolithic sites for which a techno-typological analysis is available. Of these, Gubs 1 and Gubs 7 (Satanai) rockshelters and Kasojskaya cave are located within a limited area in the Gubs River gorge, and most were excavated in the 1960s – 1980s. Mezmaiskaya cave was found more recently, and now provides the basic Upper Paleolithic–Epipaleolithic sequence in the Northern Caucasus. The Epipaleolithic Layer 1A at Baranakha 4 was excavated for only one field season, hence the study is preliminary as at Besleneevskaya (Layer 2B), Yavora, and Baranakha 1. The Epipaleolithic cave sites of Dakhovskaya 2, Korotkay 2, and Ruslan and Il'ich caves were examined only in test pits. Also, for the Epipaleolithic sites of Gubs 5 (Chygai) rockshelter and Dvoinaya cave that were studied for the last 10 years, a techno-typological analysis and composition of the collections have only recently been published (see Golovanova and Doronichev 2020).

In the Epipaleolithic Layer 1-3 at Mezmaiskaya cave, bladelet and microbladelet flaking technology continued to develop, but the most significant changes occur in the tool kit (Golovanova and Doronichev 2020). At Mezmaiskaya, within the UP sequence, geometric microliths first appear in the Epipaleolithic Layer 1-3. Among all the types of geometric microliths, segments made on bladelets by abrupt/blunted retouch forming an arch (Figure 14: 5, 9, 10, 12–14, 17–22) dominate (73.8% of the geometric microliths). Rectangles are rare (8.8%) and are represented by bladelets with one backed side made by blunted retouch and truncations on both the distal and proximal ends (Figure 14: 4, 16). Trapezes (12.5%) are made on bladelet sections with transversal ends obliquely truncated by fine, steep retouch (Figure 14: 2, 6, 11, 15).

However, a single specimen of another type of trapeze with a notched upper side (a so-called "horned trapeze"; Figure 14: 1) was found in the contact horizon of Layer 1-3 and the breccia level, which is dated to the Younger Dryas between 12.6–11.7 ka cal BP. In addition, three triangles—two small isosceles triangles (Figure 14: 3, 8) and one larger-size asymmetrical or scalene triangle (Figure 14: 7)—were found, but only in the upper horizons 3 and 4 and in the contact with the breccia level.

Among tools made on bladelets, the most numerous are backed pieces (Figure 14: 30–33), which represent 20.9% of all tools. Most of them (68.6%) are found in the lower horizons, while backed pieces are rare (10%) in the upper horizons 1–3 and the top contact horizon. There are a few double-backed pieces (Figure 14: 24) and double-backed

Figure 13. Organic artifacts from LUP layers 1A-1–1B-2 at Mezmaiskaya cave. 1–5) pendants from red deer milk teeth and bone; 6–8) stripe-beads from mammoth tusk; 9, 10) stripe-beads from bone; 11) stripe-bead from mammoth tusk; 12) stripe-beads from bone; 13) pendant made of a tubular bone of a bird; 14) ornamented needle-case; 15, 16) marine gastropod shells; 17) bone point; 18, 19) needles with eye.

pieces with inverse retouch (Figure 14: 25). Retouched bladelets and microbladelets are uncommon, as are the rare bladelets with oblique truncation (Figure 14: 27, 28), backed bladelets with a micro-endscraper (Figure 15: 26), and backed bladelets with truncation (Figure 14: 29). It is worth noting the appearance in Layer 1-3 of new bladelet tools that are not found in the earlier Upper Paleolithic layers in this cave, such as bladelets with ventral retouch (Figure 14: 23).

Points are not numerous (12.7% of the total tools) in the Epipaleolithic assemblage from Layer 1-3 and they are made exclusively on bladelets and microbladelets. Shouldered points are especially indicative for this industry. In total 13 shouldered points (Figure 15: 1–8) were found in Layer 1-3. Most of the shouldered points are fragmented. They are characterized by a lateral notch made by abrupt retouch on the basal part; this notch forms a short tang on the base of the tool. Gravette points dominate in the Epipaleolithic assemblage of Layer 1-3 (Figure 15: 9, 12, 13), including microgravette points (Figure 15: 14–17, 20). The assemblage is also characterized by the first appearance within the Mezmaiskaya UP sequence of a significant number of Vachons points, which represent a variant of Gravette/microgravette points, having additional ventral retouch on either the tip or base, or both ends (Figure 15: 10, 11, 18, 19).

The Gravette, microgravette, and Vachons points together comprise 72.9% of all points in Layer 1-3. They are

