Large mammal taphonomy of the Middle Pleistocene hominid occupation at Treugol'naya Cave (Northern Caucasus)

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Abstract

A taphonomic study was conducted of large mammal remains from the Middle Pleistocene site of Treugol'naya Cave. The site is located at an elevation of 1500 m above sea level near the town of Pregradnaya in the northwestern Caucasus region of Russia, and was excavated by Doronichev (Doronichev, V.B., 2000. Lower paleolithic occupation of the northern Caucasus. ERAUL 92, 67–77.) between 1986 and 2000. Large mammal remains were identified by Baryshnikov (Baryshnikov, G.F., 1993. Krupnye mlekopitayushchie ashelskoi stoyanki v peshchere Treugol'naya na Severnom Kavkaze. Trudy Zoologicheskogo instituta RAN 249, 3–47), and reflect predominance of red deer (*Cervus elaphus*), bison (*Bison schoetensacki*), and cave bear (*Spelaearctos deningeri*). Less common taxa include goat (*Capra* sp.), wolf (*Canis mosbachensis*), rhinoceros (*Stephanorhinus hundsheimensis*) and horse (*Equus altidens*). Data were collected on weathering, breakage, surficial damage, skeletal-part frequencies, and age and season of death from the these remains, which are stored at the Zoological Institute, Russian Academy of Sciences in St. Petersburg. Analysis of the data revealed little evidence for accumulation of the large mammal remains by the hominid occupants of the cave. The carnivore remains probably represent natural mortality, while some of the ungulate remains were apparently accumulated by stream action. Most of the remaining ungulate remains were probably collected by carnivores. © 2002 Elsevier Science Ltd. All rights reserved.

1. Introduction

Humans evolved in warm environments and were slow to occupy northern latitudes. The initial expansion of *Homo* outside Africa (1.7 million years ago) seems to have been confined to regions below approximately 40° North (Gamble, 1994). Not until roughly half a million years ago do we have evidence of substantive settlement above this latitude. During OIS 13–OIS 8 (524,000–245,000 years ago), hominids occupied many sites in Western and Central Europe as far as 52° North in Britain (Roebroeks and van Kolfschoten, 1995).

However, the extent to which the initial settlement of Europe entailed new adaptations to colder environments remains unclear. While there are exceptions (e.g., uppermost levels at Boxgrove (Roberts and Parfitt, 1999)), most occupations in this time range date to

interglacial intervals. Moreover, there is little evidence for colonization of the colder and drier regions of northern Eurasia (i.e., East European Plain and Siberia) prior to the late Middle Pleistocene (Goebel, 1999; Hoffecker, 1999). There appears to have been a strong bias towards warm climate settings, and it is conceivable that the initial occupation of Europe was simply an expansion into northern maritime areas where climate and biota became similar to those of many African and southern Eurasian environments during the warmest phases of the Middle Pleistocene (e.g., Turner, 1992).

Evidence of morphological adaptations to cool climates among the occupants of Europe prior to OIS 8 is lacking, although the sample of skeletal remains is admittedly very small (e.g., Rightmire, 1998). New technology that might have been developed in response to the demands of higher latitudes is also currently lacking in the archaeological record. The use of controlled fire may have been an important exception, but at present this seems to have been developed in southern latitudes at a much earlier date (Brain and

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Sillen, 1988; Bellomo, 1994). Advances in the diversity and complexity of wooden implements and use of animal hides may have occurred, but few of the former and none of the latter are preserved in the archaeological record.

Especially important is the current lack of evidence for a shift in diet and foraging strategy that might be expected in higher latitudes where digestible plant foods tend to be less common. Analysis of mammal remains at Hoxne and Boxgrove (Britain), Schöningen and Bilzingsleben (Germany), Aridos (Spain), Vértesszöllös (Hungary), and other sites in Western and Central Europe indicate that their occupants were butchering carcasses and stripping meat from bones (Kretzoi and Dobosi, 1990; Villa, 1990; Stopp, 1993; Mania, 1995; Thieme, 1997; Parfitt and Roberts, 1999). But the pattern does not differ significantly from that seen in Early Pleistocene *Homo* sites of Africa (e.g., Cachel and Harris, 1998). Perhaps equally striking is the lack of compelling evidence for central-place foraging among the European sites dating to 500,000–300,000 years ago. All of the sites mentioned above—as well as others in this range—represent settings in which animals and or their remains could have been concentrated by processes other than collection by hominids.

Treugol'naya Cave in the northwestern Caucasus Mountains provides a rare opportunity to address several problems related to the initial settlement of Europe. Although situated at a relatively low latitude—comparable to southwestern France at 44° North—the cave is found at a high elevation (during the early Middle Pleistocene it was approximately 1000 m above mean sea level), and occupies an environmental setting broadly similar to that of mid latitude Western Europe. The site is found in a karst cavity (few of which survive the effects of erosion for more than a quarter of a million years), and the large mammal remains are remarkably well preserved for an assemblage of early Middle Pleistocene age. Caves in the Northern Caucasus occupied by hominids of the Late Pleistocene exhibit clear evidence of the regular hunting of large mammals (apparently reflecting a heavy meat diet) and central-place foraging (e.g., Golovanova et al., 1999).

2. Treugol'naya Cave: geographic setting

Treugol'naya Cave is located on the Baranakha Plateau in the northwestern foothills of the Greater Caucasus Mountains at roughly 44°00′N 41°00′E (Fig. 1). The cave is approximately 7.5 km northeast of Pregradnaya in Karachaevo–Cherkassia (Russian Republic). It lies within the Urup River basin along the upper reaches of a large ravine (Gamovskaya) at an elevation of 1501 m asl. However, during the earlier Middle Pleistocene, the elevation of the cave was

approximately 500 m below its present position (Nesmeyanov, 1999, p. 309). Treugol'naya currently occupies the ecotone between the forest and alpine meadow zones. The cave was formed in Upper Jurassic limestone, and is relatively small, measuring 11–12 m in length, 2.5–3.0 m in width, and no more than 5 m in height (Fig. 2). The depth of deposits varies between 3.0 and 4.5 m (Doronichev, 1992, 2000).

