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Kostenki 1 and the early Upper Paleolithic of Eastern Europe

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ABSTRACT

Although best known for its spectacular Gravettian features and art, the open-air site of Kostenki 1 (located near Voronezh on the Don River [Russian Federation]) also has played an important role in the study of the early Upper Paleolithic (EUP) of Eastern Europe. New excavations at Kostenki 1 were undertaken in 2004–2012 with a focus on the EUP layers (Layers III–V), which represent temporal zones of recurring occupation, buried in low-energy slope deposits (5% slope). Soils formed during periods of increased surface stability. A new set of radiocarbon estimates on wood charcoal indicates that Layer III dates between 33,000 and 38,000 cal BP. Layer V underlies the CI tephra (~40,000 cal BP), which is redeposited and identified only by microscopic analysis of sediment samples in most of the (downslope) areas of the site excavated during 2004–2012. Large and medium mammal remains recovered from the EUP layers include mammoth, horse, reindeer, arctic fox, and wolf, and taphonomic analyses indicate that carcasses were processed at the site. All EUP layers yielded artifacts typical of the East European *Strelets* industry (e.g., bifaces, side-scrapers), but earlier excavation (1948–1953) of Layer III also produced diagnostic Aurignacian artifacts (e.g., carinated scrapers, retouched bladelets). The new chronology for Layer III suggests an association between the Aurignacian of the central East European Plain and the warm intervals (GI 8–GI 7) following the HE4 cold period (~38,000–40,000 cal BP).

1. Introduction

Kostenki 1 has played an important role in the discovery and interpretation of the early Upper Paleolithic (EUP) of Eastern Europe, extending far beyond the relatively modest quantity of EUP artifacts and features the site has yielded since 1938. From the initial discovery and recognition of an EUP presence at Kostenki 1, archaeologists have struggled to understand how it fits into the Upper Paleolithic at the Kostenki-Borshchevo sites as a whole, and also into the wider pattern of EUP settlement in Eastern Europe (e.g., Efimenko, 1958: 435–441; Rogachev et al., 1982: 62–66) (Fig. 1).

Paradoxically, the lithostratigraphy of Kostenki 1 is anomalous among the Kostenki-Borshchevo sites and this fact has complicated efforts to integrate the EUP layers with the other sites. Since the 1950s, most cultural layers at the Kostenki-Borshchevo sites that underlie the loess-like loams of the Late Pleniglacial (MIS 2) have been described in terms of their position with respect to the *Upper Humic Bed* and the *Lower Humic Bed* (both dated to the MIS 3 age equivalent), which are separated by sterile loams and a volcanic ash (e.g., Lazukov, 1957; Rogachev, 1957; Velichko, 1961; Klein, 1969). At the location of the original 1879 discovery of artifacts and extinct fauna, however, the two humic beds and volcanic ash are identifiable only in some areas of the site (Lazukov, 1982: 23). Their absence in other areas of the site has created uncertainties about the stratigraphic position of the lower EUP layers and Anikovich (1993: 5) suggested that at least some of the remains assigned to the lowest cultural layer (Layer V) at Kostenki

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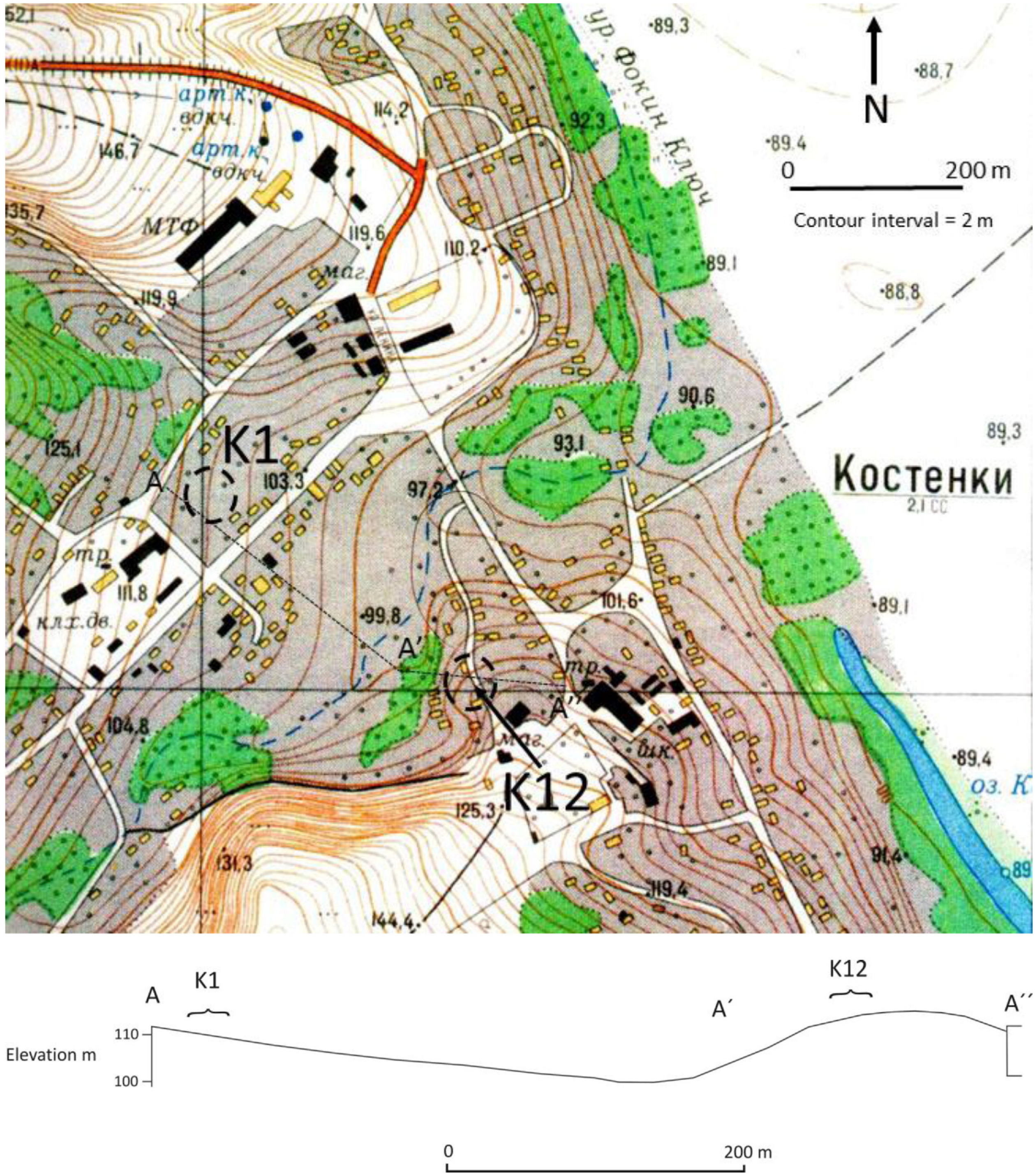

Fig. 1. Topographic setting of Kostenki 1 and Kostenki 12 on opposing sides of the mouth of Pokrovskii Ravine (above) and profile for a transect between the two sites (below), illustrating the differences in topography of the second terrace on opposite sides of the ravine (base map from ГУГК СССР).

1 were derived from a younger occupation. On the other hand, *in situ* buried soils were recognized first at Kostenki 1 (Lazukov, 1982: 24; Praslov, 1985: 25–28), including a distinct buried soil associated with EUP Layer III that exhibits many similarities to the coterminous and widely distributed *Bryansk* soil.

Unlike most EUP sites in Eastern Europe, Kostenki 1 yielded diagnostic elements of the Aurignacian technocomplex (e.g., carinated end-scrapers, retouched bladelets), which were recovered—eventually in association with skeletal remains of *Homo sapiens*—from Layer III. Along with *Syuren' 1* in Crimea, Layer III at Kostenki 1 became the most important Aurigancian locality in Eastern Europe (Anikovich et al., 2007a: 228–233). At the same time, EUP Layer V yielded small bifacial points in 1938 that became the principal diagnostic element of the *Strelets* industry—the most widespread EUP entity in Eastern Europe and one that often is compared to the "transitional" Szeletian industry of Central Europe because of its high percentage of typical Mousterian forms (e.g., Efimenko, 1958: 435–441).

2. History of research

For almost half a century after the initial discovery, research at Kostenki 1 was confined to the uppermost cultural layer (Layer I),

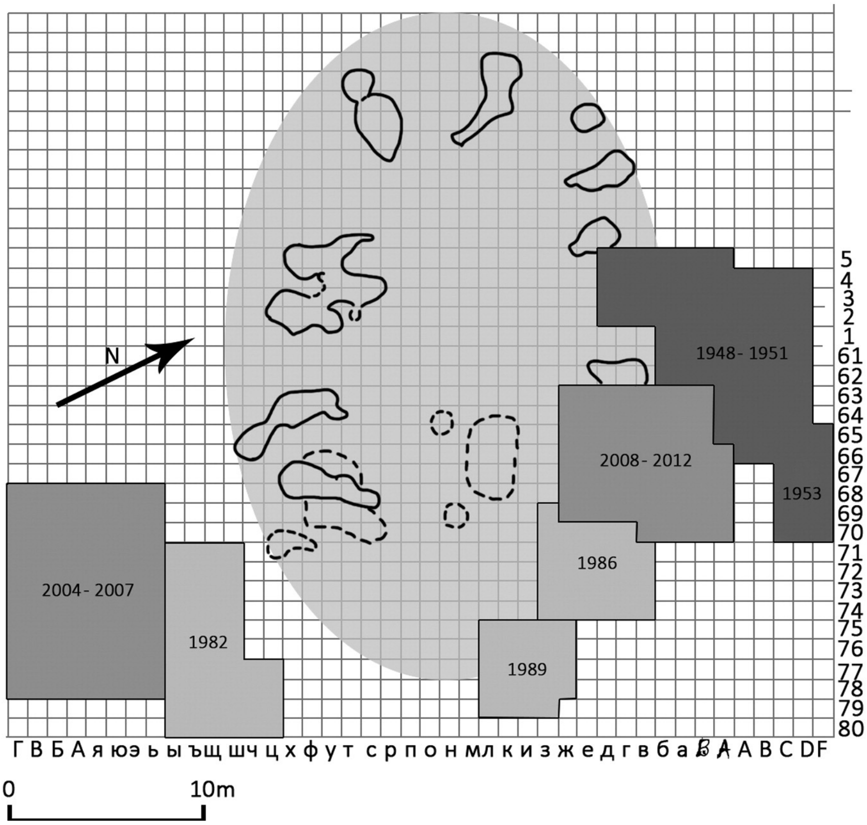

Fig. 2. Kostenki 1 excavation grid showing the location of areas investigated by Rogachev during 1948–1953, areas excavated during the 1980s, and areas excavated during 2004–2012. The positon of Feature Complex 2, which was uncovered on Layer I (Gravettian), is shown in the center (light gray) (map prepared by A. E. Dudin).

which eventually yielded spectacular features and mobile art of the Gravettian technocomplex (e.g., Efimenko, 1958). In 1931–1932, P. P. Efimenko observed older artifacts in a deep excavation unit, more than 3 m below the surface (Rogachev, 1950: 64). In 1938, A. N. Rogachev excavated a small unit (apparently located on the southwest margin of Feature Complex 1 in Layer I uncovered by Efimenko during 1931–1936) and identified an archaeological horizon 3.6 m below the surface (subsequently recognized as Layer V) containing diagnostic bifacial points with concave bases. However, Rogachev joined the Soviet Army in 1939, and two years later, field research at Kostenki came to halt with the German invasion of the Soviet Union (Rogachev et al., 1982: 42; Platonova et al., 2008: 28–30).

Rogachev resumed excavation at Kostenki 1 in 1948 with three large excavation units (in the same area of the 1938 test unit), and discovered three new horizons (Layers II–IV) in addition to the deeply buried level encountered before the war. Between 1948 and 1953, Rogachev excavated an area of approximately 110 square meters on the southwest margin of Efimenko's Feature Complex 1 (between д and E, and lines 5 and 70, inclusive on the Kostenki 1 grid). This research, which was undertaken in conjunction with excavation of EUP levels at other Kostenki sites and with the study of the geology of the area by Grishchenko and others, yielded a wealth of data on the EUP layers (Lazukov, 1957; Rogachev, 1957; Anikovich and Platonova, 2014).

Further investigation of the lower layers at Kostenki 1 did not occur until 1979 (Rogachev et al., 1982: 42), and was followed by additional excavation of areas in the southern portion of the site during 1982, 1986, and 1989. Some additional small units were opened in this area in the early 1990s, and in 2004 these units were re-exposed and examined as a whole (Anikovich et al., 2006: 87). During 2004–2012, a new phase of investigation—focused specifically on the EUP layers—was undertaken at Kostenki 1 (Anikovich and Platonova, 2014), and units in the southwestern area were excavated in 2004–2007, while an area adjoining Rogachev's 1948–1953 field research was excavated in 2008–2012 (see Fig. 2). The total area excavated was 153 square meters (Table 1).

Excavation methods employed during 2004–2012 were developed over a period of many years by the Institute of Material Culture History,

Table 1
Excavations at Kostenki 1: 2004–2012.

Year	Area excavated	Units excavated	Notes
2004		L-shaped trench (units ь-72–ь-76)	Large concentration of mammoth bones recovered from Layer V
2005	15 m^2	Units Э, Ю, Я/72–76	Small excavation, additional artifacts and mammoth remains recovered from Layer V
2006	46 m^2	Units Г–ь/68–78	22 m^2 of layer V excavated; material recovered from Layers III, IV, and V; bifacial point fragment in Layer III
2007	46 m^2	Units Г–ь/68–78	Material recovered from EUP Layers III, IV, and V
2008	24 m^2	Units β, а, б, в/63–68	Large concentration of mammal bones in Layer III
2009	25 m^2	Units β, а, б, в/65–68	Excavation of large bone concentration and anatomically articulated sequences in Layer III
2010	36 m^2	Units α, β, а, б, в/65–69	Material recovered from Layer III and lower-lying occupations
2011	16 m^2	Units г, д, е, ж/65–68	Anatomically articulated sequences of mammal bone in Layer III
2012	8 m^2	Units г, д, е, ж/63–64	Excavation of northwest margin of Layer III bone concentration; depositional setting of Layers IV and V

Table 2
Stratigraphic field description and soil micromorphology for Kostenki 1 (2004 excavation).