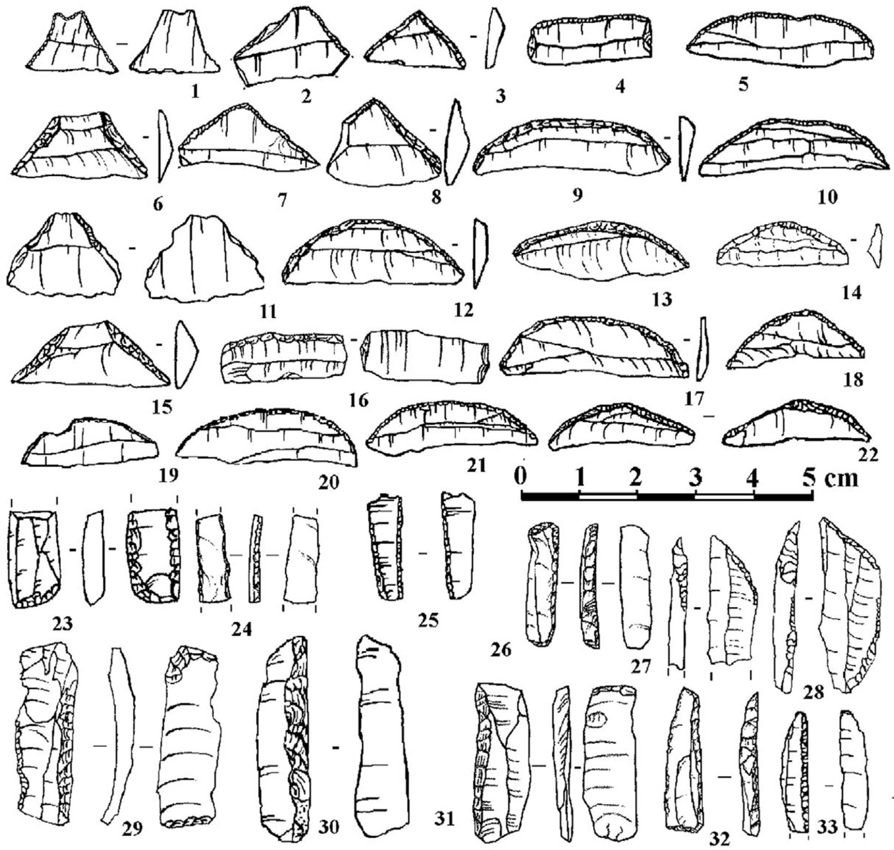

Figure 14. Mezmaiskaya cave, Epipaleolithic Layer 1-3. Geometric microliths (1–22) and other tools on bladelets and blades (23–33). 1–22) geometric microliths; 23) fragment of bladelet with ventral retouch; 24) double-backed bladelet; 25) double-backed bladelet with inverse retouch; 26) backed bladelet with a micro-endscraper; 27–28) bladelets with oblique truncation; 29) backed piece with denticulate retouch; 30–32) backed pieces; 33) fragment of Gravette point.

especially numerous in the lower horizons 6–10, in which 74.2% of these points were found, while only 8.1% were found in the upper horizons 1–3. Also, there are points made on bladelets (Figure 15: 25) and micropoints made on microbladelets, with abrupt retouch along symmetrical converged sides (Figure 15: 24), as well as other varieties of points (Figure 15: 21–23) that are more common and diverse in the lower horizons of Layer 1-3.

End-scrapers and burins together comprise only 10.9% of retouched tools in Layer 1-3. Among these, end-scrapers on blades and laminar flakes dominate (Figure 16: 1–4). Some end-scrapers are made on small, thin blades (Figure 16: 6); most of them are fragmented. There are a few end-scrapers on flakes (Figure 16: 5, 9), double end-scrapers (Figure 16: 8), and rounded or circular scrapers (Figure 16: 7). The burins (Figure 16: 10, 11) include angle and multiple burins. Among other tools, denticulates on blades are typical for the industry (Figure 16: 12, 13).

An innovative technology of biconical drilling (Figure 17: 2, 3) and a new personal decoration style using pierced shells of small terrestrial gastropods appears (Figure 17: 14) in the Epipaleolithic industry at Mezmaiskaya. The personal ornament also include a bead made from a bird bone (Figure 17: 9). Also, a few ornamented bones are represented (Figure 17: 10). The Epipaleolithic bone tools include awls (Figure 17: 13), microawls (Figure 17: 8), needles (Figure 17: 1), points with rounded (Figure 17: 5, 12) or flat (Figure 17: 6, 7, 15) cross-sections, and one flat point has ornamentation (Figure 17: 11). Particularly noteworthy is a fragment of a large pointed bone tool with a cut groove (Figure 17: 16).

Contacts between Epipaleolithic groups on both sides of the Caucasus are confirmed by data about obsidian transport from sources located in the southwestern Caucasus and in the central part of the northern Caucasus (Doronicheva 2011; Doronicheva and Kulkova 2011; Doronicheva and Shackley 2014; Golovanova and Doronichev 2020), and suggest a high mobility of Epipaleolithic groups across the Caucasus. The Younger Dryas or Heinrich 0 event between 12.6–11.7 ka cal BP represents a new period of significant climatic stress, which marks the end of the Epipaleolithic in the Caucasus (see Table 1).