Treugol'naya Cave was discovered in 1986 by Doronichev. During 1987–1991, a total of over 30 m^2 was excavated from the cave, yielding a total of 360 artifacts and tens of thousands of vertebrate remains, including approximately 3800 medium and large mammal remains (Doronichev, 1992; Baryshnikov, 1993). An additional 11 m^2 were excavated in 1995 and 2000, yielding additional artifacts and vertebrate remains (Doronichev, 2000). Although the senior author examined a sample of the large mammal remains recovered in 2000, the taphonomic study presented here is based on the analysis of materials recovered during 1986–1991 conducted at the Zoological Institute (Russian Academy of Sciences) in St. Petersburg.
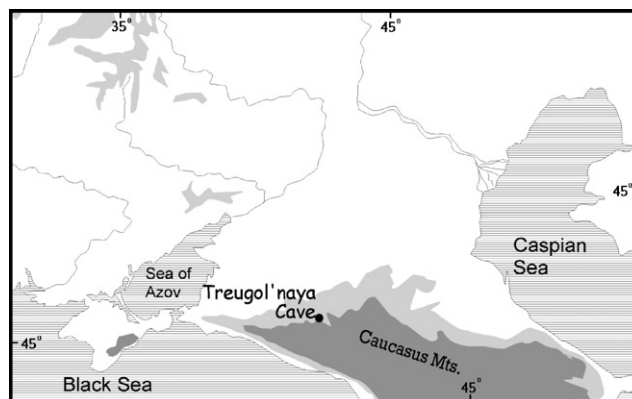

Fig. 1. Map showing the location of Treugol'naya Cave.

Fig. 2. Treugol'naya Cave and surrounding topography (photograph by JFH, 2000).

3. Treugol'naya Cave: stratigraphy and dating

The cave contains a sequence of loam and rubble layers that range from 3 to 4.5 m in total depth (Doronichev, 1992, pp. 103–107, 2000, pp. 68–69; Nesmeyanov, 1999, pp. 303–308) (Fig. 3). The upper-most layers (Layers 1–2) consist of a humic sandy loam and dark gray sandy loam with angular rubble dating to the Holocene. The two underlying units (Layers 3a and 3b) are represented by an orange–brown sandy loam and a dark brown loam with small fragments of rubble; these layers contain a cold-loving Late Quaternary fauna (e.g., snow vole (*Chionomys nivalis*)) that appar-

ently dates to the Late Pleistocene (Nadachowski and Baryshnikov, 1991, p. 441).

The lower portion of the sequence (Layers 4–7) is dated to the Middle Pleistocene on the basis of fauna, absolute dates, and paleomagnetism. Layer 4 comprises a series of sandy loams with varying quantities of weathered limestone and sandstone rubble. Many fragments of rubble, as well as bones and artifacts, are covered with calcareous and calcite concretions. Mammal remains include characteristic later Middle Pleistocene taxa, including *Bison schoetensacki*, *Capreolus sussenbornensis*, and *Canis mosbachensis*; isolated teeth are especially common among the medium–large
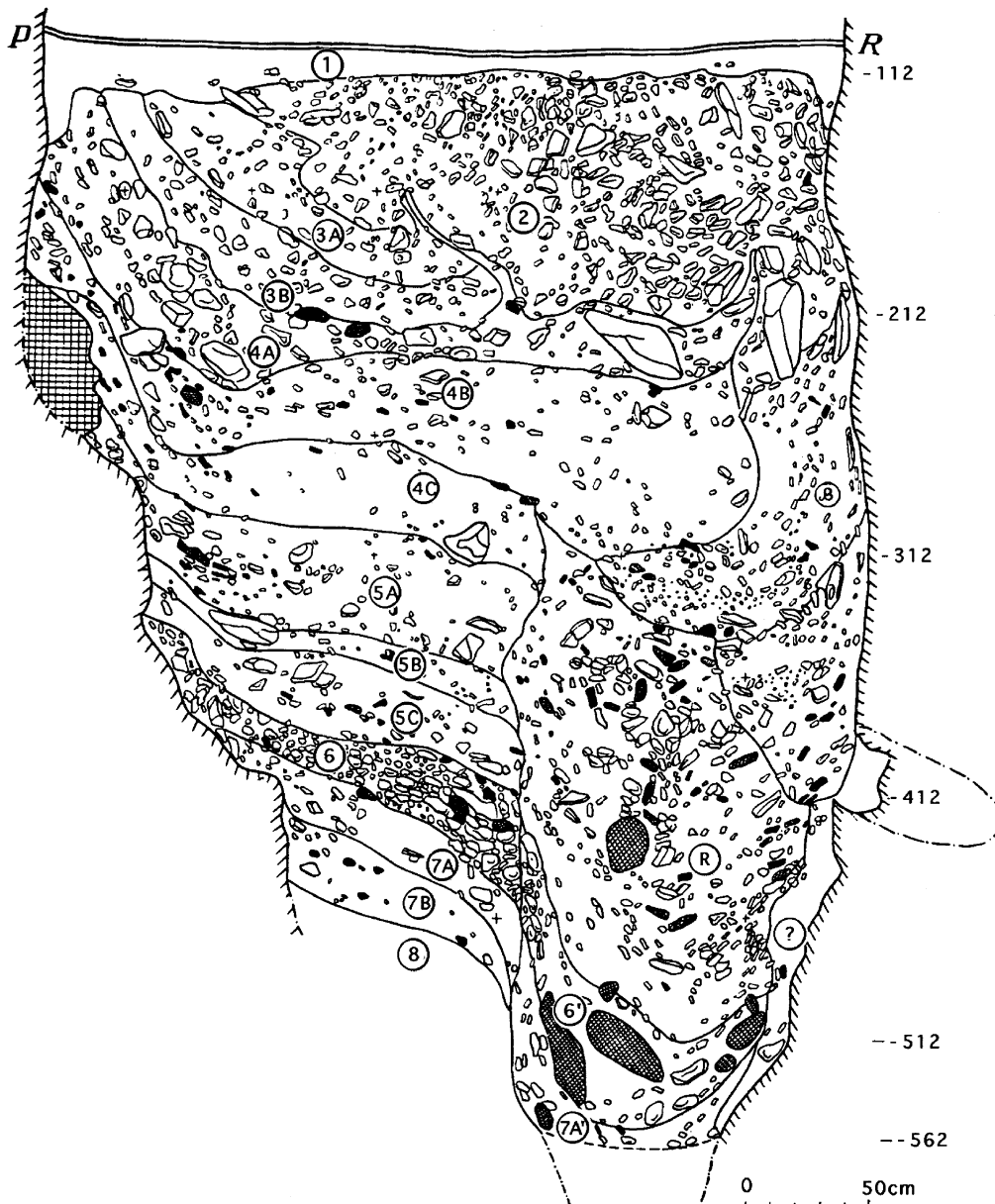

Fig. 3. Stratigraphic profile of Treugol'naya Cave.

mammal remains. Cervid tooth enamel from layers 4b and 4c yielded ESR dates of 338,000 +/−16,000 years and 381,000 +/−16,000 years, respectively (B.A.B. Blackwell, pers. comm., 2002). Analysis of pollen/spore samples indicates that one of these horizons (Layer 4c) was deposited under very cold conditions and presumably dates to a glacial period during the later Middle Pleistocene (Baryshnikov, 1993; Pospelova et al., 1996; Doronichev, 2000).

