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Emine-Bair-Khosar Cave in the Crimea, a huge bone accumulation of Late Pleistocene fauna

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A R T I C L E I N F O

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A B S T R A C T

The Crimean Mountains are well known from the abundance of Middle and Late Palaeolithic sites and palaeontological remains recovered from cultural layers in caves and rockshelters. The fossil-bearing deposits of Emine-Bair-Khosar Cave, located at the elevation of 1000 m on the Chatyrdag Plateau, yielded a very diverse and numerous vertebrate remains that widen the knowledge of Late Pleistocene faunal diversity in the Crimea. The assemblage comprised in total almost 50 species of vertebrates. Studies included geomorphological, geological and stratigraphic analyses as well AMS ^{14}C dating. Faunal remains were present in ten palaeontological sites. The main bone accumulation (section Ba2) was deposited during Middle Valdai or Vytachiv (MIS 3) interstadial, and including a long time gap, to the end of the Pleistocene and the Holocene. Comparison of the Emine-Bair-Khosar fauna with vertebrate faunas of other Crimean sites showed a remarkable stability in the faunal composition and frequency during the whole MIS 3 interstadial. Steppe and other open-country species dominated in the compared assemblages, while boreal-tundra species were far less numerous. Inhabitants of forests, including red deer and some rodents, were stable members of fossil assemblages.

1. Introduction

The Crimean peninsula, located between Central Europe and the Ponto-Caspian region, always was highly attractive for humans and animals during all phases of the Pleistocene (e.g. Marks and Chabai, 1998; Chabai and Monigal, 1999; Stepanchuk, 2002, 2006; Chabai et al., 2004, 2005, 2006; Prat et al., 2011). Many of palaeontological analyses also stress the importance of the Crimea as a refugial area for temperate species during Pleistocene glaciations in this part of Europe (e.g. Gromov, 1948; Gromov, 1961; Baryshnikov et al., 1990; Benecke, 1999; Markova, 2011; Stankovic et al., 2011). As the Black Sea level had risen considerably during warmer phases of the Middle and Late Pleistocene, the Crimea must have been an island throughout a large part of the interglacials, and perhaps interstadials. When sea level was dozen of meters below present, the peninsula became a part of the East-European Plains (Siddall et al., 2003).

At present, the Crimean peninsula is divided into two very different parts, the flat northern half, largely covered by steppe-vegetation, and the southern, marked by three ranges of hills and mountains, the Crimean Mountains. The Main ridge of the Crimean Mountains, which is about 40–50 km wide and ca. 150 km long, occupies the southern and southeastern part of the peninsula. The most southerly mountain range is a classical karst area of the Mediterranean type, with numerous caves and shafts. For a long time, at least during the Late Cenozoic, they functioned as accumulators of terrigenous sediments and palaeontological materials. This range consists of several flat plateaus (called "Yayla"), developed at altitudes of 800–1500 m and dropping away southwards almost vertically into the Black Sea.

Palaeoenvironmental records in karst sediments are acknowledged as a valid source of palaeogeographical information equally with records in loess, ice cores, and deep sea sediments. The bone accumulation – taphocenosis in cave is direct evidence of both

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fossil and recent zoocenosises. As well, fossil and subfossil faunal remains indicate palaeoclimatic and palaeoenvironmental conditions of an area. Therefore, palaeozoological research is a necessary part of complex karst-speleological exploration of any karst area.

Speleological and palaeontological investigations, carried out in the caves of the Chatyrdag karst-plateau (985–1527 m a.s.l.) of Crimea peninsula since 1999, revealed several trap-caves. At present a dozen bone-bearing caves (most of the accumulations are of Late Pleistocene and Holocene age) were investigated on this high-plateau: Mramornaya, Emine-Bair-Khosar, Emine-Bair-Koba, Krapivnyj, Cherepa, Binbash-Koba, Angar-Koba, AK4, K18, Vjalova, Primula, and Ljubimaja (Vremir and Ridush, 2002, 2005; Ridush and Vremir, 2003; Vremir et al., 2003; Ridush et al., 2010).

The Late Pleistocene bone site in the Emine-Bair-Khosar Cave (EBK) has been known since 1963 (Bachynsky and Dublyansky, 1963). At the end of 1980s, two new bone sites were discovered by A. Kozlov, but only at the beginning of 2000 was the cave recognized as a huge bone accumulation concerned with a mega-trap (Vremir et al., 2003). Several bone-bearing sites were found in various parts of the cave (Vremir and Ridush, 2005). The most informative and well-documented accumulation is represented by the EBK Ba2 site, which was studied by an international and interdisciplinary team between 2006 and 2010. Some preliminary results were published (Ridush and Proskurnyak, 2008), including the first directly dated remains of the cave lion (*Panthera spelaea*) in the Crimean peninsula (Stuart and Lister, 2010). In this article, new data on recent research in the cave during recent years is presented, as well as revision of previously published materials.

2. Geomorphology and geological structure of Chatyrdag Plateau

Emine-Bair-Khosar Cave is situated on the Chatyrdag Plateau, which is a part of the Main Ridge of the Crimean Mountains. It is typical for the Main Ridge that the southern slopes are steep (cliffs) and the northern slopes are gentle with plateaus, named “Yayla”. In Turkish, “Yayla” (Yaila, Jajla) means “summer pasture”, but this term is also used for “mountain treeless plateau” (Murzaev, 1984).

Extending 10 km to the north of the axis line of the Main Ridge, Chatyrdag is divided from the neighboring Babugan and Demerdzi plateaus by two passes: Kebit Bogaz (591 m) at the southwest and Hangar-Bogaz (752 m) at the northeast (Fig. 1). Chatyrdag massif forms a 5 km by 10 km rectangle, with sharp steep slopes except for the northern side. The total area of the massif is approximately 46 km^2.

The Chatyrdag plateau has several terrace-like flat levels, but most of the area is occupied by two levels, the upper and the lower plateaus (Dushevsky and Shutov, 1987). The upper plateau, occupying the southern part of the massif, consists of few levels at altitudes 1300–1500 m a.s.l. Its total area with the adjusting slope is only 10 km^2, and the highest point, the Eklizi-Burun Mt (1527 m) is situated here. A 200–250 m high ledge divides it from the lower plateau.

The lower plateau occupies most of the massif area and is a relatively flat terrace at altitude 950–1100 m a.s.l., which is slightly inclined northwards. In contrast to the upper plateau, there are no sharp watershed chains, residuals and deep dolinas. Most forms are smooth and not large.