DISCUSSION AND CONCLUSIONS

In the NWC, the available archaeological records suggest a region-specific dynamic in development of stone industries

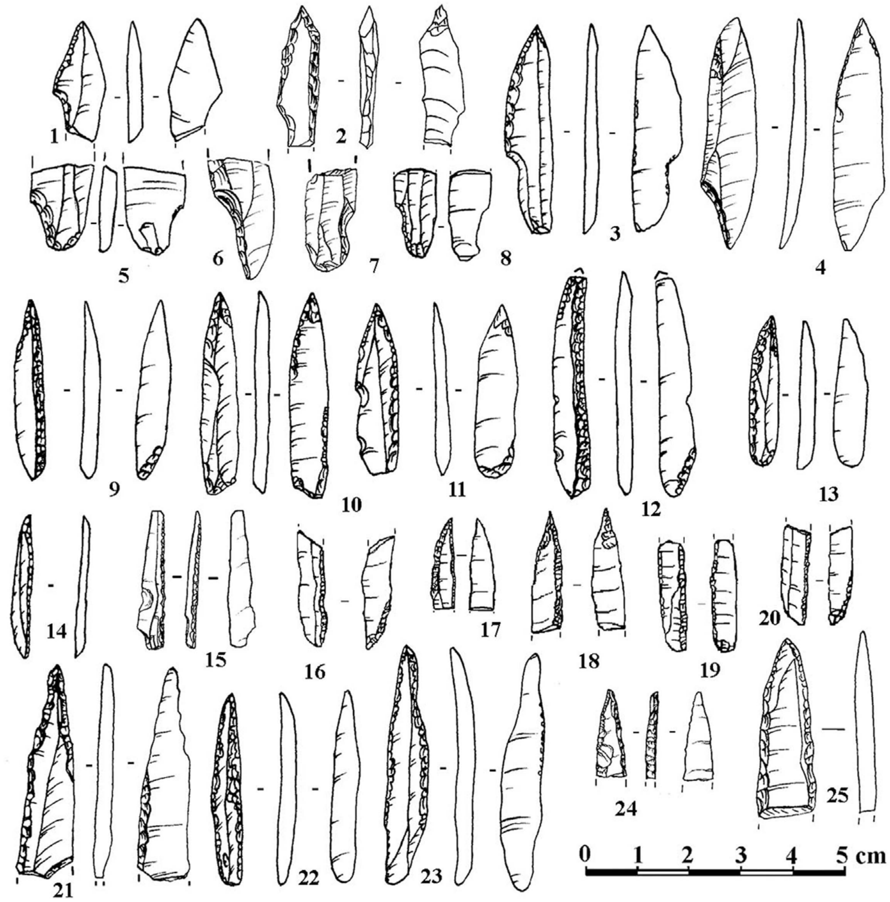

Figure 15. Mezmaiskaya cave, Epipaleolithic Layer 1-3. Points on bladelets and blades. 1–8) shouldered points; 9, 12, 13) Gravette points; 14–17, 20) microgravette points; 10, 11, 18, 19) Vachons points; 24, 25) symmetrical points with abrupt retouch; 21–23) other points.

during the MP (Golovanova and Doronichev 2017). Only during late MIS 5 does a typical MP Eastern Micoquian industry first appear in the region. The early Eastern Micoquian industry of the NWC is characterized by the lack of Levallois technique and low numbers of laminar blanks (in technology), as well as a high number of various bifacial and partially bifacial tools (in typology). Paleogenetic and paleoanthropological studies indicate that DNA sequences and morphologies of the Mez1 and Mez2 specimens from Mezmaiskaya cave, associated with the Eastern Micoquian industry, do not differ in divergence from other European Neanderthal individuals (Briggs et al. 2009; Green et al. 2010; Gunz et al. 2012; Hajdinjak et al. 2018; Ponce de Leon et al. 2008). These results indicate that the makers of the Eastern Micoquian in the NWC were similar to European Neanderthals (Golovanova 2015).

The available data on chronology of the region's MP assemblages, as well as cultural development of a local Neanderthal population and dynamics of paleoenvironmental conditions during the MP suggest that the Neanderthal population of the NWC developed the Eastern Micoquian tradition throughout the entire duration of the period, from late MIS 5 to the end of the MP and the demise of Neanderthals about 40 ka ago (Golovanova 2015; Golovanova and Doronichev 2017). Recent data also suggest that major periods of climatic deterioration had an impact on Neanderthals, and the ecological niche favorable for Neanderthal occupation in the NWC apparently declined significantly in colder periods, especially those corresponding to the EGM, between 70–60 ka, and the H5 event, between 48–47 ka. The dynamics of cycles of expansion (in warm periods) and reduction (in cold periods) of the ecological niche occupied by Eastern Micoquian Neanderthals correlates with the emergence of innovations in the lithic industry. Recently, Golovanova and Doronichev (2017) proposed a hypothesis that the appearance of Eastern Micoquian industries in Eastern Europe was associated with favorable paleoclimatic conditions of MIS 5, which followed one of the coldest periods of the Pleistocene during MIS 6.

Our recent studies at the newly discovered site of Saradj-Chuko grotto, located close to obsidian sources near the town of Zayukovo in the north-central Caucasus, indicate that the Mousterian obsidian industry from Layer 6B in Saradj-Chuko has technical (high indices of laminarity and faceted platforms, quite numerous Levallois blades) and typological (abundance of convergent tools, including unretouched and retouched Levallois points and Mousterian points, presence of rare truncated-faceted pieces) charac-

