

# Mammal Fauna First Found in Alluvial-Speleogenic Formations of the Late Neopleistocene and Holocene, Northern Urals, Locality Cheremukhovo-1

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**Abstract**—Based on results of multidisciplinary study, it is shown that locality Cheremukhovo-1 is of a new taphonomic type in the Urals and characterizes interval of geological record formerly unknown for the late Neopleistocene of the region. Presented in the work are lithologic characterization of beds, dating results, and description of paleontological material (Vertebrata remains) and palynological spectra. The locality is correlated with burials known in other regions and can be regarded as one of the reference sections of upper Neopleistocene–Holocene deposits in the northern Urals.

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*Key words:* upper Neopleistocene, Nev'yansk interglacial, Polar Urals glacial, Holocene, cave (speleogenic) and alluvial deposits (formations), mammal fauna, palynological assemblages, paleogeography.

## INTRODUCTION

Data on taxonomic composition of terrestrial mammal communities are important for solving problems of the upper Neopleistocene stratigraphy and for understanding the biota reaction in North Eurasia to global climatic changes. On the other hand, they are valuable for correlation between regional stratigraphic schemes of the Urals and other regions. As alluvium of mountainous areas is unfavorable for preservation of osteoliths, paleontological remains of the late Neopleistocene and Holocene are known here mostly from deposits filling in the karst caves. Bone remains in cave deposits are autochthonous in most cases, not subjected to redeposition after burial. In addition, they frequently occur in association with archeological artifacts that is favorable for relative dating of host deposits and stratigraphic interpretation.

In the eastern flank of northern Urals, there are known 17 bone burials in karst caves (Smirnov, 1994, 1996; Smirnov *et al.*, 1999; Bachura and Kosintsev, 2001; Teterina, 2002; Teterina and Ulitko, 2002). The burials are usually situated high enough relative to the water level of rivers, and relevant cave deposits accumulated therefore without influence of river streams. Fluvial terrace deposits of the region yield only scarce bone remains of Quaternary mammals (Lider, 1976; Bachura and Kosintsev, 2001). In the eastern flank of northern Urals, these remains from alluvial deposits have been unknown so far. The locality Cheremukhovo-1, where cave formations are associated with alluvial deposits, is suitable for elaboration of method-

ical approach to joint interpretation of data obtained from deposits of both types.

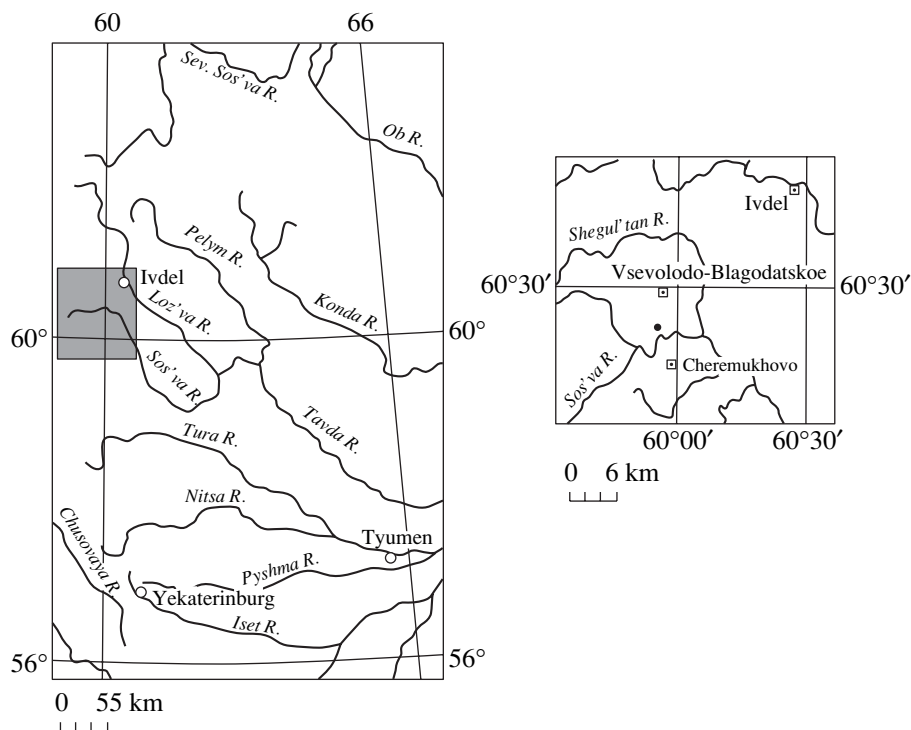
In this work, our objective was to study stratigraphy of the Cheremukhovo-1 deposits and to correlate the results of paleontological analysis with data on other bone burials in the Northern Urals and adjacent areas.

## COORDINATES AND LITHOLOGIC CHARACTERIZATION

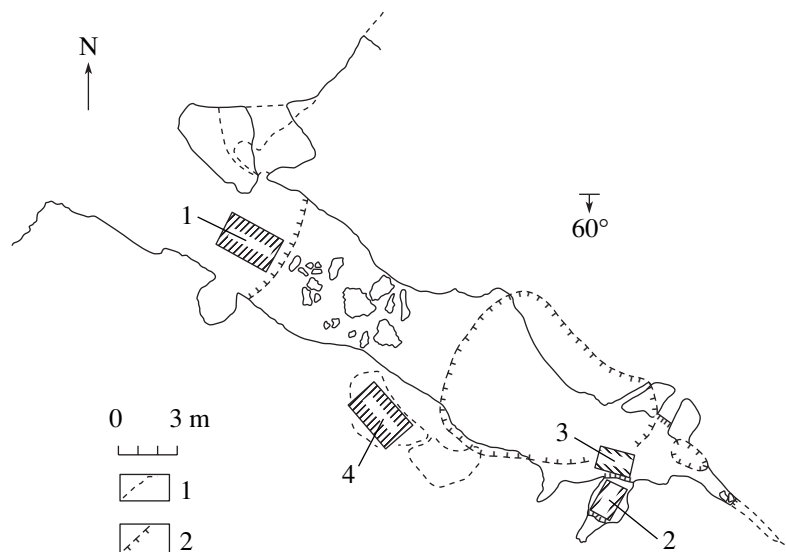
**Coordinates.** Remains of vertebrate bones and artifacts have been discovered in deposits of several karst caves of the Chertovo Gordishche rocky massif situated on the Sos'va River right side 3.5 km upstream of the Shegul'tan River mouth. The central cave (60°24'03" N, 60°03'26" E, Fig. 1), where artifacts are most abundant, is legalized as the Cheremukhovo-1 archeological monument.