During the 1986–1990 excavations, a total of 105 artifacts were recovered from Layer 4 (including Layer 4c) and Lens R, which is interstratified with Layer 4 (see Fig. 3). Roughly half of them were manufactured on imported chert, and tool types include side-scrapers, end-scrapers, denticulates, and an atypical limace; handaxes are absent (Doronichev, 1992, pp. 109–112). Several artifacts exhibit complex patterns of flake scars that are unlikely to have been created by natural processes (Fig. 4), and Layer 4 and Lens R appear to contain one of the oldest firmly documented hominid occupations in Eastern Europe (OIS 8—OIS 9?).

Layer 5 consists of a gray–brown sandy loam (Layer 5a), dark brown loam (Layer 5b), and brown sandy loam with rubble and occasional pebbles (Layer 5c). These strata also contain Middle Pleistocene mammal remains, but include some taxa not present in the younger levels (*Stephanorhinus hundsheimensis* and *Equus altidens*). As in the overlying units, isolated teeth are particularly common among large mammal remains. Terrestrial molluscs from Layer 5b yielded on ESR date of 393,000 +/−27,000 years (Molod'kov, 2001), while cervid tooth enamel from the same layer dated to 406,000 +/−15,000 years (B.A.B. Blackwell, pers. comm., 2002). Palynological data indicate that this

horizon was deposited during an interglacial, and the ESR dates suggest that this was probably OIS 11. A few artifacts (primarily imported raw materials) were recovered from each horizon (total $n = 18$), including several end-scrapers, a side-scraper, chopper, and proto-biface (Doronichev, 1992, pp. 108–109, 2000). The occurrence of artifacts in Layers 5a and 5c, which appear to have been deposited under relatively cold conditions, suggest hominid occupation during glacial and interglacial periods (presumably OIS 10 and 12). At least some of the items recovered from Layer 5 are problematic as human artifacts.

Beneath Layer 5 lies a horizon composed of rounded gravels and cobbles in a reddish-brown sandy loam matrix (Layer 6) that is devoid of artifacts, but contains the remains of red deer (*Cervus elaphus*), bear (*Spelaearctos deningeri*), horse (*Equus altidens*), and other large mammals (Baryshnikov, 1993). Many of the bones and teeth in this layer are heavily abraded and rolled, and they appear to have been sorted and deposited by stream action.

The underlying units comprise a brown sandy loam (Layer 7a) and a green–brown sandy loam (Layer 7b) with occasional weathered rubble that contain faunal remains similar to those of Layers 5–6. Paleomagnetic analysis indicates that these horizons were deposited during the Brunhes Normal Chron and postdate 780,000 years ago (Pospelova et al., 1996). Six ESR dates on mollusc shell yielded a mean age of 583,000 years ago (Molod'kov, 2001). Layer 7a contained a total of eleven probable artifacts (imported raw materials), including five flake tools (Doronichev, 2000). At the base of the sequence lies a thick bed of green glauconitic sand (Layer 8) that is archaeologically sterile.

4. Species composition

A total of 3800 large mammal bones and teeth were recovered from the Middle Pleistocene layers of the cave during 1986–1991, of which 38% were identifiable to genus or species. Most of the small fragments that could not be assigned to genus or species were discarded prior to this study, and are not included in the taphonomic analysis of the assemblage. The large mammal remains include representatives from three orders: Carnivora, Perissodactyla, and Artiodactyla. Large mammal remains from Layers 4–7 are listed in Table 1 (Baryshnikov, 1993).

The carnivore assemblage is typical for the Mindel faunas of Europe (broadly correlated with OIS 12), with the exception of *Meles hollitzeri*, which is known from older deposits (early Biharian). A very similar assemblage was recovered, for example, from the Middle Pleistocene archaeological site of Miesenheim I in Germany (van Kolfschoten and Turner, 1996). The
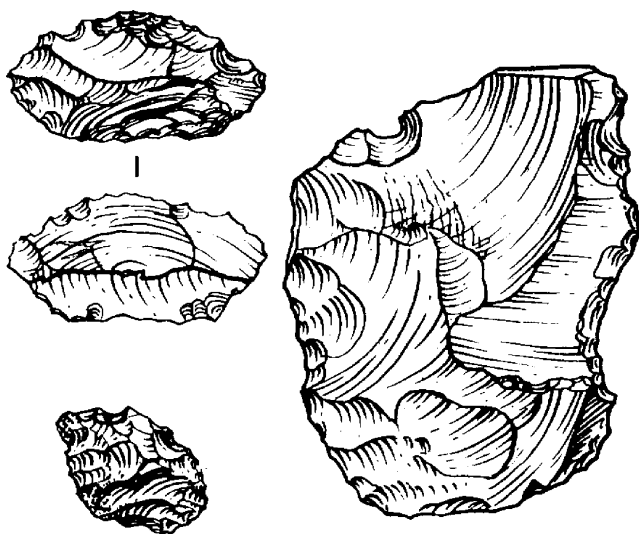

Fig. 4. Artifacts from Layer 4 and Lens R of Treugol'naya Cave, including side-scrapers (left) and denticulate (right) (after Doronichev, 1992, Fig. 5).