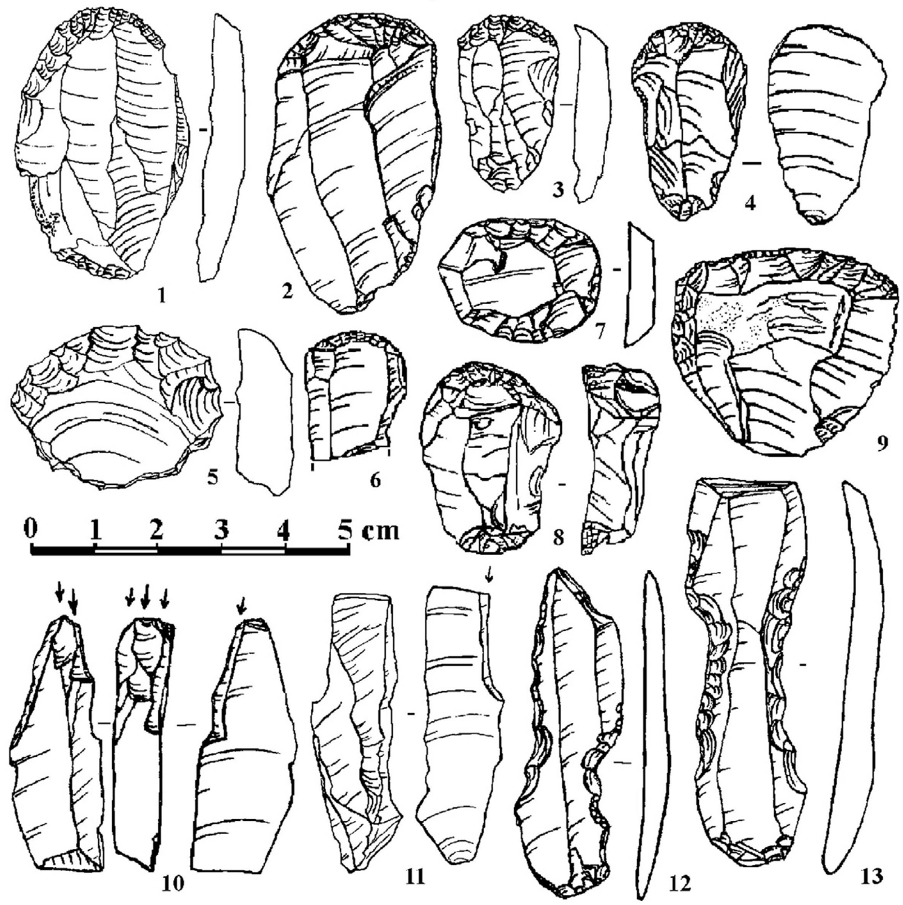

Figure 16. Mezmaiskaya cave, Epipalaeolithic Layer 1-3. End-scrapers (1-9), burins (10, 11), and denticulated or notched blades (12, 13).

teristics indicating that it is similar to the Zagros Mousterian of Zagros and the Lesser Caucasus and differs from the Eastern Micoquian assemblages in the NWC (Doronicheva et al. 2019). However, artifacts made of the Zayukovo obsidian were found in the MP layers in Mezmaiskaya cave, located ~250km to the west from Zayukovo (Doronicheva and Shackley 2014). The obsidian transport suggests contacts between the Eastern Micoquian Neanderthal population in the NWC and the Neanderthal population that occupied the north-central Caucasus who produced a different Mousterian industry.

Our research of the relationship between environmental dynamics and Neanderthal occupations in Mezmaiskaya cave suggests that stages of paleoenvironmental stress, some of which were associated with volcanic eruptions, could influence the cultural development and living conditions of Neanderthals, with the volcanic ash likely producing a negative impact on their health. The results discussed above suggest that late Neanderthals in the NWC were likely affected by a toxic contamination event, which probably had a volcanogenic nature. Unfortunately, the volcanogeneous impact on the ecology and culture of Neanderthals is poorly studied in other regions of the Caucasus.

In addition, a recent genetic analysis (Hajdinjak et al. 2018) indicates that a population turnover likely occurred towards the end of the Neanderthal occupation. The available genetic data are not yet sufficiently representative to define clearly either the region where this population turnover took place (in the Caucasus or in western Europe), or the direction of population movement (from the Caucasus to western Europe or vice-versa). However, this population turnover dates to the period when extreme cold conditions may have triggered the local extinction of Neanderthal populations in regions of Europe located north of the Alps. This suggests the northward movements of Neanderthal groups from more southern regions with milder climate in Europe or Western Asia for the subsequent re-colonization of abandoned regions in the north.

Given the data from Mezmaiskaya cave, Golovanova et al. (2010b) proposed the hypothesis that Neanderthal demise in the Caucasus occurred abruptly (on a geological timescale) at around 40 ka ago. The volcanic eruption recorded in Layer 1D at Mezmaiskaya likely caused dramatic climatic changes, which destroyed the living base of Neanderthal populations and led to their local extinction in the Caucasus. The loss of viable source populations may have been the principal factor contributing to the eventual extinction of the Neanderthals throughout their range just

Figure 17. Organic artifacts from the Epipaleolithic Layers 1-3 (1, 3–15, 16) and 1-4 (2) at Mezmaiskaya cave. 1) fragmented needle with eye; 2, 4) tooth pendants; 5–7) fragments of bone points; 8) bone microawl; 9) bead made of a tubular bone of a bird; 10) ornamented bone; 11, 15) fragments of flat bone points; 12) fragment of bone point with rounded cross-section; 13) bone awl; 14) beads made from pierced shells of terrestrial molluscs; 16) fragment of a large bone tool with cut groove.

under 40 ka ago. In the Caucasus, the Neanderthal disappearance was followed by recolonization of the abandoned territories by modern human groups in the EUP (see below).