Unit	Depth, cm	Soil Horizon	Description* (V. T. Holliday)	Archaeology	Soil Micromorphology (P. Goldberg and R. I. Macphail)
	0–20		Historic Fill		No data
3	20–60	A1	Chernozem; black (2/5/1d) loam; strong, medium granular structure; very irregular boundary		No data
	60–90	A2	Chernozem; very dark gray (3.5/1d) loam; strong medium granular and weak subangular blocky structure; very common distinct krotovinas ~5 cm in diameter; very irregular boundary		No data
	90–125	Bk	Light yellowish brown (6/4); weak prismatic, moderate subangular blocky structure; common dispersed carbonate and common carbonate threads; common distinct krotovinas ~5 cm in diameter; clear, smooth boundary		No data
Gmelin Soil	125–160	Btkw1b1	Yellowish-brown (5/4) silt loam; strong prismatic and strong subangular blocky structure; common, dispersed carbonate and carbonate threads; common, distinct krotovinas ~5 cm in diameter; clear, smooth boundary	Layer II	The upper part is sandier than the lower part (sand is concentrated in upper left-hand part of the slide). Many rounded chalk grains, some of which are coated, suggesting slope movement or cryoturbation. Some quartz also shows thin, patchy clay coatings, suggestive of a Bt, but they are not well developed. These latter clay coatings appear pedogenic, whereas the thicker coatings mentioned before these appear to be more depositional, associated with sediment transport and movement. Secondary carbonate lines some voids and appears to cover, i.e., post-date the clay coating phase.
	160–176	Btkw2b1	Dark yellowish brown (4.5/4) silt loam; weak prismatic and moderate subangular blocky structure; common, faint and common, distinct krotovinas ~5 cm in diameter; abrupt, very irregular wavy boundary		This sample is essentially carbonate and quartz sand that has been secondarily cemented by calcite. No secondary clay was observed and domains of non-calcareous matrix material can be seen as elsewhere.
	176–182	Cb1	Massive pale brown (6/3) silt loam; common, discontinuous lenses of chalk fragments; abrupt wavy lower boundary		No data
2	182–215	Btk1b2	Yellowish brown (5/4) silt loam; moderate prismatic to strong subangular blocky structure; few to common krotovinas		This is a poorly sorted calcareous mud with inclusions of quartz sand, silt, and rounded limestone fragments. Nodular carbonate and smaller hypocoatings are visible. Channel porosity is quite distinct in this sample.
	215–230	Btk2b2	Dark yellowish brown (4/4) silt loam; moderate prismatic to strong subangular blocky structure; few soft bodies of carbonate; common carbonate films and threads on ped afces; few to common krotovinas; abrupt, very irregular lower boundary (lower boundary of b2 soil represents tonguing of soil into underlying silt; tongues dipping north)	Layer III	This is a relatively fine grained sample with a matrix composed in part of rounded silty calcareous clay. Among the aggregates and within them are rounded grains of quartz sand, rounded and broken granules of chalk, rounded silty iron nodules. Fe/Mn spots occur throughout with some concentrations in biovoids. Non-calcareous domains (decalcified matrix?) with speckled b-fabrics occur. One thin fragment of bone and some brownish organic matter. Some chambers from roots. No ice lensing was observed, and there is only partial rounding of grains, aggregates, and nodules
	230–298	C1b2	Massive light yellowish brown (6/4) silt; rare small (several mm) chalk fragments; common Fe-oxide staining along root channels; clear, wavy lower boundary	Layer III	Numerous voids, particularly channels, which can be seen at the macroscale and which could be late stage after deposition. Some of this porosity could be recent as one of the vertical channels appears to have the remnants of a modern root. Overall, it is similar to sample described above, but there are Fe concretions here with concentric forms. Some non-calcareous speckled b-fabric silty clay as described above. In this thin section, there is more individualized and distinct rounding of the grains suggestive of cryoturbation. There is no evidence for water deposition or freeze-thaw other than the rounding of the grains produced by cryoturbation. Although the field designation is 'upper massive silt' in thin section there is relatively little quartz silt, and in fact, most of the material is in the form of calcareous pellets. Most of the sample is calcareous except for non-calcareous domains (quartz silt + clay).
	298–316	C2b2	Massive yellowish brown (5/4) silt; few chalk fragments; rare Fe-oxide staining along root channels; clear wavy lower boundary	Layer IV	No data
	316–330	C3b2	Massive very pale brown (7/4) silt with faint bedding; common chalk fragments; common Fe-oxide staining along root channels		No data
	330–358	Bw1b3	Yellowish-brown (5/4) silt loam; weak prismatic and moderate subangular blocky structure; common chalk fragments, locally in masses; few krotovinas	Layer V	Quite massive sandy silty calcareous matrix, which appears to have more quartz sand than sample described above. But punctuated by numerous fine channels *vs.* coarser ones in above sample. Some fine silt-sized shreds of humified organic matter. Large calcified root. The only evidence for weathering is the formation–in various stages–of goethitic nodules, which suggests that iron nodule/concretion formation took place for a relatively long time. They would be likely produced by saturation of the sediment either by ground or surface water.
	358–368	Bw2b3	Dark brown (4/3) silt loam; moderate subangular blocky structure; few krotovinas; abrupt very wavy boundary (lower boundary of b3 soil represents tonguing of soil into underlying silt; tongues dipping north)	Layer V	This sample is a very poorly sorted mixture of medium and coarse quartz sand, iron nodules and concretions in a calcareous matrix. Locally are incipient carbonate nodules which are post-dated by Fe/Mn staining and particularly void coatings. There is a considerable amount of bioturbation, both as cm-size burrows and also chambers from roots. Some snail fragments were observed, as well as one rounded, sand-sized bone

Table 2 (*continued*)

Unit	Depth, cm	Soil Horizon	Description* (V. T. Holliday)	Archaeology	Soil Micromorphology (P. Goldberg and R. I. Macphail)
					fragment. The most striking aspect of the sample are fragments of humified organic matter that are dispersed throughout. They are not concentrated in layers, but most of them are well integrated into the matrix, presumably as a result of bioturbation. They would appear to be detrital grains and appear to have been deposited along with the other components.
	368–392	C1b3	Massive light yellowish brown (6.5/4) silt		No data
1	392–400	C2b3	Bedded chalk fragments		No data

* All colors are 10YR, dry unless noted

Russian Academy of Sciences and the Kostenki Museum-Preserve. Excavation of cultural layers was performed with sharp knives, which are more suitable than trowels for the highly compact sediment at Kostenki. All artifacts and bones were individually point-provenienced (depths measured from datum with a conventional transit) except for small concentrations of occupation debris, which were mapped as units (see maps of specific excavation blocks/layers below). Excavated sediment was not sieved, however, and controlled experiments indicate that this is likely to result in loss of some small items (e.g., Payne, 1975).

3. Geoarchaeology: stratigraphy, dating, and site formation

Kostenki 1 is situated near the mouth of *Pokrovskii Ravine*, on the Don River second terrace, which extends into the ravine. The ravine is incised into the high west bank of the Don River, which is composed of Cretaceous bedrock and represents the eastern margin of the Central Russian Upland. The site is found on the north side of the ravine, roughly opposite the site of Kostenki 12 (on the south side of the ravine mouth). At Kostenki 1, a small tributary ravine (*Kozlov Ravine*) has cut a shallow channel into the second terrace on the east side of the site (see Fig. 1).

The EUP layers at both Kostenki 1 and 12 are buried in a sequence of slope deposits (with some localized alluvial deposits) that overlie alluvium of the second terrace, which is 15–20 m above the modern Don floodplain (Lazukov, 1982: 22–25; Holliday et al., 2007: 194–210). The colluvium is largely derived from the steep walls of the ravine and west bank of the river, and the surfaces of the two sites slope towards the ravine. On the north side, the second terrace has formed a relatively broad and level surface, while the south side is characterized by steeper slopes and a narrower terrace (see Fig. 1). The EUP cultural remains at both sites exhibit evidence of disturbance from slope movement however (e.g., Hoffecker et al., 2010: 1081–1083). At both Kostenki 1 and 12 and throughout the area, the deposits that contain the EUP layers also contain buried soils, indicative of episodes of sedimentation separated by periods of prolonged landscape stability with soil formation.

3.1. Stratigraphy

During 2004–2012, stratigraphic observations were made in both the area excavated during 2004–2007 (southern margin of Kostenki 1) and during 2008–2012 (northern area, adjoining Rogachev's 1948–1953 excavations) (see Fig. 2). A stratigraphic profile for the southeast part of the site was recorded in August 2004 (Unit ы-80) and is presented in Table 2, along with the results of soil micromorphology analyses by P. Goldberg and R. I. Macphail. A stratigraphic profile for the northern area was recorded in August 2008 (Units β-64 to β-66), and is presented in Table 3, along with supplemental micromorphology observations. Profile descriptions and stratigraphic nomenclature follow the protocols discussed by Holliday et al. (2007: 188–189), and soil micromorphology methods are described in Courty et al. (1989). Correlation of the lithostratigraphy, soil stratigraphy, and cultural stratigraphy in both areas is presented in Table 4.

The stratigraphy of the southern part of the site was minimally disturbed by erosion. At the base of the profile (392–400 cm; Table 2) is alluvium composed of chalk fragments and massive silt (Unit 1) (Lazukov, 1982: 23; Holliday et al., 2007: 208). The chalk fragments are probably alluvial gravel, but the exposure was very limited. The modern water table intersects this unit, inhibiting exposure of more than a few decimeters of the deposit. At other sites (e.g., Kostenki 14), where the water table is lower, the alluvium is more fully exposed (Holliday et al., 2007: 201–203).

The basal alluvium is overlain by a thick bed of silt and silt loam (Unit 2: 182–392 cm; Table 2) that represents colluvium largely derived from higher slopes that adjoin the steep walls of the ravine. The colluvial character of the deposits is indicated by the pronounced slope (towards Pokrovskii Ravine) and the soil micromorphology analyses (see Table 2). A slope angle of 3° (5% gradient) was estimated for the b2 soil (see below) in the southwest wall profile extending 4 m from Unit ы-77 to ы-80 (see Anikovich et al., 2006: 94, fig. 4).

Within the thick section of silt loam are two moderately developed buried soils (b2, b3; Table 2; Fig. 3). They are unusual in that they have zones somewhat higher in organic matter (based on color; 358–368 cm in b3; 215–230 cm in b2; Table 2) low in the respective profiles that grade up into the thicker and redder part of each soil—essentially the opposite of a typical soil profile. The implication is that the end of silt loam sedimentation was followed relatively abruptly by stability, abundant biological activity and biomass production, and humification. The micromorphology of these two zones (Table 2) also suggests some redeposition of the humified material. Formation of these two zones was followed by slow accumulation of more silt loam with a fluctuating water table indicated by iron oxidation, and then more rapid sedimentation, indicated by the lack of or minimal weathering.

The organic-rich zones may be local equivalents to humic lenses. The lower boundaries of the two buried soils are very irregular, comprising tongues of the respective soil horizons penetrating into the underlying silt. The tongues also dip north (upslope) (see Fig. 3). The darker, lower horizons of the two buried soils apparently reflect relatively dense vegetation cover following silt deposition. This vegetation included rooting into the silt (and formation of the tongues). Rates of sedimentation increased and the soil aggraded more rapidly than biomass production. The surface then stabilized and the redder Bw soils formed. The dipping tongues may represent the effects of slight mass movement, perhaps under periglacial conditions, downslope towards Pokrovskii Ravine.

The uppermost two meters of the sequence (Unit 3: 0–182 cm; Table 2) consists of discontinuous lenses of chalk gravel in a silt matrix near its base, the Gmelin Soil (125–176 cm), and the overlying loess-like loam. The lower contact is an erosional disconformity with the colluvium containing the b2 soil and the gravel lenses rest on this disconformity. This erosional contact is in the same stratigraphic position as a regional disconformity with coarse limestone rubble noted in other sites in the area (Holliday et al., 2007: 219). The Gmelin Soil is significantly better expressed than the equivalent stratigraphic unit at other Kostenki sites. It has stronger structural development and a distinct calcic horizon. This pedogenic expression may be due to the level landscape setting rather than the slope position occupied by the other sites. The micromorphology (Table 2) also suggests the possibility that the soil was subjected to cryoturbation. The top of the profile is composed of loess-like loam over 1 m thick with the characteristic Chernozem surface soil, strongly mixed by bioturbation.

The lower stratigraphy in the northern part of Kostenki 1 is more complex than that in the southern section. On the east wall the lowermost section exposed above the water table (285–376 cm; Table 3) consists of massive silts with lenses of chalk rubble (Unit 1) overlain by heavily contorted silts, humic lenses, and lenses of fine-grained carbonate (lower Unit 2). Some of these lenses can be traced up into overlying micro-stratified beds that slope down generally to the north (274–286 cm) (Fig. 4). The zone with these dipping finely-bedded lenses, which cuts out the contorted zone, also includes shallow, narrow depressions that may be small channels with nested fills. The micromorphology of a thin section of that part of the profile with the nested fills revealed repeated (very thin) lenses of carbonate and humified organic matter, similar to observations for the classic humic beds at Kostenki 12 (Holliday et al., 2007: 195–200). In a lateral section provided on the north wall, the north-dipping beds can be seen to be channel fills. A series of rills must have incised and filled along the north side of the site.

Above the more humic north-dipping beds are silts and very fine-grained carbonates (upper Unit 2: 229–274 cm) in slightly contorted north-dipping layers. This zone is capped by a discontinuous but distinct and locally contorted humic lens (225–229 cm) similar in morphology to the classic humic beds from other sites in the area such as Kostenki 12 and 14. Immediately above is a thin layer of silt (208–225 cm) modified by pedogenesis (b2 soil) also superimposed over the underlying humic lens (hence the "BwA" designation for the humic lens). This b2 soil is broadly similar to the b2 on the southeast section described above, with the distinct darker zone at the base of the B horizon (see Fig. 3). This soil was truncated (at 208 cm) and buried by more silts. In terms of morphology and stratigraphic position, the b2 soil and the underlying humic and carbonate lenses (below 274 cm) may be facies of the classic Humic Beds. And as discussed below, the zone below 274 cm has traces of tephra, which is typically above the Lower Humic Bed (Holliday et al., 2007).

Above the b2 soil are layers of silt more than two meters thick (Unit 3: 0–208 cm). The disconformity at the base of the Unit 3 silt is in the same stratigraphic position as the disconformity at the base of Unit 3 in the southern profile. The lower half of Unit 3 (90–208 cm) is strongly modified by pedogenesis with formation of the Gmelin Soil. As in the southern exposure, the soil here is more strongly expressed than it is in other Kostenki localities. The upper meter of silt is the "loess-like loam" with regional Chernozem soil.