The cave is in compact cross-bedded limestones of the Devonian. Its entrance facing northwestward is situated at the level of 5.5 m above the river flood plain, being 8 × 8.5 m in dimensions. The cave is 32 m long in total. The cave roof collapsed 11 m behind the roof-dropping line along the distance of 12 m. Cave walls are pierced by holes and have numerous niches and grottos situated near the floor and higher, up to the level of 1.5–2.5 m above the floor (Borodin *et al.*, 2000). In this work, we consider materials from the Excavation 4.

**Lithologic description.** The deposits under consideration are completely exposed in the southwestern wall of main excavation along square lines D/2–D/4.



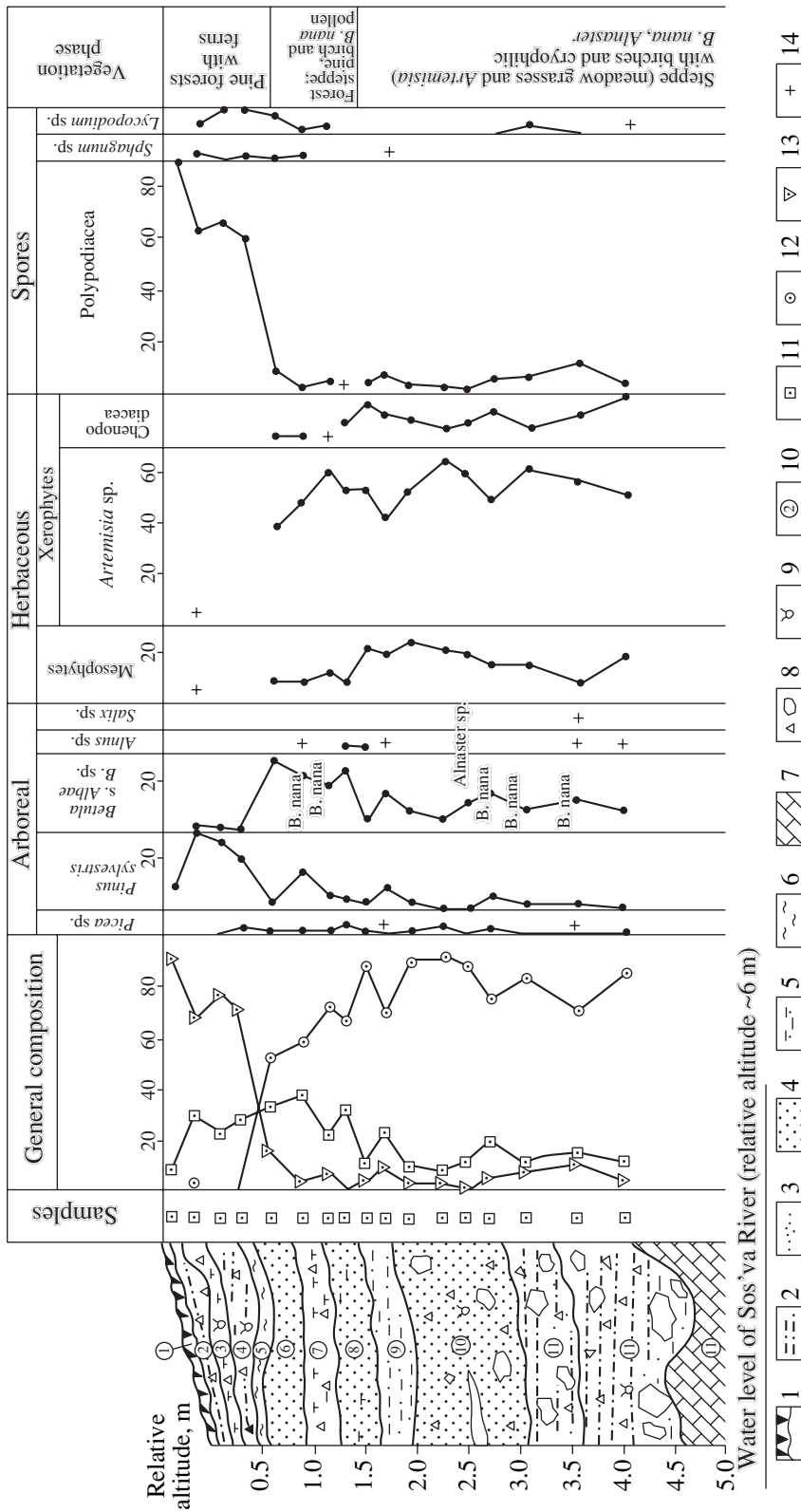
**Fig. 1.** Geographic site of the cave Cheremukhovo-1.



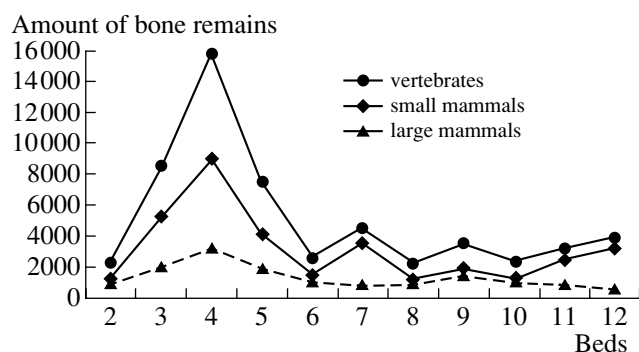
**Fig. 2.** Plan of the cave Cheremukhovo-1: (1) boundaries of inner niches and grottos; (2) line of the collapsed cave roof (excavations are denoted by shaded quadrangles 1-4).

The following bed succession is visible in this Exposure no. 209 (Fig. 3):

1. Soil (0.05–0.1 m thick).
2. Speleogenic formations. Dark gray clayey gleyed sand of loose structure, which contains limestone debris (0.10–0.15 m thick).
3. Dirty-brown clayey loose sand with bone fragments of large mammals and limestone debris (0.10–0.15 m thick).
4. Gray to light gray loose clayey sand with bone fragments of large mammals and limestone debris (0.20–0.30 m thick).



**Fig. 3.** Lithology of alluvial–speleogenic sequence in the cave Cheremukhovo-1: (1) soil; (2) clayey sand; (3) silty sand; (4) sand; (5) sandy clay; (6) marl; (7) limestone; (8) debris and boulders of limestone; (9) bones of large and small mammals; (10) bed no.; (11) arboreal pollen; (12) herbaceous pollen; (13) spores; (14) presence of a genus.



**Fig. 4.** Abundance of vertebrate bone remains in deposits of the cave Chermukhovo-1 (remains are calculated per each 10 cm of a bed within area of 1 m<sup>2</sup>).