Karst rocks on the Chatyrdag are Kimmeridgian-Lusitanian and Tithonian limestone, forming the upper structural level of the massif (Fig. 2). The heterogeneous structure of limestone results in the unequal distribution of surface and underground karst forms. There are mainly structureless limestones with phase transition into thick-bedded and locally into moderately-bedded limestone on the Lower Plateau. The latter forms the central part of the western half of the lower plateau, and almost all of the Upper Plateau. At the eastern part of the lower plateau, thick-bedded limestones dip 15–25° west. At the south, in the area of steep

Fig. 1. Location of Emine-Bair-Khosar Cave on the Chattydag Plateau, Crimea, Ukraine.

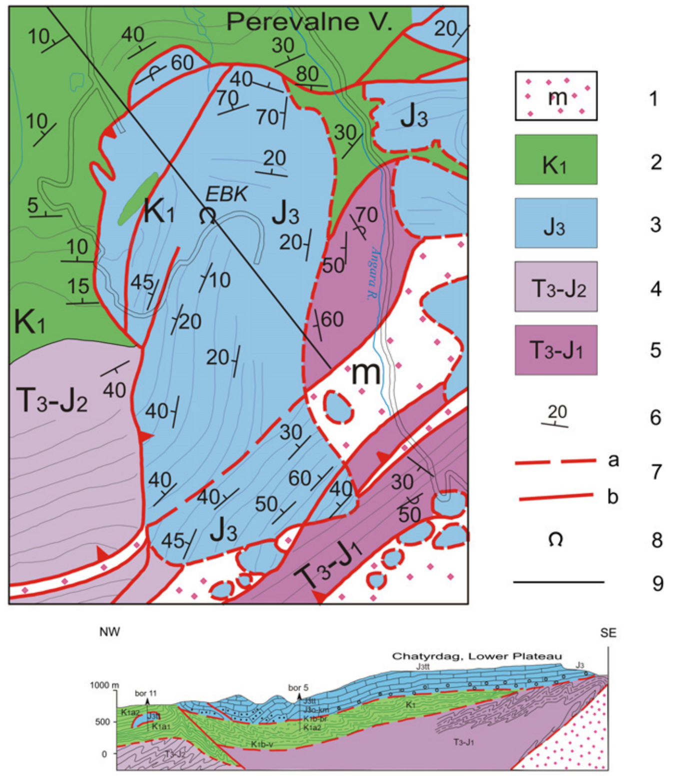

Fig. 2. Geological sketch map of Chatyrdag Plateau (a) and geological sections through the array (b) (Yudin, 2009). 1 – melange (mixed rocks in the largest thrust zones); 2 – conglomerates, limestone, clays (on olistoliths); 3 – limestone bottomed by conglomerates (in olistoliths); 4 – sandstones, siltstones, argillite; 5 – sandstones, siltstones, argillite (flysch of Tavricheska suite); 6 – direction and angle of dip; 7 – fault lines: a – suggested, b – known; 8 – Emine-Bair-Khosar Cave; 9 – line of geological section.

slopes of the upper plateau, the strike of the limestone layers changes to the northwest and the hade rises to 50–60°. Limestones of the northeastern Chatyrdag are red marble-like forms with sockets and veins of white crystalline calcite. Thick-bedded greyish-brown limestones also occur. The thickness of limestone at the southern part of Chatyrdag is up to 1250 m. In the central part, where the roof of the Tavricheskaya series is upraised, the limestone thickness decreases to 250 m, but increases to 750 m northwards (Churinov, 1959).

Traditionally, it was considered that the Upper Jurassic limestones were not displaced, and are underlain by concordant stratigraphical contacts, resting on Middle Jurassic – Triassic units and faulted by subvertical linear breaks. From the point of view of structural mobilization, Crimean karst massifs are residual-klippes of the "Yayla Nappe", pushed from the south. The thrusts and younger Early Cretaceous sediments were recognized in the base of klippes. The autonomous massifs of the Upper Jurassic limestones, including Chatyrdag, are olistoliths of the Mountain-Crimean olistostrome, which moved north during Early Cretaceous. Since the Neogene, they were remobilized by endogenous thrusts and retrothrusts (Yudin, 2001, 2008, 2012). The distance of olistolith sliding is estimated up to 20–30 km (Yudin, 2001). This corresponds with the distance to the paleomagmatogene zone along the modern seashore, which could be a source of postmagmatogene hydrothermal activity.

Thus, the upper part of the massif to a depth of 250–1250 m is composed completely of karst rocks. Most karst processes are displayed in the eastern half of the central part of the lower plateau, which is composed of pure limestone, containing less than 5% of insoluble impurities. Surface karst topography of Chatyrdag has the same characteristics as the karst surface of the Crimean Mountains in general, with widespread development of almost all known varieties of surface karst forms. From size, genesis, and age they can be divided into macroforms (karst-erosion valleys, karst depressions), meso-forms (dolinas, sinkholes), and microforms (ditches and ponors superimposed on the macro- and meso-forms).

There are more than 140 karst caves known on the Chatyrdag (Timokhina, 2007). Most are associated with the lower plateau. Many appear to be parts of an ancient cavity network, divided into fragments by huge flowstone accumulations.

Some caves illustrate different stages of local karst evolution. For example, the vertical shaft "Hod Konem" (Knight's Move), 95 m long and 213 m deep, in the NE part of the lower plateau, contains definite morphological and sedimentary evidence of hydrothermal karstification (Dublyansky, 1990). The other caves contain evidence of quite ancient (pre-Pleistocene?) subterranean streams. In addition, cave river alluvium can be observed on the Lower plateau surface, filling bottoms of so-called "unroofed caves". Previously, the fluvial sands and gravels were considered as surface river alluvium (Dublyansky, 1977; Amelichev, 2002, 2010). In some locations on the base of this alluvium, Pliocene red-coloured palaeosols developed. However, most of the inner cavities demonstrate hypogenic morphology, characteristic for caves of artesian origin (Klimchouk, 2009).

3. Description of Emine-Bair-Khosar Cave

As was established recently, Alexander Kruber, who left the first short description, explored the cave in 1908 for the first time (Kruber, 1915; Timokhina, 2007). The cave was visited by E.M. Janishevsky in 1927, when the first sketch plan and section were drawn (Vasilevsky and Zheltov, 1932). Only the Main Chamber was known at that time. The Caving Party of the Complex Karst Expedition of the Ukrainian Academy of Science (Bachynsky and Dublyansky, 1963; Dublyansky and Lomaev, 1980) made the next scientific description in 1963. At the same time, more detailed mapping of the cave was carried out. The Northern Gallery was discovered and the total known length of the cave was 150 m.