Recent results show the presence of volcanic ash in occupational layers lying on the border between the MP and UP levels also at two other sites (Baranakha 4 and Besleneevskaya) in the NWC. These data provide confirmation for an occupation hiatus between the end of the MP/Neanderthal occupation and the EUP/AMH occupation, emphasized by evidence of significant volcanic activity. Unfortunately, at present, not all sites have undergone a geochemical analysis of sediments for the presence of volcanic ashes/cryptotephra.

We also proposed that the most significant advantage of EUP modern humans over contemporary Late Middle

Paleolithic (LMP) Neanderthals was geographic localization of the main part of modern human population in the more southern parts of western Eurasia and Africa (Golovanova et al. 2010b). Consequently, most modern human groups avoided much of the direct impact of the CI volcanic eruption and following climatic deterioration. Also, a recent genetic analysis (Hajdinjak et al. 2018) did not detect any gene flow from the EUP modern humans into late Neanderthals in most parts of Europe, including the Eastern Micoquian late Neanderthal population in the NWC.

Data from the NWC agree well with results of dating the Neandertal extinction in Southern Caucasus and Europe. Recent chronometric research (Adler et al. 2008; Pinhasi et al. 2011; 2012; Pleurdeau et al. 2016) indicate that Neanderthals did not survive in the Caucasus after ca. 39–37 ka cal BP and had probably disappeared by 40 ka ago. Similarly, the refined high-precision AMS dating results from 40 key MP and Neanderthal archaeological sites, ranging from Russia to Spain, show that different Mousterian industries ended abruptly by 41–39.3 ka cal BP across Europe (Higham et al. 2014). These data provide confirmation for our earlier hypothesis (Golovanova et al. 2010b) that the CI eruption and the onset of a cold H4 event, which are precisely dated at present to the same time 39.9 ka ago (Giaccio et al. 2017), coincided, and the combined influence of the CI-H4 extremely cold event likely caused an abrupt end of the Eastern Micoquian industry in the NWC, as well as other Mousterian industries across Europe and the Near East, and the disappearance of Neanderthal populations. In addition, the most recent genetic study of late Neanderthals found no evidence of their interbreeding with AMHs (Hajdinjak et al. 2018).

However, the "volcanic winter" scenario that Golovanova et al. (2010b) proposed as a model to explain the disappearance of Neanderthals does not mean that our hypothesis suggests that the CI eruption alone killed the last Neanderthals. Although we have suggested that this catastrophe likely may have caused Neanderthal depopulation from Central Europe to the Caucasus, especially in the regions which were directly affected by the CI tephra fallout (see Marti et al. 2016: Figure 3; Giaccio et al. 2017: Figure 1), or even in most of their habitation areas across Europe and the Near East, we also proposed that the final demise of Neanderthals was a demographic consequence ("loss of viable source populations") of this cataclysm (Golovanova et al. 2010b: p. 673). More recent studies based on computational methods, including Bayesian statistics, propose models that agree well with our proposal (e.g., Black et al. 2015; Costa et al. 2012; Higham et al. 2014; Marti et al. 2016).

Moreover, paleogenetic studies indicate that the earliest EUP/AMH groups that arrived in Europe, between approximately 45 and 37 ka ago, provided no contribution to the genetic composition of present-day Europeans (Fu et al. 2016). This may indicate that the CI-H4 paleoenvironmental (volcanic winter) cataclysm may have affected not only the late Neanderthals but also the first AMH groups that entered Europe, as we (Golovanova et al. 2010b) assumed earlier. For example, Giaccio et al. (2017) suggest that in a wide region extending from Italy to eastern Europe the CI eruption marked an abrupt end to the Uluzzian and Proto-Aurignacian EUP industries. Although some authors (Lowe et al. 2012) argue that Neanderthal extinction was not associated with the CI eruption and, on the contrary, late Neanderthal groups ultimately became extinct due to a competitive pressure by EUP/AMH groups, the data available indicate that the CI eruption at 40 ka ago interrupts MP sequences across Europe (e.g., Higham et al. 2014: Figure 1; Lowe et al. 2012: Figure 4), whereas AMHs and Neanderthals coexisted for several millennia in parts of Europe before the CI and without any detectable competitive threat to each other. In addition, recent genetic studies (see Hajdinjak et al. 2018) do not detect any contacts between modern humans and late Neanderthals in most parts of Europe, including the NWC.

In the Caucasus, there is a chronological break between the end of the MP occupation and the beginning of the UP occupation wherever the LMP and EUP occupational levels are documented within one sequence in the region (e.g., Adler et al. 2008; Bar-Yosef et al. 2006; Golovanova et al. 2010b). Recent research favors a model of LMP–EUP population replacement and a chronological hiatus between these two occupational phases in the Caucasus. It also indicates that LMP Neanderthals and EUP modern humans did not interact in the region. All MP-UP sequences studied thus far in the Caucasus lack a period of transition from LMP to EUP, and instead clearly show the abrupt appearance of the EUP in the region as a fully developed technological tradition associated with the arrival of a new biological population (i.e. *Homo sapiens*).