5. Light gray kaolinic clay; the rock is highly calcareous, pierced by micropores, containing limestone debris (0.15–0.20 m thick).

6. Alluvial-speleogenic formations. Greenish gray polymictic silty sand loose and fine-grained, enclosing rusty clay lenses (up to 0.45 m thick), gravel and small debris of limestone (0.55–0.70 m thick).

7. Light brown compact sandy clay with abundant debris and rare boulders of limestone (0.40–0.45 m thick).

8. Brown polymictic fine-grained silty sand compact to a certain extent and containing insignificant admixture of limestone debris (0.40–0.50 m thick).

9. Brown fine-grained clayey sand moderately compacted and containing insignificant amount of limestone debris (0.15–0.20 m thick).

10. Brown polymictic fine-grained clayey sand, which is moderately compacted and contains abundant bone remains of large mammals, debris and boulders of limestone. In the bed middle part, there is a lens of silty clay (1–2 cm thick). In the lower part, sand is highly clayey (0.95–1.05 m thick).

11. Brownish gray clayey compacted sand with abundant debris and boulders of limestone (0.35–0.40 m thick).

12. Speleogenic formation with boulder pavement. Brownish gray clayey sand with abundant debris and boulders of limestone at the bed base (0.6–1.0 m thick).

13. Gray fissured limestone.

Alluvial-speleogenic (beds 6–10) and speleogenic (beds 1–5) formations show insignificant distinctions in mineral composition. The former contain rare grains of accessory minerals resistant to chemical weathering. Debris–boulder interlayers in alluvial-speleogenic sequence (beds 7 and 11) are products of the cave-roof collapse, and basal Bed 12 is of the boulder-pavement type. Upper beds 1–5 have been deposited in cave without influence of river waters.

According to results of granulometric analysis, sediments consist of sand (up to 70%), silt (10–15%), and

clay (from 19–38 to 53%) fractions. Bed 5 of exclusively uniform composition consists of flake kaolinite. Light fraction of alluvial sediments consisting of mineral grains is completely lacking phosphatic bone clasts and organic remains, which are typical of speleogenic formations. Their heavy fraction consists of minerals resistant to chemical weathering, which have been brought in the cave by waters of the Sos'va River. The calculated paleogeographic coefficients are extremely low (0.01–0.05) that is characteristic of the upper Neopleistocene and Holocene deposits (Stefanovskii, 1991).

## TAPHONOMIC CHARACTERIZATION

**Distribution of bone remains.** Over 70000 specimens of fossil vertebrate remains have been collected in the course of excavations. The results of taxonomic identification are presented in Table 1. Osteoliths occur in all the beds though with different abundance rates (Borodin *et al.*, 2000). In the upper interval, the maximum abundance rates are characteristic of speleogenic beds 3–5. In Bed 6, concentration of bone remains is sharply reduced and decreases further downward to the Bed 8, where the minimum abundance of osteoliths is established. Concentration of bone fragments increases in Bed 9, is at maximum in predominantly speleogenic sediments of Bed 11, and becomes reduced again in underlying bed. Three curves in Fig. 4 illustrate total occurrence frequency of osteoliths in different beds and separately of large and small mammal bones. As one can see, the curves are practically identical and depict therefore the common distribution trend of bone remains.

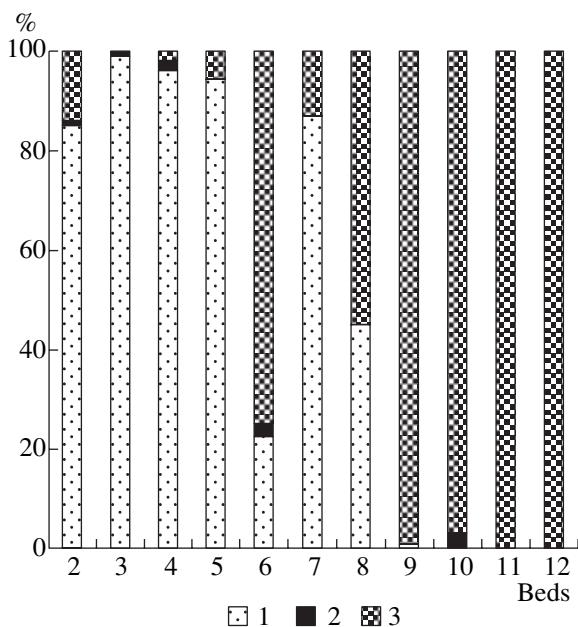
**Preservation state and coloration of bones.** Nearly all bones of mammals are fragmented, and many of them show gnawing marks left by large and medium carnivores and signs of residence in alimentary tract. Man-made treatment of bones has not been observed. Bone fragments are angular, lacking rounded areas, which could evidence in favor of long transportation of material in a water stream. The present-day position of cave above the river excludes a possibility of high stream velocity inside. Despite the distinct alluvial origin of beds 8–10, impact of fluvial activity on their oryctocoenoses was minimal. This is evident from absence of osteoliths differentiation in accord with their specific weight. Selective accumulation of particular elements of large mammal skeletons has not been observed, and remains of these animals are represented by all skeleton bones. In the taphonomic aspect, bone remains of large mammals represent a typical cave burial in terms of bone sets and their preservation state (Ovodov, 1979).

We studied coloration of postcranium bones and molars, because it is principal criterion indicative of fossil material homogeneity in a bed (Markova, 1982; Smirnov *et al.*, 1986).

**Table 1.** Taxonomic composition and abundance of diagnostic vertebrate remains from deposits in the cave Cheremukhovo-1 (amount of teeth for orders Insectivora, Chiroptera, Rodentia and genus *Ochotona*, or number of bones for other mammals, birds, reptiles, amphibians and fishes encountered in the given bed)