In 1969, Symferopol cavers extended a narrow tube at the bottom part of the Main Chamber and entered the Lower Part of the cave system. More than 10 chambers with a total length nearly 1 km were discovered. The mapping of the cave was carried out by G. Pantjuhin in 1971, and the joint expedition of Symferopol and Czech cavers in 1979 and 1981 (under A. Kozlov). An entrance to the Upper Part, which is situated at 13 m above the bottom of the Main Chamber, was discovered in 1973. The known total length was 1460 m. The Karstological Laboratory of Simferopol University (Timokhina, 2007) executed the last mapping of upper chambers in 1992. The known total length now is 1630 m, and the depth is 125 m. The 13 m deep and 7–8 m wide pit-entrance to the cave is situated on the northern edge of the lower plateau northern slope (982 m a.s.l.), on a watershed between two gorges. All known passages are not oriented towards the closest erosional base level, but southwards inside the mountain massif. This peculiar configuration is related to the initial hydrothermal/hypogenic origin of the cave. From the morphological point of view, large phreatic cavities are developed on two main levels. The upper one consists of large chambers and passages which progressively descend to −50 m. The lower level, interconnected by pits, is sub-horizontal and developed at −125 m.

Karst development on Chatyrdag massif was continuous and multi-staged (Vakhrushev, 2001). One of the earliest stages was probably linked with hydrothermal activity during Late Cretaceous

– Early Miocene (Dublyansky, 1990). It is responsible for the main phreatic-morphological features. A subsequent stage of vadose evolution can be recognized, followed by a second, cold-phreatic stage, which is well expressed by superposed under-pressure phreatic-morphological elements, especially on the flowstones and other speleothems belonging to the early vadose stage. The fourth, latest vadose stage is now developing. The spreading of numerous caves of phreatic morphology, situated in isolation on the edge of the karst-plateau (including Mramornaya Cave) can be explained by fragmentation of a huge ancient 3D maze system. Probably, it was caused by the latest neotectonic movements, which, during the Plio-Pleistocene, were responsible for the heavy uplift of the Crimean mountain range. For most of these stages, direct dating is absent. The most ancient palaeontological evidence was obtained for cave filling (redeposited reddish-brown paleosol) in Ljubimaj Cave (0.5 km from EBK). It is dated to Late Pliocene (MN 16b-17, Khaprovian faunistic complex) (Ridush and Proskurnyak, 2010). The entrance pit (the entrance trap) of the EBK Cave is an ascending channel or cupola of an ancient phreatic system. It was uncovered by general karst denudation at least not later than the Valdai cold stage (sedimentological and palaeontological evidence), but very likely it happened much earlier (sedimentological/micromineralogical analysis in progress).

The Main Chamber of the cave has an elongated elliptical shape (long axis of 118 m, short axis of 26 m) and an inclined floor (the descent from the base of the entrance pit is 30 m). The Chamber is located along the strike of bedded limestone. Morphologically, the Main Chamber is divided by a 9–12 m ledge formed by block-collapse accumulations, in two parts: the upper (rock talus under the entrance pit) and lower. Gravitational deposits of different ages accumulated. The chamber walls are covered with speleothems, which at the top are heavily weathered and corroded. The lower part of the chamber has a weakly inclined floor, covered with limestone boulders and fallen dripstone columns. The left wall, 10–12 m high, is a thick cascade of flowstone, which divides this part of cave from the next Idols' Chamber. The right-hand wall is composed of bedrock limestone. The flowstone calcite selvedge, marking the level of an ancient lake up to 2 m deep, can be seen at the bottom part of the chamber. The Northern Gallery, 50 m long, joins the Main Chamber. In its northernmost part, it comes close to the surface. It is used as the modern artificial entrance for show-cave use, but it was suggested that during Pleistocene a natural entrance, which was used by carnivores, existed here (Bachynsky and Dublyansky, 1963). Later, this entrance was closed by dripstone or other natural processes.

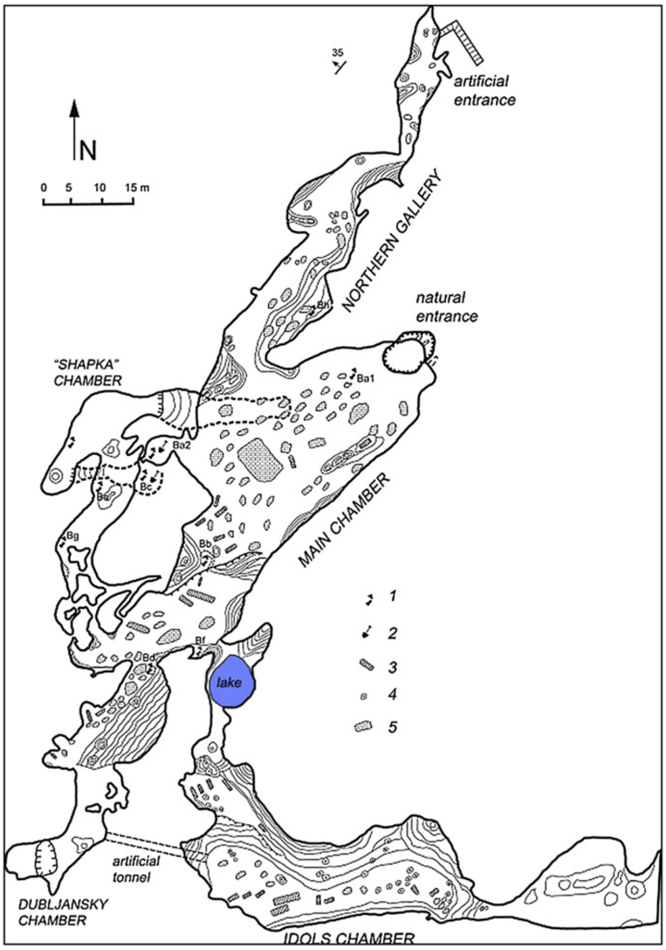

Fig. 3. Plan of the upper part of the Emine-Bair-Khosar Cave. 1 – bone accumulations; 2 – palaeontological sites; 3 – fallen stalagmites and columns; 4 – stalagmites; 5 – separate limestone blocks.

4. Palaeontological sites in Emine-Bair-Khosar Cave

There are a few sites of vertebrate faunal remains accumulation. Not all are equal in size, richness and taphonomy (Fig. 3).

Ba site is associated with the upper part of the talus below the entrance pit. It was divided into two parts: Ba1 and Ba2. The Ba1 is located directly below the pit and is represented only by very recent remains (horse, sheep etc.). Ba2 is situated in a small Museum Chamber, which is the most remote part of the talus cone.