On the basis of data from Mezmaiskaya cave and supporting evidence from other sites, we proposed (Golovanova et al. 2010b) that the first EUP modern humans appeared in the Caucasus some time after 40 ka ago. Results from recent research in the region have confirmed this hypothesis. The earliest manifestations of the UP in the Caucasus are dated a little later than the earliest EUP industry (Early Ahmarian) in southwestern Asia (see Golovanova and Doronichev 2012). The earliest estimates for the Caucasian EUP are 42–35 ka cal BP for Layers 4c and 4d at Ortvale klde (Adler et al. 2008), 39–36 ka cal BP for Layer 1C at Mezmaiskaya, 38–35 ka cal BP for Korotkaya (Golovanova and Doronichev 2012), 39–34 ka cal BP for Layer V at Sagvardjile (Meshveliani et al. 2004), 37–35 ka cal BP for Unit D at Dzudzuana (Bar-Yosef et al. 2011), 39–38 ka cal BP at Bondi (Pleurdeau et al. 2016), and 39–36 ka cal BP at Aghitu-3 (Kandel et al. 2017). The oldest radiometric estimates available today suggest that the first EUP/AMH groups may have appeared in the Caucasus during or soon after the cold H4 event, between 42 and 38 ka ago. (Pinhasi et al. 2011; 2012; Golovanova and Doronichev 2012; 2020).

Recent research involving both artifact characterization and the sourcing of lithic raw materials enhances our knowledge of how lithic raw material procurement was embedded into the survival strategies and mobility of the MP Neanderthal and the UP modern human groups in the Caucasus (e.g., Bourdonnec et al. 2012; Kandel et al. 2017;

Pleurdeau et al. 2016), particularly in the NWC (Doronicheva et al. 2012, 2013, 2019; Doronicheva and Kulkova 2011; 2014; Doronicheva and Shackley 2014). These studies show that the MP Neanderthals were dependent upon local raw material sources. Compared to the Neanderthals, the UP population of the Caucasus was less dependent on locally available raw materials—a reflection of the increased mobility of the UP human groups and the establishment of more extensive and regular social networks that provided them access to better raw materials from more distant sources. The preference for high-quality flint and obsidian was closely related to the use of blade/bladelet technology, which drove UP humans to seek better raw materials for making blades/bladelets.

Comparisons of the UP assemblages from the NWC and Southern Caucasus reveal that the UP industries on both slopes of the Greater Caucasus range demonstrate a substantial similarity, indicating dispersal of close AMH groups over the whole western Caucasus region. In the beginning of the 2000s, Golovanova (2000) proposed that the Caucasian UP is most similar to the EUP industry of the Levant, the Early Ahmarian. Later, Bar-Yosef et al. (2011: 347) also concluded that the UP industry in west Georgia "recalls the Ahmarian blade industries from the Levant." At present, there is a wide consensus among researchers working directly in the Caucasus that the Upper Paleolithic industry of this region does not represent a variant of Zagros Aurignacian or the Levantine Aurignacian or Gravettian industries (Adler et al. 2008; Bar-Yosef et al. 2006; 2011; Golovanova 2000; Golovanova and Doronichev 2012; 2020; Kandel et al. 2017; Meshveliani et al. 2004; Pleurdeau et al. 2016). This suggests a quite early northward dispersal of some EUP groups similar to the Early Ahmarian in the Levant from southwestern Asia to the Caucasus (Golovanova and Doronichev 2012; 2020).

In support of this view, the results of two recent paleogenomic analyses (Fu et al. 2016; Jones et al. 2015) of two human individuals from Kotias and Satsurblia in the Southern Caucasus indicate that the first AMHs to appear in the Caucasus shared ancestry with the UP humans of Western Asia. Both Caucasian individuals belonged to a distinct ancient clade which split from the European UP populations about 45 ka ago, shortly after expansion of AMHs into Europe.

The hypothesis that EUP groups spread northwards from southwestern Asia to the Caucasus is also supported by data on the UP obsidian transportation networks in the Caucasus. Research has shown that some artifacts from the EUP Layer 1C in Mezmaiskaya cave in the NWC were produced from obsidian procured from the Chikiani source, located in the Javakheti range in the Southern Caucasus, approximately 450km southwest of Mezmaiskaya (Doronicheva and Shackley 2014). At Bondi and Ortvale klde, western Georgia, some artifacts were produced using obsidian procured from the same Chikiani source, located about 110km southeast of the sites, as well as from more southern sources in eastern Anatolia and the Lesser Caucasus (Bourdonnec et al. 2012; Pleurdeau et al. 2016).

However, research also indicates that the EUP of the Caucasus is not identical to the Early Ahmarian industry. Typical el-Wad points with fine lateral retouch are especially characteristic of the Early Ahmarian assemblages in the Levant but are absent from Mezmaiskaya and other UP sites in the Caucasus. In comparison to other regions, including the Levant, the Caucasus' archaeological record shows distinct regional peculiarities and a specific pathway of UP development (Golovanova and Doronichev 2012). We identify this particular industry as the "Caucasus Upper Paleolithic" (Golovanova and Doronichev 2020).

