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Biostratigraphy of the Upper Pleistocene (Upper Neopleistocene)–Holocene deposits of the Lemeza River valley of the Southern Urals region (Russia)

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Abstract

Numerous caves and terraces with late Late Pleistocene (Upper Neopleistocene according to the Russian stratigraphic scale)–Holocene deposits are located in the Lemeza River valley in the surroundings of the Atysh waterfall, the native reserve territory of the Bashkortostan Republic. Lemeza River runs in the southern part of the western slope of the Urals and belongs to the Belaya River valley system (Russian Federation). A summary of the biostratigraphical investigations between 1992 and 2007 in this area is given. Deposits of cave and fluvial origin are characterized in the framework of the regional stratigraphy. The results of mammalian investigations and radiocarbon dating provide the basis for the stratigraphical subdivision. Palynology, mollusca, fishes, amphibian and reptiles are used for the reconstruction the palaeoenvironments. The Southern Urals stratigraphic subdivisions are correlated with Western European (Weichselian-Holocene), Eastern European (Russia) (Leningrad–Ostashkov–Shuvalov) and Uralian (Nevyansk–Polar Urals–Gorbunovsky) stratigraphic schemes.

1. Introduction

Karst caves (54°33′N, 57°16′E) affecting Carboniferous limestone and river terraces are known along the banks of the Lemeza River, in the Belaya River basin. They are located on the western slope of the Southern Urals (Fig. 1). Numerous caves such as Verkhnaya, Zapovednaya, Atysh I, Ust-Atysh and Lemeza I–IV are located around the Atysh waterfall, in the native reserve territory of the Bashkortostan Republic. The waterfall was first described by the Russian academician Tchernyshov (1889). The main terrace localities are located in the vicinity of Zorenka, Kalinovka and Verkhnaya Lemeza down to the stream of the Lemeza River, in an area at the front of the first Urals ridges.

Detailed biostratigraphic investigation of this area started by Yakovlev in 1992 in cooperation with the archaeologists from the Institute of History, Language and Literature of Ufa Scientific Centre RAS, and scientists from different scientific organizations continue to investigate the caves. Late Cenozoic deposits of this area have not been studied before. A comprehensive study of the Late Quaternary caves and sites with numerous faunal and floral finds of the beautiful Atysh waterfall native reserve territory is presented. Saving this type of information was necessary because several acts of vandalism were committed in the caves. This research will help in a better understanding of reconstruction of the palaeoenvironment during the late Late Pleistocene and Holocene of this mountain territory and will help to correlate data between European and Asiatic areas. Studies of equivalent complexes (faunal, floral, stratigraphical, archaeological and dating at the same time) and biostratigraphical investigations of the Southern Urals area are rare because of the difficulties in reaching

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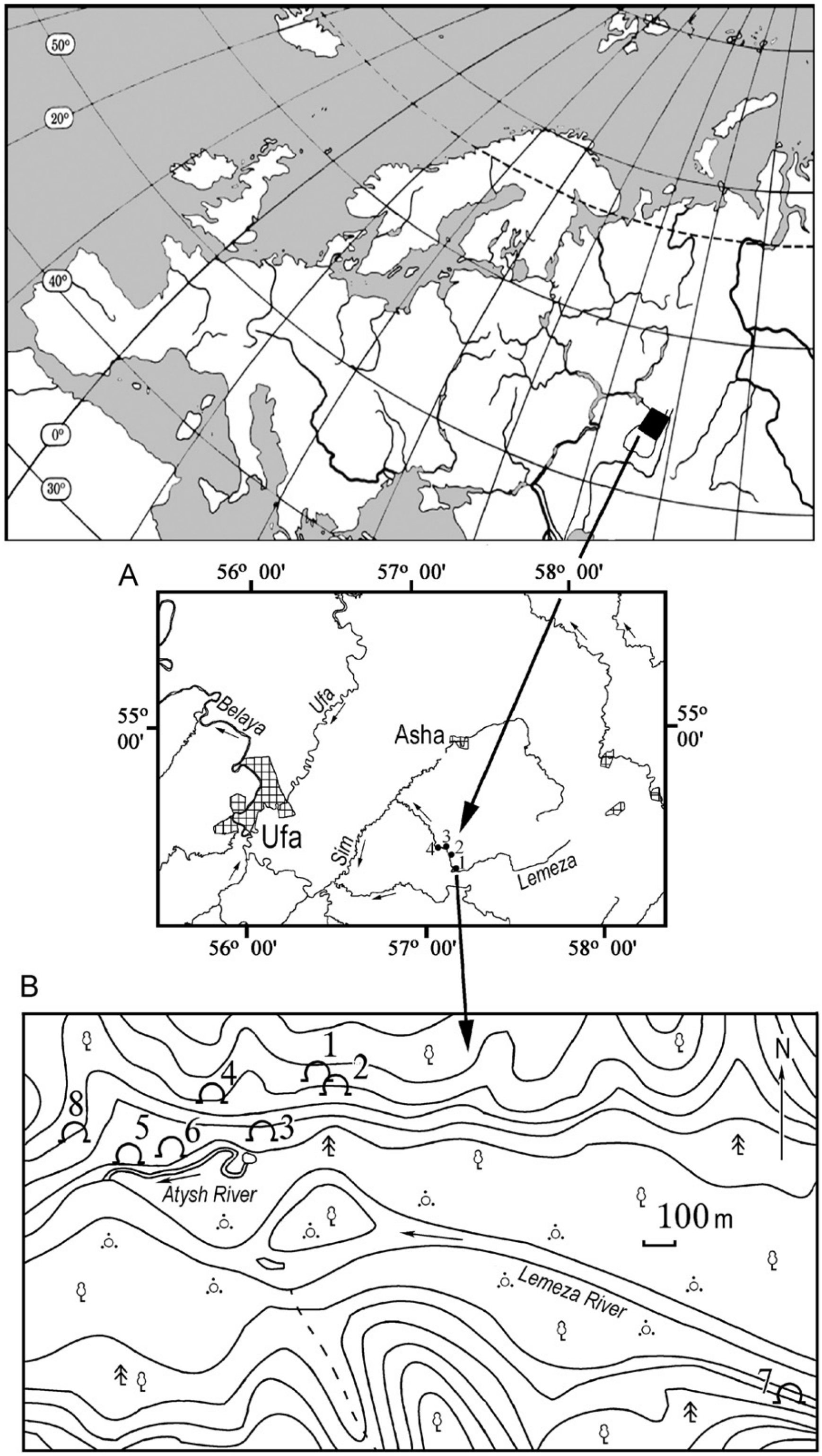

Fig. 1. (A) General map and location of the studied area showing the distribution of the caves and terraces of the Lemeza river valley. Legend: 1—Cave complex; 2—Verkhnaya Lemeza terrace; 3—Kalinovka terrace; 4—Zorenka terrace. (B) Location of the Atysh waterfall cave complex. Caves: 1—Verkhnaya; 2—Zapovednaya; 3—Atysh I grotto and waterfall; 4—Lemeza I; 5—Lemeza II; 6—Lemeza III; 7—Lemeza IV; 8—Ust-Atysh.

remote places in these mountains. Previous studies have only involved some locations (Yakovlev et al., 2000, 2006, and others). In several cases scientists collected only faunal remains and did not complete study of the sites. Geological information is necessary for a better preservation of this native reservation territory.

The results of the biostratigraphical studies of the main localities are given below. These results concern the stratigraphic description of the unconsolidated deposits, the determination of the fossil plants, molluscs, amphibians, reptiles, and mammal species and the radiocarbon dating.

2. Methods

The investigated material was collected during field work spanning between 1992 and 2005 by scientists of the Institute of Geology and Institute of History, Language and Literature of Ufa Scientific Centre RAS; Bashkir State

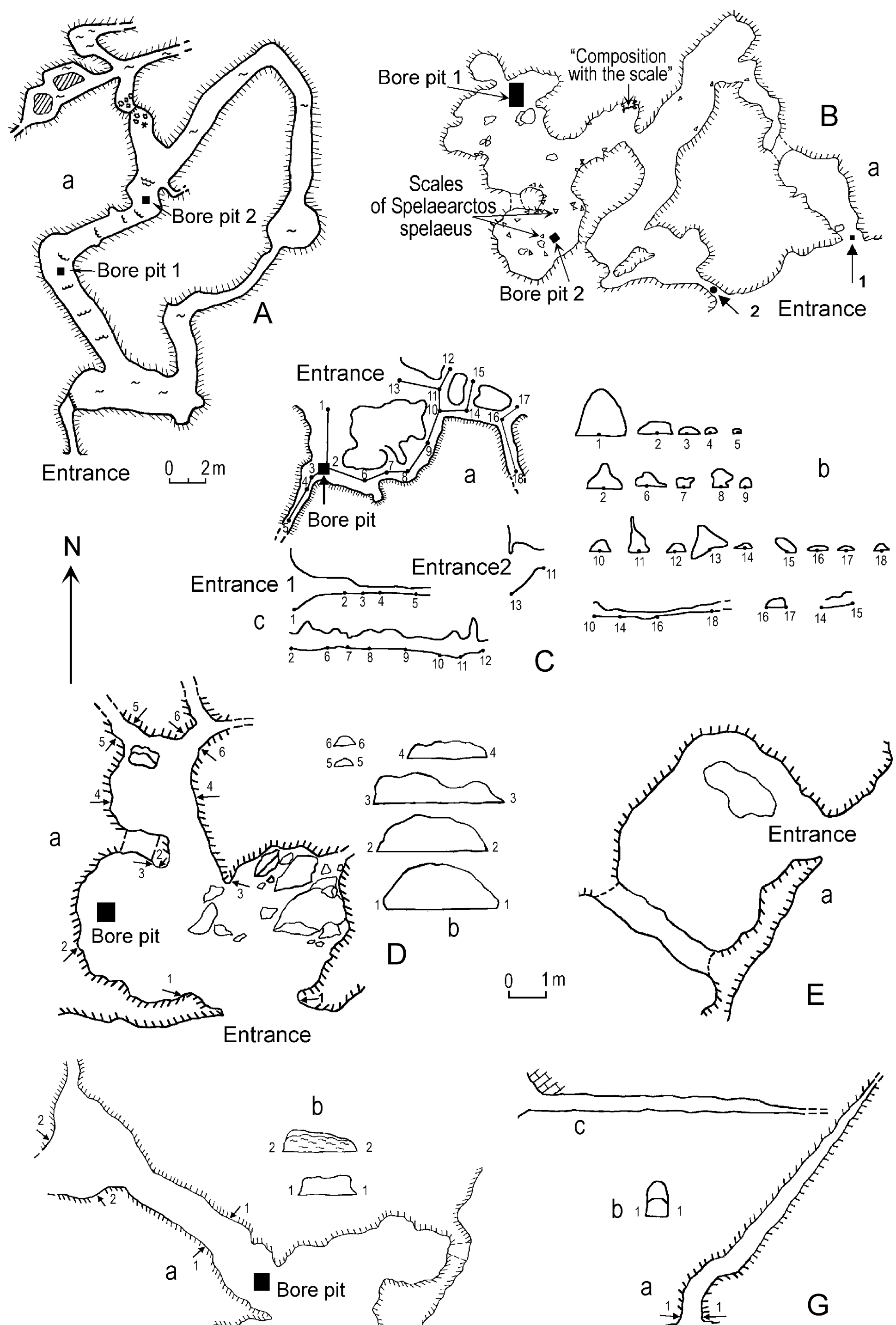

Fig. 2. Profiles and plans of the investigated caves. Legend: A: Verkhnaya cave; B: Zapovednaya cave; C: Lemeza IV cave; D: Lemeza II cave; E: Atysh I grotto; F: Lemeza III cave; G: Ust-Atysh cave; a—plan, b—cross section, c—profile. Origin of data: D, F, G is taken from V.G. Kotov; A, E—from Yu.V. Sokolov; B—from V.K. Fedorov and C—from T.I. Yakovleva; unpublished data.