Bb site is situated inside the huge limestone block accumulation, which builds the base of talus cone under the entrance pit. Rock blocks are represented both by the mother bed and by flowstone. No fine clay-loamy filler is present. Probably, it was washed out by water from melted snow, which accumulated on the entrance pit floor. Bone accumulation is represented by bone breccia, cemented by calcite crust, consisting of mixed, disarticulated skeletal elements. Rolling and impact marks on bones are frequent. In some cases, secondary transport inside the cave can be noticed. Rarely, rodent gnawing marks were observed on bone material.

Bc site is located in an ascendant passage and a small room located at the depth of −41 to −37 m, situated below the main talus cone. At present, it is a lower part of Ba2. However, the junction of these two sites was realised only recently (January 2012). The detailed description of the Bc site has been published (Vremir and Ridush, 2005, 2006).

Bd site is situated in the bottom part of the Main Chamber. It is represented by subfossil bats and rodent remains, reflecting the activity of owls.

Be site is located in a horizontal gallery leading from the Main Chamber to "Shapka Monomakha" Chamber ("Skull Chamber" in previous publications). It is divided into two locations. Be1 is located under the right (East) wall, in a small dry flowstone basin. Numerous small bones were partly covered and mixed with calcite crust. Fauna is represented by *Vulpes vulpes*, *Vulpes* (*Alopex*) *lagopus*, *Canis lupus,* and Mustelidae indet. The site is attributed as a small carnivore den. On the left side (West) of this gallery on the floor between fallen blocks, an almost complete saiga skeleton, partly crushed by fallen stones, was found. This place was marked as Be2. Numerous puparia of blow-flies (Sarcophagidae/Callyphoridae, Diptera), associated with the saiga skeleton, were found in loose ground below bones (Vremir and Ridush, 2006). Very likely, the saiga fell into the "Shapka" Chamber at the time when the space between Ba2 and Bc was not closed by sediments. Most probably, it did not die immediately and moved a few meters away from the place of falling.

Bf site, located in the foot of flowstone wall in the Main Chamber, is similar to Bd.

Bg site is situated in the same gallery as Be. Undeterminable bone fragments were collected on the surface of the floor.

Bh site was found in the lowest part of the Northern Gallery. It was recognised from a few crushed long bones and metatarsal/metacarpal saiga bones between coarse cryogenic debris, slightly cemented by calcite crust. It is very likely that this site represents the finds of the 1960s and is associated with large carnivores' dens.

Most of the palaeontological sites are of Late Pleistocene age, except for Ba1, Bd and Bf, which are probably Holocene.

5. Emine-Bair-Khosar Cave, site Ba2

5.1. Stratigraphy

In 2006, B. Ridush began regular excavations of the Ba2 site, which were continued by international and interdisciplinary team in 2008–2010. Deposits at this site are formed by soil/loess material, transported into the cave through the entrance pit, and limestone debris. The cave fill contains many palaeontological remains, and has visible horizontal stratification in the upper part of the section, providing the possibility of obtaining a secular variation record and applying magnetostratigraphic dating. The studied section is currently about 5 m thick. The upper part of the sequence revealed by excavations is composed of nine units (A–I), described here from the top to the bottom (Fig. 4). The floor in Museum Chamber before excavations was covered with a concrete and cement blanket from 0.0 to 0.25 m.

Unit A (0.25–0.75 m) is dark grey, loose, unstructured, light loamy, containing mainly soil material.

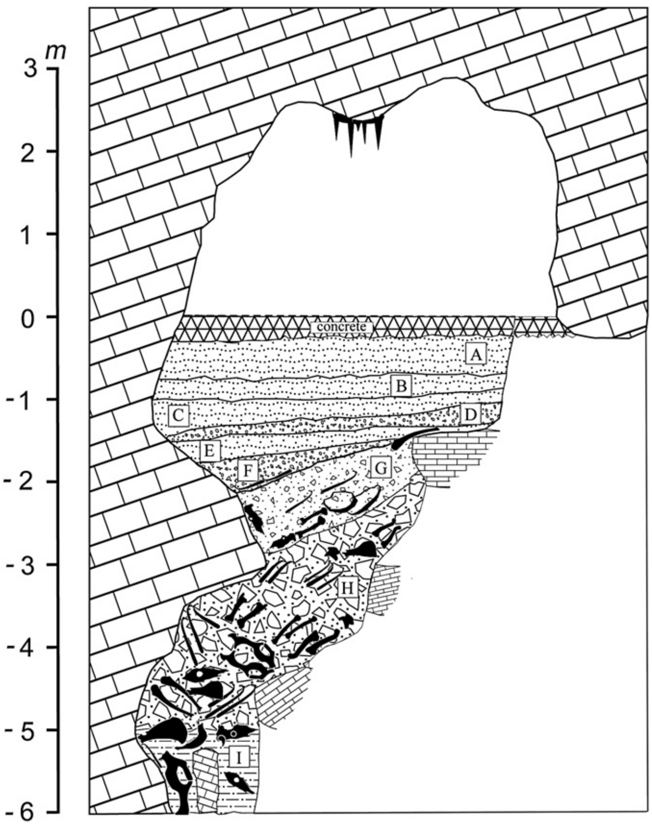

Fig. 4. Emine-Bair-Khosar Cave, cross-section. A, B, C, D, E, F, G, H, and I – stratigraphic units.

Unit B (0.75–1 m), consists of eight brown clayey-debris interbedded layers. The size of limestone particles in debris interlayers increases from 1 to 2 mm in the top to 1 cm at the foot of the layer.

Unit C (1–1.3 m) is light pale-yellow, homogeneous, clayey loam with small contents of debris particles. In the sequence, two detrital units were noted: D (1.3–1.5 m) and F (1.8–2 m), composed of chaotic accumulations of angular limestone debris with diameter up to 5 cm.

Unit E (1.5–1.8 cm) has morphological features similar to layer C.

Unit G (2.0–2.6 m) is greyish-brown wet clays with thin rounded limestone debris interlayers.

Unit H (2.6–5 m) is large limestone blocks and angular debris accumulation with clay fill, gently inclined to the south. Blocks and debris are composed of parent limestone rock and speleothem clasts. The loam fill constitutes 30% of sediment volume. The percentage of rubble on average is 5%, and up to 30% in some interlayers. A loose brown-yellow loam interlayer including abundant land gastropods divides the stratified deposits and parent rock. Probably it filled a gap, which appeared due to the shrinkage of clayey sediments.

Unit I (5.0–6.0 m) is formed of loam with fine limestone debris.