Taxon	Beds										
	2	3	4	5	6	7	8	9	10	11	12
Insectivora											
<i>Talpa europaea</i> L., 1758	–	7	6	3	–	–	–	–	–	–	–
<i>Sorex</i> sp.	11	16	38	21	5	19	2	–	14	3	6
Chiroptera	4	2	13	32	–	9	1	–	–	+	–
Lagomorpha											
<i>Ochotona pusilla</i> * Pall., 1768	2	–	2	19	4	6	3	5	34	13	111
<i>Lepus tanaiticus</i> Gureev, 1964	–	–	–	–	–	–	23	55	174	37	17
<i>Lepus</i> sp.	7	9	15	55	14	33	–	–	–	–	–
Rodentia											
<i>Sciurus vulgaris</i> L., 1758	4	5	19	4	–	–	–	–	–	–	–
<i>Tamias sibiricus</i> Laxm., 1769	–	–	6	–	–	–	–	–	–	–	–
<i>Spermophilus</i> sp.	–	–	–	–	–	–	–	–	–	1	–
<i>Marmota bobac</i> Mull., 1776	–	–	–	–	–	–	–	–	2	–	–
<i>Castor fiber</i> L., 1758	1	–	6	3	–	1	–	–	–	–	–
<i>Sicista</i> sp.	–	–	3	–	–	–	–	–	–	–	–
<i>Cricetulus migratorius</i> Pall., 1773	–	–	–	–	–	–	–	–	10	–	–
<i>Clethrionomys rufocanus</i> Sunder., 1846–1847	40	113	250	132	–	289	26	–	–	–	–
<i>Cl. rutilus</i> Schreber, 1780	51	175	412	165	–	159	8	–	–	–	–
<i>Lagurus lagurus</i> Pall., 1773	–	–	4	56	3	9	–	14	20	–	–
<i>Dicrostonyx gulielmi</i> Sandford, 1869	–	–	–	–	279	–	7	1043	2398	215	648
<i>D. ex gr. gulielmi-torquatus</i>	8	–	70	1920	–	399	–	–	–	–	–
<i>Lemmus sibiricus</i> Kerr, 1792	–	–	–	–	54	–	–	70	432	76	133
<i>Lemmus</i> (? <i>Myopus</i> ) sp.	27	41	191	1970	–	245	19	–	–	–	–
<i>Arvicola terrestris</i> L., 1758	4	4	11	5	–	5	–	–	–	–	–
<i>M. gregalis</i> Pall., 1779	–	2	12	187	28	120	13	51	192	32	129
<i>M. oeconomus</i> Pall., 1776	8	32	52	64	2	158	5	–	2	–	–
<i>M. agrestis</i> L., 1761	16	17	46	179	–	17	–	–	–	–	–
<i>M. middendorffi</i> Pol., 1881	–	–	6	–	1	2	3	1	36	4	8
<i>Microtus</i> sp.	80	201	506	2086	130	845	75	148	742	123	377
Carnivora											
<i>Alopex lagopus</i> L., 1758	–	–	–	5	–	1	3	11	64	7	10
<i>Canis lupus</i> L., 1758	–	–	–	–	–	–	–	–	4	–	–
<i>Vulpes vulpes</i> L., 1758	1	–	–	1	1	1	–	–	–	–	–
<i>Ursus arctos</i> L., 1758	–	–	1	–	–	–	–	–	–	–	–
<i>Martes</i> sp.	–	19	17	35	1	7	–	–	–	–	–
<i>Meles meles</i> L., 1758	–	–	–	1	–	–	–	–	–	–	–
<i>Lutra lutra</i> L., 1758	–	–	3	3	–	–	–	–	–	–	–
<i>Mustela erminea</i> L., 1758	–	1	3	4	–	–	–	1	5	1	9
<i>Mustela nivalis</i> L., 1766	1	10	6	8	–	3	–	–	1	8	6
<i>Mustela</i> sp.	–	13	5	4	–	–	–	–	–	–	–
<i>Panthera spelaea</i> Goldfuss, 1810	–	–	–	–	–	–	–	1	1	–	–
<i>Peryssodactyla</i>											
<i>Coelodonta antiquitatis</i> Blum., 1799	–	–	–	–	–	–	–	1	12	–	–
<i>Equus uralensis</i> Kuzmina, 1975	–	–	–	–	–	–	3	4	34	2	–
Artiodactyla											
<i>Alces alces</i> L., 1758	2	4	2	5	2	–	–	–	–	–	–
<i>Rangifer tarandus</i> L., 1758	4	5	13	12	1	1	4	18	112	8	–
<i>Bison priscus</i> Bojan., 1827	–	–	–	–	–	–	1	1	3	2	–
<i>Saiga borealis</i> L., 1766	–	–	–	–	–	–	–	–	1	–	–
Micromammalia indet.	520	2500	6000	9000	2500	2750	1450	2000	11250	1500	5100
Megamammalia indet.	30	250	760	160	240	180	190	450	2178	180	350
<i>Aves</i> indet.	40	550	1010	220	57	40	3	5	10	20	150
Reptilia	–	+	+	+	–	–	–	–	–	–	–
Amphibia											
<i>Rana</i> sp.	10	120	190	33	19	15	–	–	–	1	–
<i>Pisces</i> indet.	20	400	800	140	33	2	–	3	25	67	52

\* Determinations by A.A. Teterina, Institute of Plants and Animals Ecology, Uralian Division, Russian Academy of Sciences.



**Fig. 5.** Coloration of vole molars from deposits of the Cheremukhovo-1 site: (1) white or grayish (type 1); (2) beige (type 2); (3) gray-brown and brown (type 3).

In the Bed 2, nearly all postcranium bones are of gray–yellow color, and only some of them are dark gray, probably colored by humic acid that percolated from overlying bed. In beds 3–5, all bones are straw-colored dark or light. In the Bed 3, some bones of small mammals are corroded, whereas in Bed 5 nearly all bones reveal corrosion marks. Straw-colored, black, and variegate (darker spots on lighter background) bones jointly occur in beds 6 and 7. Proportion of black bones is relatively lower in Bed 6. Beds 8 and 9 yield dark gray and variegate bones. Dark gray bones are also typical of underlying Bed 10, whereas bones of Bed 12 are colored dark brown. Light-colored bones do not occur in lower beds 8–12.

Thus, there is a general tendency to darker coloration of postcranium mammal bones in deeper horizons: bones are light colored in upper beds and dark colored in the lower ones. Bones of most diverse coloration are confined to beds 6 and 7. The possible reason is that both beds have been accumulated in the terminal stage of alluvial cycle, when bone remains of different age have been washed out from lateral niches and grottos to be mixed.

In addition to postcranium bones, we analyzed coloration of teeth belonging to small mammals. As one can see in Fig. 5, brown teeth prevail in the lower part of excavation (beds 12–9), where their content is over 97% in average in distinction from light-colored specimens representing not more than 3% of the material. Beds 7–2 yield predominantly light-colored teeth (over 90% in average), while in Bed 8 brown and white teeth occur in approximately equal proportions (55 and 45%

respectively). Thus, abundance of dark-colored teeth increases toward deeper beds of the section.

Bed 6 containing 75% of brown teeth is an exclusion from above tendency. This bed inside sequence of greenish gray polymictic sand is composed of rusty clay. According to lithologic characteristics of sediments in lateral niches of the cave (Borodin *et al.*, 2000; Bachura and Strukova, 2002) and evolutionary level of *Dicrostonyx* molars, this bed was deposited when older Late Neopleistocene deposits were washed out the distant or lateral cave niches to become mixed with Holocene sediments accumulating in central grotto. In general, changes in coloration of small-mammal teeth and large-mammal bones show the same trend.