Previous investigators (e.g., Lazukov, 1957, 1982; Rogachev, 1957) noted humic beds and volcanic ash exposed at Kostenki 1, similar to the classic stratigraphy exposed at other archaeological sites along Pokrovskii Ravine. The profiles exposed in 2004–2012 did not reveal the classic humic beds, but only the buried soil sequence described above. The truncated b2 soil (208–229 cm) and the underlying humic layers (225–229 and 274–285 cm) in the north block (Table 3) have some similarities to the classic humic beds with dictinct, convoluted gray humic lenses, and distinct, somewhat contorted lenses of very fine-grained carbonate.

There are several characteristics of the setting of Kostenki 1 that are unusual compared to other sites in the area, and may explain the anomalous stratigraphy. The sediments are predominately fine-grained and limestone fragments are rare. This is probably due to distance from bedrock valley walls. The humic beds described by other workers were exposed upslope (to the northeast and north) and in thicker sequences of loam. Their formation was directly or indirectly driven by seeps and springs (Holliday et al., 2007: 221), which in turn probably were linked to the bedrock. Thus, proximity to the ravine walls probably played a role in formation of the humic beds. Seeps and springs are more likely nearer the slopes, as are the thicker, slope-derived strata, which include silt redeposited from the upland loess, and fragments of limestone bedrock. Thicker slope-derived deposits are therefore more likely to contain humic beds; well drained soils and sediments farther away from the slopes, and thus farther from the seeps and springs, will exhibit better drained soils. The distance from the slopes also explains the relative scarcity of limestone fragments.

Kostenki 1 occupies a relatively broad and level second terrace surface, which is due to the lack of slopewash coming off of the ravine wall. The slopewash is more limited in extent, perhaps because the ravine wall above the site has a more gentle slope than that of the EUP occupations on the south side of the ravine (Kostenki 12 and 14). [A slope angle of 7° (11% gradient) was estimated for the layer containing Layer IV on the east wall at Kostenki 12 (1999–2004 excavations) between Unit ы-84 and ы-91 (see Anikovich et al., 2005: 85, fig. 8).] Redeposited sediment is present in the strata, based on micromorphology (Table 2), but the terrace deposits observed are not as overwhelmed with slopewash in terms of thickness and coarser sediments, as are the other sites.

Because Kostenki 1 is positioned farther out from the ravine slopes than other Kostenki sites it could be affected by river water backed up

Table 3
Stratigraphic profile for Kostenki 1 (2008 excavation), recorded in August 2008 in Unit ß-66.

Unit	Depth, cm	Soil Horizon	Description
3	0-55	A1	Chernozem; very dark brown (2.5/1) loam; strong, medium granular structure; very irregular boundary
	55-75	A2	Chernozem; dark gray (3.5/1) loam; strong, medium granular and weak subangular blocky structure; very common, distinct krotovinas, ~5cm in diameter; very irregular boundary.
	75-90	Bk	Light yellowish brown (6/4) silt loam; weak prismatic, moderate subangular blocky structure; common, dispersed carbonate and common carbonate threads; common, distinct krotovinas, ~5cm in diameter; clear, smooth boundary
Gmelin Soil	90-126	Btkb1	Yellowish brown (5/4) silt loam; strong prismatic and strong subangular blocky structure; common, dispersed carbonate and carbonate threads; common, distinct krotovinas, ~5cm in diameter; clear, smooth boundary
	126-208	Bkb1 (Btwkb1?)	Dark yellowish brown (4.5/4) silt loam; coarse weak prismatic and moderate subangular blocky structure; common, faint and common, distinct black to dark gray krotovinas, ~5cm in diameter; abrupt, very irregular wavy boundary
2	208-225	Bwb2	Yellowish brown (5/4) silt loam; moderate fine prismatic to strong fine subangular blocky structure; few to common krotovinas
HB?	225-229	BwAb2	Dark yellowish brown (4/4) (ped interiors 5/4cm) silt loam; moderate prismatic to strong subangular blocky structure; few soft bodies of carbonate; common carbonate films and threads on ped faces; few to common krotovinas; abrupt, very irregular lower boundary; 226-229 cm encases **Layer III**
	229-256		shallowly N-dipping beds of silt and carbonate; light gray (7/2), brownish yellow (6/6), very pale brown (8/2) slightly moist; few ls clasts; most contacts on beds are abrupt, wavy
	256-274		as above but darker; light gray (7/1, 7/3 slightly moist); most contacts on beds are abrupt, wavy
	274-285	b3?	laminated, microstratified, organic-enriched silts; pale brown (6/3), light gray (7/2); localized lenses if fine carbonate; north-dipping laminae with pockets of nested, concave laminae (filling microchannels?); Fe-ox stains 6/6 as discrete bodies along bedding planes; abrupt, wavy.
	285-332		heavily contorted beds and laminae of silty clay, humic lenses, and carbonate that can be traced up into above laminae; 5/3, 5/8, 8/1, 3/2; Fe-ox mottling (6/6sm) locally common, rarely following bedding; underlying silt locally interfingers with this zone; abrupt, irregular
1	332-376+		homogeneous silt with zone local faint bedding; 7/2sm; krot 7/4sm; pocket of ls rubble locally common.

Section measured down to Layer III in Southeast corner of Main Excavation Block; measured in and below Layer III on Northeast corner of deep pit at north end of block All colors = 10YR, dry unless noted

Table 4
Stratigraphic correlation of lithostratigraphic units, soils, and cultural layers for the areas excavated in 2004–2007 (southwest) and 2008–2012 (northeast) at Kostenki 1.

	Southwest (2004 profile)		Northeast (2008) profile	
Stratigraphic unit	Soil horizonation	Cultural layer	Soil horizonation	Regional correlation
3	A1		A1	Loess-like Loam
	A2		A2	with Chernozem
	Bk		Bk	
Gmelin Soil	Btkw1b1	Layer II	Btkb1	*Gmelin Soil*
	Btkw2b1		Bkb1	
	Cb1			
2	Btk1b2		Btwb2	Upper Humic Bed?
	Btk2b2	Layer III	BwAb2	
	C1b2			
	C2b2	Layer IV		
	C3b2			
	Bw1b3	Layer V	humic beds	Lower Humic Bed?
	Bw2b3	Layer V		
	C1b3			
1	C2b3			

into the ravine during flooding on the Don. Such floodwater would likewise leave behind redeposited silt originally derived from upland loess. The exception to the otherwise ubiquitous evidence for low-energy geomorphic processes are the laminated and convoluted layers, and the cut-and-fill sequences, noted at the base of the north exposures below 103 cm (Table 3). This area of the site is closer to the valley wall however and—more significantly—near the channel on the east side of Kozlov ravine.

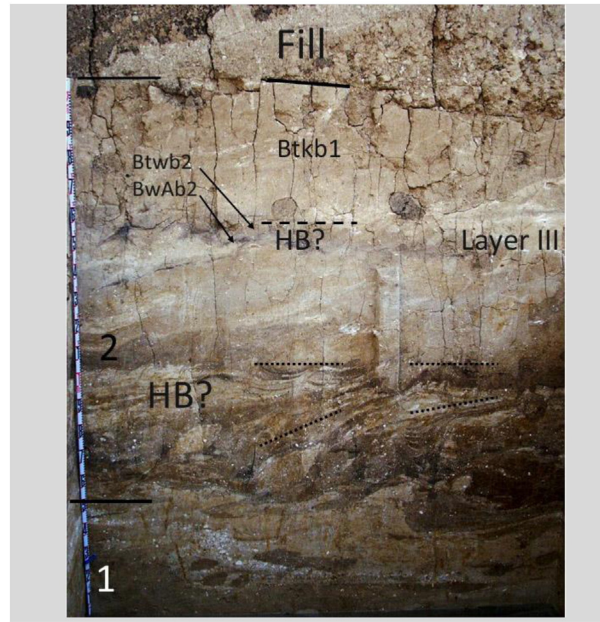

Fig. 4. Stratigraphic profile at Kostenki 1 exposed on the east wall of Unit ß-66 (northern excavation 2008) showing the lower lithostratigraphic sequence (Units 1 and 2 at right), soil stratigraphy (center), and position of Layer III (right) (see Table 3). The photo illustrates the heavily contorted silts, humic lenses, and carbonate below the possible Humic Bed equivalent ("HB?") consisting of finely bedded, north dipping (i.e., dipping to the left) silt, humic lenses and carbonates (bracketed by the two pairs of dotted lines). Scale is 2 m long, subdivided in decimeters (photo by V.T. Holliday, August, 2008).

3.2. EUP occupations: cultural layers III–V

In defining the EUP archaeological layers, Rogachev (1957: 30–37) followed an approach similar to that employed with the younger layers (Layers I–II), which represent distinct occupation horizons (even if they may contain multiple occupation events). Rogachev (1957: 32) nevertheless described the uppermost EUP level (Layer III) as "unusually thick" (40–50 cm), without clear upper and lower boundaries, and containing at least three micro-stratigraphically separated occupation levels (based on the vertical provenience of multiple hearths in an area of ~30 m^2) (see Klein, 1969: 112–113). Rogachev (1957: 35) also reported that the remains from underlying Layer IV were very sparse (and in small concentrations), and that most of the material in the lowermost EUP level (Layer V) were concentrated in an area roughly 6 m in diameter.

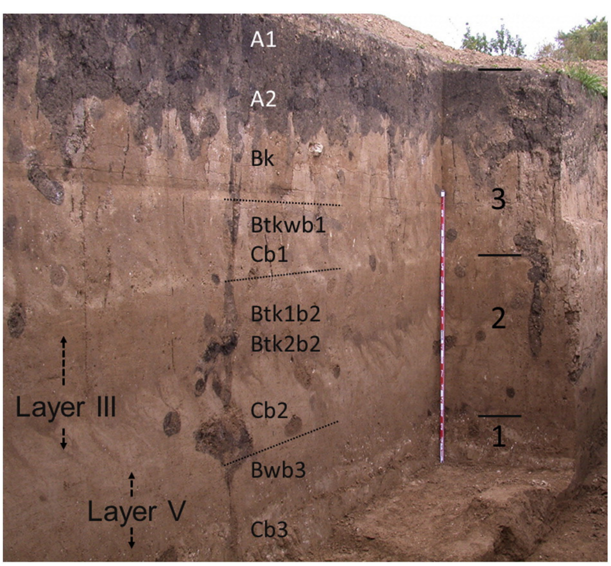

Fig. 3. Stratigraphic profile at Kostenki 1 exposed on the southwest wall of Units ь-72 through ь-75, southeast excavation block (2004) indicating: 1) the lithostratigraphy, Units 1–3 (right); 2) the soil stratigraphy (center); and 3) the stratigraphic position of cultural layers (left) (see Table 2) (subdivisions of the Btkwb1, Cb2, Bwb3, and Cb3 horizons, described in Table 2, are not indicated here). The darker color (due to enrichment by organic matter) of the lower b2 soil (Btk2b2) is apparent as are the north-dipping tongues of this horizon, penetrating into the underlying C horizon. Scale is 2 m long, subdivided in decimeters (photo by V. T. Holliday August 2004).

Although the depositional context of Layer III was originally described as "the middle part of a loess-like loam" at 220–260 cm below the surface (within the areas excavated during 1948–1953 [see Fig. 2]) (Rogachev, 1957: 30), later excavations in other areas revealed that Layer III was associated with a buried soil (e.g., Praslov, 1985: 26–28). The latter is particularly well represented in the southern areas of Kostenki 1 excavated during 2004–2007 and is identified as the "middle buried soil" Btk2b2 in the 2004 stratigraphic profile (see Fig. 3; Table 2). The underlying archaeological layers were assigned to the upper portions of the Upper Humic Bed (Layer IV: 315–325 cm below the surface) and Lower Humic Bed (Layer V: 350–380 cm below the surface), respectively, thus subdividing them by the volcanic ash (Rogachev, 1957: 35).

The absence of visible traces of the volcanic ash in many areas of Kostenki 1 (and other variations in the stratigraphy) made it difficult to assign artifacts to the lower layers in later excavations, and Anikovich (1977: 70) suggested that at least some of the remains assigned to Layer V might derive from younger levels. The problem was exacerbated by the scarcity or absence of artifacts in some areas. During 2004 and 2007, sediment samples were collected from wall profiles and analyzed for microscopic traces of tephra. The results indicated that the artifacts assigned to Layer V in areas excavated during 2004–2007 probably underlie the volcanic ash; this conclusion is supported by the soil stratigraphy (see above).

The area containing traces of Layers III–V exposed during 2004–2012 was almost 40% larger than the area excavated by Rogachev in 1948–1953, and the expanded sample provided new insight to the pattern of EUP occupation at Kostenki 1. In general, the spatial and vertical distribution of archaeological remains conformed to Rogachev's earlier observations, but the wider sample offered a clearer picture of the overall pattern. Evidence for micro-stratigraphic separation of occupation debris was encountered at the base of Layer III during the 2008–2009 excavations in the form of anatomically articulated large and medium mammal bones on different levels in the same unit (the articulated elements indicating that the bones had not been displaced vertically after deposition). Equally important, significant variations in both the horizontal and vertical provenience of artifacts and associated occupation debris indicated multiple occupation episodes in different places during the timespan represented by individual cultural layers. Examples include a concentration of artifacts encountered stratigraphically above the level of other finds assigned to Layer V in 2007 (described below). Many units contained only isolated artifacts or no artifacts assignable to specific layers.

The overall pattern of EUP occupation most likely represents one of recurring short-term visits over much, if not all, of the timespan represented by Layers III–V (i.e., >40,000 cal BP–ca. 30,000 cal BP [see below]). During this timespan, the EUP occupants of Kostenki 1 may have visited or camped in many different locations within the broad surface area of the second terrace on the north side of Pokrovskii Ravine (see Fig. 1). The small percentage of this area excavated below Layer II probably contains only a fraction of the total EUP sequence of occupations, which conceivably represent annual visits to the site. The apparent gaps in occupation below Layer II that encouraged Rogachev to assign the underlying artifacts to discrete cultural layers are equally, if not more likely, to represent a function of limited sampling.

The three EUP layers (Layers III–V) are more realistically conceived as "zones of occupation" without clear upper and lower boundaries. Each layer likely represents a large number of short-term visits over a period of several thousand years. The analysis of faunal remains recovered during 2004–2012 sheds new light on the EUP occupation at Kostenki 1, providing evidence of mammal carcass-processing at the site (see below). The pattern is consistent with short-term occupations related to kill-butchery activities and presumably reflects the sustained attraction of the active springs at Kostenki for animals and their human predators (especially during the late winter).