Pedagogical University, Ufa; Institute of Ecology of Plants and Animals of the Ural Branch, RAS, Ekaterinburg. In the surroundings of the Atysh waterfall other caves such as Verkhnaya, Zapovednaya, Atysh I, Ust-Atysh and Lemeza I–IV were investigated. Additional geological information about the river terraces is necessary for a better reconstruction of the palaeoenvironment (Figs. 1 and 2).

The palaentological collections are kept at the Institute of Geology of the Ufa Scientific Centre (RAS, Ufa). They include molluscs, reptiles and small mammals. Large mammals are stored at the Institute of Ecology of Plants and Animals (Uralian Branch, RAS in Ekaterinburg).

Excavations and sampling for palynological, fauna and radiocarbon investigations were made according to standard methods (Grichuk and Zaklinskaya, 1948; Pokrovskaja, 1950; Gromov, 1955a, b; Arslanov, 1987). The soil was taken from the excavation pit in splits of 10–20 cm and then washed using sieves of 0.8–1.0 mm (Zhadyn, 1952; Agadjanyan, 1979). The late Late Pleistocene cave and terrace deposits are rather poor in fossil flora remains. All samples of separated pollen and spores were completely examined. The quantity of pollen and spores for each sample is shown in the pollen diagrams in the special column "Sum Total of SP Grains in a Sample". The base of calculation of the percentages for the various taxa is the sum of all pollen grains and spores (100%) in the sample. Species determination was done according to Likharev and Rammelmeier (1952), Zhadyn (1952), Starobogatov (1970), Shileiko (1978, 1984), Gromov and Baranova (1981), Shileiko and Likharev (1986), Gromov and Erbaeva (1995), Nederlandse Fauna 2 (1998) and Kerney and Cameron (1999). Radiocarbon data were done by the geochronological laboratories of the Geological institute (GIN) RAS (Moscow), Institute of Geography of the Saint-Petersburg University (LU) and Institute of Geology of the Siberian branch (SOAN) RAS.

The text uses the General stratigraphic subdivision of the Russian stratigraphic scale (Zhamoida et al., 2006). The Neopleistocene is correlated with the Middle and lower part of the Upper Pleistocene of southern Europe (Berggren, 1995) and with the Cromerian—the Upper Weichselian of the Netherlands (Zagwijn, 1996). Its lower boundary is at the age level 800 ka, its upper boundary is at the level 10 ka. The subdivision of the Holocene for the investigated region is given in accordance with Smirnov et al. (1990). Local stratigraphic subdivisions for the Southern Urals region are given in accordance with Danukalova (2007). The stratigraphic scheme of the Late Neopleistocene and Holocene of the Southern Urals region and correlation with schemes of other regions is given in Table 1.

3. Stratigraphical units and reference sections

3.1. Cave unconsolidated deposits

The caves and grottos occur in the surroundings of the Atysh waterfall of the Lemeza River valley at three

Table 1
Stratigraphic scheme of the Middle and Late Neopleistocene and Holocene of the Southern Urals region and correlation with schemes of other regions

Global Quaternary scheme, Gibbard et al. (2004)			Russia, Zhamoida et al. (2006)		Southern Urals region, Danukalova (2007) and Smirnov et al. (1990)		European Russia, Shik (2004) and Shik et al. (2004)		Urals, Stefanovsky (1997)		West European stratigraphic divisions (The Netherlands), Zagwijn (1996) and Turner (1998)
System	Series	Subseries, stages	Division	Link	Horizon		SuperHorizon	Horizon	SuperHorizon	Horizon	Stage
Quaternary	Holocene		Holocene		Late Holocene Middle Holocene Early Holocene			Shuvalov		Gorbunovsky	Holocene
	Pleistocene	Upper	Neopleistocene	Upper	Valdai	Kudashevo	Valdai	Ostashkov	North Uralian	Polar Urals	Upper Weichselian
						Tabulda		Leningrad		Nevyansk	Middle Weichselian
						Saigatka		Kalinin		Khanmei	Lower Weichselian
						Kushnarenkovo		Mikulino		Streletsky	Eemian
		Middle (upper part)		Middle	Central Russian plain	Elovka	Central Russian plain	Moscow	Middle Urals	Leplinsky	Drenthe glaciation, cooling interval with permafrost
						Klimovka		Gorkinsky		Nicinsky	Bantega Interstadial, Cold Interval, Hoogeveen Interstadial
						Larevka		Kaluga		Vilgortovsky	Cooling interval with permafrost
						Belaya		Likhvin		Sylvitcky	Holsteinian Interglacial

topographic levels (Figs. 1 and 2). Unconsolidated deposits of eluvial-slope genesis cover the bottom surfaces in these caves and consist of light brown loam and sandy loam with limestone debris, rare floral and sometimes with numerous faunal remains and archaeological artefacts (Figs. 3–5). Thickness of these deposits is different and depends from the period of sedimentation and of neotectonic activity (alteration of the periods of acceleration and stable) of discussed territory.

The highest Verkhnaya cave level of 255.2 m a.s.l. (80 m above modern river water level) is formed with Upper Neopleistocene sediments. Deposits of the Middle Neopleistocene were not saved probably because of uplift of the Urals (Puchkov and Danukalova, in press) but remains of *Ursus* cf. *deningeri* are present.

The second Zapovednaya cave level is located at a height of 235.2 m a.s.l. (60 m above modern river water level). It is composed of Upper Neopleistocene deposits. The latter cave level is associated with small caves and grottos at heights not more than 179.7 m a.s.l. (4–5 m above modern river water level) and consist of Lower, Middle, and Upper Holocene and modern deposits 0.5–0.9 m in thickness which fulfil almost all their inside space and are in process of forming now. Caves Ust-Atysh (25 m above river level) and Lemeza I (60 m above river level) were formed during the Late Holocene and are also fulfilled by modern deposits.

3.2. Fluvial deposits

Four main terrace levels have been identified in the Lemeza River valley. The highest first overflood plain terrace of 141.0 m a.s.l. (5.3 m above river water level) is formed with Upper Neopleistocene eluvial-slope sediments, and sand of Middle Neopleistocene at the basement. Kalinovka village was situated on this terrace on the right bank of the Lemeza River; fragments of this terrace occur downstream.

Another terrace is established at a height of 140.2 m a.s.l. (4.5 m above river water level). It is composed of Middle and Upper Holocene peat and lacustrine deposits. This terrace occurs only in one place in the valley in the surroundings of Kalinovka.

The next terrace level is associated with Upper Holocene deposits and the height of the latter is not more than 135.2 m a.s.l. (2.7 m above river water level). Zorenka is situated on this terrace on the left bank of the Lemeza River. Fragments of this terrace occur downstream. The second and third terrace levels form the high flood terrace which could be covered by river waters during springs following anomalously high snowfalls. The difference in their levels shows the existence of recent tectonic activity. The latter terrace level was investigated upstream of Verkhnaya Lemeza at the height of 139.0 m a.s.l. (1.8 m above river water level) and is associated with the modern flood plain deposits.

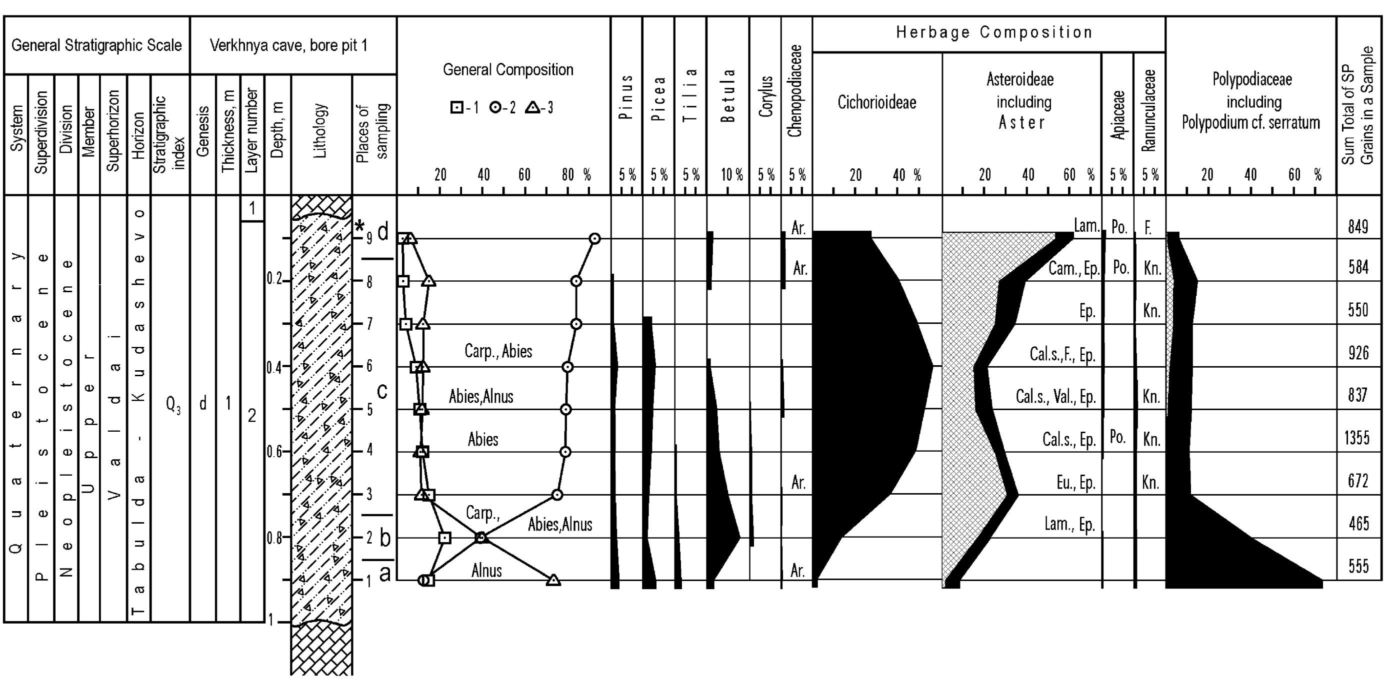

Fig. 3. Cross section across the Verkhnaya cave showing the sequence of unconsolidated sediments in the cave. The Quaternary section and the percentage diagrams of the main taxons (A.G. Yakovlev and A.A. Eremeev). Legend: Ar.—*Artemisia* sp., Abies—*Abies* sp., Alnus—*Alnus* sp., Cal.s.—Calystegia sepium R. Br., Carp.—*Carpinus* sp., Ep.—*Epilobium* sp., Eu.—Euphorbiaceae, F.—Fabaceae, Cam.—Campanulaceae, Kn.—*Knautia* sp., Lam.—Lamiaceae, Po.—Poaceae, Val.—*Valeriana* sp. General composition: 1—trees and bushes, 2—grass, 3—sporophytes. SP—spores and pollen; a, b, c, d—palynological zones (see explanation in the text). Radiocarbon data: *—LU-3714: 22,750 ± 1210 yr BP. Stratigraphic data: Q_3—Upper Neopleistocene, Tabulda–Kudashevo horizon; d—slope deposits (loam with limestone debris).