The EUP assemblages of the Caucasus are characterized by tool types made on bladelets and microbladelets, including various points, backed bladelets, and bladelets with fine retouch. The regional differences of the Caucasian EUP include typical Gravette and microgravette points with straight backs made by blunted retouch on bladelets and microbladelets (the most common point type in Mezmaiskaya 1C and a majority of other EUP sites), as well as needle-like and symmetrical retouched points. Numerous and various backed or retouched tools made on bladelets and microbladelets are found in all EUP sites in the region (Golovanova and Doronichev 2012; 2020). Backed bladelets are more abundant in Mezmaiskaya 1C and Korotkaya caves, in the NWC, but finely retouched bladelets are more numerous in Dzudzuana D and Bondi caves, in the Southern Caucasus. However, no typical Dufour bladelets were found in any securely excavated and dated EUP assemblage in this region. End-scrapers and burins are much less abundant than backed and retouched bladelets in most Caucasian EUP assemblages.

The Caucasian EUP also demonstrates a wide assortment of bone tools, which include characteristic points with rounded cross-sections, bone awls, smoothers, and needles (Bar-Yosef et al. 2011; Golovanova et al. 2010a; Golovanova and Doronichev 2020). Studies show that bone tools and personal ornaments, together with new fully-developed bone-processing technologies using organic materials (bones, antlers, teeth and shells) appeared abruptly in the Caucasus with the arrival of EUP modern humans, and were further developed throughout the Upper Paleolithic.

Starting from approximately 30,000 years ago, after a cold H3 event (~33,5–32,5 ka), the Caucasus UP industry began to undergo notable changes, evidenced by the lithic assemblages and bone artifacts, a stage of cultural development we identify as the Caucasus LUP industry (Golovanova and Doronichev 2020). The technological and behavioral changes include:

1. The development of microblade technology towards higher production of blades in some LUP sites (Mezmaiskaya, Satsurblia, Aghitu-3) or the production of bladelets/microbladelets from carinated cores in other sites (Dzudzuana C and Gubs rockshelter 1);
2. A higher variability of stone points during the LUP, with the addition of Font-Yves and Sakajia points at some sites;
3. The appearance of geometric microliths (rectangles at Satsurblia; Pinhasi et al. 2014) at the end of the LUP

stage;

4. A higher diversity of personal ornaments (pendants and beads) made from bone, ivory and stone, and the appearance of bone artifacts with geometric ornamentation.
5. The results of some recent studies can be interpreted as signs pointing to the initial formation of regional differences between the LUP industries in the Southern and Northern Caucasus. Sakajia points have been found in the LUP Unit C in Dzudzuana, in the southwestern Caucasus (Bar-Yosef et al. 2011) but are unknown in Mezmaiskaya and other sites in the NWC. The LUP layers in Mezmaiskaya have yielded some lithic and organic artifacts—such as a shouldered point with a long tang in Layer 1A-1, stripe-beads made from mammoth tusk, and a tubular bead from a long-bone of bird in Layer 1A1/1A2—which have analogies in the Upper Paleolithic of Eastern Europe, but are unknown in the LUP industries in the Southern Caucasus.
6. The Last Glacial Maximum (LGM) was one of the most extreme glacial events of the Pleistocene which had a major demographic impact on the UP human populations in Eurasia (e.g., Banks et al. 2009, 2011; Soffer and Gamble 1990). The UP humans in the Caucasus were affected by this event. During the LGM, the northern and southern slopes of the Greater Caucasus were covered by a large and continuous glacial shield, which was especially massive on the northern slopes, where it was two to three times larger than on the southern slopes (Gobejishvili et al. 2011: Figure 12.1; Tielidze 2016). The LGM glaciation resulted in a decline of approximately 7˚–8˚C in mean annual temperature and depression of the firn line by 1200–1300m in the Greater Caucasus, with the depression increasing from west to east.
7. The deterioration of the natural environment with the onset of the LGM led to a decrease in the intensity of human occupation across the entire Caucasus. The results of excavations in Mezmaiskaya, Satsurblia, and Dzudzuana indicate breaks in human occupation at most of the sites located above 350m asl during the height of the LGM, between 24 and 20 ka cal BP (Bar-Yosef et al. 2011; Golovanova and Doronichev 2020; Golovanova et al. 2014; Pinhasi et al. 2014). During this period, the UP humans could only survive in habitats at very low elevations, most probably in the low foothills of the southwestern Caucasus, which provided the main refuge region (Colchis refugium). At present, the Colchis region shows the highest concentration of UP sites in the Caucasus.
8. Recent genetic research (Jones et al. 2015) has detected a sharp genomic distinction in the Caucasian clade after the LGM, suggesting that the post-LGM population of the Caucasus emerged as a result of habitat restrictions during the glacial period. After the LGM, an industry with geometric microliths develops from approximately 20 to 12/11 ka cal BP in both the Southern and Northern Caucasus.
9. The application of the term "Epipaleolithic" to the Caucasian Upper Paleolithic assemblages dating between the LGM and the start of the Holocene, and containing various geometric microlithic tools (Golovanova et al. 2014; Golovanova and Doronichev 2020), follows the Levantine scheme (Belfer-Cohen and Goring-Morris 2014: Table 3.3.1.) and seems the most reasonable for the Caucasian materials. The appearance of geometric backed microliths marks a significant cultural transformation—the "Upper/Epi-Paleolithic transition" (Belfer-Cohen and Goring-Morris 2014: 1383). This microlithic transformation occurred in the Near East about halfway through the Upper Paleolithic, bringing a distinct subdivision, the Epipaleolithic, which is treated as the final chrono-cultural stage of the UP in West Asia. The term "Epipaleolithic" avoids inconsistency between the Caucasian and the Near Eastern (first of all the Levantine) schemes which may be caused by the introduction of different terms, and it does fit the UP record of the Caucasus, whose common peculiar feature—the early appearance of microlithic geometric tools—has been conservatively stressed by all scholars (see Golovanova et al. 2014; Golovanova and Doronichev 2020; and references therein) as an analogy with the UP of the Near East, particularly the Zagros and the Levant.
10. The oldest Epipaleolithic sites in the NWC (basal horizons of Layer 1-3 at Mezmaiskaya, Layer 5 at Kasojskaya, Layers 9–13 at Chygai, Layer 2B at Besleneevskaya) are dated to the end of the Oldest Dryas, but the more active and wider occupation of this region occurred during the Bølling–Allerød interstadial, when the climate was warmer than at present. During that time, a milder climate is recorded event at sites located in the mid-mountain zone, such as Mezmaiskaya (1310m asl) and Baranakha 4 (147 m asl).
11. Recent research at Mezmaiskaya, Satsurblia, Dzudzuana, and other sites indicates that the Epipaleolithic industries in the northwestern and southwestern Caucasus were built upon LUP industries that preceded the LGM. In both regions, Epipaleolithic industries show further developments in microblade technology. The flaking technology in almost all Epipaleolithic assemblages in the Caucasus is based on the reduction of prismatic cores, with various conical and pyramidal cores identified in many sites, although narrow-fronted and carinated cores are rare in most of the assemblages (Golovanova et al. 2014; Golovanova and Doronichev 2020). Also, recent research (Nedomolkin 2019) indicates an important change in the flaking technique in the NWC Epipaleolithic—the initial appearance of the pressure technique to produce small laminar blanks.
12. The most important tool groups in the Epipaleolithic of the Caucasus are points and geometric microliths. The Caucasus Epipaleolithic industry is characterized by a variety of straight-backed points, including Gravette,