Large bones and skeletons fragments occurred mainly in loose sediments, within 1 m from a wall. In the block accumulation (unit H), mainly single bones and bone fragments were found. In the line from SW to NE the thickness of units A–F decreases. The top of unit H rises up to 1.6 m in the easternmost part of the explored pit.

The upper part of sequence contained mainly small mammal and bird remains. Only one date from saiga bone (10,490 ± 170 BP, cal. 12,341 ± 267 BP), found in unit F, at the depth of 2.0 m, was obtained (Table 1). Therefore, palaeomagnetic examination of the upper part of the section at the depth of 0.5–2.6 m was undertaken. Magnetic properties and palaeosecular variations of the Earth's magnetic field were investigated along the section of horizontally layered non-cemented loamy sediments. From complex interpretation of magnetic, palaeomagnetic, palaeontological and radiocarbon data, the dynamics of paleoclimatic changes on the Chatyrdag plateau during the Holocene – Upper Pleistocene was reconstructed (Bondar and Ridush, 2009, 2010).

There are two horizons of cryogenic crushed limestone (units D, F), formed in Holocene – Late Glacial time. These horizons were thought to originate during minimum temperature periods, which, according to the East-European Plain climatostratography, took place during the late Subboreal (SB3) – unit D, and Younger Dryas (DR3) – unit F. Radiocarbon dating of saiga bone, found in the unit F, do not contradict this assumption. During the warmest periods, humus-bearing material, well diagnosed after magnetic properties, was introduced into the cave. Units A and B correspond to the Subatlantic period with warm and humid climate in the Crimea. Paleomagnetic dating of the top of unit C attributes it to the relative cool late Subboreal, which was preceded by a warmer period, SB1+2. The maximum magnetization of unit C is observed in its lower part. Unit E was formed, probably during early and middle Holocene in Preboreal (PB), Boreal (BO) and Atlantic (AT), under a temperate climate. The top of unit G was deposited during the cold period, which was preceded by a warm one, recorded as the increased magnetic performance in the base of this layer. Layers F + G may correspond to the early stages of MIS 1 (Bølling/Allerød – Younger Dryas events?). The rate of loamy material accumulation was relatively low during the Late Pleistocene – Early/Middle Holocene, increasing slightly in late Holocene. Thus, the magnetic horizons A, B, C and G correspond to the lower part of a period of relative warming, debris (D, F) correspond to cold, and weak-magnetic ones (E, top of G) to transition periods for Chatyrdag plateau and the surrounding area (Bondar and Ridush, 2009, 2010).

Table 1
Results of C-14 dating of mammalian bones from Emine-Bair-Khosar Cave, site Ba2. Dates have been calibrated useing CalPal program (Weninger et al., 2008). Mt – metatarsus.

Sample	C^{14} age	Calibrated age	Unit	Depth (m)	Species	Material dated
Ki-13063	10,490 ± 170 BP	12,341 ± 267 BP	F	2.0	*Saiga tatarica*	Rib fragment
Poz-28732	12,050 ± 60 BP	14,054 ± 231 BP	G	1.65	*Cervus elaphus*	Left tibia shaft
Poz-28889	33,500 ± 400 BP	38,791 ± 1526 BP	H	2.9	*Cervus elaphus*	Tibia shaft
Poz-35027	42,000 ± 1200 BP	45,641 ± 1334 BP	H	3.2	*Cervus elaphus*	Left M_1
Poz-28893	48,500 ± 2000 BP	53,020 ± 3262 BP	H	4.6	*Saiga tatarica*	Rib fragment
Poz-28731	>46,000 BP		H	4.7	*Cervus elaphus*	Left Mt shaft
Poz-35026	>47,000 BP		H	4.6	*Cervus elaphus*	Left Mt shaft

Radiocarbon dates obtained for units G and H can be attributed to the end of the Bug stadial (Gerasimenko, 2007) or MIS 2 (the *Cervus elaphus* bone at the top of layer G was dated to 12,050 ± 60 BP) and various parts of Vytachiv (MIS 3) interstadial (Gerasimenko, 2007). The dates range from 33,100 ± 400 BP for the sample at the boundary between units G/H to >47,000 BP at the lower part of unit H (Table 1). At present, there is a time gap for almost the whole Upper Pleniglacial (MIS 2), the coldest period of the last glaciation. The G layer, being comparatively poor in bone remains and containing mainly redeposited bones, is less than 1 m thick and cannot represent more than 20,000 years of sedimentation history. It is assumed that during the cold Upper Pleniglacial (MIS 2), sediment and bone accumulation was almost stopped and renewed only when deglaciation started. Such an interruption could be caused by a snow-ice plug, which most likely formed in the entrance pit of the cave with the beginning of the cold phase. This assumption is also confirmed by the absence of reindeer (*Rangifer tarandus*) in the faunal list of the EBK Ba2 site, although it was quite abundant during MIS 2 in the foothills of the Crimean Mountains (e.g. Benecke, 1999; Burke, 1999a).

5.2. Fauna

Bone remains belonging probably to almost 50 species of mammals were found in Emine-Bair-Khosar Cave, site Ba2. The studied material contained numerous bones of reptiles. Bird remains were also present (Table 2). Abundant bird material will be presented in another publication.

For study of Ba2, the archaeological method was applied, with 3D location of each find on level-to-level plans. Since 2008, complete screening was done on all excavated loose deposits. They yielded rich remains of amphibians, reptiles, birds, rodents and other small vertebrates.

Among the recorded mammals, six taxa were represented by extinct species (*Mammuthus primigenius*, *Equus ferus latipes*, *Equus hydruntinus*, *Coelodonta antiquitatis*, *Bison priscus* and perhaps *Megaloceros* sp.). Most were associated with open areas and inhabited various steppes developed in cool or temperate climate as well as forest-steppe. In rare cases, these forms (*B. priscus*) could also occur in boreal forests.

Another group was composed of species, which do not occur in the Crimea at present, and included 12 taxa. Most were species associated with various kinds of steppe areas (*Ochotona pusilla*, *Marmota bobak*, *Eolagurus luteus*, *Lagurus lagurus*, *Microtus gregalis*, *Vulpes corsac*, *Saiga tatarica*). Another group included forms inhabiting various habitats, with such species as *Microtus agrestis*, *Microtus oeconomus* and *Mustela erminea*. A small group was composed of species that are extant at present mainly in tundra areas (e.g. *Vulpes* (*Alopex*) *lagopus*). Forest-associated species (*Lynx lynx*) were equally few.