### DATING OF BONE BEDS

**According to geomorphological position** (relative altitude 7–8 m), the cave section is correlative with the Rzhev alluvial terrace above flood-plain, which is dated back to the second half of the late Neopleistocene. In other words, it is correlative with the Nev'yansk (=Bryansk=Leningrad) and Polar Urals (Ostashkov) horizons (*Stratigraphic...*, 1997).

**Radiocarbon dates.** Absolute age has been determined for separate bones of large mammals and for postcranium skeletons of Cricetidae (Table 2). Radiocarbon dates obtained for different bone material from one bed are close.

Material from speleogenic basal sediments of the section (Bed 12) yielded radiocarbon date of >34 ka, that is beyond the allowable limit. Series of radiocarbon dates obtained for beds 9–10 is within the range of 31–26 ka. This time span corresponds to the Bryansk interstadial (Arslanov, 1992). The date  $18900 \pm 320$  years (SOAN-4531), which has been obtained for a femur fragment of *Mammuthus primigenius* from the upper part of Bed 9, is only one of six discordant with the others. It corresponds to the Bologoe–Edrovo cryostage of the Polar Urals glaciation. According to formal standpoint, age of deposits should be determined based on the latest date of about 19 ka, which means that Bed 9 is deposited in the Polar Urals (Ostashkov) time. Nevertheless, we prefer the main series of dates, which imply that beds 9–10 accumulated in the Nev'yansk (=Bryansk=Leningrad) time. We omit the case of a younger bone redeposited in underlying strata, although this is a possible consequence of rock sliding in a cave.

The date  $4930 \pm 75$  years (SOAN-5137), which has been obtained for Bed 5, implies that this and overlying beds accumulated in the Holocene time.

**Archeological artifacts.** As for archeological artifacts found, they are not abundant, represented by 21 items of knapped flint, 20 of which are collected from Bed 7 and one from Bed 10. The following categories of knapped flint are encountered in the Bed 7: flint waste, flakes, blades, burins and microburins,

**Table 2.** Radiocarbon dates obtained for bones from deposits of the excavation

Site	Taxon	Dated material	Age, years
Square E/3, Bed 5	Cricetidae	Postcranium skeleton	4930 ± 75 (SOAN-5137)
Square C/4, Bed 9 (horizon 28)	<i>Mammuthus primigenius</i>	Femur	18900 ± 320 (SOAN-4531)
Square C/3, Bed 9 (horizon 27)	Cricetidae	Postcranium skeleton	27000 ± 710 (AA-36471)
Square E/3, Bed 9	<i>Panthera spelaea</i>	Metapodium	29120 ± 230 (OxA-10894)
Square E/3, Bed 10	<i>Coelodonta antiquitatis</i>	Thoracic vertebra	26480 ± 840 (OxA-10926)
Square C/3, Bed 10 (horizon 29)	Cricetidae	Postcranium skeleton	31500 ± 1200 (AA-36470)
Square D/3, Bed 10 (horizon 36)	<i>Coelodonta antiquitatis</i>	Pelvis	25150 ± 500 (SOAN-5302)
Square D/3, Bed 12 (horizon 53)	Cricetidae	Postcranium skeleton	28520 ± 840 (AA-36469)
Square D/3, Bed 12, floor (horizon 54)	Cricetidae	Postcranium skeleton	>34140 (GIN-101152)

ribbed blade, and stone tools with signs of secondary knapping. Morphological and technological characteristics of the inventory suggest that Bed 7 corresponds to the terminal Paleolithic or Mesolithic (early Holocene). An asymmetric fragment of knife found in the Bed 10 can be dated back to 17–20 ka.

Judging from the implements found at the cultural level indistinct in stratigraphic aspect, they characterize a temporary site of hunters of the final Paleolithic or Mesolithic time (Borodin *et al.*, 2000).

**Species composition and morphological characteristics of mammal remains.** Taxonomic composition and morphological peculiarities of mammal bones from the cave can be used for relative dating of their host deposits based on available data on the late Neopleistocene and Holocene mammals of the Northern Urals and adjacent territories (Bachura and Kosintsev, 1996; Kosintsev, 1996; Smirnov, 1994, 1996). Diagnostic taxa of large and small mammals identified in different beds are listed in Table 1.

Species composition of large mammal remains from beds 9–12 is characteristic of the late stage of the upper Paleolithic terrestrial fauna. Based on species composition of small mammals and evolutionary level of molars of *Dicrostonyx gulielmi*, fauna from these beds can be correlated with Zone MQR 1 of Eastern Europe (Vangengeim *et al.*, 2001), which is not older than the late Neopleistocene.

Large mammals buried in beds 2–7 (Table 1) correspond in species composition to the Holocene faunal assemblage. Based on a bone of *Bos taurus* found in Bed 3, this and overlying horizons can be attributed to the late Holocene, because remains of domestic animals are known in the study region since that time only (Bachura and Kasintsev, 2001).

Thus, the excavation section consists of two groups of sediments different in age. The lower group (beds 9–12) was deposited in the Bryansk time of the late Neopleistocene, and upper beds 1–7 accumulated in the Holocene. It is more difficult to characterize Bed 8 that yielded a few bone remains. Bones from this bed are of the mixed coloration, brown and light colored that is

most likely points to redeposition of osteoliths different in age. The same is evident from the taxa list (Table 1). According to species composition of large mammals, the bed is close to the Holocene group. On the other hand, dominant among dark colored bones of small mammals from the bed are remains of the late Neopleistocene taxa (collared and Siberian lemmings, narrow-skulled vole), whereas light-colored bones belong to the Holocene fauna (forest voles).

We failed to distinguish deposits of the upper Neopleistocene (time of the Polar Urals glaciation) in the axial part of the cave based on faunal remains. Deposits of that time are preserved in inner lateral niches only (Bachura and Strukova, 2002; Borodin *et al.*, 2000), which are at the height 1–2 m above the floor of the cave Cheremukhovo-1. Consequently, loose deposits of the Polar Urals time have been washed out from the main grotto, when river waters flooded it.