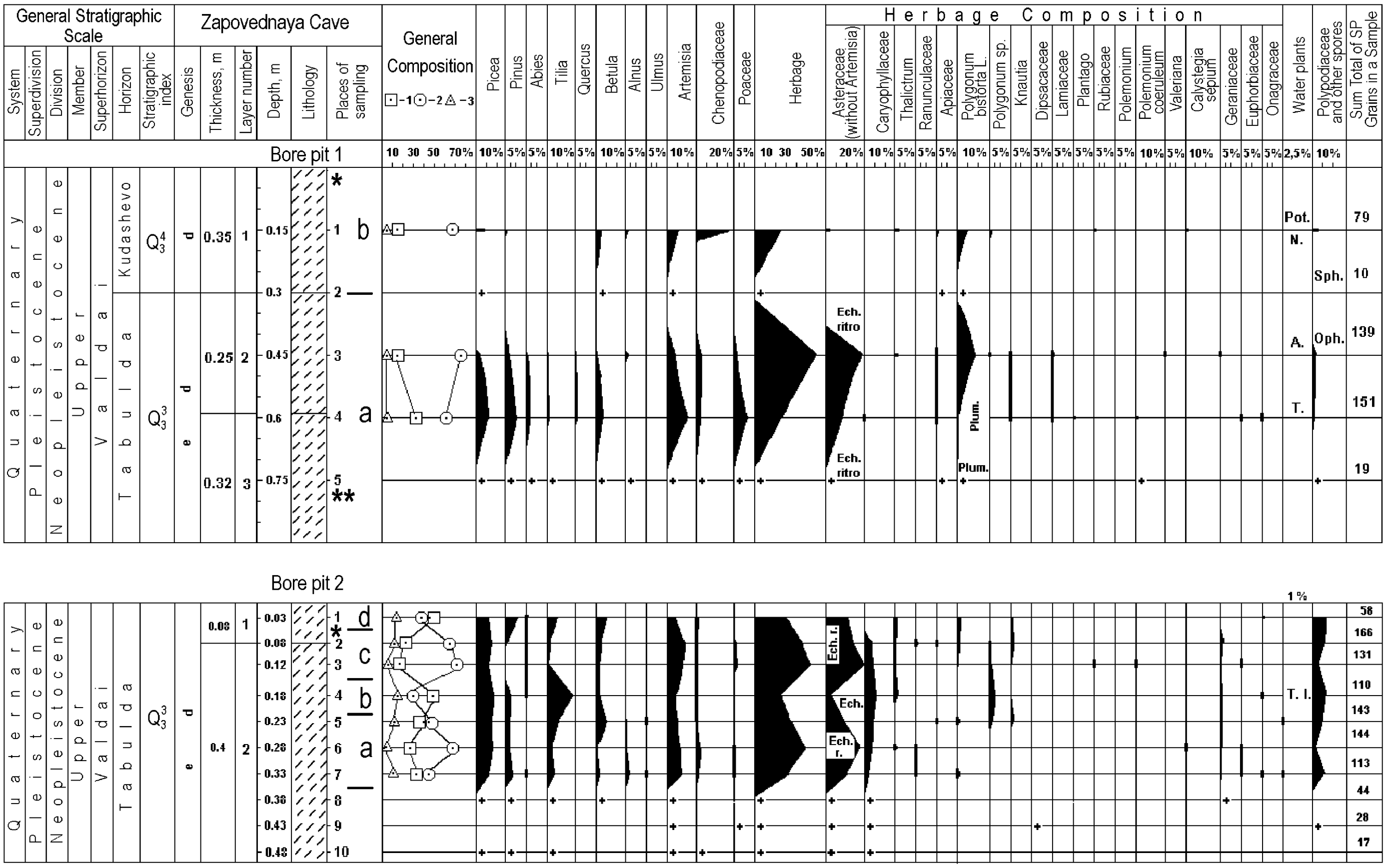

Fig. 4. Cross section across the Zapovednaya cave showing the sequence of unconsolidated sediments in the cave. The section of the Quaternary deposits and the percentage diagrams for the main taxons (by R.M. Sataev and L.I. Alimbekova). Legend: Ech. ritro—*Echinops ritro*, Plum.—Plumbaginaceae, Pot.—*Potamogeton* sp., A.—*Alisma* sp., Oph.—Ophioglossaceae, Sph.—*Sphagnum* sp., T.l.—*Typha latifolia* L., T.—*Typha* sp., N.—*Nuphar* sp. General composition: 1—trees and bushes, 2—grass, 3—sporophytes. SP—spores and pollen; a, b, c, d—palynological zones (see explanation in the text). Radiocarbon data: bore pit 1: *—LU-3861: 12,380 ± 260 yr BP, **—SBRAS-6174: 4200 ± 110 yr BP; bore pit 2: *—LU-3876: 37,250 yr BP. Stratigraphic data: Q_3^3—Upper Neopleistocene, Tabulda horizon; Q_3^4—Upper Neopleistocene, Kudashevo horizon; e, d—eluvial-slope deposits (loam).

3.2.1. Upper Neopleistocene terrace level

The section Kalinovka II was studied in 2000. The following stratigraphy was described from the top to the bottom (Fig. 9).

Upper Holocene:

(1) Grey modern forest soil (thickness 0.2 m).

Upper Neopleistocene, Kudashevo horizon:

(2) Brown loam, pedogenically reworked, with humus and terrestrial and freshwater mollusc shells (thickness 0.4 m).
(3) Yellowish brown sandy loam with ferruginization. The lower part of the layer is denser (thickness 1.2 m).
(4) Brown clayed unconsolidated ferruginated loam (thickness 1.6 m).
(5) Brown clayed dense loam with coal plant remains (thickness 0.5 m).

Middle–Upper Neopleistocene:

(6) Greyish orange fluvial pebble with loam and sand intensively ferruginated (thickness 0.6 m).
(7) Cemented rounded pebble with medium-grained sand and small pebble with stripes of ferruginization and manganese oxide (observed thickness 0.8 m).

Water level.

3.2.2. Middle Holocene terrace level

The section Kalinovka I was studied in 1997 and 2000. The following stratigraphy was described from the top to the bottom (Fig. 8).

Upper Holocene:

(1) Grey modern forest soil (thickness 0.26 m).
(2) Yellowish brown sandy loam slightly ferruginated (thickness 0.3 m).

Erosional base.

Middle Holocene:

(3) Dark brown loamy peat with lenses of silicified Equisetaceae remains (length 0.3–0.5 m, thickness 0.08 m), with shells of freshwater gastropods (thickness 1.3 m).

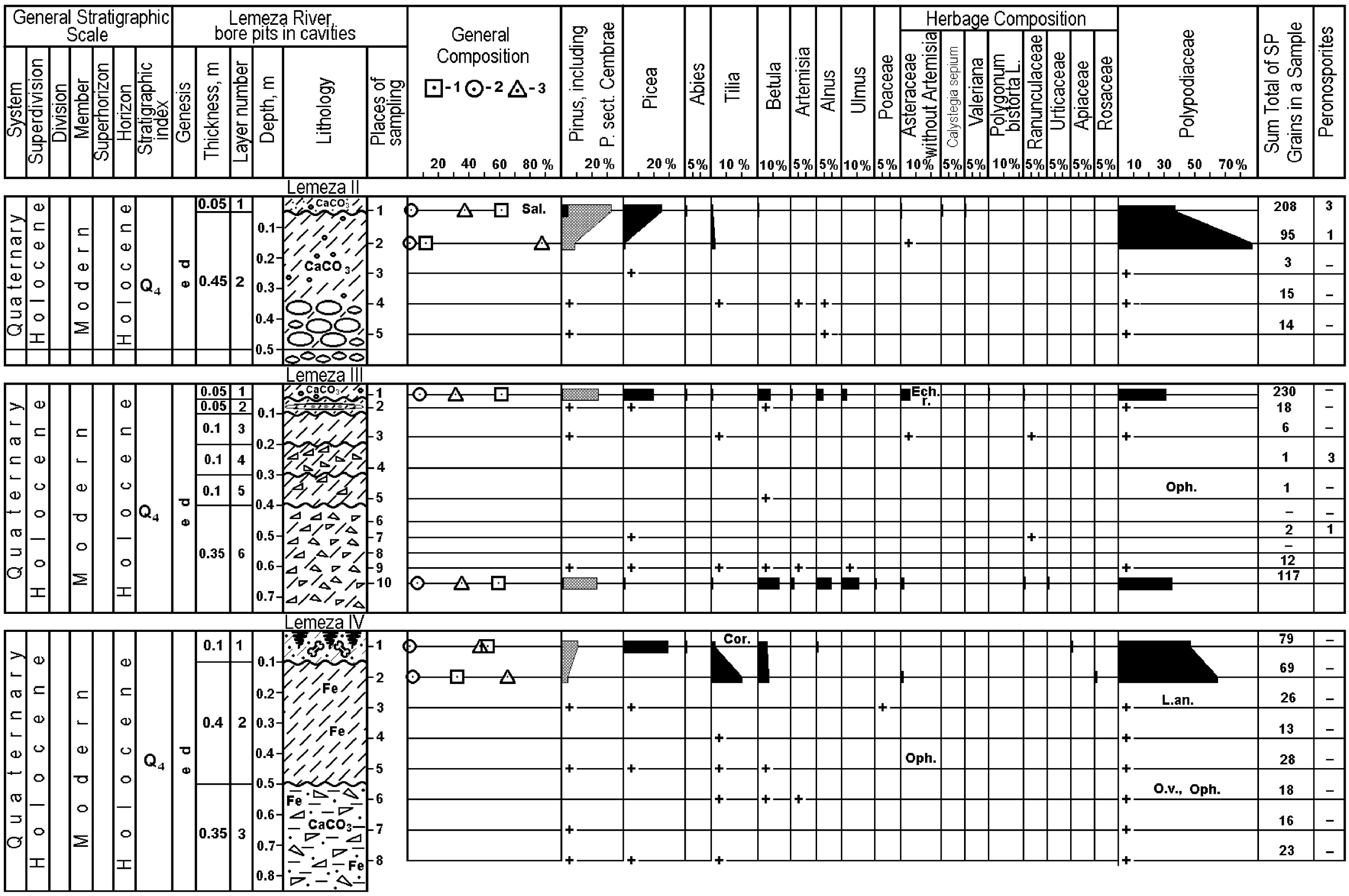

Fig. 5. Cross section across the Lemeza II and IV caves showing the sequence of unconsolidated sediments in the caves. The sections of the Quaternary deposits and the percentage diagrams for the main taxons (A.G. Yakovlev and L.I. Alimbekova). Legend: Sal.—*Salsola* sp., Ech. r.—*Echinops ritro*, Cor.—*Corylus* sp., Oph.—Ophioglossaceae, O.v.—*Ophioglossum vulgatum* L., L.an.—*Lycopodium annotinum* L. General composition: 1—trees and bushes, 2—grass, 3—sporophytes. SP—spores and pollen. Stratigraphic data: Q_4—Holocene; e, d—eluvial-slope deposits (loam with rock debris).

(4) Light grey loam with numerous plants remains and shells of freshwater and terrestrial molluscs (thickness 0.15 m).
(5) Clayed peat with numerous mollusc shells, with lenses (length 0.3–0.5 m, thickness 0.03–0.05 m) of silicified plant remains in the lower part of the bed and with numerous fragments of tree trunks, mainly birches (thickness 1.47 m).
(6) Sphagnum peat (thickness 0.05 m).
Erosional base.
(7) Bluish grey clay with hydrogen sulphite smelling, with numerous plant remains and mollusc shells (observed thickness 0.75 m).