There are nevertheless two periods within the overall timespan of EUP occupation that may have witnessed significant departures from the broader pattern of settlement: (1) the cold interval following the CI volcanic eruption (Heinrich Event 4 [HE4]: ~40,000–38,000 cal BP), which may represent a hiatus or major decline in site use; and (2) the warm intervals following HE4 (~38,000–32,000), which may have seen more intense use of the site by larger groups of people. The EUP levels at Kostenki 1 yield supporting evidence for both of these departures from the overall pattern of occupation, but the challenge to investigators is to eliminate the possibility that it also is a function of limited sampling.

3.3. Dating: radiocarbon, OSL, and tephrochronology

By the mid-1990s, over a dozen radiocarbon dates had been obtained on the EUP levels at Kostenki 1 (Sinitsyn et al., 1997: Table 1). The dates were processed at five different laboratories by both conventional and accelerator methods and the materials dated included wood charcoal, bone, and ivory. These dates are shown in Table 5, along with several additional dates obtained before the 2004–2012 excavations, with calibrated ages. Most of the dates on Layer III are roughly 3000–5000 years younger than dates obtained more recently for this layer, and this presumably reflects the application of more effective pretreatment methods to the latter (e.g., Douka et al., 2010).

Eight new radiocarbon dates were obtained on the upper EUP occupation zone during and after the 2004–2012 excavations (see Table 6). All dates were obtained on wood charcoal with A-B-A pretreatment by accelerator method at two laboratories. With one exception (CURL-15811), the samples were collected from levels assigned to "Layer III," but may be considered to represent an extended phase of EUP occupation that post-dates the CI tephra (~40,000 cal BP). The calibrated ages fall between roughly 33,000 and 38,000 cal BP (95% probability), suggesting that the occupation zone may be correlated with several warm oscillations in the later part of MIS 3 (GI 5–8 in the Greenland stable isotope record) that followed the cold Heinrich 4 Event (see Fig. 5). No new radiocarbon dates were obtained on the lower occupation zone.

Five OSL dates were obtained on sediments from Kostenki 1 during 2004–2012 by S. L. Forman (see Table 7). The methodology is described in Forman et al. (2000) and Holliday et al. (2007: 225–228). Three OSL dates were obtained on samples collected from the stratigraphic profile shown in Table 2 (on the southern margin of the excavation area) and two dates were obtained from the 2008 profile shown in Table 3 (northeast). In general, the OSL dates on Kostenki 1 are consistent with the radiocarbon chronology, although one date (UIC1523) indicates a younger age, and another date (UIC2485) an older age, than the latter.

The most important chrono-stratigraphic marker for the EUP occupations at the Kostenki-Borshchevo sites is the volcanic ash, which has been identified as the *Campanian Ignimbrite* Y-5 (CI tephra), dating to ca. 40,000 cal BP (Pyle et al., 2006; Anikovich et al., 2007b; Hoffecker et al., 2008: 281–862). As at Kostenki 12, volcanic ash is visible to the

Table 5
Kostenki 1, Layers III–V: radiocarbon dates from excavations before 2004 (adapted from Sinitsyn et al., 1997: Table 1).

Lab No.	Provenience	Material	Radiocarbon date	Calibrated date[a]
GIN-4848	Layer III Unit Ж-72	Charcoal	20,900 ± 1600	29,357–21,887 calBP
GIN-2942	Layer III Unit Ж-72	Tusk[b]	22,000	
GIN-4850	Layer III Unit Д-72	Charcoal	24,500 ± 1300	31,588–26,251 calBP
GIN-6248	Layer III Unit Д-72	Charcoal	25,400 ± 400	30,581–28,708 calBP
GIN-4852	Layer III Unit Д-72	Burned bone	25,600 ± 100	30,176–29,395 calBP
GIN-4902	Layer III Unit Д-72	Burned bone	25,700 ± 600	30,998–28,715 calBP
LE-3541	Layer III	Charcoal	25,730 ± 1800	35,053–26,800 calBP
GIN-4849	Layer III Unit Ж-72	Charcoal	25,900 ± 2200	37,954–26,228 calBP
GrN-22,276	Layer III	Charcoal	25,820 ± 400	30,868–29,136 calBP
GIN-4885	Layer III Unit Д-74	Charcoal	26,200 ± 1500	34,076–27,721 calBP
GrN-17,117	Layer III	Charcoal	32,600 ± 400	37,987–35,697 calBP
OxA-7073	Layer III	Human bone	32,600 ± 1100	39,677–34,640 calBP
AA-5590	Layer III	Charcoal	38,080 ± 5460/3200	–36,649 calBP
GIN-6247	Layer V	Charcoal	> 18,800	
LE-2030	Layer V	Tooth[b]	27,390 ± 300	31,849–30,867 calBP
LE-3542	Layer V	Charcoal	30,170 ± 570	35,430–33,254 calBP
GrA-5557	Layer V	Charcoal	32,300 ± 220	36,714–35,672 calBP
GrA-5245	Layer V	Charcoal	34,900 ± 350	40,242–38,663 calBP
GrA-5245	Layer V	Charcoal	37,900 ± 2800/2100	49,416–38,497 calBP

[a] IntCal 13 (OxCal 4.2).
[b] *Mammuthus*.

Table 6
Radiocarbon dates from Kostenki 1, Layer III (upper EUP occupation zone).

Lab No.	Unit/depth	Material	Graphite used	∂^{13} C wrt PDB	Fraction modern	^{14}C age	Calibrated age[a]
AA-91463	(1989 units)	Charcoal	–	−23.6‰	0.0187±.001	31,960±430	36,902–34,894 calBP
AA-91464	(1989 units)	Charcoal	–	−23.8‰	0.0175±.001	32,500±460	38,049–35,498 calBP
CURL-15796	(2011 units) −285 cm	Charcoal	0.64 mg	−23.6‰	0.0266±.001	29,130±320	33,963–32,491 calBP
CURL-17829	вг-65, 66 −287–8 cm	Charcoal	0.62 mg	−22.5‰	0.0257±.0012	29,400±370	34,267–32,729 calBP
CURL-15801	(2011 units) −280 cm	Charcoal	0.59 mg	−25.9‰	0.0176±.001	32,460±480	38,055–35,412 calBP
CURL-17827	(2009 units)	*Pinus* sp.	0.57 mg	−23.7‰	0.0189±.0012	31,880±500	37,077–34,721 calBP
CURL-17832	вг-65, 66 −287–88 cm	*Pinus* sp.	0.53 mg	−23.2‰	0.018±.0012	32,280±530	37,926–35,086 calBP
CURL-15811[b]	(2011 units) −295 cm	Charcoal	0.55 mg	−23.9‰	0.021±.001	31,020±400	35,810–34,198 calBP

[a] IntCal 13 (OxCal 4.2).
[b] This sample was recorded as “Layer IV”.

unaided eye at Kostenki 1 only in limited (upslope) areas of the site (Lazukov, 1982: 23). In the areas excavated during 2004–2012, traces of the ash were detected microscopically by B. J. Carter in sediment samples collected by the senior authors (Holliday et al., 2007: 209). Sediments collected from the 2004 profile (Table 2) revealed “significant amounts of ash” between 260 and 310 cm below the surface (i.e., between the b2 and b3 buried soils) and smaller amounts of ash (similar morphology) in other samples collected at depths between 230 cm and 360 cm.

A similar pattern was observed in the analysis of samples collected from sediments underlying EUP Layer III to below Layer V (170–330 cm below surface) in the west wall of the 2007 excavations (Unit Г-72): a small quantity of ash (<1%) in all samples with slightly higher concentration at 290–295 cm (immediately above EUP Layer V). A different pattern was found, however, in the northern area excavated during 2008–2010 in samples collected from Unit β-64 (see Table 3), which yielded small quantities of ash (<1%) only from between 281 cm and 331 cm below surface within the lower portion of and below the b2 buried soil (see Table 4). Thus, although no new radiocarbon dates were obtained on Layer V, the position of the CI tephra suggests that it antedates 40,000 cal BP in the areas of the site excavated during 2004–2012.

4. Bioarchaeology: flora and fauna

4.1. Plant macro-fossils

In 2009 and 2011, G. M. Levkovskaya collected charcoal fragments from EUP Layer III. A total of 106 fragments were examined under 40–400× magnification by L. J. Crawford, who identified 98 specimens to the genus level. Among the latter, 90 specimens (89%) were assigned to the genus *Pinus* (pine) and 8 specimens (11%) were identified as *Abies* (fir). The remaining fragments (n = 8) were too decayed or damaged for identification to the genus level; 6 were identified as gymnosperms (softwoods) and 2 could not be identified as either an angiosperm (hardwood) or gymnosperm. A number of samples exhibited an

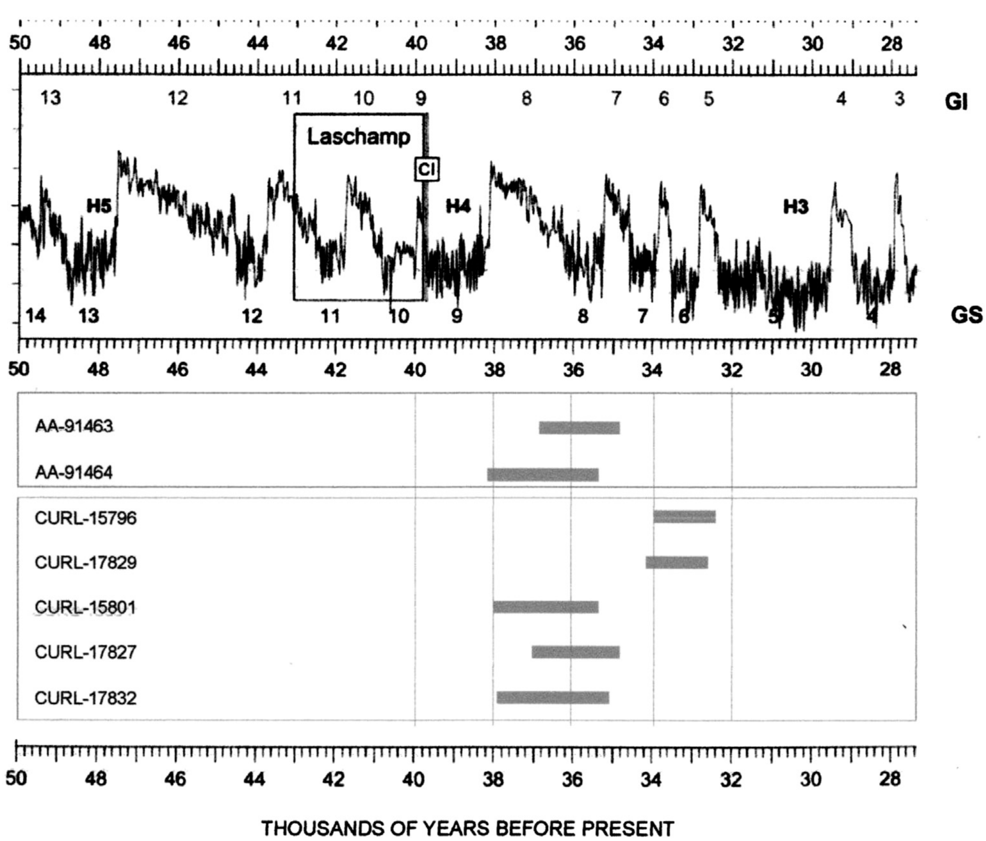

Fig. 5. Calibrated radiocarbon dates for Kostenki 1, Layer III compared with the Greenland NGRIP stable isotope record (adapted from Weninger and Jöris, 2008: 776, fig. 3). GI = Greenland Interstadial. GS = Greenland Stadial. H = Heinrich Event. Laschamp = Laschamp Paleomagnetic Excursion. CI = Campanian Ignimbrite volcanic eruption. The dates were calibrated with the IntCal13 curve (OxCal 4.2) (Bronk Ramsey et al., 2013).

Table 7
Optically stimulated luminescence ages for sediments from Kostenki 1 (S. L. Forman).

Lab No.	Unit	Depth	Equivalent dose (grays)	A value[c]	Uranium (ppm)[d]	Thorium (ppm)[d]	K_2O (%)[d]	Cosmic dose rate (Grays/ka)[e]	Total dose rate (Grays/ka)[f]	OSL age[g]
UIC1522	Ъ-80	185–195 cm	66.37 ± 0.07[a]	0.070 ± 0.002	1.83 ± 0.25	4.63 ± 0.66	1.04 ± 0.02	0.160 ± 0.016	2.16 ± 0.10	30,670 ± 2750
UIC1523	Ъ-80	260–270 cm	67.63 ± 0.12[a]	0.050 ± 0.002	1.76 ± 0.25	5.74 ± 0.74	1.15 ± 0.02	0.140 ± 0.014	2.21 ± 0.10	30,580 ± 2740
UIC2483	Ъ-80	304–315 cm	79.26 ± 0.61[b]	0.044 ± 0.004	2.0 ± 0.1	6.2 ± 0.1	0.97 ± 0.01	0.140 ± 0.014	2.13 ± 0.10	37,220 ± 2680
UIC2484	β-66	282–290 cm	71.48 ± 0.31[b]	0.041 ± 0.004	1.7 ± 0.1	5.2 ± 0.1	1.08 ± 0.01	0.140 ± 0.014	2.03 ± 0.10	35,230 ± 2540
UIC2485	б-65	380–386 cm	82.77 ± 0.74[b]	0.047 ± 0.004	1.3 ± 0.1	3.6 ± 0.1	0.68 ± 0.01	0.140 ± 0.014	1.44 ± 0.07	57,345 ± 4250

[a] Equivalent dose determined for this sample by the multiple aliquot additive dose method (Forman and Pierson, 2002).
[b] Equivalent dose determined for this sample by the multiple aliquot regenerative dose method (Jain et al., 2003). Blue emissions are measured with 3-mm-thick Schott BG-39 and one, 3-mm-thick Corning 7–59 glass filters that blocks >90% luminescence emitted below 390 mm and above 490 mm in front of the photomultiplier tube.
[c] Measured alpha efficiency factor as defined by Aitken and Bowman (1975).
[d] U, Th, and K content analyzed by inductively-coupled plasma-mass spectrometry analyzed by Activation Laboratory LTD, Ontario, Canada.
[e] Cosmic dose rate calculated from parameters in Prescott and Hutton (1994).
[f] Assumes a moisture content of 15 ± 5%.
[g] Systematic and random errors are included and reported errors are at one sigma; reference year for ages is AD 2000.

off-white residue on the exterior surface (calcium carbonate?). In some cases, this residue helped obscure identification. During the 1948–1953 excavations, wood charcoal fragments (unidentified) were encountered in all EUP layers (Layers III, IV, and V) (Lazukov, 1957: 148–150; Rogachev, 1957: 35–41).