## VEGETATION

Palynological data (determinations by L.A. P'yankova from the Uralian Geological Survey Expedition) reveal three distinct phases of the vegetation development (from the base upward, Fig. 3):

Phase I (beds 12–8) characterizes cryoxerophilous vegetation with *Artemisia*–herbaceous groupings. Dominant herbaceous pollen (67 to 91% in total) mainly represents xerophilous *Artemisia* sp. (59 to 84%), Chenopodiaceae (6–21%), and mesophilic Asteraceae (3–13%), Caryophyllaceae (up to 10%), Poaceae (up to 8%) and Brassicaceae (up to 6%) associated with accessory Ranunculaceae, Apiaceae, Scrophulariaceae, Rosaceae, Cyperaceae, and Polygonaceae (up to 1%). Dominant taxa of arboreal pollen group (from 9 to 23%) are *Betula* sp. (8–24%), *Pinus sylvestris* (4–20%), *Picea* sp. (up to 4%), which occur along with rare pollen grains of *Salix*, *Alder*, and cryophilic fruticose *Betula s. nana* and *Alnaster* sp. Spores (1 to 12% of palynological spectra) belong to ferns Polypodiaceae associated with occasional *Lycopodium* sp. and *Sphagnum* sp.

Phase II (beds 7 and 6) corresponds to meadow-steppe vegetation with birch-pine sparse forest groupings. Characteristic of the phase are predominance of herbaceous (51–59%) and higher abundance of arboreal pollen (33–39%). Spores are subordinate components (1–3%). Taxa of herbaceous pollen group are dominated by *Artemisia* sp. (up to 40%) and associated mesophilic Asteraceae (up to 7%), Poaceae (1–2%), Rosaceae (1–2%), Ranunculaceae (0.7–1.6%), and Polygonaceae (1–2%). Arboreal pollen belongs to birch (18–22%), pine (2–16%), and spruce (up to 1.6%).

Phase III (beds 5–2) marks vegetation of mixed forests with abundant ferns in ground cover. Palynological spectra are dominated by pollen of Polypodiaceae (up to 90%) and *Pinus sylvestris* (up to 30%). Associated components are pollen of *Betula* sp., *Picea* sp. (up to 2%), and herbs (single grains), and spores of lycopods and *Sphagnum*. These successive phases characterize evolution of vegetation from periglacial steppe (Phase I) to interglacial forest (Phase III) phytocoenoses via transitional forest-steppe landscapes (Phase II).

#### MAMMAL FAUNA OF THE LATE NEOPLEISTOCENE

Among mammal remains from late Neopleistocene deposits (beds 12–9), we identified 23 species of 7 orders (Table 1).

Order Insectivora is represented by remains of the genus *Sorex*, which occur practically in all the beds. Two species *Lepus tanaiticus* and *Ochotona pusilla* represent order Lagomorpha. Upward in the section, from Bed 12 to Bed 9, abundance of *Lepus tanaiticus* bones is gradually increasing, while distribution of *Ochotona pusilla* remains shows opposite trends of decreasing from 8% in Bed 12 to 0.9% in Bed 10 (percentages relative to small mammal remains in total). Among 10 species representing order Rodentia (Table 1), *Dicrostonyx gulielmi* is dominant, constituting 45 to 49% in beds 11–12 and 64 to 78% in beds 9–10. Subdominant is *Microtus gregalis* (35 to 38% in two lower beds and 15 to 20% in overlying beds 10 and 9). *Lemmus sibiricus* is a common component of rodent fauna including steppe forms as well, which are more diverse in upper beds of the interval. *Ochotona pusilla* occurring in beds 12 and 11 is associated in higher two beds with *Lagurus lagurus* (about 2%), *Cricetulus migratorius*, *Spermophilus* sp., and *Marmota bobac*. Coexistence of steppe and tundra species suggests that the rodent fauna is of the periglacial type.

Bones of polar fox (*Alopex lagopus*) prevailing among remains of the order Carnivora occur in association with less abundant bones of *Mustela erminea* and *Mustela nivalis*. Percentage of polar fox bones relative to all Carnivora remains is greater in beds 9–10 (85 to 88%) than in underlying beds (33 to 52%). *Mustela* remains are, in contrast, more abundant in beds 11 and 12 than in beds 9 and 10. Four bones of *Canis lupus*

found in Bed 10 belonged to one animal. This bed and Bed 9 also yielded two bones of *Panthera spelaea*. The last species became extinct all over its distribution area at the end of the late Neopleistocene. At the initial stage of sediments accumulation, small carnivores (genus *Mustela*) likely visited the cave more frequently than larger ones. This is evident from taxonomic composition and relative abundance of osteoliths, which belong to small and large mammals, in particular to Ochotonidae (see above). At the accumulation time of beds 9 and 10, the more frequent visitors of the cave were polar fox, wolf, and cave lion. This situation was likely responsible for a greater proportion of *Lepus tanaiticus* bones and appearance of ungulate remains in upper beds.

Order Perissodactyla is represented by two species *Equus uralensis* and *Coelodonta antiquitatis*. Bones of the former are rather large, comparable in size with the common morphometric range of *Equus latipes* and *Equus uralensis* bones (Kuz'mina, 1997). The indicated *Equus* form is identified based on Eisenmann's approach to analysis of teeth and metapodia (Bachura and Podoprigora, 2003).

Order Artiodactyla is represented by three species (Table 1), the most abundant of which is *Rangifer tarandus*. Fragmented bones of *Bison priscus* occur in all the beds, whereas species *Saiga borealis* is identified based on the lower fourth premolar found in Bed 10. In general, ungulate remains are confined to beds 9 and 10, while underlying strata are lacking them. Dominant among ungulates of both orders is *Rangifer tarandus* (67%). Noticeable percentages are characteristic also of *Equus uralensis* (22%) and *Coelodonta antiquitatis* (8%) remains. Abundant remains of reindeer and *Equus* suggest open landscapes they dwelt in. At the same time, perceptible proportion of woolly rhinoceros remains is indicative of bushy vegetation that is consistent with palynological data.

#### MAMMAL FAUNA OF THE HOLOCENE

In the Holocene deposits (beds 2–7), we identified 28 mammal species of 6 orders (Table 1). Order Insectivora is represented in these beds by species *Talpa europaea* and by genus *Sorex*. Remains of order Chiroptera are found in all the Holocene beds. Two taxa *Lepus* sp. and *Ochotona* sp. belong to order Lagomorpha being unidentifiable more precisely, because their bones are lacking species-diagnostic characters. The Lagomorpha remains are dominant among all bones of large mammals from beds 6 and 7, whereas their abundance in overlying beds decreases. Single remains of *Ochotona pusilla* represent not more than 0.2% of bones belonging to small mammals.