Water level.

3.2.3. Upper Holocene terrace level

The section Zorenka was studied in 1997 and 2000. The following sequence was described from the top to the bottom (Fig. 7).

Upper Holocene:

(1) Grey modern forest soil with traces of erosion in the lower part (thickness 0.19 m).
(2) Light brown sandy loam with traces of erosion in the lower part (thickness 0.69 m).
(3) Light grey sandy clay intensively ferruginated with traces of erosion in the lower part (thickness 1.45 m).
(4) Bluish grey clay with hydrogen sulphite smelling, slightly ferruginated with numerous plant remains (observed thickness 0.45 m).

Water level.

3.2.4. Upper Holocene (Modern) terrace level

The section Verkhnaya Lemeza was studied in 1997 and 2000. The following sequence was described from the top to the bottom. All beds have traces of erosion in their lower parts (Fig. 6).

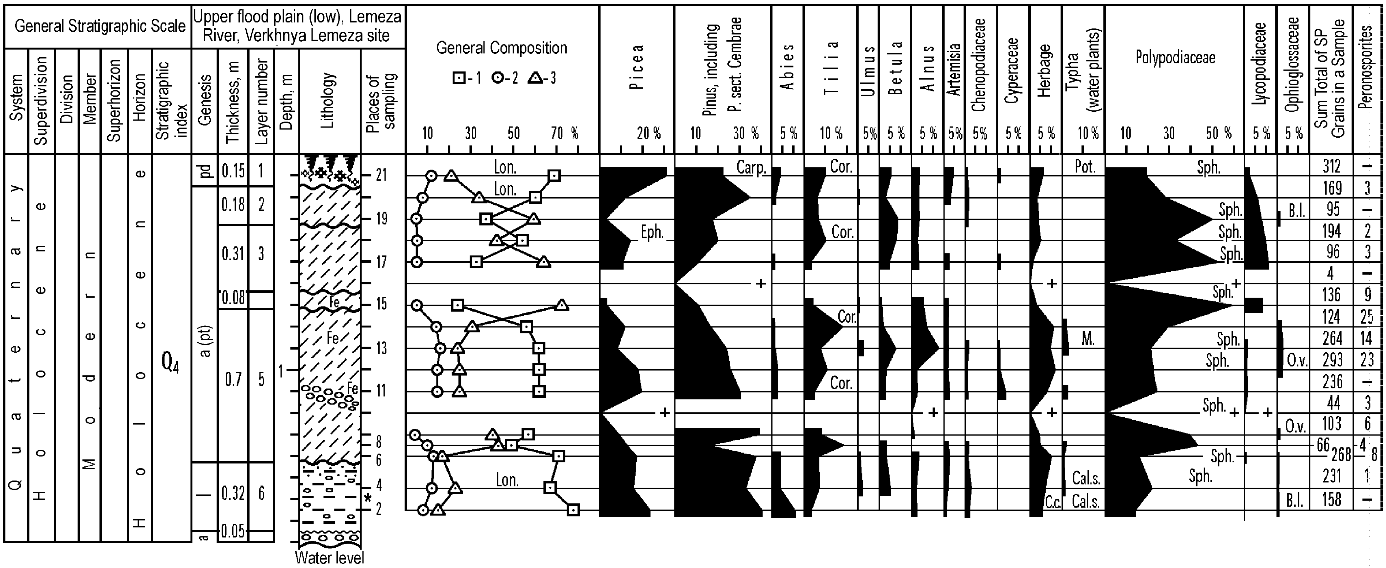

Fig. 6. Cross section across the Verkhnaya Lemeza terrace showing the sequence of unconsolidated sediments in the terrace. The section of the Quaternary deposits and the percentage diagrams for the main taxons (G.A. Danukalova, A.G. Yakovlev and L.I. Alimbekova). Legend: Cor.—*Corylus* sp., Carp.—*Carpinus* sp., Cal. s.—*Calystegia sepium* R. Br., C.c.—*Centaurea* cyanus L., Eph.—*Ephedra* sp., Lon.—*Lonicera* sp., O.v.—*Ophioglossum vulgatum* L., Sph.—*Sphagnum* sp., B.l.—*Botrychium lunaria* (L.) Sw., Pot.—*Potamogeton* sp., M.—*Myriophyllum* sp. General composition: 1—trees and bushes, 2—grass, 3—sporophytes. SP—spores and pollen. Radiocarbon data: *—GIN-10858: 250±40 yr BP. Stratigraphic data: Q_4—Holocene; pd—soil (loam); l—lacustrine deposits (clay with small pebble and plant remains); a (pt)—alluvium (flooded plain deposits, loam) (loam); a—alluvium (pebble).

Table 2
Radiocarbon dating results

Sampling places (locality, layer)	Age in yr BP	Reference of specimen	Material
Zapovednaya, surface of ground	>50,200	LU-5134	Bone of Ursus spelaeus
Zapovednaya, bore pit 3, layers 3	>46,600	LU-5135	Bone of Ursus spelaeus
Zapovednaya, bore pit 2, layers 1, 2	>37,250	LU-3876	Bone of Ursus spelaeus
Zapovednaya, bore pit 1, layer 3	28,700!1000	LU-3715	Bone of Ursus spelaeus
Verkhnya, layer 2	22,750!1210	LU-3714	Bone
Zapovednaya: bore pit 1, layer 1	12,380!260	LU-3861	Wood coal
Kalinovka I, layer 3	3610±80	SBRAS-6175	Wood
Kalinovka I, layer 5	4200±110	SBRAS-6174	Wood
Kalinovka I, layer 7	4620±40	GIN-10859	Wood
Zorenka, layer 4	1770±50	GIN-10857b	Wood
Verkhnya Lemeza, layer 6	250±40	GIN-10858	Wood

Upper Holocene:

(1) Grey modern forest soil with traces of erosion in the lower part (thickness 0.15 m).
(2) Light brown sandy loam (thickness 0.18 m).
(3) Light brown loam with yellow strip at the upper boundary (thickness 0.31 m).
(4) Brownish grey loam with numerous plant remains and traces of ferruginization (thickness 0.08 m).
(5) Light brown loam intensively ferriginated with lenses (length 0.5 m, thickness 0.05 m) of polymictic pebbles, mainly black flints and siliceous limestone (diameter 2–5 cm; thickness 0.71 m).
(6) Bluish grey sandy clay with hydrogen sulphide, slightly ferruginated with numerous plant remains and rare small pebbles (diameter 2 cm). Observed thickness 0.32 m; traces of erosion at the lower boundary of the bed.
(7) Polymictic pebble gravel (observed thickness 0.05 m).

Water level.

4. Results

4.1. Radiocarbon dating

Results of the radiocarbon dating are presented below (Table 2). These data separated the Middle–Late Neopleistocene, the Early Holocene and the Middle and Late Holocene horizons.

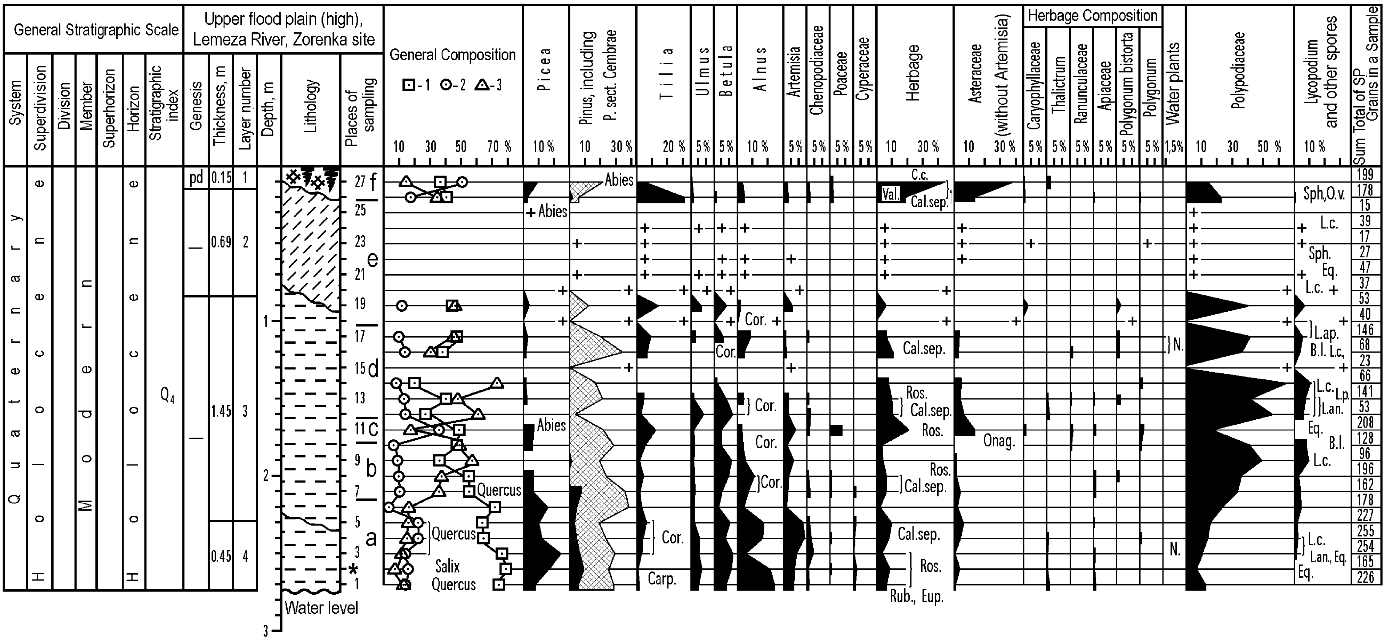

Fig. 7. Cross section across the Zorenka terrace showing the sequence of unconsolidated sediments in the terrace. The section of the Quaternary deposits and the percentage diagrams for the main taxons (G.A. Danukalova, A.G. Yakovlev and L.I. Alimbekova). Legend: Salix—*Salix* sp., Quercus—*Quercus* sp., Abies—*Abies* sp., Cor.—*Corylus* sp., Carp.—*Carpinus* sp., Val.—*Valeriana* sp., Cal. sep.—*Calystegia sepium* R. Br., C.c.—*Centaurea cyanus* L., Ros.—Rosaceae, Rub.—Rubiaceae, Eup.—Euphorbiaceae, Eq.—*Equisetum* sp., Onag.—Onagraceae, N.—*Nuphar* sp., O.v.—*Ophioglossum vulgatum* L., L. ap.—*Lycopodium appressum* (Desv.) Petr., Sph.—*Sphagnum* sp., B.l.—*Botrychium lunaria* (L.) Sw., L.c.—*Lycopodium clavatum* L., L.p.—*Lycopodium pungens* La Pyl., L.an.—*Lycopodium annotinum* L., Eq.—*Equisetum* sp. General composition: 1—trees and bushes, 2—grass, 3—sporophytes. SP—spores and pollen; a, b, c, d, e, f—palynological zones (see explanation in the text). Radiocarbon data: *—GIN-10857b: 1770 ± 50 yr BP. Stratigraphic data: Q_4—Holocene; pd—soil (loam); l—lacustrine deposits (loam and clay).

4.2. Pollen record

One hundred and forty-seven samples of unconsolidated deposits from ten localities were palynologically investigated (Figs. 3–10). All the separated pollen and spores samples have been examined in detail. Determination of the spore and pollen spectra was made for the following stratigraphic intervals: Upper Neopleistocene (Tabulda and Kudashevo intervals), Lower, Middle, and Upper Holocene.