4.2. Pollen analysis

In 2008, G. M. Levkovskaya collected samples from sediments below, within, and above Layer III (~50 cm thick) in Unit a-67, and also from a level below Layer III in Unit a-64. (Unit a-67 is 2–3 m west, and Unit a-64 is immediately southeast, of the stratigraphic profile shown in Table 3 and Fig. 4). Based on the analysis of the samples, the following *pollen complexes* were defined (see Table 8):

Complex 0 (approximately 1.0 meter below Layer III): warm period with a high percentage of arboreal pollen (AP = 63%) and predominance of elm among the latter, represented by the microtherm *Ulmus laevis*.

Complex 1 (immediately below Layer III): cold period with wet and cold forest-tundra climate (AP = 14% with *Alnaster* dominant; non-arboreal pollen [NAP] = 75%, with Cyperaceae dominant).

Complex 2 (lower part of Layer III and associated with arctic fox skeleton): warm period with forest-steppe, but cooler than present day (AP = 41%, including alder [predominant], birch [abundant], and microtherm water elm [chiefly *Ulmus laevis*] with xerophilic [dominant] and mesophilic non-arboreal associations).

Complex 3 (upper part of Layer III): cold and dry (AP = 25%, including birch, floodplain alder, and isolated elms with xerophilic (dominant) and mesophilic non-arboreal groups. Heavy dominance (98%) of under-developed and dwarf forms (possibly *Artemisia*), indicating geo-botanical stress (Levkovskaya, 1999, 2012; Levkovskaya and Bogolyubova, 2005, 2011).

Complex 4 (above Layer III): transition to dry phase of a new warm period (AP = 62%) represented by coniferous trees with moss [Bryales] and water elm, associated with xerophilic shrubs (*Ephedra*) on the watersheds.

Within the chrono-stratigraphic framework described above, the defined pollen complexes appear to correspond to various warm and cold periods preceding and following the CI tephra (~40,000 cal BP) identified in the Greenland ice core record (see Fig. 5). The earliest complex (*Complex 0*) likely represents one of the warm intervals between HE5 and the CI event, such as GI 11 or possibly GI 12. The cold interval that immediately precedes the Layer III occupation (*Complex 1*) probably corresponds to HE4 (given the new radiocarbon dating of Layer III described above), while the warmer and cooler phases associated with Layer III (*Complex 2* & *3*) may be correlated with GI 8 and GS 8, respectively. A total of 53 plant taxa were identified in the pollen samples, which underscores the diversity of plant life in the vicinity of Kostenki 1 during the EUP.

4.3. Vertebrate remains

During the 1970s, Vereshchagin and Kuz'mina (1977: 100) published a list of identified vertebrate remains recovered during 1951 and 1953 from Layers III–V at Kostenki 1 (see also Rogachev et al., 1982: 64–66; Vereshchagin and Kuz'mina, 1982) (Table 9). Most of the identifiable specimens (97%) were derived from Layer III. The majority of the latter (63%) were assigned to *Alopex lagopus* (arctic fox).

Table 8
Analysis of pollen samples from below, within, and above Kostenki 1, Layer III (G. M. Levkovskaya).

	Pollen complex 0	Pollen complex 1	Pollen complex 2	Pollen complex 3	Pollen complex 4
Total palynomorphs (identified & unidentified)	1866	180	706	1300	1258
Unidentified palynomorphs	1766 (95%)	0	196 (28%)	1100 (85%)	1158 (89%)
Identified pollen grains & spores	100 (5%)	180 (100%)	510 (72%)	200 (15%)	116 (11%)
Identified palynomorphs: general composition					
Arboreal Pollen (AP)	63 (63%)	25 (14%)	211 (41%)	50 (25%)	72 (62%)
Non-arboreal pollen (NAP)	27 (27%)	136 (76%)	251 (49%)	147 (74%)	12 (10%)
Aquatic taxa	2 (2%)	13 (7%)	4 (1%)0		8 (7%)
Spores	8 (8%)	6 (3%)	44 (9%)	3 (2%)	24 (21%)
Identified palynomorphs: morphology					
Pollen grains & spores normal morphology	70 (70%)	46 (26.5%)	193 (38%)	5 (2.5%)	44 (38%)
Pollen grains & spores abnormal morphology (immature, dwarf & aberrant forms)	30 (30%)	134 (75.5%)	317 (62%)	195 (97.5%)	72 (62%)

Table 9
Vertebrate Remains from Kostenki 1, Layers III–V (1951–1959 excavations of A. N. Rogachev) (from Vereshchagin and Kuz'mina (1977): 100).

Species	Layer III	Layer IV	Layer V
Canis lupus (wolf)	39/1[a]	–/–	–/–
Alopex lagopus (arctic fox)	450/18	–/–	–/–
Gulo gulo (wolverine)	17/1	–/–	–/–
Lepus tanaiticus (Don hare)	25/3	–/–	–/–
Spalax microphtalmus (mole-rat)	10/1	–/–	–/–
Cricetus cricetus (hamster)	1/1	–/–	–/–
Arvicola terrestris (water vole)	1/1	–/–	–/–
Mammuthus primigenius (wooly mammoth)	5/1	13/1	–/–
Equus latipes (broad-toed horse)	71/2	5/1	2/1
Rangifer tarandus (reindeer)	69/2	–/–	–/–
Bison (bison)	–/–	–/–	1/1
Saiga tatarica (saiga)	3/1	–/–	–/–

[a] Number of Identified Specimens/Minimum Number of Individuals.

Other common taxa included *Equus latipes* (horse) and *Rangifer tarandus* (reindeer), both of which are abundant in the EUP layers at Kostenki 12 (Hoffecker et al., 2010).

During the 2004–2011 excavations, a substantial quantity of mammalian remains was recovered from the EUP layers, including—for the first time—a significant number of identifiable bones and teeth from Layer V. The minimum number of individuals (MNI) was calculated for all taxa during each year of excavation by I. E. Kuz'mina, E. V. Syromyatnikova, and N. D. Burova, but because the latter is influenced by the varying quantity of units excavated (e.g., Grayson, 1984), only the total number of identified specimens (NISP) recovered during 2004–2011 is given in Table 10.

All of the identifiable faunal remains from Layer III were recovered from the areas excavated in 2008–2011. The most significant contrast with the material excavated in the 1950s is the predominance of *Mammuthus primigenius* (woolly mammoth), which comprises 53% of the total NISP for Layer III. Almost all parts of the skeleton are represented (see Table 11). The distribution of skeletal parts for horse, which is the second most common taxon (21% of total NISP for Layer III) and also is represented by most parts, is shown in Table 12. Another significant discovery is the presence of anatomically articulated bones in Layer III, indicating they were deposited as intact portions of the carcass (see Table 13). The majority (60%) of a sample of horse long-bone fragments from Layer III (n = 20) exhibit typical green or fresh breakage (e.g., V-shaped, spiral fractures) and at least one percussion mark.

The distribution of skeletal parts for horse in Kostenki 1, Layer III is compared with that for Kostenki 12, Layer III in Table 12. Although the distribution of parts is generally similar, statistical comparison between the two sites yields a Kolmogorov–Smirnov value of 1.9 ($p < .01$), indicating the difference is significant. Lower limb bones, including the radius, calcaneus, astragalus, and metatarsal, are better represented at Kostenki 1. Because the degree of weathering appears comparable between the two samples, differential preservation is unlikely to explain the pattern. Most of the well represented elements at Kostenki 1 are of low food value (Outram and Rowley-Conwy, 1998: 845, Table 6) and their frequencies probably reflect differential treatment of these parts.

Table 10
Vertebrate remains from Kostenki 1, Layers III–V (2004–2011 excavations) (identified by I. E. Kuz'mina, E. V. Syromyatnikova, and N. D. Burova).

Species	Layer III	Layer IV	Layer V
Canis lupus (wolf)	31[1]	–	–
Alopex lagopus (arctic fox)	54	–	–
Ursus arctos (brown bear)	1	–	–
Gulo gulo (wolverine)	1	–	–
Mammuthus primigenius (woolly mammoth)	203	–	634
Equus latipes (broad-toed horse)	80	–	25
Rangifer tarandus (reindeer)	11	–	5

[1] Number of Identified Specimens.

Table 11
Representation of skeletal elements for mammoth from Kostenki 1, Layers III and V.

Skeletal element	Layer III[a]	Layer V
Cranium	24	0
Maxilla	0	
Mandible	1	20
Tusk fragments	11	3
Isolated teeth	5	3
Isolated tooth fragments	10	17
Atlas	1	0
Axis	1	0
Other vertebrae	21	5
Sacrum	1	0
Ribs	43	506
Scapula	5	1
Humerus	6	1
Proximal humerus		1
Distal humerus		
Radius	2	0
Proximal radius	1	
Distal radius		
Ulna	4	4
Fibula	0	1
Carpals	9	1
Metacarpal	?	0
Innominate	5	7
Femur	3	1
Proximal femur		
Distal femur	1	
Patella	0	1
Tibia	0	2
Proximal tibia		
Distal tibia		
Calcaneus	1	0
Astragalus	1	0
Tarsals	3	0
Metatarsal	1	0
Metapodial	4	
Phalanges	5	0
Longbone fragments	5	21
Unidentified fragments	32	40
Totals	206	634

[a] Numbers include skeletal parts encountered during the 1948–1953 excavations and described by Rogachev (1957: 30–34).

Another potentially important variable is slope, which is lower (5% gradient) at Kostenki 1 than on the opposite side of the ravine mouth at Kostenki 12 (11% gradient). Studies of the effect of gradient on soil erosion indicate a significantly higher potential for transport on a slope gradient above 9–10% (McCool et al., 1987) and there is evidence for orientation of bones along the slope axis and sorting of elements by weight at Kostenki 12 (Hoffecker et al., 2010: 1082–1083). By contrast, the orientation of bones at Kostenki 1, Layer III shows little deviation from a random pattern (see below). Slope disturbance also may explain the absence of anatomically articulated sequences at Kostenki 12. It should be noted that Frostick and Reid (1983) found bone shape to be a "major determinant" of transport on steep slopes.

Almost all of the remains from Layer V were recovered during 2004–2007 from the southern margin of excavated areas at Kostenki 1. In this level, the predominance of mammoth is especially pronounced (96% of NISP). Most of these data already have been published (Hoffecker et al., 2010: 1083–1085), but the distribution of skeletal parts is reproduced (and updated) in Table 11 for comparison with Layer III. Most if not all of the bones, teeth, and tusks in Layer V may represent a single individual (sub-adult) and several bones exhibit possible traces of tool damage (discussed below).

4.4. Human remains

In 1989, human remains were recovered from Layer III in association with a burial pit (?) containing large quantities of ocher. The remains, which comprised two tibia fragments (poorly preserved) and the

Table 12
Representation of skeletal elements for horse from Kostenki 1, Layer III (2008–2011 excavations) and Kostenki 12, Layer III (2002–2003 excavations).

Skeletal element	K 1-III	K 12-III
Cranium	0	0
Mandible	0	2
Isolated teeth	1	11
Atlas	0	0
Axis	0	0
Other vertebrae	0	1
Ribs	3	1(?)
Scapula	0	2
Humerus		
Proximal humerus	0	0
Distal humerus	1	5
Radius	3	
Proximal radius	1	2
Distal radius	2	0
Ulna	3	0
Carpals	1	8
Metacarpal	3(?)	
Proximal metacarpal	0	5
Distal metacarpal	1	4
Innominate	2	1
Femur	1	
Proximal femur	3	2
Distal femur	2	1
Patella	1	1
Tibia	4	
Proximal tibia	0	1
Distal tibia	1	2
Calcaneus	7	1
Astragalus	8	1
Tarsals	4	3
Metatarsal	7(?)	
Proximal metatarsal	2	1
Distal metatarsal	0	1
Phalanges		
1st phalanx	4	6
2nd phalanx	3	4
3rd phalanx	1	1
Totals	69	67

fragment of a pelvic bone and tooth, were assigned to *Homo sapiens* by I. I. Gokhman (Gerasimova et al., 2007: 82–85). One of the bone fragments yielded a radiocarbon date of 37,253 ± 1490 cal BP (OxA-7073), which confirms its association with Layer III, and stable isotope values indicating high consumption of freshwater aquatic foods (Richards et al., 2001). During 2004, 7 bone fragments, tentatively identified as rib fragments of *Homo* by I. E. Kuz'mina, were recovered from Layer V.

5. Archeology: artifacts and features

Despite the larger area excavated during 2004–2012, a significantly smaller number of artifacts was recovered from the EUP layers than during the 1948–1953 excavations. Nevertheless, the artifacts recovered during 2004–2012 provide a new perspective on EUP occupation at Kostenki 1—especially Layer III—and especially when considered in conjunction with the faunal remains described above. Features discovered during 2004–2012 are confined to concentrations of artifacts and/or mammal bones, but they also reveal much about EUP occupation. In general, the artifacts and features in Layers III–V suggest a pattern of short-term occupations related to large-mammal procurement and carcass processing. During the later EUP (i.e., Layer III), the carcasses of medium fur-bearing mammals probably were processed for clothing materials as well.

5.1. Layer III artifacts

Rogachev's 1948–1953 excavations of Layer III produced roughly 4500 artifacts, including about 40 cores and 200 retouched items (Rogachev, 1957: 34–35; Klein, 1969: 116, table 22; Rogachev et al., 1982: 64). Prismatic blade cores were common, including microblade cores. Retouched pieces included end-scrapers (n = 42), burins (n = 20), *pièces ésquillées* (n = 20), and a large number of retouched microblades (n > 90). Among the end-scrapers, 14 were classified as typical carinated forms. The retouched microblades included backed forms (n = 7) and pointed specimens (n = 4) (Rogachev et al., 1982: 64). The non-stone inventory included bone awls and rods and perforated shell and fox teeth (Fig. 6).