Table 1
Large mammal remains from Middle Pleistocene layers of Treugol'naya Cave (Baryshnikov, 1993, p. 41, Table 19)

Taxa	Layers											
	4a	4b	4c	4d	*B*	5a	5b	5c	5d	6	7a	7b
Canis mosbachensis	3/2	3/1	/	4/1	–/–	–/–	6/3	2/1	–/–	–/–	2/1	6/1
Vulpes vulpes	–/–	1/1	1/1	1/1	1/1	–/–	–/–	–/–	–/–	–/–	–/–	–/–
Selenarctos thibetanus mediterraneus	–/–	–/–	–/–	–/–	–/–	–/–	3/1	–/–	–/–	–/–	–/–	–/–
Ursus (Spelaearctos) deningeri	11/2	13/2	3/2	4/2	1/1	–/–	16/2	40/3	1/1	19/2	19/4	28/3
Meles hollitzeri	–/–	1/1	–/–	–/–	–/–	–/–	–/–	–/–	–/–	1/1	–/–	–/–
Mustela nivalis	–/–	–/–	–/–	–/–	–/–	1/1	3/1	–/–	–/–	–/–	1/1	–/–
Crocuta spelaea cf. *Praespelaea*	–/–	–/–	–/–	–/–	–/–	–/–	–/–	–/–	–/–	–/–	1/1	–/–
Panthera spelaea	–/–	1/1	–/–	–/–	–/–	–/–	–/–	–/–	–/–	1/1	–/–	–/–
Felis cf. *F. lybica*	–/–	–/–	–/–	2/1	–/–	–/–	–/–	–/–	–/–	–/–	–/–	–/–
Equus altidens	–/–	–/–	–/–	–/–	–/–	1/1	–/–	–/–	–/–	13/2	–/–	–/–
Stephanorhinus hundsheimensis	–/–	–/–	–/–	–/–	–/–	–/–	1/1	8/1	1/1	8/4	–/–	1/1
Capreolus cf. *C. sussenbornensis*	6/2	5/2	–/–	3/1	1/1	–/–	–/–	2/1	–/–	5/1	–/–	–/–
cf. *Praedama* sp.	–/–	–/–	–/–	–/–	–/–	–/–	–/–	1/1	–/–	–/–	–/–	–/–
cf. *Dama* sp.	–/–	–/–	–/–	–/–	–/–	–/–	–/–	1/1	–/–	–/–	–/–	–/–
Cervus elaphus (f. *acoronatus*)	39/3	118/6	33/3	41/2	27/2	–/–	177/9	276/10	42/3	46/3	27/2	15/1
Bison sp. (ex gr. *priscus schoetensacki*)	4/1	7/1	3/1	–/–	2/1	–/–	23/2	33/2	16/2	5/1	1/1	2/1
Capra sp. (ex gr. *caucasica*)	2/1	2/1	1/1	–/–	4/1	13/2	17/3	15/2	1/1	–/–	–/–	–/–

most abundant carnivore remains at Treugol'naya Cave belongs to cave bear (*Ursus (Spelaearctos) deningeri*). Although the sample of molars is insufficient for morphotypic analysis, the large dimensions of the teeth (especially the size of two upper second molars from Layers 5c and 7a, which exceed 47.8 mm in length) are characteristic.

Perissodactyls include *Equus altidens* (previously classified as *Equus* cf. *namadicus*) and *Stephanorhinus hundsheimensis* (previously assigned to *S. etruscus brachycephalus*) (Baryshnikov, 1993, pp. 22–27). European paleozoologists currently distinguish *S. hundsheimensis* from *S. etruscus* as a characteristic species of the early Middle Pleistocene (Sala and Fortelius, 1993). This small rhinoceros is known from localities in Western Europe (e.g., Pirro in Italy), and the Transcaucasus (Kudaro I, Azykh Cave, and Erevan Cave). The small *E. altidens* is diagnostic of the early Middle Pleistocene Galerian fauna, and is present at localities such as Sussenborn (Germany), Tiraspol' (Moldavia), and Dmanisi (Georgia) (Gabuniya and Vekua, 1989).

Artiodactyls are represented by six taxa. On the basis of the tooth dimensions, the roe deer at Treugol'naya Cave are somewhat smaller than *Capreolus sussenbornensis*, which is characteristic of the early Middle Pleistocene in Western Europe. On the other hand, the red deer is larger than *Cervus elaphus* cf. *acoronatus* from the Caune de l'Arago (France) (Lister, 1986), nd perhaps can be correlated with the deer of the late Mindel period. The bison may be assigned to a steppe form with morphometric similarities to *Bison schoetensacki*, which is present in the Tiraspolian complex of the early Middle Pleistocene (Flerov and David, 1971).

The ratio of carnivores to ungulates and carnivores combined in the Middle Pleistocene layers of Treugol'naya Cave is 1:2.9 (i.e., carnivores represent approximately 35% of the total large mammal assemblage) when calculated on the basis of the estimated minimum numbers of individuals (MNI) for each taxon. The percentage of carnivores is lower (16%) when calculated on number of identified specimens (NISP) for each taxon, which does not inflate the proportion of rare species—more common among carnivores than ungulates in this assemblage—as do MNI estimates (Klein and Cruz-Uribe, 1984, pp. 32–34). The proportion of carnivores is high and may be compared to assemblages accumulated by carnivores (e.g., Stiner, 1994, pp. 82–92); for example, carnivores typically account for at least 20% of the total carnivore/ungulate MNI in hyaena dens (Cruz-Uribe, 1991, pp. 475–476). By contrast, the carnivore percentage at Treugol'naya Cave is very high for a hominid accumulation, in which carnivores are usually less than 10% of the total (Klein and Cruz-Uribe, 1984, pp. 82–85).

5. Weathering and breakage

Large mammal remains from the Middle Pleistocene layers of Treugol'naya Cave display a low degree of discoloration and geochemical weathering. Most bones do not appear to have been exposed to an extended period of subaerial weathering prior to burial in the cave. However, the bones have been heavily fragmented. The distribution of fracture types indicates that bones were broken in both a fresh and dry condition.

Most of the bones and teeth do not exhibit substantial discoloration or staining. With reference to *Munsell Color Charts*, bones are typically very pale brown (10YR8/3 or 10YR8/4) or pale yellow (2.5Y8/3 or 10YR8/6) and less commonly white (10YR8/2); some bones possess a light gray mottled appearance. In order to assess overall degree of weathering and identify any variations among layers and taxa, bones were classified according to weathering stage (Behrensmeyer, 1978, pp. 151–153; Johnson, 1985, pp. 187, Table 5.1). Because bone weathering rates vary due to differences in structural density, the samples were subdivided according to skeletal parts (e.g., longbones versus carpals/tarsals) and taxa (Lyman, 1994, p. 361). Among samples from Layer 5, 76% of bison and 94% of red deer longbone fragments were assigned to weathering "stage 1" or less. Other skeletal part groups of these taxa from Layer 5 exhibit a similar low degree of weathering (see Table 2). Samples from other layers are too small for quantitative comparison, but also reflect limited weathering.