4.2.1. Tabulda interval

Spore and pollen spectra of this interval have been studied in details in the deposits of the Zapovednaya cave (bore pit 1, layers 2, 3; bore pit 2, layers 1, 2, samples 1–10). Several other palynological zones (a, b, c, d) have been being determined in the bore pit 2 (Fig. 4). Details of these determinations are given below:

- *Palynological zone a (samples 5–7)*: Pollen and spores spectra are characterized by grasses predominance, with a high numbers of Asteraceae (type Aster, Crepis, Cichorium, Carduus and *Echinops ritro* L.) and *Artemisia* grains. Pollen of Poaceae, Chenopodiaceae, Geraniaceae, Caryophyllaceae, etc. also exist in the spectra. The quantity of tree grains is 25–35%: *Picea* pollen predominated (18%), *Tilia* (8%) and Pinus are present.
- *Palynological zone b (sample 4)*: Increasing number of tree pollen (mainly Tilia) and a decreasing amount of grasses quantity.
- *Palynological zone c (samples 2–3)*: Pollen of *Pinus* disappear from spectra, and the quantity of *Tilia* grains decreases. Part of the herbage and Artemisia increased.
- *Palynological zone d (sample 1)*: There is an equal correlation between trees and grasses and between grains of *Picea* and *Pinus*. The number of *Betula* and *Tilia* grains increased.

Similar spectra were obtained from the Zapovednaya cave in borehole 1 (Fig. 4) (palynological zone a—layers 2, 3). Pollen of grasses (Asteraceae, *Polygonum* sp.) dominates in the spectra. Pollen of Poaceae, *Artemisia* and Chenopodiaceae exist. Trees are represented by *Picea*, *Pinus*, *Abies* and a small quantity of *Quercus* and *Tilia* (5%).

Forest–steppes predominated during Tabulda time in the Lemeza River surroundings. *Picea*, *Tilia*, *Pinus*, *Abies*, *Quercus*, *Betula*, *Alnus* and *Ulmus* formed the forest. Herbage, Artemisia, Chenopodiaceae and Poaceae covered the open landscapes.

4.2.2. Tabulda–Kudashevo transitional interval

Pollen and spore spectra of the Verkhnaya cave (palynological zones a, b; samples 1, 2) represent the forest–steppe of the transitional stage from the Tabulda to

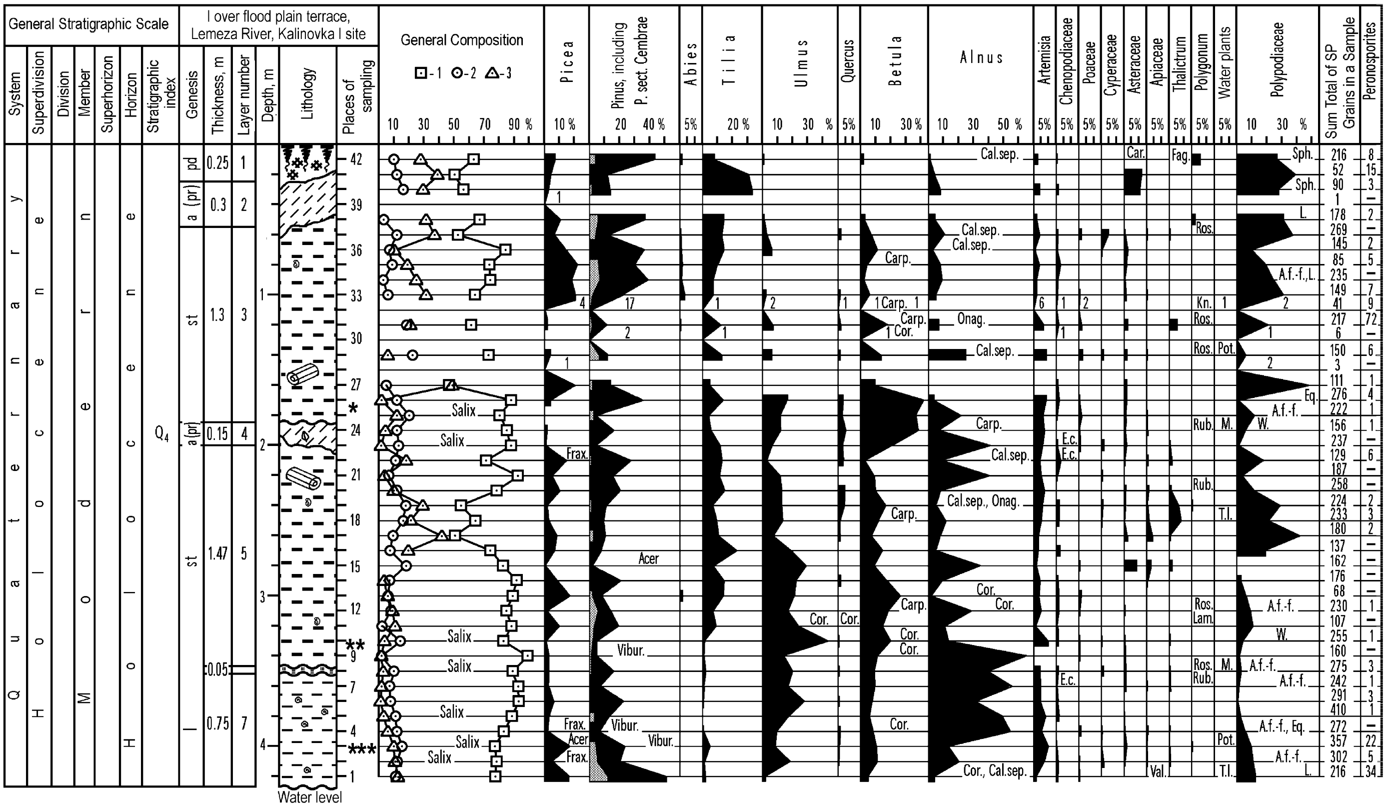

Fig. 8. Cross section across the Kalinovka I terrace showing the sequence of unconsolidated sediments in the terrace. The section of the Quaternary deposits and the percentage diagrams for the main taxons (G.A. Danukalova, A.G. Yakovlev and L.I. Alimbekova). Legend: Salix—*Salix* sp., Acer—*Acer* sp., Frax.—*Fraxinus* sp., Cor.—*Corylus* sp., Carp.—*Carpinus* sp., Vibur.—*Viburnum* L., Fag.—*Fagopyrum* sp., Kn.—*Knautia* sp., E.c.—*Eurotia ceratoides* (L.) C.A.M., Lam.—Lamiaceae, Val.—*Valeriana* sp., Pot.—*Potamogeton* sp., Cal. sep.—*Calystegia sepium* R. Br., Ros.—Rosaceae, Rub.—Rubiaceae, Onag.—Onagraceae, W.—*Woodsia* sp., L.—*Lycopodium* sp., A.f.-f.—*Athyrium filix-femina* (L.) Roth., Sph.—*Sphagnum* sp., T.l.—*Typha latifolia* L., M.—*Myriophyllum* sp. General composition: 1—trees and bushes, 2—grass, 3—sporophytes. SP—spores and pollen; a, b, c, d, e, f, g, h, i—palynological zones (see explanation in the text). Radiocarbon data: *—SBRAS-6175: 3610±80 yr BP, **—SBRAS-6174: 4200±110 yr BP, ***—GIN-10859: 4620±40 yr BP. Stratigraphic data: Q_4—Holocene; pd—soil (loam); st—peat; a (pr)—alluvium (lake deposits, loam); l—lacustrine deposits (clay).

the Kudashevo interval (Fig. 3). Sparse growth of trees was formed by *Betula*, *Pinus*, *Picea* and single *Tilia*. Herbs (Asteraceae) were distributed in the open landscapes. Pollen and spore spectra are characterized by a very high number of Polypodiaceae which grew near the cave entrances.

4.2.3. Kudashevo interval

Spore and pollen spectra of this interval were determined from the deposits of the Verkhnaya cave (palynological zone d; layer 1, samples 3–9), Zapovednaya cave (palynological zone b; bore pit 1, layer 1) and described the steppe character of the vegetation (Figs. 3 and 4). Asteraceae was a part of periglacial steppe community. Rare forests consisted of *Betula* and *Picea*. The age of the deposits was determined in accordance with the radiocarbon dating (Table 2).

4.2.4. Early Holocene interval

Spore and pollen spectra from the deposits of the Lemeza III locality (layers 2–6) are characterized by predominance of trees (*Pinus* sp., *P*. sect. Cembrae, *Betula*, *Ulmus*, *Alnus*) and by large quantities of Polypodiaceae spores (Fig. 5). Probably, mixed forests of *Pinus*, *Betula*, *Ulmus*, *Alnus* with small admixture of *Picea* and *Tilia* covered the surroundings of the Lemeza River in the Early Holocene. Grasses were distributed in open landscapes (Poaceae, Ranunculaceae and Asteraceae including *Artemisia*).

4.2.5. Middle Holocene interval

Spore and pollen spectra from the deposits of the Lemeza II locality (layer 2, sample 2) are characterized by the predominance of Polypodiaceae spores: *Woodsia alpina* (Bolton) Gray, *Cystopteris fragilis* (L.) Borb (Fig. 5). *Pinus*, *Picea* and *Tilia* represent trees.

Spore and pollen spectra from the Kalinovka I locality (layer 2–7) characterize this interval in details. Several palynological zones could be determined in the deposits (Fig. 8):

- *Palynological zone a (samples 1–3)*: Grains of *Pinus* sp. (45%) predominated. Significant amounts of *Picea*, *Betula*, *Ulmus*, and *Alnus* sp. (10–15%) pollen are present.