The 2004–2011 excavations yielded a much smaller quantity of artifacts (~250 items) along with roughly 100 artifacts recovered in association with a large concentration of bones deposited in the lower portion of Layer III (see Table 14; Fig. 7). A significant proportion of the Layer III assemblage is composed of imported chert (as opposed to local chert of poor quality, quartzite, and other rock). Among the retouched pieces is a small bifacial point (on local chert) (Fig. 7c). The burins include both dihedral and on the corner of a snapped blade (Fig. 7f and j). The end-scrapers are atypical (i.e., not carinated forms). Several large cobbles also were recovered from Layer III; these may have been used as hammer-stones.

5.2. Layer III features

Rogachev (1957: 30–32) described multiple hearths and associated occupation debris in Layer III excavated during 1948–1953. Traces of four hearths were found associated with large quantities of artifacts and faunal remains (Klein, 1969: 112, fig. 32). Three of the hearths were recorded on different micro-stratigraphic levels, indicating separate occupation episodes. Overall, the features exhibited signs of post-depositional disturbance (e.g., vertical or sub-vertical position of artifacts and bones).

During 2008–2009, a sub-oval concentration of large mammal bones and artifacts was excavated in Units β, а 66–68; б, в, г 65–68 (see Fig. 8). This feature occupies an area of roughly 18 square meters; the center is 40–45 cm in thickness and its margins are well defined (Dudin, 2014: 173–174). Among the 130 identified mammal bones in the feature,

Table 13
Skeletal parts observed in anatomically articulated order from Kostenki 1, Layer III (2009–2011 excavations). Identified by E. V. Syromyatnikova and N. D. Burova.

Unit(s)	Depth	Species	Skeletal parts
г-65, г-66	256–265 cm	*Alopex lagopus*	Cervical & thoracic vertebrae, scapula (right), radius (right), humerus (right & left), rib fragment (proximal), rib fragment (n = 14)
г-66	255–272 cm	*Mammuthus primigenius*	Foot bones, metapodial (left) (n = 11)
г-66	281–282 cm	*Equus latipes*	Calcaneus, astragalus, tarsal, proximal metapodial (n = 4)
а-β-67	Lower horizon	*Canis lupus*	Metatarsus/metacarpus, 2 first phalanges, 3 second phalanges, 1 third phalanx (n = 7)
а-66	Lower horizon	*Equus latipes*	Calcaneus, astragalus, 2 tarsal bones, femur fragment (n = 5) (left)
а-68	Lower horizon	*Equus latipes*	Calcaneus, astragalus (n = 2) (left)
а-б-68	Lower horizon	*Rangifer tarandus*	Calcaneus, astragalus (n = 2) (left)
в-65	Lower horizon	*Alopex lagopus*	Cervical vertebrae (n = 7) 3 metatarsal/metacarpal bones, 2 first phalanges (n = 5)

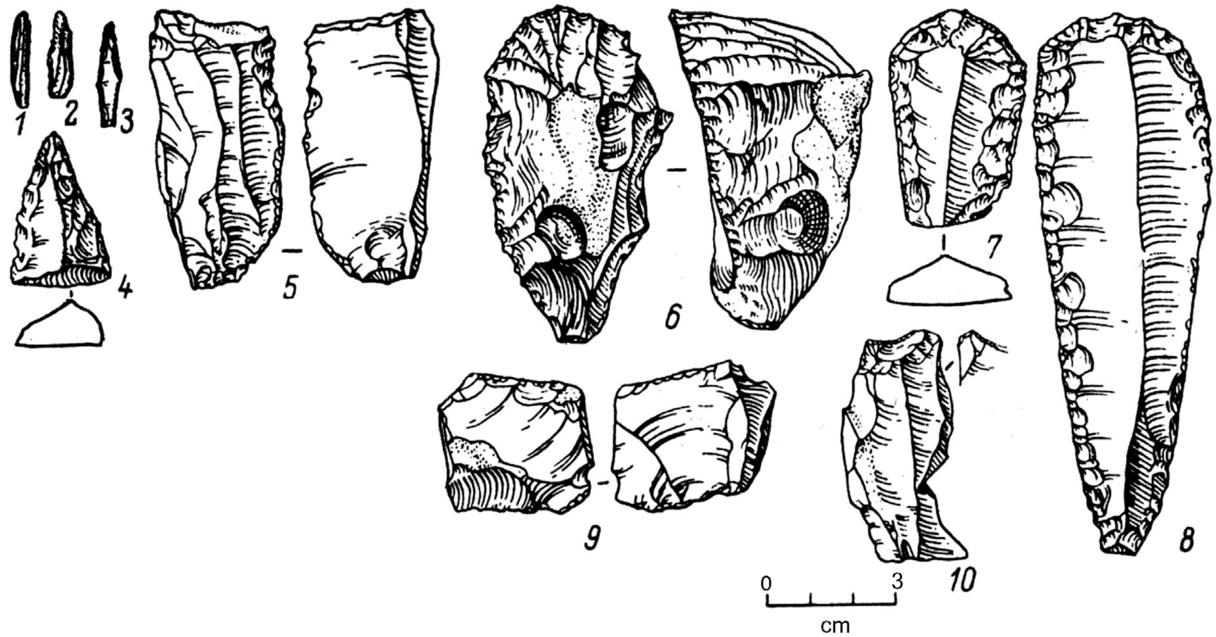

Fig. 6. Kostenki 1, Layer III stone artifacts (1948–1953 excavations), including retouched bladelets (1–3), point fragment (4), retouched blade (5), carinated end-scraper (6), end-scrapers on blades (7–8), and *pièce ésquillée* (9) (adapted from Rogachev et al., 1982: 63, fig. 22).

44% (n = 59) belong to mammoth, 22% (n = 29) to arctic fox, 22% (n = 28) to horse, and 8% (n = 10) to wolf. The remaining bones (n = 6) represent reindeer. Especially significant is the presence of anatomically articulated mammal bones (listed in Table 13 for the "lower horizon" of Layer III), which comprise portions of the lower extremities of horse, reindeer, arctic fox, and wolf, and cervical vertebrae of arctic fox. Imported chert predominates (68%) among the lithic artifacts (n = 98), which include two micro-cores, a burin, burin spall, two atypical retouched pieces, and 13 unretouched microblades. Other unretouched items include flakes (n = 32) and blades (n = 10) (Dudin, 2014: 177–178).

The intact portions of mammal skeletons indicate that a significant portion of the feature constitutes an *in situ* occupation, subject to limited post-depositional disturbance. Although slopewash could have accumulated some of the smaller items against the large bones, the orientation of bones exhibits minimal deviation from a random pattern (as indicated by the standardized residuals [e.g., Everitt, 1992: 46–48]). In other words, the position of the bones does not appear to have been affected by the slope. The orientation of a sample of long bones and elongate fragments (n = 66) from the feature is shown in Table 15 by 10° orientation class within a 180° arc relative to the excavation grid, and in comparison to the bone orientation in Layer III at Kostenki 12 (where a high proportion of the bones were oriented along the axis of the steeper slope [Hoffecker et al., 2010: 1081–1083]).

The anatomically articulated bones are unlikely to represent animals that died of natural causes, and they probably are the remains of prey carcasses that were processed during the occupation. The prey included horse and reindeer, and also two fur-bearing taxa (arctic fox and wolf) that may have been more important as a material source than a food source. The portions of the skeleton represented (i.e., lower extremities, vertebral sequences) are typical for carcass-processing areas, including other EUP occupations in Eastern Europe (e.g., Olsen, 1989: 305–314; Hoffecker et al., 2010: 1076–1081, 2014: 74). Additional supporting evidence includes green breakage of horse long-bone shafts and at least one percussion mark (described above). While the associated retouched artifacts are not necessarily tied to carcass processing, at least one large cobble (i.e., possible hammer-stone) was found in the feature.

Table 14
Lithic artifacts recovered from Kostenki 1, Layers III–V during the 2004–2011 excavations.

	Layer III	Layer IV	Layer V
Cores	5	0	2
Flakes (unretouched)	75	5	xx
Blades (unretouched)	14	1	1
Microblades	23	0	1
Fragments, splinters	137	6	xx
Bifacial points (complete)	0	0	1
Bifacial points (fragments)	1	0	6
Bifaces	0	0	3
End-scrapers	2	0	4
Burins	4	1	2
Burin spalls	4	1	0
Borers	0	0	1
Pièces ésquillées	0	0	0
Side-scrapers	1	1	4
Retouched blades	1	4	0
Other tools	5	3	4
Totals	346	37	818

xx = present in significant numbers.

5.3. Layer IV artifacts

A small quantity of stone artifacts (n = ~20) was recovered from Layer IV during 1948–1979, including two retouched pieces (possible tool fragment and core). Raw materials were confined to quartzite and local chert (Rogachev et al., 1982: 65). During 2004–2011, roughly 40 artifacts were excavated from Layer IV (see Table 14). About 25% of the assemblage comprised imported chert. Although no new cores were recovered, Layer IV yielded four retouched blades (all imported chert), a burin (on a retouched flake), and a side-scraper (see Anikovich et al., 2006: 99).

5.4. Layer V artifacts and features

Roughly 2000 stone artifacts were reported from the 1948–1953 excavations. The overwhelming majority (>99%) were local chert of poor quality and quartzite (Rogachev et al., 1982: 65–66). Although flake production was predominant, 18% of the tools were made on blade-like flakes or atypical blades. Retouched items (n = 119) included

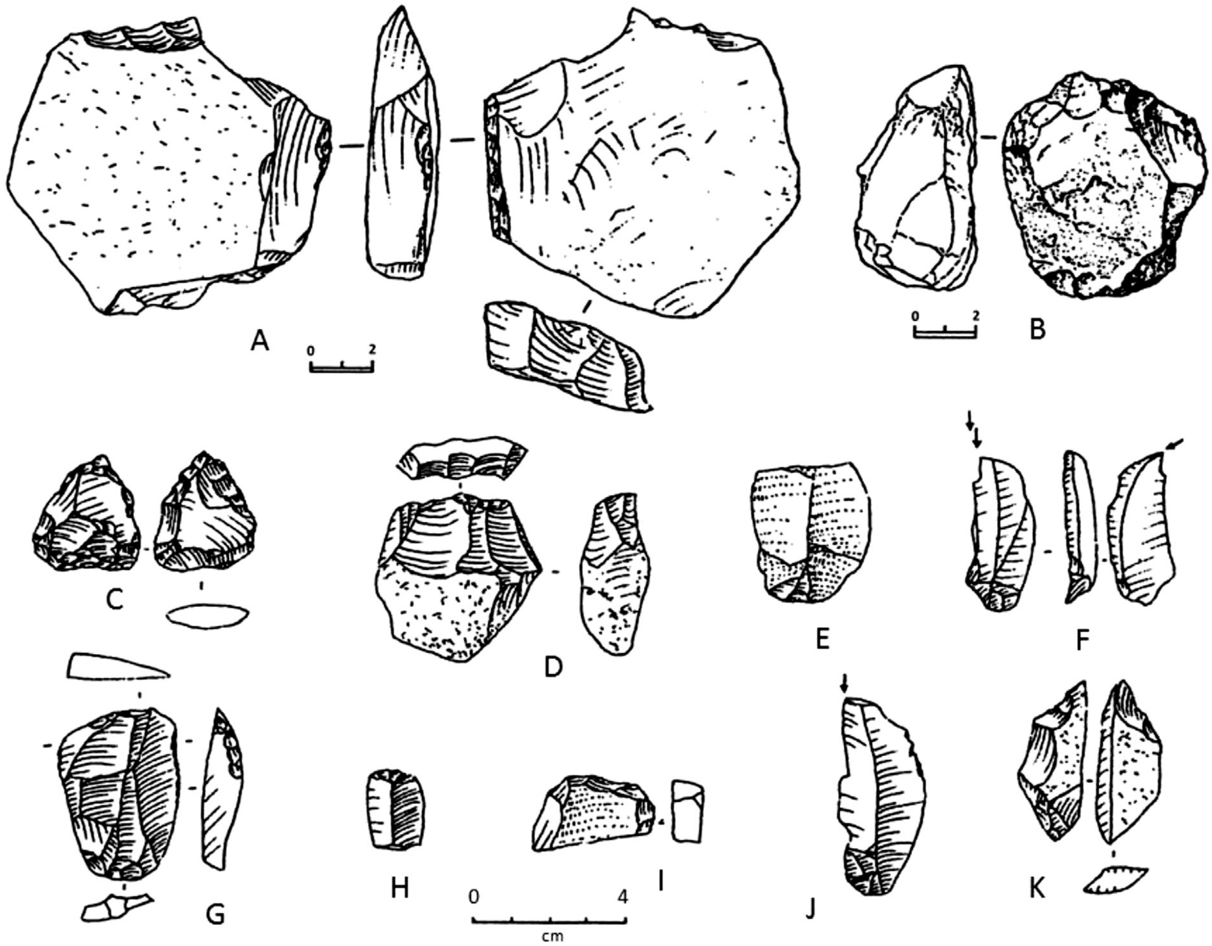

Fig. 7. Kostenki 1, Layer III stone artifacts, including small bifacial point (C), burins (F, J), and a small end-scraper (H) (see Table 14) (adapted from Anikovich et al., 2008: 103, fig. 54).

43 whole or fragmentary small bifacial points with concave bases (Strelets type), 24 end-scrapers (sub-triangular and cordiform), 8 burins, 4 borers, and 6 side-scrapers. A 1979 trench also yielded a simple ornament (on marl), and a large biface (~12 cm in length) was recovered in 1989 (see Fig. 9). Rogachev (1957: 36–37, fig. 11) found much of the occupation debris in Layer V concentrated around traces of a hearth in an oval pattern occupying roughly 20 square meters (centered in Units б–а/3–4), which he suggested might represent a former dwelling structure (Klein, 1969: 78, Fig. 18).

During 2007, a large concentration of artifacts and other debris was excavated in Units Б-В-Г/76–78 in a lens (25–35 cm in thickness) at a slightly higher stratigraphic level than other artifacts assigned to Layer V (see Fig. 10). Like the feature encountered by Rogachev in Layer V, it exhibited signs of disturbance (primarily slope movement), which may account for the absence of a hearth (wood charcoal is present).

Most of the artifacts assigned to Layer V from the 2004–2012 excavations were found in this concentration (n = 777). In contrast to 1948–1953, a significant proportion of the assemblage comprised imported chert. However, the typological composition of the assemblage was similar to that of the earlier excavations. The bifacial points included one complete and six fragmentary specimens (see Fig 11). Most of the end-scrapers were triangular in form, while the burins included dihedral and on the corner of a snapped blade. Among the side-scrapers are both transverse and convergent forms, and several bifaces and biface fragments also were present (see Table 14). More than 95% of the artifacts in this feature comprised lithic debris from multiple reduction sequences (both local and imported raw material).