More than 90% of the identifiable bones are fragmented, including all crania, antlers, mandibles, vertebrae (with the exception of one cervical vertebra of *Capra* sp. from Layer 5), scapulae, pelves, and longbones (with the exception of a *Spelaearctos* femur from Layer 6). Also, many isolated teeth are fractured or damaged. The only intact skeletal parts are small compact bones, including some tarsals and carpals (e.g., astragalus, cuneiform, naviculo-cuboid) and phalanges.

No significant variations in fragmentation intensity among layers were detected. The mean maximum lengths of red deer longbone fragments were calculated for each layer and (where adequate samples were present) failed to yield any significant variations among the layers. However, it should be noted that most fragments unidentifiable to genus or species were not available for study, which is likely to bias samples towards larger fragments and may conceal differences in fragmentation intensity. Although major differences occur among layers in the ratio of numbers of identified specimens (NISP) to the minimum number of individuals (MNI) (see Table 1), which is sometimes used as a measure of fragmentation intensity (e.g., Chaplin, 1971, p. 67; Klein and Cruz-Uribe, 1984, pp. 70–71), these variations may be accounted for by sample size (which influences both MNI values and NISP:MNI ratios (Grayson, 1984, pp. 49–84)).

Bone breakage patterns were assessed by classification of fracture types among longbones (e.g., Shipman et al., 1981; Johnson, 1985). Longbone shaft fragments exhibit types of fracture that often indicate the condition of the bones (i.e., fresh versus dry) at the time of breakage (Morlan, 1980, pp. 48–49). Other skeletal parts (e.g., cranial fragments) are more difficult to classify in these terms. Among red deer and bison longbones ($n = 100$) from Layer 5, 56% exhibit fresh or "green" fractures

Table 2
Classification of bones of red deer (*Cervus elaphus*) by weathering stage (following Behrensmeyer, 1978)

	Weathering stage					
	Stage 0/1	Stage 1	Stage 1/2	Stage 2	Stage 2/3	Stage 3
Layer 4						
Mandible	1	4	3	—	—	—
Axial parts	3	4	—	—	—	—
Longbones	3	3	1	—	—	—
Carpals/tarsals	3	2	—	—	—	—
Layer 5						
Mandible	7	19	4	5	1	—
Axial parts	20	26	4	5	—	—
Longbones	30	16	1	1	1	—
Carpals/tarsals	5	3	5	1	—	1
Layer 6						
Mandible	—	1	—	—	—	—
Axial parts	—	3	—	—	—	—
Longbones	2	1	—	—	—	—
Carpals/tarsals	5	2	—	—	—	—
Layer 7						
Mandible	—	4	1	—	—	—
Axial parts	—	1	—	—	—	—
Longbones	—	—	—	—	—	—
Carpals/tarsals	2	—	—	—	—	—

(e.g., Type II spiral, V-shaped, sawtooth) and 21% exhibit dry fractures (e.g., step, perpendicular); remaining specimens either display a mixture of fresh and dry fractures (9%) or could not be classified (14%). Longbone fragments from other layers also exhibit both fresh and dry fractures, but sample sizes are too small for quantitative analysis. The percentage of bones broken in fresh condition appears low in comparison to hominid bone accumulations; for example, over 90% of large mammal longbone fragments from Neanderthal occupation layers at Mezmaiskaya Cave exhibited fresh fractures (Baryshnikov et al., 1996, pp. 327–328).

6. Surficial bone damage

Owing to their low degree of weathering, bones from Treugol'naya Cave exhibit a broad array of surficial damage. The most common forms of damage (observed with an unaided eye or low-power magnification (8 × hand lens)) include shallow scratches, incisions, and pits, which are randomly distributed on bone surfaces, and polish, which sometimes occurs on fracture edges. These types of surficial damage are most probably caused by a combination of trampling prior to burial, and various forms of sediment abrasion after burial (Behrensmeyer et al., 1986; Oliver, 1989).

Traces of heavy sediment abrasion or "rolling" are visible on many teeth and bones from Layer 6, but not from other layers. Roughly 70% of rhinoceros and 100% of horse remains from Layer 6 are heavily abraded or rolled (Fig. 5); however, most of the red deer and bison bones and teeth from this unit are not abraded. The rolled teeth and bones appear to have been transported by running water (Baryshnikov, 1993, p. 23). This conclusion is supported by the sediments in Layer 6, which comprise fluvial gravels in a sandy loam matrix. Many of the rhinoceros and horse remains

are found in this unit, and these remains apparently were accumulated by stream action. However, the presence of unabraded teeth and bones of other taxa indicates that at least some of the large mammal remains in Layer 6 were deposited by other processes.

Some bones exhibit damage characteristic of carnivores, in the form of scratches, furrows, gouge marks, pits, and punctures—sometimes bipolar (e.g., Binford, 1981; Haynes, 1982, 1983; Stiner, 1994). Among the large sample of red deer and bison bones from Layer 5 ($n = 240$), 13% display definite or highly probable carnivore damage and another 11% display possible carnivore damage. Such damage can be observed on cranial fragments, mandibles, vertebrae, scapulae, pelves, longbone epiphyses and diaphyses, tarsals, and phalanges. Tooth punctures on specimens from Layer 5 are not common, but include examples that exhibit diameters of more than 5 mm (Fig. 6).

The percentage of bones in Layer 5 with clear traces of carnivore gnawing is low in comparison to hyaena accumulations, which typically contain over 40% damaged bone (Cruz-Uribe, 1991, pp. 476–477). It is also relatively low in comparison to assemblages collected by large felids, which may contain more than 20% gnawed bone (e.g., Brain, 1981, p. 144), although felids tend to inflict less damage than other carnivores (Haynes, 1983, pp. 169–171). The percentage of gnawed bones in canid accumulations appears to vary widely, but, in some cases, may be very low and within the range observed for Layer 5 (Kent, 1981; Haynes, 1982; Lyman, 1994, pp. 211–215).

A small number of bones from Treugol'naya Cave bear possible traces of human activity. Several

Fig. 5. Isolated teeth of *Equus altidens* (horse) from Layer 6 of Treugol'naya Cave that exhibit traces of heavy abrasion or rolling (photograph by JFH, 1998).