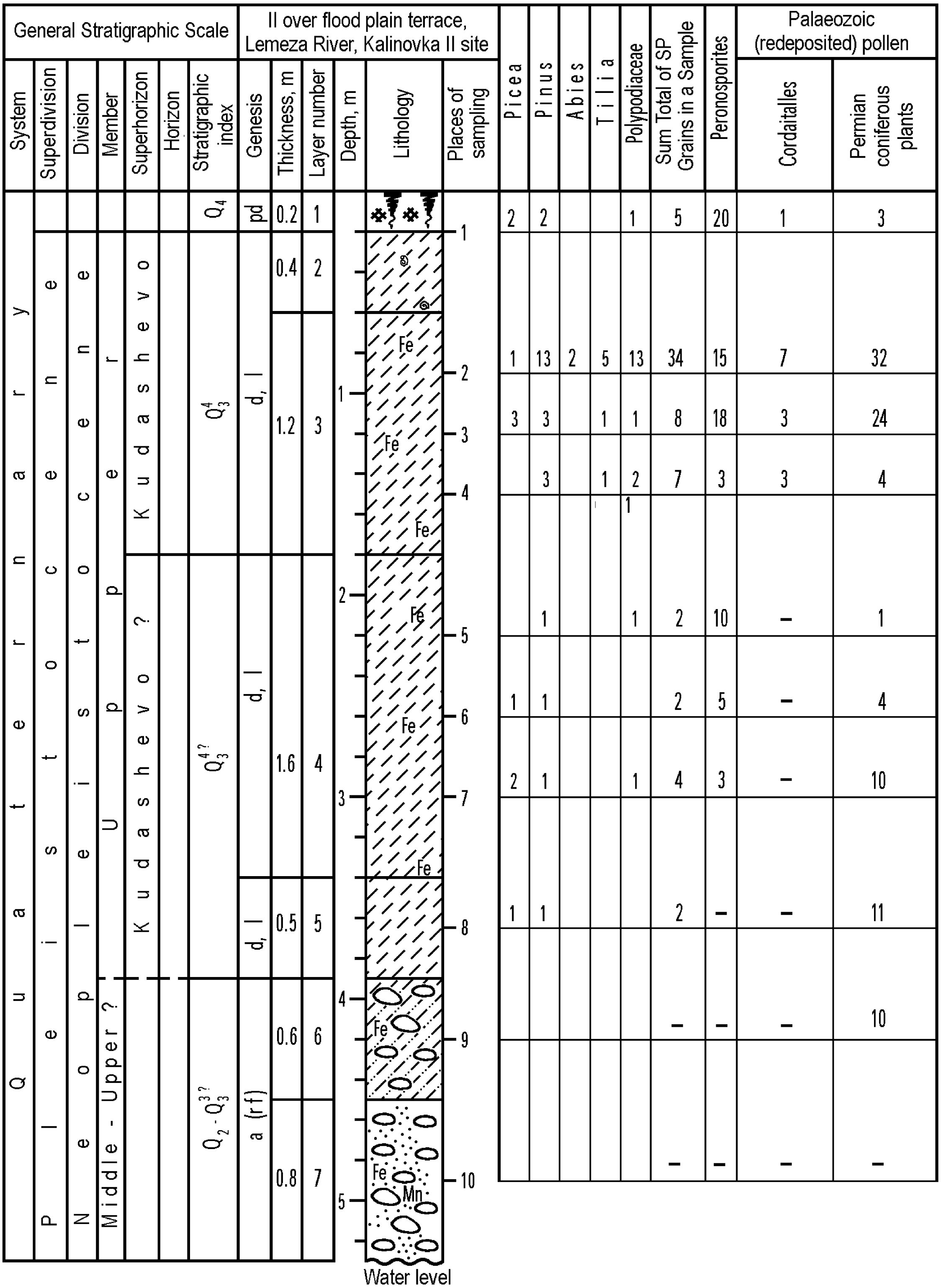

Fig. 9. Cross section across the Kalinovka II terrace showing the sequence of unconsolidated sediments in the terrace. The section of the Quaternary deposits and the percentage diagrams for the main taxons (G.A. Danukalova, A.G. Yakovlev and L.I. Alimbekova). Legend: Stratigraphic data: Q_4—Holocene; Q_3^4—Upper Neopleistocene, Kudashevo horizon; Q_2–Q_3^3—Middle–Upper Neopleistocene (Tabulda horizon); pd—soil (loam); d, l—slope-lacustrine deposits (loam); a (rf)—alluvium (pebble, boulders).

- *Palynological zone b (samples 4–9)*: The pollen of *Alnus* sp. (50%) predominated in the spectra, with Pinus (15%), *Betula* (10%) and *Ulmus* (20%).
- *Palynological zone c (samples 10–19)*: Quantity of *Alnus* grains decreases in the spectra; the quantities of *Pinus* sp., *Ulmus* sp. and *Betula* sp. grains are

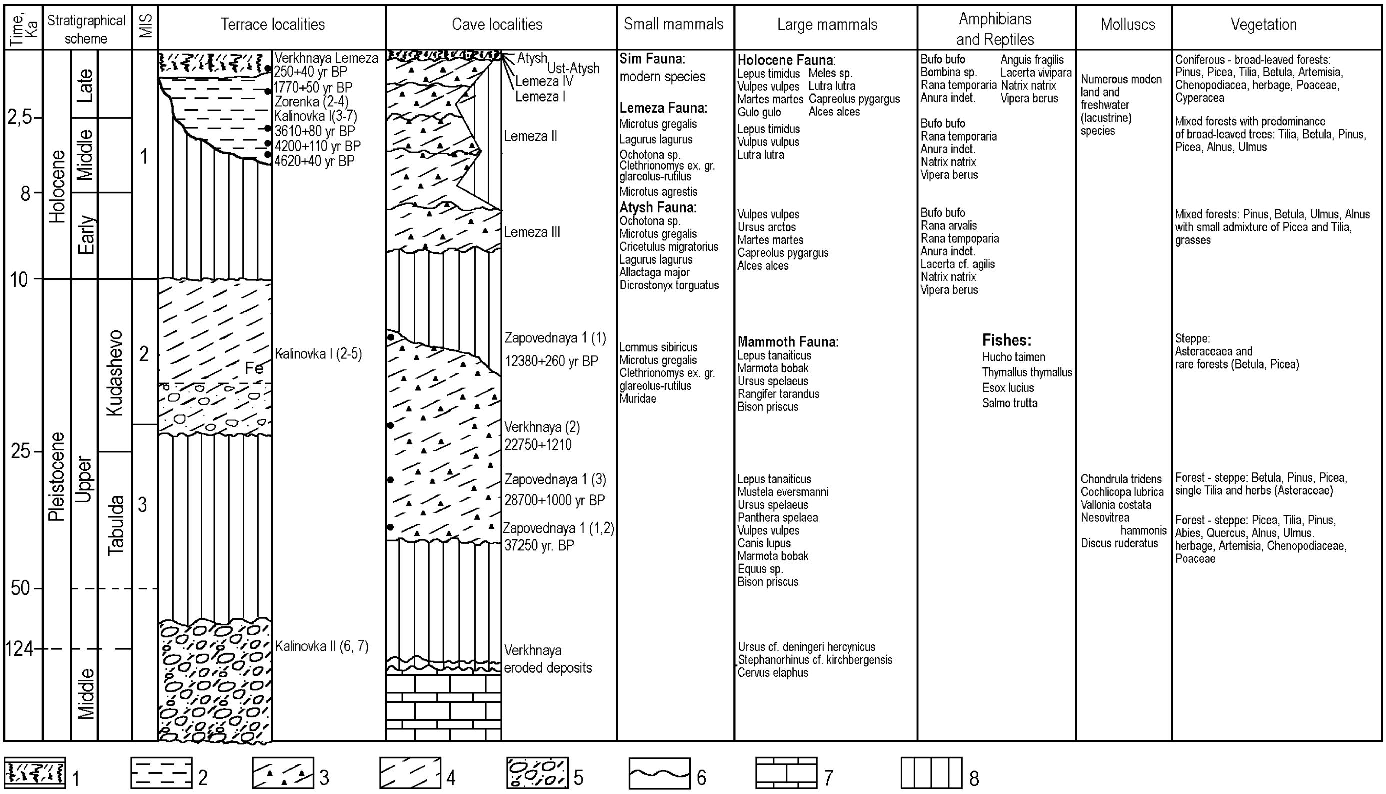

Fig. 10. Summary section of the late Late Pleistocene and Holocene deposits excavated in the Lemeza River valley (the Southern Urals). Legend: 1—soil (loam); 2—clay; 3—eluvial-slope deposits (loam with limestone debris); 4—slope-lacustrine deposits (loam); 5—alluvium (pebble, boulders with loam and sand); 6—erosion levels; 7—limestone; 8—erosion of the deposits.

similar (15–20%); the quantity of *Tilia* sp. grains is 22%.

- *Palynological zone d (samples 20–22)*: The quantity of *Pinus* grains increased up to 25–30%; the quantity of *Alnus* sp. is 20–25%.
- *Palynological zone e (samples 23–26)*: The pollen of *Betula* sp. predominated (up to 40%); and the quantity of *Quercus* sp. pollen was of 5%.
- *Palynological zone f (samples 27–32)*: Pollen of trees such as *Tilia* sp., *Pinus* sp., *Betula* sp., *Picea* sp. and *Ulmus* sp. predominated.
- *Palynological zone g (samples 33–38)*: Pollen of *Pinus* sp. predominated (40%); others include *Picea* sp. (20%), *Tilia* sp. (15%), *Alnus* sp. (10%), *Betula* sp. (10%) and *Ulmus* sp. (10%).
- *Palynological zone h (samples 40, 41)*: Pollen of *Tilia* sp. predominated (30%); *Pinus* sp. is 15%.
- *Palynological zone i (sample 42)*: Pollen of *Pinus* (40%) predominated; *Tilia* is 10%.

These data suggest that the forests predominated during the Middle Holocene. Gallery forests of *Ulmus* and *Alnus* grew in river valleys. Mixed forests of *Tilia*, *Betula*, *Pinus* and *Picea* grew on the hills and mountain slopes.

4.2.6. Late Holocene interval

Several palynological zones have been determined from Zorenka locality spectra (Fig. 7):

- *Palynological zone a (samples 1–6)*: Pollen of trees predominated in the spectra (*Pinus*, *Picea*, *Alnus*, *Betula*, *Ulmus* and *Tilia*). The quantity of spores and grasses pollen is small.
- *Palynological zone b (samples 7–10)*: *Pinus* pollen predominated in spectra. The quantity of spores increased up to 50%.
- *Palynological zone c (sample 11)*: *Pinus* pollen are dominating. The quantity of grass pollen (herbage, Poaceae, *Artemisia*) increases up to 35%.
- *Palynological zone d (samples 12–17)*: Alternation of spores or trees pollen. *Pinus* and herb pollen predominate.
- *Palynological zone e (samples 18–25)*: Small quantity of pollen and spores.
- *Palynological zone f (sample 27)*: Palynological assemblage of herbs (Asteraceae).

Forests of *Picea*, *Pinus*, *Tilia* and *Betula* predominated in the first stage of the Subatlantic (GIN-10857-1770 ± 50 yr BP) in the surroundings of the Lemeza River. *Alnus* and

Ulmus grew in the river valleys. *Artemisia*, Chenopodiaceae, herbage, Poaceae and Cyperaceae covered the open landscapes. Later, *Pinus* dominated in the forest composition and *Alnus* decreased. Open woodlands increased during the formation of the soil in accordance with the human activity. Asteraceae covered open territories. *Pinus*, *Picea* and *Tilia* grew in forests.

Picea and *Pinus* predominated in the forests with admixtures of *Tilia*, *Betula*, *Alnus*, *Ulmus* and *Quercus* during the sedimentation of the Late Holocene deposits in Lemeza II (layer 1, sample 1), Lemeza III (layer 1, sample 1), Lemeza IV (layers 1, 2, samples 1, 2), Verkhnaya Lemeza localities. The quantity of grass pollen was no more than 10%. Forests of *Pinus*, *Picea* and *Tilia* with the admixture of *Betula*, *Ulmus* and *Alnus* and with Polipodiaceae predominated during the Late Holocene in the same area. Pollen and spores from the Kalinovka II deposits (Fig. 9) are rare; only Polypodiaceae, *Picea*, *Pinus*, *Tilia* and *Abies* were found.

4.3. Molluscs

A total of 2490 mollusc shells (and fragments) were identified from the Upper Neopleistocene and Holocene deposits of the Zapovednaya cave and Kalinovka I terrace (Table 3). Mollusc shells are rare in the eluvial-slope deposits of the Zapovednaya cave and belong to the Late Neopleistocene complex (Table 3). Shells were collected from the deposits of layer 3 (bore pit 1) at a depth of 0.3 m (Fig. 2). This complex is characterized by Holarctic species which preferred moist habitats under the old leaves and branches in the wood or in the grass of the meadow. Exceptional is the xerophile species *Chondrula tridens* (Müll.), which lived on the soil and in grass and is indicative of steppe localities situated on slopes with southern exposures.

A Middle Holocene molluscan complex was identified in the Kalinovka I terrace locality (Fig. 8; Table 3). The molluscan fauna is represented by numerous freshwater and terrestrial species. Freshwater molluscs lived on water plants in small shallow water lakes. Terrestrial molluscs are characterized by hydrophilous species. *Succinea* cf. *pfeifferi* Rossm. and *Succinea oblonga* Drap. are amphibious species.