As noted earlier, virtually all of the faunal remains from Layer V were recovered during 2004–2012 (see Tables 9 and 10) and most belong to mammoth. A majority of the mammoth remains, moreover, are concentrated in an area of roughly 20 square meters in the southernmost excavated portion of Kostenki 1 (Units Ь–Э–Ю, 71–78). Most of the bones and teeth represent a single sub-adult mammoth (see Table 11) associated with isolated artifacts. As reported elsewhere (Hoffecker et al., 2010: 1083–1085), the bones exhibit some green breakage (Type II spiral fractures on a scapula, ulna, and tibia) and several possible tool cut marks on an ulna fragment. Because of the association with the artifacts, they may tentatively be interpreted as the remains of a young mammoth butchered (and possibly hunted) by the occupants of the site. Similar sites are known in North America (e.g., Johnson, 2006, 2007), but not in the EUP of northern Eurasia.

The broad area excavated in 2006–2007 (46 square meters) exposed a portion of the concentration of mammoth remains, as well as an additional scatter of mammoth and horse bones in Layer V (see Fig. 12). Isolated bones of reindeer also are present. Like the concentration of mammoth remains, the other mammal bones are associated with a few isolated artifacts (flakes, splinters, and fragments of local chert). Most or all of these bones and artifacts are micro-stratigraphically below the large artifact concentration shown in Fig. 10 and presumably represent one or more earlier occupation episodes.

6. Discussion

Kostenki 1 exhibits both similarities and differences with Kostenki 12, located on the opposite (south) side of Pokrovskii Ravine. Many of the differences appear related to the contrast in topographic setting. While represented by a broad and comparatively level surface on the north side of the ravine, which attracted large Gravettian settlements

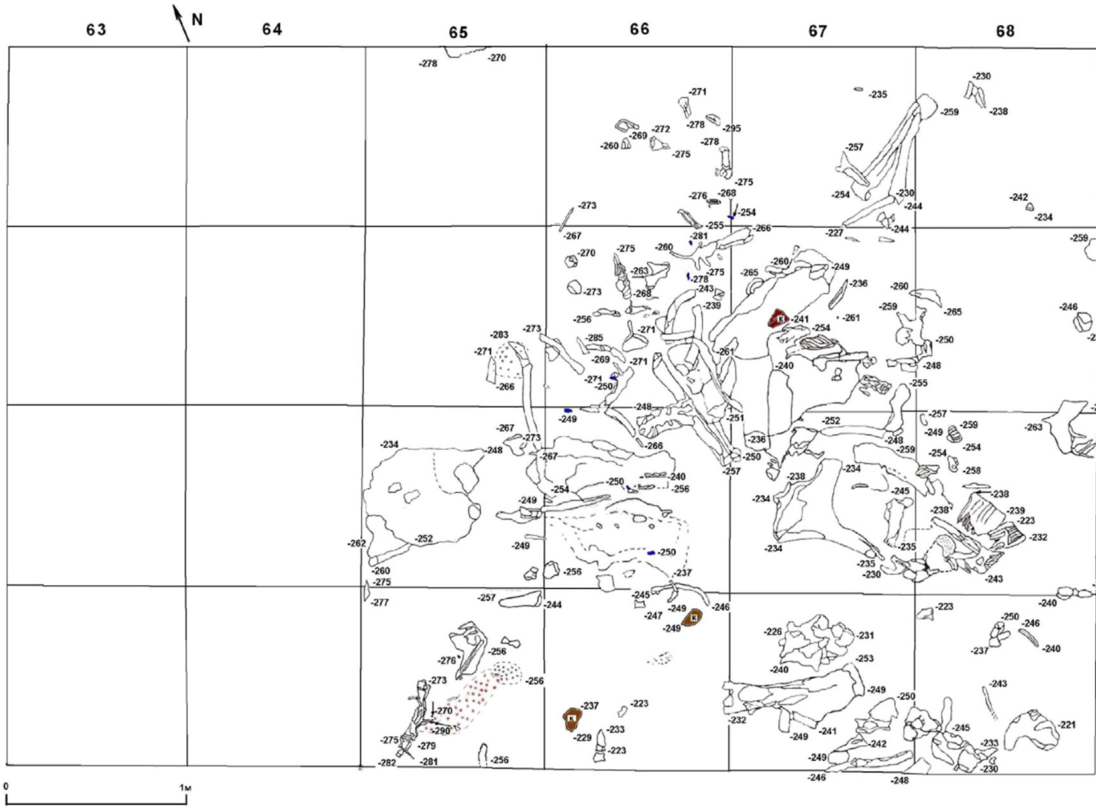

Fig. 8. Distribution of bones and artifacts in Kostenki 1, Layer III for Units β, a 66–68; б, в 65–68 excavated in 2008 and representing the upper horizon of a large concentration (map prepared by A. E. Dudin). The numbers refer to depth from datum (cm).

in post-EUP times (e.g., Efimenko, 1958; Rogachev et al., 1982), the second terrace is characterized by steeper slopes and a narrower occupation surface on the south side (see Fig. 1). The sediments containing the EUP layers at Kostenki 12 exhibit roughly twice the slope gradient (11% versus 5%) as the sediments containing EUP remains on the opposite side of the ravine (see discussion in Sections 3.1 and 4.3).

One consequence of the difference is that post-depositional disturbance of the EUP occupations has been less severe at Kostenki 1, where the orientation of mammal bones exhibits minimal evidence of slope movement and multiple sequences of bones were found anatomically articulated in Layer III (see Tables 13 and 15), while the bone beds in Layer III at Kostenki 12 exhibited evidence of sorting and reorientation along the slope axis (Hoffecker et al., 2010: 1081–1083). Another consequence is the development of intact buried soil profiles (see Fig. 3), reflecting comparatively stable slopes (and probably distance from the valley wall), which is rare at most Kostenki sites during the MIS 3 age equivalent (i.e., before formation of the Gmelin Soil).

The results of the 2004–2012 excavations were consistent with the pattern of EUP occupation described by Rogachev (1957: 30–37) on the basis of his ground-breaking investigations at Kostenki 1 during 1948–1953. The EUP layers at the site are characterized by small

Table 15
Frequencies of long bones and elongate bone fragments in Kostenki 12, Layer III and Kostenki 1, Layer III by 10° orientation class. Standardized residuals greater than an absolute value of 2.0 (in bold) indicate a significant deviation from the expected value for that orientation class.

	Kostenki 12-III		Kostenki 1-III	
Orientation class	Observed value	Standardized residual	Observed value	Standardized residual
270–279°	2	−1.69	7	+1.72
280–289°	5	−0.48	3	−0.36
290–299°	4	−0.88	8	**+2.24**
300–309°	2	−1.69	4	+0.16
310–319°	4	−0.88	6	+1.20
320–329°	12	**+2.33**	5	+0.68
330–339°	16	**+3.94**	0	−1.93
340–349°	11	+1.93	1	−1.41
350–359°	20	**+5.54**	3	−0.36
0–9°	16	**+3.94**	3	−0.36
10–19°	3	−1.29	3	−0.36
20–29°	0	**−2.49**	2	−0.89
30–39°	1	**−2.09**	3	−0.36
40–49°	1	**−2.09**	1	−1.41
50–59°	2	−1.69	5	+0.68
60–69°	3	−1.29	3	−0.36
70–79°	2	−1.69	2	−0.89
80–89°	7	+0.32	7	+1.72
Total	111		66	

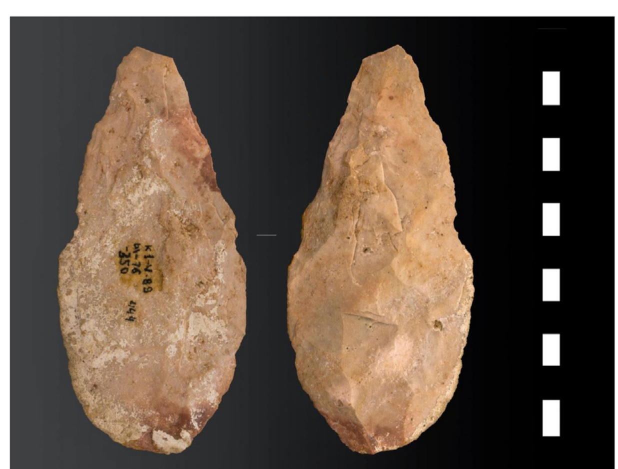

Fig. 9. Large bifacial tool from Kostenki 1, Layer V recovered during the 1989 excavation. (The scale bar is in cm.)

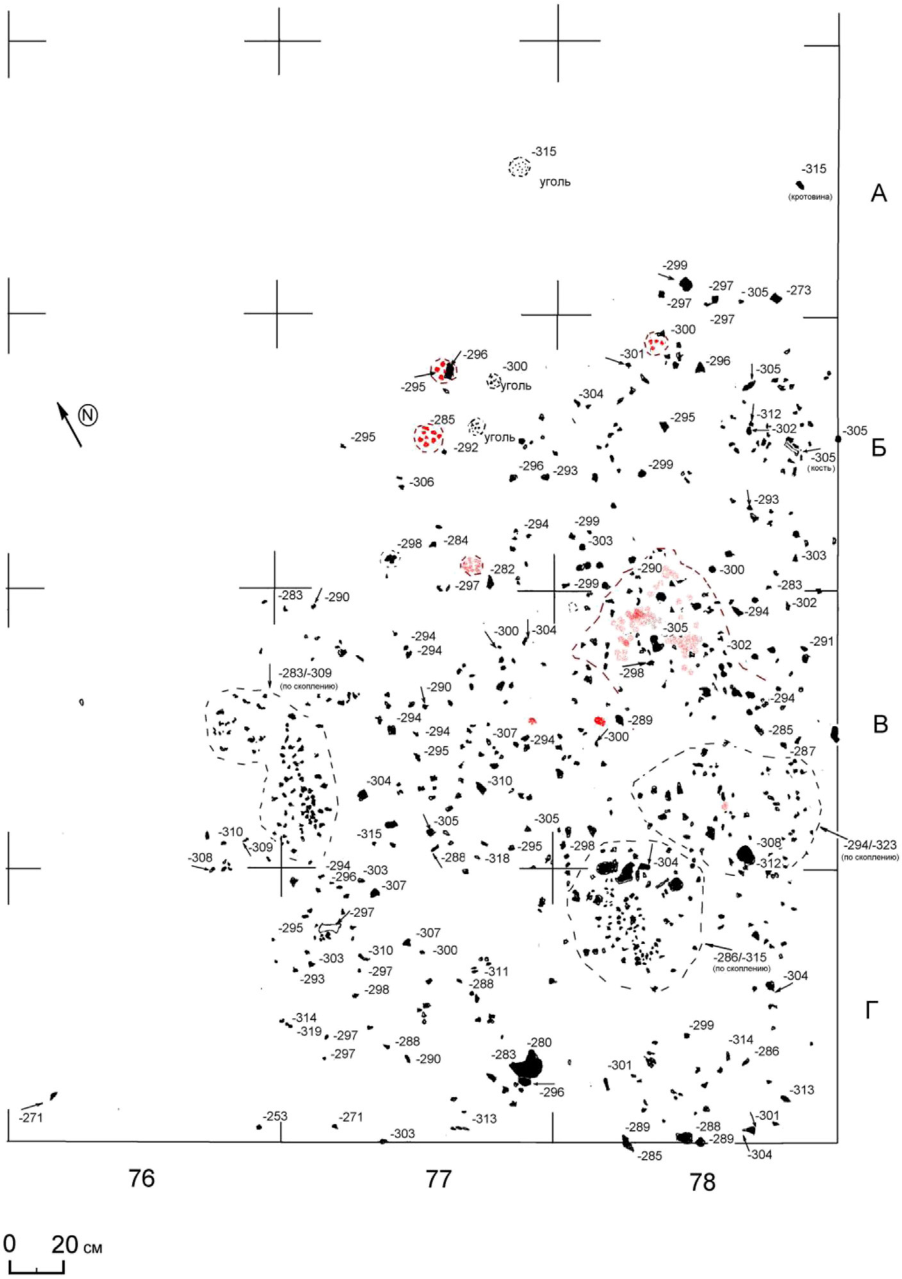

Fig. 10. A concentration of lithic artifacts in Kostenki 1, Layer V excavated during 2007 (map prepared by A. E. Dudin). The numbers refer to depth from datum (cm).

concentrations of artifacts and/or faunal remains on micro-stratigraphically separated levels, and isolated traces of occupation debris distributed both horizontally and vertically (i.e., in space and time) as background noise. At least some of the latter undoubtedly is due to post-depositional disturbance (e.g., slopewash, trampling, frost-driving), which probably dispersed artifacts and bones more than it concentrated them. The overall pattern of EUP occupation appears to have been one of recurring short-term occupations and most of the apparent gaps in archaeological stratigraphy (in any specific excavated area) are likely to reflect shifting camp or activity locations across the broad area of the second terrace level on the north side of the ravine mouth. The potentially significant exception to this pattern (HE4: 40,000–38,000 cal BP) is discussed below.

Following the approach used to define the post-EUP occupations (Layers I–II)—which represent relatively distinct horizons of artifacts, bones, and features—Rogachev assigned the EUP remains at Kostenki 1 to specific layers (Layers III–V). The EUP levels at the site are more appropriately described, however, as "zones of occupation" with significant vertical dispersion and temporal spread. The Layer V zone is represented in sediments that underlie the CI tephra, while the Layer IV zone is represented in the sediments that immediately overlie the tephra. The Layer III zone is associated with the b2 buried soil (although it largely antedates formation of the soil) (see Table 4). With the already noted possible exception of the HE4 cold period, which is represented by the deposits that immediately overlie the CI tephra, EUP occupation at Kostenki 1 may have been nearly continuous (presumably on a seasonal basis).

Wider excavation of the second terrace level on the north side of the ravine mouth (only a small percentage of the total area has been excavated to date) probably would reveal more micro-stratigraphically separated occupation loci within and below the b2 buried soil (as did the 2004–2012 excavations). These loci probably would fall into existing gaps in the sequence of EUP occupations, especially with respect to concentrations of artifacts and/or bones.

Fig. 11. Bifacial point in situ in Kostenki 1, Layer V, associated with a large concentration of artifacts (photo by A. E. Dudin, August 2007).