Fig. 6. Vertebra fragment of *Cervus elaphus* (red deer) from Layer 5 of Treugol'naya Cave exhibiting large tooth puncture marks (diameter = 5–6 mm) (photograph by JFH, 1998).

specimens display possible stone tool cut marks in the form of multiple incisions at anatomical locations where cut marks have been recorded in ethnographic or archaeological studies (e.g., Guilday et al., 1962; Frison, 1973; Binford, 1981). Examples include: (1) red deer mandible with light parallel incisions below the second and third molars on the medial face (Layer 5c); (2) bison metapodial condyle with oblique incisions on the lateral surface (Layer 7b (no artifacts reported to date)); and (3) bison distal tibia with subparallel incisions on the medial shaft (Layer 5). Several bones exhibit possible examples of hammerstone percussion marks in the form of concoidal fractures (i.e., green breakage) associated with microstriations (Blumenschine and Selvaggio, 1988) (Fig. 7). Possible tool percussion marks were observed on three red deer longbone shaft fragments from Layer 5, and on one bison longbone shaft fragment from Layer 4. However, a potential alternative source of percussion marks is represented by rockfall (e.g., Dixon, 1984, pp. 210–212), which is present in all of the units containing these fragments (see Fig. 3).

Possible traces of human activity are also evident on a number of red deer bone fragments (primarily recovered from Layer 5) that may have been used as tools. These specimens are represented by seven upper and lower longbone shaft fragments (6–11 cm in length) and one distal scapula fragment (4.5 cm in length) that display varying degrees of flaking and polish along one longitudinal fracture edge. All of them were broken and damaged in green condition, and three of them exhibit microstriations either parallel or transverse to the damaged edge. These fragments possess the same set of characteristics (skeletal part, size, location and type of edge damage) as those classified as utilized bone tools in the Lower Paleolithic of East Africa (Shipman, 1989). However, carnivores can cause similar damage to limb bones (e.g., Binford, 1981, pp. 59–60; Villa and Bartram, 1996), and the Treugol'naya Cave specimens (two of

which exhibit possible carnivore marks) remain problematic pending more detailed analysis of the microstriations (which provides the most reliable evidence of tool use (Shipman, 1989, pp. 322–324)).

7. Distribution of skeletal parts

Because the Middle Pleistocene mammal remains from Treugol'naya Cave are relatively well preserved, weathering appears unlikely to be the primary determinant of the distribution of skeletal parts. However, the high degree of fragmentation has almost certainly influenced observed part frequencies by converting a significant percentage of the assemblage into small fragments that probably weather more rapidly (due to increased surface area and exposed cancellous bone) and are more difficult to identify (Lyman and O'Brien, 1987). More specifically, the absence of most of the smaller fragments that could not be identified to genus or species has probably reduced the visibility of postcranial parts (Marean, 1998; Marean and Kim, 1998).

Most of the large mammal taxa are represented by samples that are too small for analysis of skeletal part distribution. These samples are chiefly composed of isolated teeth, which probably reflects the effects of fragmentation. Horse and rhinoceros are represented almost exclusively by cheek teeth. As noted above, many of these remains were recovered from fluvial gravels (Layer 6) and exhibit heavy sediment abrasion (or "rolling"), indicating that they were deposited by running water. Water transport sorts bones and teeth by size, shape, and density (e.g., Voorhies, 1969; Behrensmeyer, 1975), and it is likely that the distribution of part frequencies for these taxa was influenced by fluvial sorting and the reduced identifiability of the rolled bone fragments.

The distribution of skeletal parts for red deer, which is based on the comparatively large sample from Layer 5, is presented in Table 3. In order to control for variations in anatomical frequency and fragmentation, numbers of identified specimens (NISP) have been converted to estimated minimum number of individuals (MNI) represented by each part. The problem of assigning longbone shaft fragments to specific elements has been addressed to some degree by including generic categories for upper and lower limbs, because middle shaft fragments provide a more accurate basis than articular ends for estimates of limb bones (Marean and Spencer, 1991).

Head parts are best represented among red deer skeletal elements from Layer 5 (Fig. 8). This pattern is even more strongly expressed by the isolated teeth (excluded from Table 3), which yield a combined MNI of 22 for this layer (see Table 1). In a heavily fragmented assemblage, head parts are likely to be better represented than most other skeletal elements
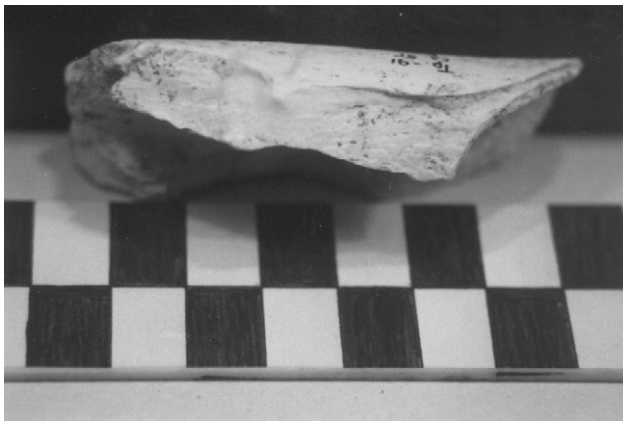

Fig. 7. Fragment of longbone of *Cervus elaphus* (red deer) from Layer 5 of Treugol'naya Cave exhibiting impact fracture (photograph by JFH, 1998).

Table 3
Distribution of red deer (*Cervus elaphus*) skeletal parts from Layer 5 of Treugol'naya Cave