Table 3
List of species and number of fossil mollusc shell remains

Species	Late Neopleistocene, Tabulda horizon	Late Holocene
	Zapovednaya	Kalinovka I
Carychium minimum Müll.		1
Succinea cf. *pfeifferi* Rossm.		131
Succinea oblonga Drap.		7
Succinea sp.		1[a] + 37 juv.
Vertigo pusilla Müll.		1
Vertigo antivertigo Drap.		5
Euconulus fulvus Müll.		9
Pseudotrichia rubiginosa A.Schm.		2
Chondrula tridens Müll.	1[a]	
Cochlicopa lubrica (Müll.)	5 + 1 juv. + 1[a]	
Vallonia costata Müll.	58	5
Nesovitrea hammonis (Ström)	18 + 2[a]	
Nesovitrea cf. *hammonis* Ström.		1
Nesovitrea sp.		1[a]
Discus cf. *ruderatus* (Stud.)	9	
Radix pereger (Müll.)		3
Radix sp.		6 juv.
Galba palustris (Müll.)		(14 + 27 juv.)
Bathyomphalus contortus (L.)		70
Gyraulus cf. *rossmaessleri* Auerswald		2000
Gyraulus (Armiger) crista Lindh.		54
Valvata cristata Müll.		18
Sphaerium rivicola Lam.		1 juv.
Gastropoda	1	1[a]
Total	96	2385

[a]Fragments of mollusk shells.

4.4. Fishes

Fossil fish remains were found and determined in the deposits of the borehole from at the entrance of the Zapovednaya cave (Figs. 2 and 4). They were restricted to two levels, at 0.15–0.2 m below the light dusty loam and the other 0.7–0.9 m below the light brown loam. Scales of *Hucho taimen* (Pall.) (13), *Thymallus thymallus* (L.) (28), *Esox lucius* (8) and *Salmo trutta* L. (1) were determined by Nurmukhametov (1997).

4.5. Amphibians and reptiles

A total of 8096 remains of amphibians and reptiles were collected and identified from the five caves located in Lemeza I–IV and Zapovednaya (Table 4). Radiocarbon data and palaeontology indicate Early, Middle and Late Holocene ages. An Early Holocene fauna is known in the sediments collected from the Lemeza III cave (layers 2–6) (Table 4). It is characterized by recent species which are living now in the Lemeza River valley and by *Rana arvalis* Nilsson. *Lacerta* cf. *agilis* L. indicates forest–steppe conditions.

Bone remains of amphibians and reptiles of the Middle Holocene deposits of the Lemeza II cave (layer 2) are represented by modern species typical for the forest biotopes of the Southern Urals.

Late Holocene herpetofauna from the Zapovednaya cave (bore pit 3 at the entrance) and Lemeza I and IV is characterized by modern species, but bone remains of *Bombina* sp. (Lemeza IV) and *Triturus cristatus* (Laurenti) (Zapovednaya cave) were identified. These two species do not live now in this area, as they prefer the forest–steppe zone of the Southern Urals. This result suggests that the deposition of these remains occurred at the beginning of the Late Holocene when steppe biotopes existed in the surroundings of the cave.

Table 4
List of species and number of fossil amphibians and reptiles bone remains

Species	Holocene				
	Early	Middle	Late		
	Lemeza III	Lemeza II	Lemeza IV	Zapovednaya: bore pit III	Lemeza I
Bufo bufo (L.)	18	1	442		2
Bufo sp.	19				
Bombina sp.			1		
Rana arvalis Nilsson	2				
Rana temporaria L.	125	20	2942	3	11
Rana sp.	9				
Anura indet.	185	83	4081	13	14
Triturus cristatus (Laurenti)				1	
Anguis fragilis L.			5	4	4
Lacerta cf. *agilis* L.	1				
Lacerta vivipara Jacq.				1	
Natrix natrix (L.)	2	6	2	43	6
Natricinae	1				
Vipera berus (L.)	2	1	3	36	1
Serpentes indet.				6	
Total	364	111	7476	107	38

Table 5
List of species and number of fossil small mammals bone remains

Species	Late Neopleistocene, Kudashevo horizon	Early Holocene	Middle Holocene	Late Holocene	
	Verkhnaya	Lemeza III, layers 2–6	Lemeza II, layer 2	Lemeza IV	Lemeza I
Talpa europaea L.	4	1		57	87
Sorex sp.		6	4	6	28
Chiroptera				24	
Ochotona sp.	1	120	6		
Lepus sp.		6	17	3	5
Pteromys volans L.					2
Sciurus vulgaris L.					2
Tamias sibiricus Laxmann					2
Spermophilus sp.		6	2		
Sicista sp.	1		3	1	2
Allactaga major Kerr		1			
Cricetulus migratorius Pallas		5			
Cricetus cricetus L.	3	1		15	10
Apodemus uralensis Pallas	1				1
A. flavicollis Melchior	3				2
Apodemus ex gr. *Uralensis-agrarius*			1	2	
Rattus sp.					2
Ellobius talpinus Pallas		1	1		
Lemmus sibiricus Kerr	15				
Dicrostonyx torquatus Pallas		3			
Lagurus lagurus Pallas		10	8		
Clethrionomys rufocanus Sundevall			1	13	1
Clethrionomys ex gr. *glareolus-rutilus*	12	1	24	53	110
Arvicola terrestris L.	12	15	19	14	12
Microtus oeconomus Pallas	4	75	23	11	9
M. gregalis Pallas	3	45	36		
M. agrestis L.	5		6	10	14
M. ex gr. *agrestis-arvalis*				28	16
M. arvalis Pallas	3	3	1		13
Microtus sp.	58	485	158	76	165
Mustela nivalis L.	2	1			
Total	127	785	310	313	483

4.6. Small mammals

A total of 2018 bone remains of small mammals were collected in the caves of Verkhnaya and Lemeza I–IV (Table 5). Radiocarbon data and the small and large mammals indicate a Late Neopleistocene (Kudashevo time), Early, Middle and Late Holocene age.

A fauna, which probably indicates the final stages of the Last Glacial (Late Neopleistocene) was discovered in the deposits of the Verkhnaya cave. The age of this fauna was determined in accordance with the accompanying large mammal remains. *Lemmus sibiricus* Kerr, *Microrus gregalis* Pallas, *Clethrionomys* ex gr. *glareolus*-*rutilus* and Muridae have been recognized. In Southern Urals the same species were distinguished in the Ignatievskaya fauna (of Kudashevo age). They are known in several caves from the upper reaches of the Sim River (Smirnov et al., 1990).

Fauna from the Lemeza III locality consist of numerous species living in open biotopes such as *Ochotona* sp., *Microtus gregalis* Pallas, *Cricetulus migratorius* Pallas, *Lagurus lagurus* Pallas, *Allactaga major* Kerr and *Dicrostonyx torquatus* Pallas. There are also a small number of forest species. Deposition of the bones in this locality occurred in open steppe landscapes during the Early Holocene interval. Other Early Holocene fauna are known in the Nukatskaya cave (Southern Urals) (Yakovlev et al., 2000). The Early Holocene small mammal associations of Southern Urals have been consolidated in the local Atysh fauna.

A Middle Holocene regional Lemeza fauna is known in the Lemeza II locality. *Microtus gregalis* Pallas, *Lagurus lagurus* Pallas and *Ochotona* sp. were living in the steppe biotope. These species do not live now in the mountain–forest zone of the western slope of the Southern Urals. *Clethrionomys* ex gr. *glareolus*-*rutilus* and *Microtus agrestis* L. inhabited the forest biotope. This species association existed in the forest–steppe landscapes of the Middle Holocene but this period is mainly characterized by the existence of meadow and steppe species.

Small mammal associations from the Lemeza I and IV localities were described in the past as Later Holocene Sim fauna. This fauna is only characterized by modern species which inhabit the mountain-forest zone of the Southern Urals. Bone remains of *Rattus norvegicus* Berkenhout were discovered in the Lemeza I locality. This species only appeared in this area 250 years ago. The Sim fauna is known from caves of the upper reaches of the Sim River (Smirnov et al., 1990).

Table 6
List of species and number of fossil large mammals bone remains

Species	Neopleistocene			Holocene				
	Middle	Late, Tabulda horizon	Late, Kudashevo horizon	Early?	Middle?	Late		
	Verkhnaya (c)	Zapovednaya	Verkhnaya (b)	Lemeza III	Lemeza II	Verkhnaya (a)	Atysh I	Ust-Atysh
Lepus timidus L.					1	4	16	1
Lepus tanaiticus L.		1	1					
Marmota bobak Mull.		5	21					
Canis lupus L.		61						
Vulpes vulpes L.		46		4	9	7	4	
Ursus arctos L.				10		4		
Ursus spelaeus Rosenmüller		15211	3					
Ursus cf. *deningeri hercynicus* Rode	172							
Martes martes L.				4		4	315	
Gulo gulo L.						1		
Mustela eversmanni Lesson		11						
Meles sp.						18		
Lutra lutra L.					15		1	2
Panthera spelaea Goldfuss		9						
Stephanorhinus cf. *kirchbergensis* Jäger	1							
Equus (Equus) sp.		2						
Cervus elaphus L.	3							
Capreolus pygargus Pall.				2		2	107	
Alces alces L.				2		1	43	
Rangifer tarandus L.			2					
Bison priscus Bojanus		3	1					
Total	176	15349	28	22	25	41	486	3

a, b, c—different complexes.

4.7. Large mammals

A total of 16,129 bone remains of large mammals were found in 6 sites (Table 6). Based on the species analyses of the bone remains, the skeleton elements of some species, the degree and character of bone fragmentation, the taphonomy of the site was determined. Most bones of *Ursus spelaeus* and *Ursus arctos* are well-preserved. In these conditions it was established that in every site the bone assemblages accumulated under natural conditions except in the grotto of Atysh. In the sites Verkhnaya, Zapovednaya, and Lemeza III, bear bone accumulation happened as a consequence of animal death in the state of hibernation. Bone assemblages of bobac (*Marmota bobak*), wolf (*Canis lupus*), red fox (*Vulpes vulpes*), pine marten (*Martes martes*), steppe polecat (*Mustela eversmanni*), badger (*Meles* sp.) and otter (*Lutra lutra*) resulted from the death of animals in these caves and grottos. Bones of hares (*Lepus timidus* and *L. tanaiticus*), horse (*Equus caballus*), red deer (*Cervus elaphus*), reindeer (*Rangifer tarandus*), elk (*Alces alces*), roe deer (*Capreolus pygargus*) and bison (*Bison priscus*) were brought by predators. The grotto of Atysh was identified as a site of medieval hunters, and animal bones were considered as remains of their hunts.

The analysis of the species and the correlation of bone remains distinguish three stages in the large fauna development of the Southern Urals. The oldest stage is represented by fauna "c" from the Verkhnaya cave. *Ursus* cf. *deningeri hercynicus* and *Stephanorhinus* cf. *kirchbergensis* date this complex to the Middle Neopleistocene. The deposits of this age are absent in the cave, probably because of their erosion.

Fauna from the Zapovednaya cave with numerous bones *Ursus spelaeus* belongs to the late Mammoth complex. This fauna in according with the radiocarbon dates 28,700 ± 1000, > 37,250, > 46,600 and > 50,200 BP (Table 2) belongs to the Tabulda horizon of the Late Neopleistocene.