In the areas excavated by Rogachev during 1948–1953, which lie upslope of the areas excavated during the 1980s and later, Lazukov (1982: 23) observed visible traces of volcanic ash (as a "thin, discontinuous lens") that almost certainly represents the CI tephra (dated at ~40,000 cal BP) (Pyle et al., 2006; Hoffecker et al., 2008). In most of the other areas excavated in later years, the tephra was redeposited by slope action and identified primarily by microscopic examination of sediment samples (Holliday et al., 2007: 189). Nevertheless, at the two other major EUP sites on Pokrovskii Ravine (Kostenki 12 and 14), where the CI tephra also was redeposited by slope action, its chrono-stratigraphic position—determined by radiocarbon dating—was found to be coterminous to the CI eruption (Anikovich et al., 2007b; Douka et al., 2010). At both sites, the CI tephra appears to have been redeposited at roughly the same time as its initial deposition.

At Kostenki 1, artifacts and features assigned to Layer V were found stratigraphically below visible traces of the CI tephra during 1948–1953 (Lazukov, 1982: 22–24). Whether redeposited or not, the pattern at Kostenki 12 and 14 suggests that the tephra in this part of the site probably represents a chrono-stratigraphic marker for ~40,000 cal BP and the underlying zone of occupation antedates the CI eruption and cold period that follows it (HE4). This conclusion is supported by at least some of the previously reported radiocarbon dates obtained on Layer V (Sinitsyn et al., 1997; Anikovich et al., 2006: 92; see Table 5). The stratigraphic position of the redeposited tephra in the southernmost excavated area of the site (see Section 3.3) indicates that the artifacts and features recovered during 2004–2007 and assigned to Layer V may be at least tentatively dated to before 40,000 cal BP. Future radiocarbon dating of materials from this layer with state-of-the-art pretreatment techniques (e.g., ultra-filtration of bone collagen) is likely to resolve the issue.

In sum, the EUP occupation sequence at Kostenki 1 probably begins at some point before the deposition of the CI tephra, as at Kostenki 12 and 14, although it is unclear how much earlier than 40,000 cal BP it extends. The earliest EUP occupation at Kostenki 1 conceivably coincides with one of the warm phases (GI 11 or GI 10) that precede the CI eruption in the Greenland ice core record, dating to roughly 44,000 or 42,000 cal BP. On the other hand, new radiocarbon dates obtained on the lowest-lying concentration of artifacts and bones assigned to Layer III (see Table 6), which was excavated in 2008–2009, indicate that the late phase of EUP occupation began following the HE4 cold period (which ends about 38,000 cal BP) and beginning of an interval of sustained warmth that corresponds to GI 8 in the Greenland record (see Fig. 5). This is supported by the analysis of pollen-spore samples from the same concentration of debris assigned to Layer III (*pollen complexes 2–3*), which indicate warm conditions in the lower horizon of the occupation zone (see Section 4.2).

The problematic zone of occupation is Layer IV, which although now excavated over an area of more than 250 square meters, has yielded only about 60 artifacts and less than 20 identifiable mammal remains (see Section 5.3; Table 9). Because of uncertainties about the position of the CI tephra across most of the excavated area of Kostenki 1, as well as the likelihood of post-depositional movement of artifacts, it is unclear if Layer IV contains traces of an occupation in sediments deposited during the roughly two millennia that followed the CI eruption (corresponding to the HE4 cold interval). At the very least, the extreme poverty of artifacts and bones observed to date in Layer IV suggests a severe reduction in occupation intensity. Conceivably, the isolated artifacts and bones are secondarily derived from deposits that antedate and/or postdate HE4, and the site remained unoccupied throughout this interval. The problem is difficult to resolve because of the general pattern of EUP occupation at Kostenki 1 described earlier (i.e., the likelihood that unexcavated areas of the site were occupied during the EUP).

The most important result of the 2004–2012 excavations was the recovery and analysis of a large sample of mammal remains from both EUP Layers III and V (see Table 10). The earlier excavations yielded several hundred medium—and a modest quantity of large—mammal remains from Layer III, and only isolated material from Layers IV and V (Table 9). The 2004–2012 faunal remains provide major insights to site function during the EUP and underscore the importance of sampling at Kostenki 1 (earlier excavations had largely missed the critical large-mammal data). They reveal an emphasis on large mammal procurement and carcass-processing throughout the EUP.

The scatter of mammoth remains in the lower horizon of Layer V (2004–2007 excavations) apparently represents the dismemberment of a sub-adult mammoth (possibly hunted by the occupants of the site) and is unique in the EUP of northern Eurasia (Hoffecker et al., 2010: 1083–1085). (The closest analogs to this feature are found in the Paleoindian record of North America [e.g., Johnson, 2007].) The concentration of large and medium mammal bones in the lower horizon of Layer III yield unambiguous evidence for the processing of carcasses, probably for clothing material as well as food. The presence of multiple examples (n = 8) of anatomically articulated portions of the skeleton indicates dismemberment of carcasses (specifically, discard of low-utility parts of the carcass—chiefly lower extremities) (see Table 13). The large mammals represented are mammoth, horse, and reindeer, and the medium (fur-bearing) mammals are arctic fox and wolf. Supporting evidence includes a high percentage of green fractures and at least one percussion mark on the horse long-bone shaft fragments (and almost complete absence of carnivore damage).

Similar activities took place on the opposite side of the ravine mouth at Kostenki 12, and the EUP layers at both sites yielded artifacts often found in association with large mammal kill-butchery in North America (e.g., projectile points, side-scrapers, end-scrapers, bifaces, hammer-stones and heavy implements) (Hoffecker et al., 2010: 1085–1088). Examples of a projectile point *in situ* and heavy implement recovered from Kostenki 1, Layer V are shown in Figs. 9 and 11, respectively. As today, springs were active in Prokovskii and the other ravines around Kostenki during EUP times (Holliday et al., 2007) and presumably attracted animals to the area, perhaps especially during the late winter period. Both the partial mammoth skeleton in Layer V and the anatomically articulated mammoth, horse, and reindeer bones in Layer III suggest that these animals died in the immediate vicinity of Kostenki 1.

At the same time, the 2004–2012 faunal remains provided new evidence for a wider range of site activities, and probably more extended occupations, during the later EUP (i.e., Layer III zone). A wider range of activities in Layer III was indicated by the variety of artifacts (e.g., perforated shell and carnivore teeth) and large quantity of arctic fox remains (NISP = 450) recovered by Rogachev during 1948–1959

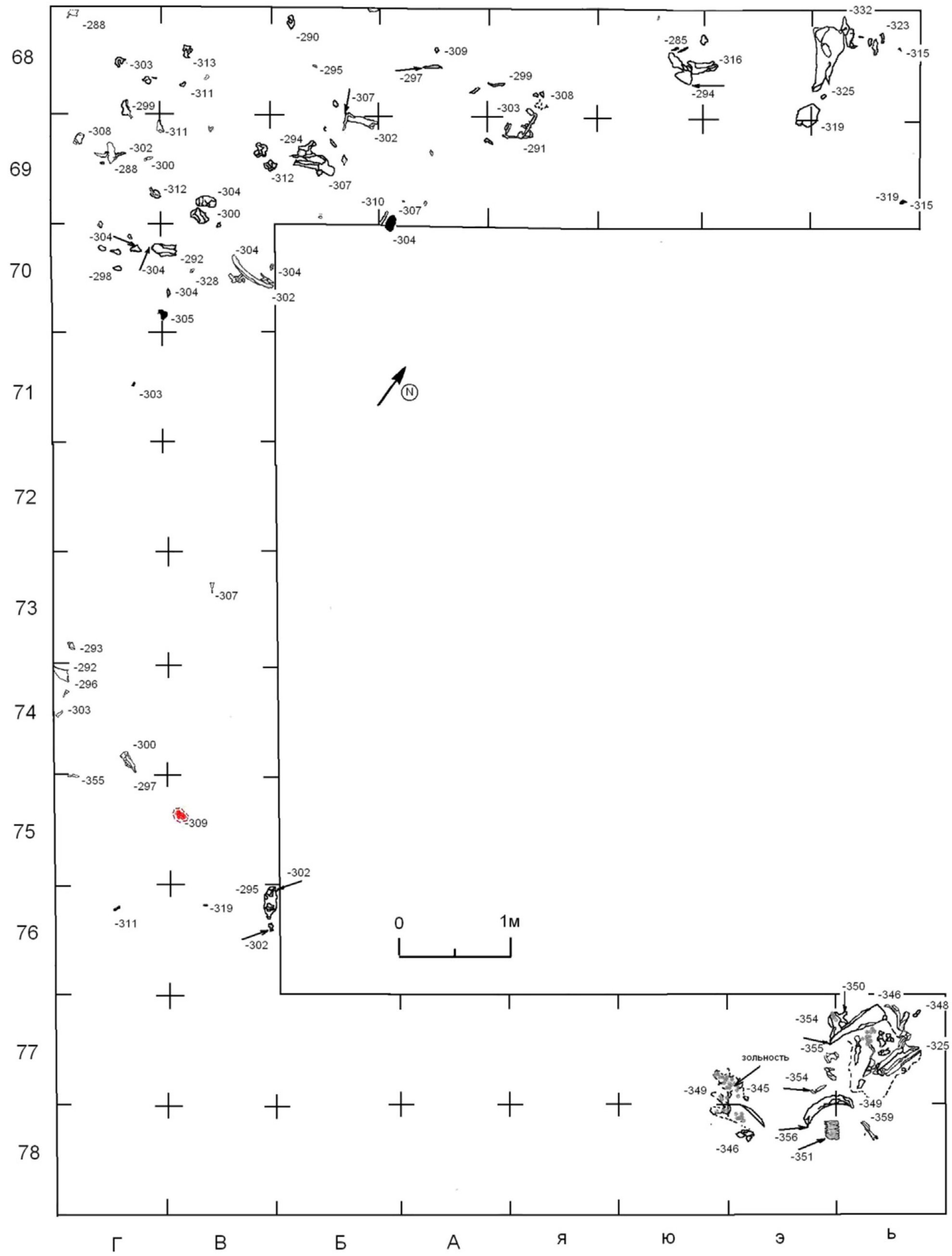

Fig. 12. The distribution of large mammal bones in Kostenki 1, Layer V for areas excavated during 2007 (map prepared by A. E. Dudin). The numbers refer to depth from datum (cm).

(Rogachev et al., 1982: 64) and also by the 1989 discovery of a possible human burial pit containing ocher (see Section 4.4). The anatomically articulated bones of arctic fox and wolf encountered on the lower level of Layer III in 2009–2011 suggest not only that these fur-bearing taxa were dismembered at Kostenki 1, but also that snares and/or traps were used (or made and used) in conjunction with visits to the site (i.e., it is unlikely that foxes were being stalked, ambushed, or driven in groups like the large mammals).

Two major culture-stratigraphic units (or *archaeological cultures*) are represented in the EUP layers at Kostenki 1. As a result of the earlier excavations, Rogachev and others recognized that the artifacts recovered from Layer III were similar to those in EUP levels at Syuren' 1 in Crimea, and that they represented the most significant occurrence of diagnostic *Aurignacian* elements on the East European Plain (e.g., Rogachev, 1957: 35; Anikovich et al., 2008: 144–149). Diagnostic forms in Layer III include carinated end-scrapers, blades with scalar retouch, retouched bladelets, and busked burins (see Fig. 6). Only one other assemblage at Kostenki is assigned to the Aurignacian. It is associated with the CI tephra at Kostenki 14 and contains Dufour bladelets (Sinitsyn, 2003).

The radiocarbon chronology at Kostenki 1, including especially the new series of dates obtained during 2004–2012 (see Tables 5 and 6), reveals that Layer III dates to between ~38,000 and 32,000 cal BP and correlates to several warm intervals (GI 8–GI 5) in the Greenland ice core record (see Fig. 5). It is not clear exactly where the diagnostic Aurignacian artifacts recovered by Rogachev fall in this six-thousand-year timespan, but they might occupy a relatively small portion of it. The later excavations failed to yield materials that could be firmly assigned to the Aurignacian.

With the exception of the assemblage in the CI tephra at Kostenki 14, diagnostic Aurignacian artifacts in other East European sites (i.e., Syuren' 1, Molodova 5) date to the same interval as Layer III at Kostenki 1 (Haesaerts et al., 2003; Demidenko and Noiret, 2012).

Because the West European Aurignacian now is reliably dated to before 40,000 cal BP (Higham et al., 2012; Nigst et al., 2014), it presumably represents the source of the East European industry. Conceivably, the latter is an archaeological proxy for a human population that colonized Eastern Europe following the end of the HE4 cold interval (during which much of it may have been abandoned), although the Dufour bladelets at Kostenki 14 suggest that it might have been present at the time of the CI eruption.

The other EUP culture-stratigraphic unit at Kostenki 1 is an industry that was and remains unique to Eastern Europe. Although bifacial points had been recovered at Kostenki 6 (aka Streletskaya 1) in 1928, it was the deep burial context of Layer V at Kostenki 1 (supported by newly inaugurated geologic studies in 1938 and after the war) that established the relatively early age of what became known as the *Strelets* industry or archaeological culture (Rogachev, 1957). The bifacial points are typically associated with side-scrapers, bifaces, and end-scrapers, as well as heavy tools. Strelets assemblages are found both below and above the CI tephra level on the opposite side of Pokrovskii Ravine at Kostenki 12 (Rogachev and Anikovich, 1982).

The consistent association of Strelets assemblages with taphonomic evidence for large-mammal butchery at Kostenki 1 and 12, as well as other sites (e.g., Sungir' [Gromov, 1966]), suggests that the artifact types diagnostic of the industry may be accounted for—at least in part—in terms of their function (i.e., as implements used to kill and butcher large mammals) (Hoffecker et al., 2010: 1087–1088). (Diagnostic Aurignacian artifacts (including carinated and nosed scrapers) were found associated with a Strelets assemblage at Vys' in south-central Ukraine; although undated, the artifacts are buried in a soil similar to the b2 soil at Kostenki 1 [Zaliznyak and Belenko, 2011]). The results of the 2004–2012 excavations at Kostenki 1 strengthened the association by documenting large-mammal carcass processing in Layer V, and yielding both typical Strelets artifacts and evidence for large-mammal butchery in Layer III. The most parsimonious interpretation of the Strelets assemblages is that they represent a functional subset of one or more EUP industries, including possibly the Aurignacian, but also older EUP industries that underlie the CI tephra and remain poorly defined at present (Anikovich et al., 2007b; Hoffecker, 2011). This view is not shared by all the authors, however.

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