| Anatomical region	Skeletal element	Stratum				
		5a	5b	5c	5d	Totals
Head and neck	Antler	1/1	35/1	22/1	5/1	63/4
	Cranium	1/1	3/1	47/5	1/1	52/8
	Mandible	3/2	9/1	22/4	1/1	35/8
	Atlas					0/0
	Axis		2/1			2/1
	Cervical vertebrae			1/1		1/1
Axial	Thoracic vertebrae			2/1		2/1
	Ribs		1/1			1/1
	Lumbar vertebrae					0/0
	Innominate			1/1		1/1
Upper forelimb	Scapula		1/1	3/2		4/3
	Humerus			3/2		3/2
Upper hindlimb	Femur		1/1	1/1		2/2
Upper limbs	Shaft fragments	1/1	2/1	3/1	2/1	8/4
Lower forelimb	Radius					0/0
	Ulna	1/1				1/1
	Carpals			2/2	1/1	3/3
	Metacarpal	1/1				1/1
Lower hindlimb	Tibia			2/1		2/1
	Patella			1/1		1/1
	Tarsals		2/1	2/1	1/1	5/3
	Metatarsal	1/1	1/1		1/1	3/3
Lower limbs	Shaft fragments	4/1	4/1	3/1	7/1	18/4
Feet	First phalanx	1/1	1/1	1/1		3/3
	Second phalanx					
	Third phalanx		1/1			1/1
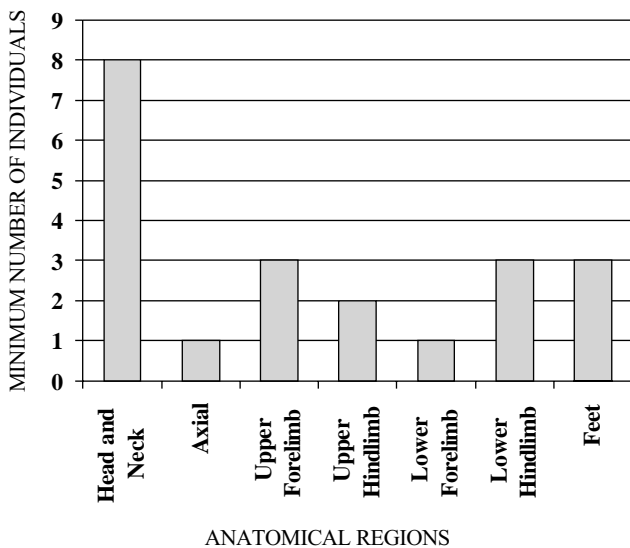
Fig. 8. Distribution of body parts (represented by anatomical regions) for *Cervus elaphus* (red deer) from Layer 5 of Treugol'naya Cave.

because of their high identifiability. Antlers, crania, and mandibles may be broken into many small but easily identified fragments. This phenomenon may account for the predominance of head parts among the red deer remains at Treugol'naya Cave. The absence of most of the small "unidentifiable" fragments (which were discarded prior to this study) probably contributes to the bias against post-cranial elements (Marean, 1998; Marean and Kim, 1998). Many of these fragments can be assigned to broader taxonomic categories (e.g., medium ungulates) and factored into the analysis at a higher level. Among carnivore accumulations, head-dominated assemblages are found in hyaena species (Stiner 1991, 1994).

8. Age and season of death

Sample sizes are too small for most of the taxa represented at Treugol'naya Cave to draw conclusions

about age and season of death. Among carnivores, the cave bear remains include a large quantity of isolated teeth ($n = 70$). Approximately 45% of these are deciduous, while the permanent teeth exhibit a wide range of wear and reflect the presence of prime-age and old adults (Baryshnikov, 1993, pp. 8–17). The bison remains contain a small sample of isolated molars ($n = 15$) of which 80% are either relatively heavily or extremely heavily worn, indicating a predominance of old individuals among adults.

An age (mortality) profile was generated for the large red deer sample on the basis of crown-height measurements on lower third molars (Klein et al., 1981). Measurements were taken of mesial-buccal minimum crown height on specimens recovered from all of the Middle Pleistocene levels ($n = 40$). Heavily worn crowns predominate, indicating that most of the individuals represented in the sample were old adults at the time of death (Fig. 9). Because the third molar does not erupt in red deer until the age of 2.5 years, juveniles are not represented and the age profile is not complete for the sample population. Several specimens of the deciduous fourth premolar, which is sometimes used in conjunc-

tion with the third molar to generate a complete age profile (Klein and Cruz-Uribe, 1984, pp. 46–53), were recovered from Layers 4–7 ($n = 3$). However, the small size of the sample of deciduous teeth probably reflects the impact of taphonomic factors (including carnivore activity (Binford and Bertram, 1977; Munson, 2000, pp. 399–401)) that had less effect on the permanent teeth, and they were excluded from the age profile. The latter indicates that among adults, mortality was attritional (Voorhies, 1969).

Some data regarding season of death are also available for red deer. Fragments of the frontal bone include specimens with shed antlers (indicating death during the winter or early spring) and unshed antlers (indicating death between late summer and late autumn). The presence of an unworn deciduous incisor (Layer 4b) reflects death during the summer period. Also, several upper and lower first molars from Layers 4–5 exhibit extremely light wear, indicating probable death between November and January (Baryshnikov, 1993, p. 34). Red deer mortality thus appears to have occurred at various times throughout the year, and was not concentrated in one season.

9. Analysis and conclusions

Like most cave faunas, the large mammal assemblage from the Middle Pleistocene layers of Treugol'naya Cave reflects a complex history. Multiple abiotic and biotic processes have acted—and sometimes interacted—in the accumulation and modification of the remains. These processes are summarized below in the context of the major represented taxa in an effort to isolate and identify the possible role of hominids in the assemblage.

9.1. Carnivores

Most carnivore remains appear to represent animals that died of natural causes during habitation of the cave. Cave bear is the most abundant carnivore taxon and most likely reflects mortality associated with hibernation; the high proportion of juveniles and presence of old adults is generally consistent with the expectations of attritional mortality due to old age, disease, and starvation (Baryshnikov, 1993, p. 17). The remains are highly fragmented and dispersed, which was probably caused by trampling and gnawing by other occupants of the cave. In contrast to caves in which bears represent over 85% of the large mammal assemblage (e.g., Matuzka (Baryshnikov and Golovanova, 1989)), Treugol'naya Cave bears apparently shared the site more fully with other carnivores and hominids.
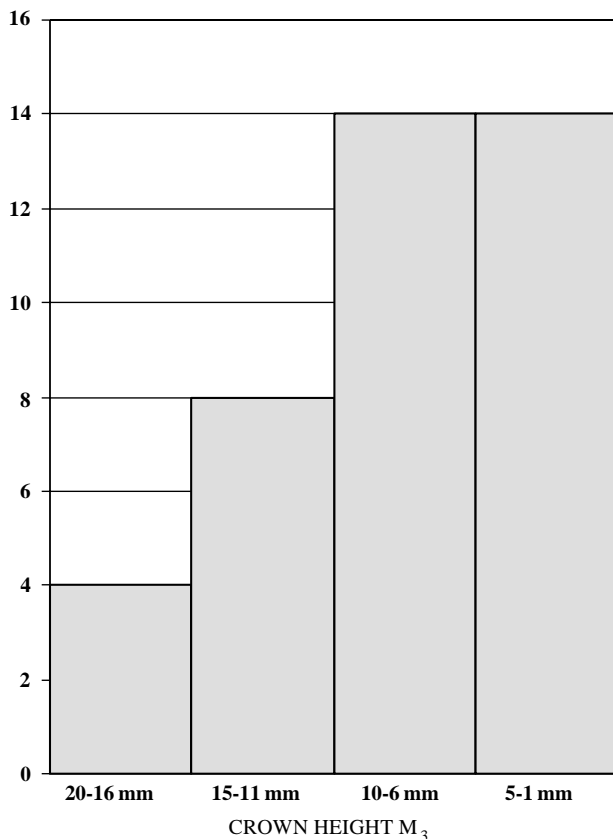

Fig. 9. Distribution of crown-height measurements on the lower third molar for *Cervus elaphus* (red deer) from Layers 4–7 in Treugol'naya Cave.