micrograveтte and Vachons points made on bladelets or micro-bladelets, and occasionally on small blades. Vachons points first appear in the LUP and became widespread in the region during the Epipaleolithic. Also, many Epipaleolithic assemblages in the Caucasus contain points with symmetrically retouched converging lateral sides, while some assemblages in the Southern Caucasus contain rare Sakajia points. The presence of rare shouldered points, including the specific Imeretian-type shouldered point (Golovanova et al. 2014), is an important innovation that characterises the Epipaleolithic industry of the Caucasus.

13. Like the Epipaleolithic industries in the Near East, geometric microliths appeared early on in the Caucasian Epipaleolithic. The available radiocarbon dates indicate that a wide variety of geometric microlithic forms appeared in the Caucasus during the middle stage of the Epipaleolithic, with geometric microliths especially widespread and variable between ca. 18/17.5 and 14 ka cal BP in both the Southern and Northern Caucasus. Contacts among the Epipaleolithic groups that inhabited the NWC and southwestern Caucasus have been confirmed by new data on the obsidian transport networks that supplied this raw material from sources located in the Lesser Caucasus and central Northern Caucasus to sites in the southwestern and northwestern Caucasus (Doronicheva et al. 2013; Doronicheva and Shackley 2014; Golovanova et al. 2014).
14. Also, a recent study by Fu et al. (2016) found that beginning with the Villabruna Cluster at least 14 ka ago, the European Epigravettian groups show a genetic component related to human populations in the Near East and the Satsurblia Cluster from the Caucasus. This correlates in time with the warming period of the Bølling-Allerød interstadial, as well as with cultural changes within the Epigravettian in southern Europe (Montoya and Peresani 2005) and the Magdalenian-to-Azilian transition in western Europe (Valentin 2008). The most plausible scenario to explain the appearance of this genetic component in the Villabruna Cluster is a human migration from West Asia into Europe at the end of the Pleistocene. The Satsurblia Cluster individuals were not the direct source of this gene flow but were related to the population that migrated to Europe and contributed to the genome of the Villabruna Cluster (Fu et al. 2016). This suggests that the Epipaleolithic population of the Caucasus could provide some genetic and probably cultural contributions to the development of the Epigravettian populations of Europe, particularly in Italy, but not vice-versa.
15. The substantiation of the cultural specificity of Epipaleolithic assemblages from different parts of the Caucasus is an important goal of future research. At present we can only suggest the formation of two local variants within the Epipaleolithic Imeretian entity in the Caucasus (see Golovanova and Doronichev 2020)—the Northern Caucasus variant (with trapezes and beads made from pierced shells of terrestrial molluscs), and the Southern Caucasus variant (with scalene triangles and stone pendants).

In conclusion, it should be underlined that the results of recent studies, available to date and presented in this article, indicate that the most crucial factors for hominin settlement during the entire Upper Pleistocene in the northwestern Caucasus were favorable climatic and environmental conditions. It is during these periods that the number of sites significantly increases and the sites are confined to different landscapes, which suggests a wider human exploitation of the NWC and a good knowledge of the regional resources by Paleolithic hunter-gatherers.

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