The last group included mammals, which occurred in the Crimea both in the past and at present. The group was dominated by species of wide ecological tolerance (*Arvicola amphibius*, *Microtus arvalis obscurus*, *Lepus europaeus*, *Canis lupus*, *V. vulpes*, *Mustela*

Table 2
Qualitative composition of vertebrate remains in the deposits of Emine-Bair-Khosar Cave, site Ba2. Original determinations of P. Socha, K. Stefaniak and A. Marciszak. † – extinct species; ? - probably redeposited remains.

Taxon/Species	Unit								
	A	B	C	D	E	F	G	H	I
Aves indet.	●	●	●	●	●	●	●	●	●
Pyrrhocorax graculus (Linnaeus, 1766)		●	●	●	●	●	●	●	●
Soricomorpha	●	●			●	●	●	●	
Chiroptera	●	●						●	
Marmota bobac (Müller, 1776)								●	
Spermophilus sp.							●	●	
Allactaga major (Kerr, 1792)								●	
Sicista subtilis (Pallas, 1773)							●	●	
Arvicola amphibius (Linnaeus, 1758)							●	●	
Ellobius talpinus (Pallas, 1770)							●	●	
Eolagurus luteus (Eversmann, 1840)					●	●		●	
Lagurus lagurus (Pallas, 1773)					●	●	●	●	
Microtus cf. *agrestis* (Linnaeus, 1761)	●	●			●	●	●	●	
Microtus arvalis obscurus (Eversmann, 1841)	●	●			●	●	●	●	
Microtus cf. *gregalis* (Pallas, 1779)								●	
Microtus cf. *oeconomus* (Pallas, 1776)								●	
Cricetulus migratorius (Pallas, 1773)								●	
Cricetus cricetus (Linnaeus, 1758)					●	●		●	
Apodemus cf. *flavicollis* (Melchior, 1834)	●	●					●	●	
Ochotona pusilla (Pallas, 1769)							●	●	
Lepus europaeus Pallas, 1778		●		●	●	●	●	●	●
Felis sp.		●						●	
Lynx cf. *lynx* (Linnaeus, 1758)							●		
Vulpes corsac (Linnaeus, 1768)				●				●	
Vulpes (*Alopex*) *lagopus* (Linnaeus, 1758)								●	
Vulpes vulpes (Linnaeus, 1758)								●	
Vulpes sp.							●		
Martes sp.								●	
Mustela sp. (*putorius* group)								●	
Mustela erminea Linnaeus, 1758									
Mustela eversmanii Lesson, 1872				●				●	
Mustela nivalis Linnaeus, 1766								●	
Mustelidae indet.									●
Carnivora indet.					●			●	
Mammuthus primigenius (Blumenbach, 1799)							†	†	†
Equus ferus latipes (Gromova, 1949)								†	†
Equus hydruntinus Regalia, 1907								†	†
Equus sp.							●		
Coelodonta antiquitatis (Blumenbach, 1807)				?				†	†
Rhinicerotidae indet.								†	
Perissodactyla indet.								●	
Cervus elaphus Linnaeus, 1758				●			●	●	●
Cervus sp. or *Megaloceros* sp.							●	●	
Saiga tatarica (Linnaeus, 1766)					●	●	●	●	●
Bison priscus Bojanus, 1827					†		†	†	†
Bison sp. or *Bos* sp.						●			
Capra sp.							?		
Bovidae indet.								●	
Artiodactyla indet.					●		●		
Ungulata indet.									●

nivalis). Another subset was composed of species, which prefer open habitats, mainly steppes, but also semi-deserts and deserts (*Mustela eversmanii*, *Allactaga major*, *Ellobius talpinus*, *Cricetus cricetus* and *Cricetulus migratorius*, *Sicista subtilis*). Only two species (*Apodemus flavicollis* and *C. elaphus*) are typical representatives of forest fauna in this set.

The remains come from nine units of different thickness, geological structure, time of deposition, and composition of vertebrate fauna. The analysis of species composition of the bone remains from the individual distinguished units showed quantitative and qualitative differences among the described faunal assemblages. The oldest series is formed of units I, H and G. Their accumulation is associated with MIS 3, most probably with older part of this stage (Table 1).

Unit I contained few mammal and bird remains. Small mammals included hare. Carnivores were represented by unidentified mustelids. Large herbivores dominated in the assemblage. They were most abundantly represented by artiodactyls, with the steppe bison (*B. priscus*) dominant. Remains of the red deer (*C. elaphus*) and saiga (*S. tatarica*) were also numerous. Perissodactyla included a large horse (*Equus ferus latipes*) and ass (*Equus hydruntinus)*. Remains of the mammoth (*M. primigenius*) and woolly rhinoceros (*C. antiquitatis*) were very few. Most of the forms recorded from unit I represented extinct representatives of the Pleistocene megafauna associated with extant species inhabiting open areas of a steppe or steppe-tundra character. Only the red deer remains indicate the presence of wooded areas during the deposition of the unit.

According to the geological data, and the radiocarbon dating (Table 1), deposition of unit H took place during the MIS 3 or Vytachiv interstadial, of Valdai (Weichselian) glaciation. This unit yielded the most abundant and the most diverse faunal assemblage in the whole profile of Ba2 site. The small mammals included representatives of Insectivora, Chiroptera, Rodentia and Lagomorpha. Within this group, rodents were the most abundantly represented, with the dominance of arvicolids (*Arvicola*, *Ellobius*, *Eolagurus*, *Lagurus*, *Microtus*). As well, the unit contained remains of sciurids (*Spermophilus* and *Marmota*), dipodids (*Sicista* and *Allactaga*), cricetids (*Cricetulus* and *Cricetus*) and murids (*Apodemus*). The common vole (*Microtus arvalis obscurus*) dominated among the small mammals. The lagomorphs were represented by members of Leporidae (*Lepus*) and Ochotonidae (*Ochotona*). The carnivores included an unidentified representative of the genus *Felis*, and three members of *Vulpes*. Most of the carnivores were representatives of the family Mustelidae (*Martes* and *Mustela*). Remains of the red deer (*C. elaphus*) dominated among the ungulate remains. The steppe bison (*B. priscus*) and saiga (*S. tatarica*) were also numerous. Probable remains of the giant deer (*Megaloceros* sp.) and unidentified representatives of bovids were found among the Artiodactyla. Perissodactyla were represented mainly by two horse species: the large horse (*Equus ferus latipes*) and ass (*E. hydruntinus*) (Van Asperen et al., 2012). Rhinoceroses were represented by two forms: woolly rhinoceros (*C. antiquitatis*) and another, undetermined member of Rhinocerotidae. Mammoth (*M. primigenius*) remains were few. Birds were represented by numerous remains of rock dove (*Columba livia*), which still inhabits karst cave entrances in the Crimea, and of the Alpine chough (*Pyrrhocorax graculus*), a large corvid, not occurring in the Crimea today, and by unidentified bird remains.