9.2. Perissodactyls

Many remains of odd-toed ungulate taxa—horse and rhinoceros—appear to have been accumulated by stream action. A high percentage of these remains comprise heavily abraded teeth concentrated in a fluvial gravel deposit (Layer 6). Some unabraded rhinoceros remains (chiefly tooth fragments) were also recovered from other units and were evidently accumulated by different means. Fluvial processes have thus altered the overall composition of the assemblage by increasing the representation of taxa that would otherwise be less common in the cave.

9.3. Artiodactyls

Most of the artiodactyl remains, which are primarily represented by red deer, bison, and goat, were probably accumulated and fragmented by carnivores that occupied the cave (see Table 4). The high overall proportion of carnivores in the assemblage and the pattern of attritional mortality are typical of a carnivore accumulation (Klein and Cruz-Uribe, 1984; Stiner, 1994). The high degree of fragmentation and modest percentage of carnivore-damaged bones may be found in some carnivore and hominid bone accumulations. However, the low incidence of tool percussion and cut marks on (unweathered) bones is not consistent with a hominid accumulation.

Among the carnivores identified in Treugol'naya Cave, wolves seem most likely to have accumulated and fractured the bulk of the artiodactyl assemblage, although cave lion also may have played a role in the latter. Bears and wolves are the most commonly represented carnivores in the cave, but the former do not collect large quantities of prey remains. Although hyaena is represented by an isolated tooth in Layer 7a, most of the assemblage characteristics do not match those of a hyaena accumulation. The relatively low percentage of gnawed (unweathered) bones is especially unusual for this taxon, but less so for wolves and large felids (Lyman, 1994). For example, only 16% of roe deer

and 18% of ibex bones from a Late Pleistocene wolf accumulation in Italy exhibited gnaw damage (Stiner, 1994, p. 121). Also, the common occurrence of small compact bones (e.g., carpals) is uncharacteristic of hyaena accumulations (Cruz-Uribe, 1991, pp. 479–481), but observed in modern wolf den assemblages (e.g., Binford, 1981, p 213). Although the abundance of head parts among skeletal elements is more typical of hyaena than wolf (Stiner, 1991, pp. 463–465), this pattern might be accounted for by the comparatively high identifiability of head parts—and correspondingly low identifiability of specific limb bones—in a heavily fragmented assemblage. The large diameters observed on some of the tooth puncture marks suggest that large felids (which are represented by isolated remains of cave lion in Layers 4 and 6) contributed to the collection and/or modification of the artiodactyl remains.

9.4. Hominid activity

Hominids occupied Treugol'naya Cave on a recurrent basis during the Middle Pleistocene, but their role in the accumulation and modification of the large mammal assemblage seems to have been limited. The most likely traces of hominid behavior on the large mammal remains are several examples of percussion marks on ungulate longbone fragments (tool cut marks are rare and problematic) and the possible use of some bone fragments as tools. However, other (i.e., non-human) agencies might account for both the percussion marks and the tool-like appearance of some fragments (see earlier discussion).

Although the possibility that hominids brought at least some of these bones to the cave as hunted or scavenged prey cannot be excluded, there is no compelling evidence for this conclusion. Features characteristic of hominid bone accumulations of the Late Pleistocene (i.e., high incidence of tool marks, prime-dominated age profile, low percentage of carnivores (e.g., Baryshnikov et al., 1996)) are not present. Moreover, the highest concentrations of artiodactyl remains occur in units that contain the lowest numbers of stone artifacts. Hominid occupants of the

Table 4
Summary characteristics of the artiodactyl assemblage from the Middle Pleistocene layers of Treugol'naya Cave

Category	Treugol'naya Cave
Carnivore: Ungulate ratio	Carnivores represent 35% of the total large mammal assemblage (MNI)
Fragmentation intensity	More than 90% of the bones are broken, including all cranial parts and longbones; 56% of longbones were broken in a fresh (or green) condition
Carnivore damage	13% of bones exhibit clear traces of carnivore damage
Tool marks	Several bones bear possible cut marks and probable percussion marks
Skeletal part distribution	Head parts are best represented, but the pattern may primarily reflect greater identifiability of head parts in a fragmented assemblage
Age (mortality) profile	Predominance of old individuals among adults indicating attritional mortality
Season of death	Mortality distributed throughout the year, not concentrated during one season

cave may simply have broken and used bones gathered by carnivores. This activity might have affected the assemblage by further reducing the visibility of ungulate longbones through increased fragmentation; wolf den accumulations normally contain a higher proportion of limbs than those represented at Treugol'naya Cave (Binford, 1981, pp. 198–202; Stiner, 1991, 1994).

Hominds of the early Middle Pleistocene may have pursued a foraging strategy that differed significantly from that of Late Pleistocene hominids, entailing a greater emphasis on scavenging abandoned carcasses (e.g., Binford, 1981; Gamble, 1986). This strategy might have entailed relatively little central-place foraging (e.g., Binford, 1984, pp. 259–264). Such behavior probably would be more difficult to recognize among an assemblage of large mammal remains than the hunting activity of the Late Pleistocene. However, in the case of Treugol'naya Cave there are no taphonomic characteristics of the assemblage that cannot be accounted for by the processes of natural mortality, stream deposition, and carnivore accumulation—particularly when the effects of fragmentation are taken into consideration—beyond some possible fracture and utilization of bone by hominids. The latter may have hunted or scavenged large mammals at other locations, but there is no evidence that they did so at this site, which appears to have been used for other purposes.

Acknowledgements

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