Order Rodentia is represented by 14 species (Table 1). The dominant genus is *Clethrionomys*, remains of which grow in abundance from Bed 7 (24%) up to Bed 2 (50%). Species *Cl. rufocanus* is dominant at the base of



the Holocene sequence (Bed 7), whereas *Cl. rutilus* is abundant in upper beds 5–2. Prevalence of the former species near the base may be indicative of considerable forest areas in the region at that time (Borodin, 1991). This species usually populated overgrown talus areas in taiga zone and represents a typical granivorous vole feeding on grass seeds and green shoots. Conifer seeds are important components of its diet, and red vole usually populated dark conifer forests (Vorontsov, 1967). The subdominant of vole group is species *Microtus agrestis* (32–35% in average), which prefers to dwell in larch forests with grounds covered by moss and grass. In addition to species listed above, beds 5–2 yielded remains of *Sciurus vulgaris*. Single bone fragments of *Castor fiber* have been found in beds 7–1. Separate bones of *Tamias sibiricus* are identified in beds 4 and 3. Proportion of species most typical of the late Neopleistocene assemblage (collared lemming, narrow-skulled and steppe lemmings) is decreasing from the base upward. In beds 4 and 3, they represent only 6% of rodent remains.

Bones of the order Carnivora characterize very diverse species (Table 1). Remains of *Alopex lagopus* are found in beds 5–7 being absent in all overlying beds. Rare remains of *Vulpes vulpes* occur in almost all Holocene beds. Beginning from Bed 5 and higher, most frequent among bones of carnivores are remains of Mustelidae, mainly of the genus *Martes*. One bone of *Meles meles* and several bones of *Lutra lutra* are identified in Bed 5. In Bed 4 and at the top of excavation, there have been found two *Ursus* bones.

The found bones of polar fox are indicative of open landscapes during the accumulation time of beds 7–5, which are typical habitats of these animals. Open areas probably reduced at the time of deposition of beds 5–2 that forced the animals to migrate in areas located northward. Progradation of forest landscapes at this time is also evident from a considerable proportion of species characteristic of the forest vegetation (*Martes* sp., squirrel, chipmunk).

Order Artiodactyla is represented by three species: *Alces alces*, *Rangifer tarandus*, and *Bos taurus*. Prevailing bones belong to reindeers. One bone of *Bos taurus* from Bed 3 indicates the late Holocene age of host deposits.

Mammal fauna from beds 7–2 differs in species composition from the underlying one, because it includes many species, which usually inhabit forest landscapes (Table 1). Abundance of these species remains increases from Bed 7 upward to Bed 2. The same trend is characteristic of the mammal species diversification that is at maximum in Bed 5 (Table 1).

#### NATURAL ENVIRONMENTS

In paleogeographic aspect, we suggest the following history of sedimentation in the cave Cheremukhovo-1. The cave originated under influence of infiltration and

river waters during the regional neotectonic uplift at the time of the Karga interglacial. Beds 12–9 (flood-plain facies alternating with speleogenic sediments) accumulated when the Sos'va River periodically flooded the cave (high-flood periods) between 31 and 26 ka ago.

Within the late Neopleistocene (Bryansk) sequence, theriofauna is of the periglacial type, because remains of tundra animals, which prevail among bones of large and small mammals, occur in association with osteoliths of steppe forms. The analyzed dynamics of species diversification and occurrence frequency of particular species imply that development of surrounding landscape in the late Neopleistocene time progressed without principal changes, which are recorded however in upper beds, where a greater proportion of bones belonging to steppe animals is established. The Bryansk time corresponds to Phase I of palynological succession, which is indicative of cryoxerophilous vegetation with 9 to 23% of arboreal taxa.

Materials from lateral grottos of the cave imply that natural environments of the Polar Urals (Ostashkov) time did not differ in principle from the previous stage (Bachura and Strukova, 2002; Borodin *et al.*, 2000). This is consistent with data on other localities in the Northern Urals (Kosintsev, 1996; Smirnov, 1996).

According to lithological and palynological data (Phase II), beds 7 and 6 accumulated under influence of river floods, when climatic conditions were softer than before, as it is evident from the greater percentage (up to 39%) of arboreal pollen in phytocoenoses of that time. These phytocoenoses presumably characterize one of terminal thermophases of the Polar Urals glaciation, when appearing taxa of forest fauna led to disintegration of periglacial mammal communities.

Beds 5–2 are of speleogenic origin and have been formed in the second half of the Holocene. Vegetation of that time was of the mixed-forest type with ferns dominated in grass cover (Phase III). Mammal fauna from these beds is more diverse than below, predominantly consisting of species, which populated forest landscapes. The sequence of upper beds recorded the ongoing degradation of the late Neopleistocene fauna and formation of the present-day regional community of mammals.

#### CORRELATION WITH PALEONTOLOGICAL DATA FROM ADJACENT TERRITORIES

Correlation of biostratigraphic data obtained with the European mammal zonation is important for a deeper insight into stratigraphy of continental deposits in the Urals. As is shown above, sedimentary sequence of the cave Cheremukhovo-1 is composed of late Neopleistocene and Holocene deposits.

New data on the cave deposits, which are consistent with other results obtained in the study region (Smirnov, 1994, 1996; Teterina, 2002; Teterina and Ulitko, 2002), elucidate dynamics of natural processes

and development of terrestrial faunas in the Northern Urals from the early Holocene until present time.

Based on new radiocarbon dates, it is possible to state that the late Neopleistocene deposits of the cave Cheremukhovo-1 (beds 12–9) accumulated during the Nev'yansk (= Bryansk) interstadial. Biostratigraphic characterization of this period in the Northern Urals has not been known before.

Markova (2002) characterized in detail the period of Bryansk interstadial in the Russian Plain. She showed that the plain was lacking the present-day natural zones at that time. Biogeographic provinces distinguished by Markova are as follows: forest tundra, periglacial forest-tundra-steppe, periglacial forest steppe, periglacial steppe, and southern periglacial steppe of mountain and plain areas. Distinctions between these provinces were of a low gradient. The reconstructed landscapes are indicative of a moderately cold climate in that epoch. Because of absence of a continuous forest zone at the time of Bryansk interstadial, steppe animals had opportunity to migrate far to the north (Markova *et al.*, 2002). Consequently, the eastern flank of the Northern Urals corresponded in the Nev'yansk time to the tundra-steppe zone with areas of forest vegetation in the river flood plains. Our data on mammal fauna and palynological assemblages from the site Cheremukhovo-1 are completely consistent with this reconstruction.

### CONCLUSIONS

The locality Cheremukhovo-1 studied in the eastern flank of the Northern Urals and described above is of a new taphonomic type in the region. The late Neopleistocene deposits at this locality recorded geological and biotic events, which have not been described before in the region. In the taphonomic respect, composition and preservation state of large mammal remains from the locality are typical of cave assemblages. Based on radiocarbon dates, archeological artifacts, and species composition of mammals, we distinguished two sequences in the cave excavation. The lower one (beds 12–9) accumulated in the Nev'yansk (Bryansk) time of the late Neopleistocene, and the upper sequence (beds 7–1) is of the Holocene age.