Open-country forms dominated among the small mammals. They represented forms which at present inhabit dry steppes, semi-deserts or deserts (*Marmota bobac*, *Spermophilus* sp., *A. major*, *S. subtilis*, *E. talpinus*, *E. luteus*, *L. lagurus*, *Microtus* cf. *gregalis*, *C. migratorius*, *C. cricetus*, *O. pusilla*) or open areas (*Microtus arvalis obscurus*, *A. amphibius*, *M. oeconomus*, *L. europaeus*). Among these forms, numerous group consists of species which do not occur in the Crimea today (*O. pusilla*, *M. bobak*, *E. luteus*, *L. lagurus*, *Microtus* cf. *gregalis*, *M. oeconomus*). Only the members of the genus *Apodemus* may indicate the presence of wooded areas. Based on the small mammal remains, steppe was the dominant landscape in the environs of Emine-Bair-Khosar Cave during the deposition of this unit. The hypothesis is supported also by the occurrence of *V. corsac*, *M. eversmanii* and *M. primigenius*, *Equus ferus latipes*, *E. hydruntinus*, *C. antiquitatis*, *B. priscus*, of the extinct Pleistocene megafauna, as well as saiga. The co-occurrence of the red deer *C. elaphus* and members of the genus *Apodemus* with the above-mentioned forms indicates the presence of wooded areas in the cave environs.

Unit G showed a smaller species diversity compared to unit H. As in unit H, representatives of voles, with the dominant common vole (*Microtus arvalis obscurus*) prevailed in the assemblage. *E. luteus* was not found among the voles in the deposits of the discussed unit. As well, the genera *Spermophilus*, *Sicista* and *Apodemus* were represented among the rodents. The lagomorphs included members of two genera (*Lepus* and *Ochotona*). Insectivores were few. A distinct impoverishment was observed, compared to the earlier strata with respect to the carnivores. Only remains of the lynx (*L. lynx*) and an unidentified fox (*Vulpes* sp.) were found in unit G. Remains of the red deer and saiga dominated among the ungulates. Among the deer remains, one bone fragment probably represented the giant deer (*Megaloceros giganteus*) or a large form of red deer. Remains of the steppe bison and an unidentified member of the genus *Capra* were few. Perissodactyla were represented by an unidentified horse and the woolly rhinoceros. Mammoth remains were very few and probably were redeposited.

The vertebrate species composition, similar to though poorer than that from unit H, indicates that the dominant landscape type during the deposition of unit G was open-country with a small admixture of woodland. In addition, this unit contained forms which at present are not represented in the Crimean fauna (*L. lagurus*, *O. pusilla*, *S. tatarica*) and extinct representatives of the Pleistocene megafauna (*B. priscus*, *C. antiquitatis*, *M. primigenius*). Rare remains of birds are under determination.

A distinct decrease in the vertebrate species diversity was observed in layer F. Rodents were represented by voles (*E. luteus*, *L. lagurus*, *Microtus* cf. *agrestis* and *Microtus arvalis obscurus*) and the European hamster (*C. cricetus*). The deposit contained remains of insectivores and members of the genus *Lepus*. The remaining vertebrates were represented by saiga, *Bison, Bos*, and unidentified birds. At the bottom of this unit, scanty saiga remains with carnivore gnawing marks were found. Open-country forms dominated distinctly among the small mammals. The dominant species in the group was the common vole *Microtus arvalis obscurus*, which occurs in the Crimea at present. Typical steppe species were found, both extinct in the Crimea today (*L. lagurus* and *E. luteus*) and present in the extant fauna (*C. cricetus*).

The vertebrate assemblage of unit E was similar to that described from unit F. The comparison of species composition indicates that during the deposition of unit E, the dominant landscape type in the environs of the cave was an open dry steppe. This is indicated by the presence of species which are now absent from the Crimean fauna: *L. lagurus* and *E. luteus*; at present they inhabit dry steppe, semi-desert or desert areas in the continental climatic zone. The dominance of steppe in the discussed time span is supported also by the occurrence of remains of the European hamster and the common vole.

Unit D contained only seven mammalian taxa. Among them, remains of an unidentified hare were the most numerous. Remains of the corsak fox and red deer were few. The dominance of steppe habitats in the environs of the cave is indicated by the presence of such species as *V. corsac* which are absent from the contemporary fauna of the Crimea, and also by *M. eversmanii*, a species which is present in the Crimea today.

Units C and B were found to contain few mammalian remains representing birds, insectivores, bats, rodents, lagomorphs and carnivores. Most of the taxa are extant today and living in varied plant communities, ranging from open areas to temperate forests.

The few vertebrate remains found in the deposits of unit A included mainly mammals representing Soricomorpha, Chiroptera and Rodentia. The bone material contained remains of unidentified birds. Based on the analysis of species composition, the fauna from layer A is mainly composed of components of the extant fauna of the Crimea (e.g. *Microtus arvalis obscurus*, *A. flavicollis*). A comparison of habitat preferences of the mammals from this unit indicates co-occurrence of various open habitats and temperate forests during the deposition of this layer.

The mammal assemblages from units H and G are very similar (Table 2). At the same time, the radiocarbon dating (Table 1) indicates a heterogeneous character of unit G. The lower part of the unit G should be referred to the late Vytachiv or Bryansk interphase (late MIS 3), and the upper part most probably corresponds to the end of the Valdai glaciation (Bug Stadial or Late Glacial) or the boundary between last glaciation and the Holocene. In spite of these differences, both large and small mammal assemblages indicate a prevalence of open areas, with the presence of some wooded habitats. Units F and E can be correlated with the upper levels of unit G. Their mammal assemblages show a great similarity indicating the dominance of open areas in the environs of the cave during their deposition.

A distinct change of the mammal species composition is observed only in units D, C, B and A. Among the small mammals, strictly steppe forms disappear completely (boundary between units E and D) and the extinct woolly rhinoceros found in unit D is probably a contamination from older layers. Only representatives of the recent Crimean fauna are observed among the small mammals in units D to A. This indicates that the deposition of units C, B and A took place during the Holocene.