Fauna "b" from the Verkhnaya cave is also related to the late Mammoth complex (Kosintsev, 2007). *Ursus spelaeus* bones were radiocarbon dated at 22,750 ± 1210 BP. This fauna can be considered as dating from the Kudashevo horizon (Late Neopleistocene).

The other faunas belong to the Holocene complexes: Lemeza II, Lemeza III, Verkhnaya (a), Atysh I, Ust-Atysh. The Late Holocene Fauna is better characterized in comparison with Early and Middle Holocene faunas due to numerous bone remains from the grotto Atysh.

5. Discussion

Deposits of late Late Neopleistocene (Tabulda and Kudashevo horizons) as well as late Middle–Late Holocene deposits are widespread in this region and form well-developed river terraces and fulfilled caves and grottos in the western slope of Urals. In agreement with the radiocarbon dating and the species determinations, the stratigraphical investigations of the studied sites show two successive formations in the cave and fluvial deposits. They range from the Middle–Late Neopleistocene (Pleistocene) to the Holocene, and can be easily correlated. They also sometimes complement each other (Fig. 10). However several gaps exist in this succession. There are no reliable deposits from the intervals of the Middle Neopleistocene (upper part of the Middle Pleistocene)—the beginning of the Late Neopleistocene (Late Pleistocene), the beginning of the Early Holocene and the beginning of the Middle Holocene. The absence of deposits at these levels can be related to the uplift of the Urals (Puchkov and Danukalova, in press).

Twelve localities with Holocene Amphibians and Reptilians were found in the Russian Plain (Ratnikov, 2002): they show *Bufo bufo* (L.), *B. viridis* Laurenti, *B. calamita* Laurenti, *Rana lessonae* Camerano, *R. ridibunda* Pallas, *R.a arvalis* Nilsson, *R. temporaria* L., *Anguis fragilis* L., *Natrix natrix* L., *N.x tesselata* (Laurenti) and *Vipera berus* (L.). All these localities are located in the modern forest zone. This fauna differs considerably from the South Uralian Holocene fauna. *Bufo viridis* Laurenti, *B. calamita* Laurenti, *Rana lessonae* Camerano, *R. ridibunda* Pallas and *Natrix tesselata* (Laurenti) from the Russian plain characterize the forest-steppe and steppe associations. In the Southern Urals, during Holocene, similar associations were rare—*Bombina* sp., *Triturus cristatus* (Laurenti) and *Lacerta* cf. *agilis* L. Due to taphonomic features, the bone remains of these species were rare. The present Holocene herpetofauna was never established previously in the Ural mountains.

Holocene, and especially Late Pleistocene, small mammal faunas have been investigated in many localities of Western and Central Europe (Chaline, 1972; Sutcliffe and Kowalski, 1976; Nadachowski, 1982; Sala, 1990; Valde-Nowak et al., 2003). These faunas differ from the contemporaneous Eastern European fauna and even more from the Uralian faunas by a significant number of the species which characterized the forest biotopes. In Eastern Europe there are more detailed studies dealing with the Holocene and Late Pleistocene small mammals (Smirnov et al., 1990; Smirnov, 1993). Southern Uralian faunas differ due to the synchronous existence of the steppe and forest species during Holocene and steppe, forest and tundra species during Early Holocene. In these ecological groups, the proportion of the forest species increased to today.

Fauna "c" from the Verkhnaya cave is the most interesting among the studied mammal faunas. It consists of species which are typical of the Middle Pleistocene—*Ursus (Spelearctos) deningeri* von Reichenau, 1904 and *Stephanorhinus* cf. *kirchbergensis* Jäger, 1839 (Sataev, 2006). *Ursus deningeri* belongs to the subspecies *U. (S.)* cf. *d. hercynicus* Rode, 1935 according to the teeth morphotype analysis (Rabeder, 1999). Teeth structure of this bear is most similar to that of the bears from Repolusthöhle in Austria (Rabeder, 1999) and Furtins in

France (Baryshnikov, 2007). The bear from the locality of Repolusthöhle firstly was described as the subspecies *U. (S.) deningeroides* Mottl, 1964 (Mottl, 1964), but it is now proved that it is the synonym of the subspecies *U. (S.) d. hercynicus* Rode, 1935 (Baryshnikov, 2007). The *U. (S.) d. hercynicus* in the Verkhnaya cave is the first find of this subspecies in Urals and the most northeastern find of this species. It is consequently possible to suggest that at different periods of the Middle Pleistocene *U. (S.) deningeri* inhabited the southern part of the Eastern European Plain. Subspecies *U. (S.) d. hercynicus* is the latest subspecies of the *U. (S.) deningeri* which existed at the end of the Middle—beginning of the Late Pleistocene and evolved into *U. (S). spelaeus* Rosenmüller, 1794 (Rabeder et al., 2000; Baryshnikov, 2007). The place of the first appearance of *U. (S). spelaeus* is unknown, but the find of subspecies *U. (S.) d. hercynicus* indicate that the Urals corresponds to a possible region of its first appearance. Cave bear is endemic in the Late Pleistocene large mammal fauna of Europe; as a consequence the mammal fauna of the Southern Urals belongs to the European type of fauna.

Stephanorhinus cf. *kirchbergensis* Jäger, 1839 is represented by a M3 tooth, and characterizes mostly the Middle Pleistocene, although it also inhabited some other regions during the Late Pleistocene (Guérin, 1982; Ziegler, 1995). As a result it is possible to date the fauna "c" from the second part of the Middle—beginning of the Late Neopleistocene (Klimovka?—Kushnarenkovo horizons of the South Uralian scheme) (Dnieper?—Mikulino; Bantega Interstadial?—Eemian periods, MIS 7–5e).

Species composition of the Zapovednaya cave fauna is typical from the Mammoth complex of the Late Neopleistocene of the Urals (Table 6) (Kosintsev, 2003). The largest part of the bone remains belongs to the numerous skeletons of *Ursus (Spelearctos) spelaeus* Rosenmüller (Vorobiev, 2004). This locality is the place of wintering of the cave bears. Localities of this type exist in all mountain regions where cave bear lived (Kurtén, 1976; Rabeder et al., 2000; Germonpre, Sablin, 2001; Kosintsev, Vorobiev, 2001; Baryshnikov, 2007). The species composition of this locality depends on the taphonomic features, it is restricted and only consists of predators (Table 6). The fauna of the Zapovednaya cave, in accordance with the radiocarbon dates (Table 2), belongs to the middle part of the Late Neopleistocene (Saigatka–Tabulda horizons of the South Uralian scheme) (Early–Middle Valdai; Lower–Middle Weichselian periods; MIS 5a–3). The large mammal fauna of the end of the Late Neopleistocene consists of a single species (Table 6).

Data on Holocene large mammal fauna are rare but they reflect a specific composition. The existence of *Capreolus* which is characteristic of the Holocene Urals fauna was absent during the Neopleistocene (Kosintsev, 2003). Siberian *Capreolus pygargus* Pallas, 1771 inhabited the Urals in the Holocene. During the Pleistocene and Holocene, other species *Capreolus capreolus* L., 1758 inhabited Central and Western Europe (Paaver, 1965; Kurtén, 1968; David, 1982; Stuart, 1982;Lepiksaar, 1986; Altuna and Mariezkurrena, 1987; Vörös, 1987; Bon et al., 1991). *Lepus timidus* L. replaced *Lepus tanaiticus* Gureev, and *Alces alces* L., *Ursus arctos* L., *Martes martes* L., *Meles meles* L., *Lutra lutra* L. increased during the Holocene (Table 6). It is possible to assume that the species composition and the distribution of large mammal fauna in Southern Urals from the end of the Middle Pleistocene until the Late Holocene were close to those of the European territory.

Neopleistocene and Holocene land and freshwater molluscs were well investigated in Eastern and Western Europe (Stworzewicz, 1973; Alexandrowicz, 1988, 1989, 1992; Alexandrowicz, 1997; Pakiet, 1999; Svoboda et al., 2000; Valde-Nowak et al., 2003). Malacofauna of the European assemblage is represented by numerous forest and steppe species (around 64 species of land molluscs), European and Alpine-Carpathian species prevail in mollusc complexes. Malacofauna of the Southern Urals is represented by Holarctic forest species (*Vertigo pusilla* Müll., *Vertigo antivertigo* Drap., *Euconulus fulvus* Müll., *Pseudotrichia rubiginosa* A. Schm., *Vallonia costata* Müll., *Nesovitrea hammonis* (Ström) and there was a single finds of xerofile *Chondrula tridens* Müll. The main difference with the European localities is that rare freshwater molluscs (9 species) determined in Uralian cave were transportated by humans and animals.

Palynological investigations of the Late Neopleistocene–Holocene deposits are rare in the mountainous part of Southern Urals. Palynological data show the existence of the forest during the Holocene (Serpievskaya 1 cave) and meadow–steppe associations with small *Picea* forests in the Kudashevo time (the Late Neopleistocene) (Ignatievskaya cave, Serpievskaya 1, 2 cave) (Smirnov et al., 1990). Palynological investigations in the Syrtinskaya cave in the eastern slope of the Southern Urals indicate the predominance of the steppe landscapes during Tabulda interglacial and Kudashevo cold periods of the Late Neopleistocene (Lapteva, 2006a, b). According to the palynological data from the Lemeza river surroundings (as shown in the Bajslan-Tash cave, Yakovlev et al., 2006), forest–steppe existed during the Late Neopleistocene. It was warm during the Tabulda interval and cold during the Kudashevo interval. Mixed forests of *Pinus*, *Betula* with small a quantity of *Picea*, *Ulmus*, *Alnus* and *Tilia* grew during the Early Holocene. Mixed forests with predominance of *Tilia*, *Ulmus* and *Betula* were widespread in some regions the Middle Holocene. Coniferous-broadleaved forests predominated during the Late Holocene.

6. Conclusions

The detailed study of the geological sequences, fauna and flora found in the series of cave and terrace of the Lemeza river valley and the radiocarbon dates provide an age for the alluvial and eluvial-slope deposits. The stratigraphy of the late Late Pleistocene (Neopleistocene) and Holocene transition has been refined. Investigation of the different faunal material has allowed an accurate and complete qualitative and quantitative description of the faunal assemblages (molluscs, amphibians, reptilians, fishes, small and large mammals).

The cave sequence are characterized by mammals of the late Mammoth and Holocene complexes. Species *Ursus (Spelearctos) deningeri hercynicus* and *Stephanorhinus* cf. *kirchbergensis* indicate the existence, in the past the Middle Pleistocene deposits, of erosion of the caves during the uplift of the Urals. The specimen of *U. (S.) d. hercynicus* is the first find of this subspecies in the Urals and the northeasternmost of this species.

The small as well as large mammal fauna allows determination of several biostratigraphical levels in the sediments of the Lemeza river area. The Late Pleistocene (Late Glacial, Kudashevo interval) Early, Middle and Late Holocene levels have been recognized. Southern Uralian small mammal faunas indicate the synchronous existence of steppe and forest species during Middle and Late Holocene, and steppe, forest and tundra species during Late Neopleistocene and Early Holocene. In these ecological groups, the contribution of the forest species increased to the present.

Palynological investigations of the Late Neopleistocene–Holocene deposits show the existence of forest–steppe during the Late Neopleistocene, mixed forests—at the Early and Middle Holocene and coniferous-broadleaved forests—during the Late Holocene. The new data indicated that the Lemeza river area corresponds to a key area for this mountain part of the Southern Urals and confirms the importance of this area for the refinement of the Quaternary stratigraphy at the regional scale.

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