Two formation phases are detectable in the lower sequence. Deposits of the initial phase (beds 12 and 11) contain mammal remains of low diversity, lacking species of steppe biotopes and ungulate bones but enriched in osteoliths belonging to *Ochotona pusilla* and small *Mustela* forms. Characteristic of the next phase (beds 10 and 9) are a decreased proportion of Ochotonidae and Mustelidae remains and appearance of new mammal taxa, which do not occur in underlying sediments. The lower proportion of *Lemmus sibiricus* but higher abundance of *Dicrostonyx gulielmi* are characteristic of the small mammal fauna corresponding to this phase. Dominant among ungulates of that time is *Rangifer tarandus* occurring in association with *Equus uralensis*

and *Coelodonta antiquitatis* whose percentages in the assemblage are perceptible.

The upper sequence contains abundant remains of diverse mammal species whose life activity is connected with the forest vegetation. This sequence recorded the degradation of the late Neopleistocene fauna and its gradual transformation into present-day mammal community of the study region.

The studied succession of sediments can be regarded as one of reference sections of the late Neopleistocene–Holocene deposits in the northern Urals.

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### REFERENCES

1. Kh. A. Arslanov, "Geochronological Scale of the Late Neopleistocene in the Russian Plain," in *Geochronology of the Quaternary Period* (Nauka, Moscow, 1992), pp. 10–19 [in Russian].
2. O. P. Bachura and P. A. Kosintsev, "Large Mammals of the Late Pleistocene and Holocene in the Northern Urals Eastern Flank," in *Proceedings of the Conference: The Uralian North in a Panorama of Millennia* (Sever, Severoural'sk, 2001), pp. 63–77 [in Russian].
3. O. P. Bachura and I. N. Podoprigora, "Systematics of the Late Neopleistocene *Equus* Remains (*Equus* s.l.) from the Urals," in *Quaternary Paleozoology of the Urals* (Universitet, Yekaterinburg, 2003), pp. 221–226 [in Russian].
4. O. P. Bachura and T. V. Strukova, "Mammal Remains from the Cheremukhovo-1 Site (Excavation 4)," in *Fauna in the Urals during the Pleistocene and Holocene* (Universitet, Yekaterinburg, 2002), pp. 37–55 [in Russian].
5. A. V. Borodin, "Scope of Vole Communities, Genus *Clethrionomys* Tilesius (1850), in Research of Paleofaunas," in *History of Modern fauna in the Southern Urals* (Ural. Otd. Ross. Akad. Nauk, Sverdlovsk, 1991), pp. 87–97 [in Russian].
6. A. V. Borodin, T. V. Strukova, A. I. Ulitko, *et al.*, "Cheremukhovo-1 – a New Historic–Ecological and Archeological Site in the Northern Urals (Locality and Stratigraphy)," in *Pleistocene and Holocene Faunas of the Urals* (Rifei, Chelyabinsk, 2000), pp. 36–58 [in Russian].
7. P. A. Kosintsev, "Late Pleistocene and Holocene Fauna of Large Mammals in the Northern Urals," in *Materials and Historical Research of Modern Fauna in the Urals* (Yekaterinburg, Yekaterinburg, 1996), pp. 84–110 [in Russian].
8. I. E. Kuz'mina, *Horses of North Eurasia from the Pleistocene until Recent Time* (ZIN RAN, St. Petersburg, 1997) [in Russian].

9. V. A. Lider, *Quaternary Deposits of the Urals* (Nedra, Moscow, 1976) [in Russian].
10. A. K. Markova, *Pleistocene Rodents of the Russian Plain* (Nauka, Moscow, 1982) [in Russian].
11. A. K. Markova, A. N. Simakova, A. Yu. Puzachenko, and L. M. Kitaev, "Nature of the Russian Plain during the Bryansk Warming (33–24 ka Ago)," *Izv. Akad. Nauk, Ser. Geograf.*, No. 4, 45–57 (2002).
12. N. D. Ovodov, "Investigation of Caves with Faunal Remains," in *General Methods to Study History of Modern Ecosystems* (Nauka, Moscow, 1979), pp. 102–129 [in Russian].
13. N. G. Smirnov, Extended Abstract of Doctoral Dissertation in Biology (Yekaterinburg, 1994).
14. N. G. Smirnov, "Diversity of Small Mammals in the Northern Urals during the Pleistocene and Holocene," in *Materials and Historical Research of Modern Fauna in the Urals* (Yekaterinburg, Yekaterinburg, 1996), pp. 39–83 [in Russian].
15. N. G. Smirnov, V. N. Bol'shakov, and A. V. Borodin, *Pleistocene Rodents of Northwestern Siberia* (Nauka, Moscow, 1986) [in Russian].
16. N. G. Smirnov, E. A. Kuz'mina, and T. P. Kourova, "New Data on Postglacial Mammals of the Northern Urals," in *Pleistocene and Holocene Biota of the Circum-Urals Subarctic* (Yekaterinburg, Yekaterinburg, 1999), pp. 68–77 [in Russian].
17. V. V. Stefanovskii, "Mineral Spectra of Heavy Fractions from Upper Cenozoic Deposits of the Trans-Urals," in *Geology and Mineral Reserves of the West Siberian Plate and Its Fold Structures* (Zap. Sib. NIGNI, Tyumen, 1991), pp. 97–98 [in Russian].
18. *Stratigraphic Scheme of the Urals (Mesozoic and Cenozoic) Adopted at the IV Uralian Interdepartmental Stratigraphic Conference, April 20, 1990, and Authorized by the Interdepartmental Stratigraphic Committee of Russia* (UGSE, Yekaterinburg, 1997) [in Russian].
19. A. A. Teterina, "Fossil Faunas of Small Mammals from Localities of the Northern Urals," in *Fauna of the Urals in the Pleistocene and Holocene* (Universitet, Yekaterinburg, 2002), pp. 111–136 [in Russian].
20. A. A. Teterina and A. I. Ulitko, "New Localities of the Late Pleistocene and Holocene Mammal Faunas in Karst Caves of the Northern Urals," in *Fauna of the Urals in the Pleistocene and Holocene* (Universitet, Yekaterinburg, 2002), pp. 155–162 [in Russian].
21. E. A. Vangengeim, M. A. Pevzner, and A. S. Tesakov, "Zonal Subdivisions of the Quaternary in Eastern Europe Based on Small Mammals," *Stratigr. Geol. Korrelyatsiya* **9** (3), 76–88 (2001) [*Stratigr. Geol. Correlation* **9** (3), 280–292 (2001)].
22. N. N. Vorontsov, *Evolution of Digestive System of Rodents* (Nauka, Novosibirsk, 1967) [in Russian].