6. Discussion

Faunal assemblages from the south Crimea studied in detail by R. Benecke, A. Burke, A. Markova, M. Patou-Mathis, S. C. Péan and others concern collections from the Middle and Upper Palaeolithic as well as Mesolithic archaeological sites in caves and rock-shelters. They are mostly located in the internal range of the mountainous zone at elevations from 200 to 700 m (for details see Marks and Chabai, 1998; Benecke, 1999; Chabai and Monigal, 1999; Chabai et al., 2004, 2005, 2006; Markova, 2011; Prat et al., 2011). In contrast, fossil vertebrate remains studied in this paper represent assemblages characteristic of higher elevations (ca. 1000 m) and sites without any traces of human occupation and artificial prey selection. This also explains some differences observed in the quantitative and qualitative composition of the faunal remains between both types of localities.

The paper presents preliminary results of the studies on fossil vertebrates, from the deposits of the profile Ba2 in Emine-Bair-Khosar Cave. Earlier studies on the deposits of this cave included sites Bb, Bc and Be (Table 3). The results of those studies were presented in Vremir and Ridush (2002, 2005), Ridush and Vremir (2008) and Ridush and Proskurnyak (2008). However, the assemblage from profile Ba2 shows the greatest taxonomic diversity in comparison with other EBK sites. It is noteworthy that the presence of some mammalian taxa described from other sites was not confirmed in profile Ba2 and, on the other hand, some new species appeared in the faunal list. The taxa not found in profile Ba2 included, among others, *Clethrionomys glareolus*, *Lepus timidus*, *P. spelaea*, *Equus hemionus*, *Capreolus capreolus* and *R. tarandus*. At the same time, the forms recorded for the first time in the site and associated with steppe habitats, include *L. lagurus*, *E. luteus*, *E. talpinus*, *Microtus* cf. *gregalis*, *C. migratorius*, *C. cricetus* and *O. pusilla*. The results of dating of the bone remains from unit H (Table 1) indicate that the deposition took place within the Middle Valdai

Table 3
Qualitative composition of mammalian remains in particular sites (Ba2, Bb, Bc and Be) of Emine-Bair-Khosar Cave (after Vremir and Ridush, 2002, 2005; Ridush and Vremir, 2008; Ridush and Proskurnyak, 2008, changed and suplemented); ? - probably redeposited remains.

Taxa/Species	Sites			
	Ba2	Bb	Bc	Be
Soricomorpha	●			
Chiroptera	●		●	●
Marmota bobac (Müller, 1776)	●			
Spermophilus sp.	●			
Allactaga major (Kerr, 1792)	●			
Allactaga sp.			●	
Sicista subtilis (Pallas, 1773)	●			
Arvicola amphibius (Linnaeus, 1758)	●			
Arvicola sp.			●	
Ellobius talpinus (Pallas, 1770)	●			
Eolagurus luteus (Eversmann, 1840)	●			
Lagurus lagurus (Pallas, 1773)	●			
Microtus cf. *agrestis* (Linnaeus, 1761)	●			
Microtus arvalis obscurus (Eversmann, 1841)	●		●	
Microtus arvalis/levis			●	
Microtus cf. *gregalis* (Pallas, 1779)	●			
Microtus cf. *oeconomus* (Pallas, 1776)	●			
Clethrionomys glareolus (Schreber, 1780)			●	
Cricetulus migratorius (Pallas, 1773)	●			
Cricetus cricetus (Linnaeus, 1758)	●			
Apodemus cf. *flavicollis* (Melchior, 1834)	●		●	
Rodentia indet.		●		
Ochotona pusilla (Pallas, 1769)	●			
Lepus europaeus Pallas, 1778	●	●		
Lepus europaeus ponticus (Ognev, 1929)			●	
Lepus timidus Linnaeus, 1758			●	
Felis sp.	●			
Lynx cf. *lynx* (Linnaeus, 1758)	●			
Panthera spelaea (Goldfuss, 1823)			●	
Ursus cf. *spelaeus* Rosenmüller, 1794		●		
Canis lupus Linnaeus, 1758			●	●
Canis sp.		●		
Vulpes corsac (Linnaeus, 1768)	●	●	●	
Vulpes (*Alopex*) *lagopus* (Linnaeus, 1758)	●			●
Vulpes vulpes (Linnaeus, 1758)	●			●
Vulpes sp.	●			
Martes sp.	●			●
Mustela sp. (*putorius* group)	●			
Mustela erminea Linnaeus, 1758	●			
Mustela eversmanii Lesson, 1872	●	●	●	
Mustela nivalis Linnaeus, 1766	●			
Mustelidae indet.	●			
Carnivora indet.	●			
Mammuthus primigenius (Blumenbach, 1799)	●	●	●	
Equus ferus latipes (Gromova, 1949)	●	●		
Equus hydruntinus Regalia, 1907	●	●	●	
Coelodonta antiquitatis (Blumenbach, 1807)	●	●	●	
Rhinocerotidae indet.	●	●		
Perissodactyla indet.	●			
Capreolus capreolus (Linnaeus, 1768)		●		
Rangifer tarandus (Linnaeus, 1768)			?	
Cervus elaphus Linnaeus, 1758	●	●	●	●
Cervus sp. or *Megaloceros* sp.	●			
Saiga tatarica (Linnaeus, 1766)	●	●	●	●
Sus scrofa Linnaeus, 1758		●		
Bison priscus Bojanus, 1827	●	●	●	
Bison sp. or *Bos* sp.	●			
Bos sp.			●	
Capra sp.	?	?	?	
Bovidae indet.	●			
Artiodactyla indet.	●			
Ungulata indet.	●			

(MIS 3) or Vytachiv Interstadial, most probably from the Hengelo interphase to the Bryansk (= Denekamp) interphase of the last glaciation. The results of the analysis of species composition of both large and small mammals from unit H reveal a high similarity with the data presented by Burke (1999a,b, 2004), Patou-Mathis (1999, 2004a,b, 2005), Markova (1999, 2011) and Prat et al. (2011) on the fossil mammal faunas from Palaeolithic sites in the Crimea dated to MIS 3. Large mammal fauna at archaeological sites during MIS 3 show a remarkable stability in the presence and absence of species, as well as their frequencies. In general, all sites exhibit a very pronounced domination towards steppe species. Among these, equids and saiga dominate while bovids and mammoth are less numerous. However, there occur some differences between sites at lower elevations in comparison with EBK assemblages. This applies to red deer (*C. elaphus*), a forest dweller, very common in EBK fauna and rare in all archaeological sites as well as the presence of some steppe species, e.g. the pika (*O. pusilla*).

According to Burke (1999a, 1999b, 2004), Patou-Mathis (1999, 2004a,b, 2005), Markova (1999, 2011) and Prat et al. (2011), mammal faunas from the sites dated to ca. 64–24 ka BP can be divided into several horizons. The oldest horizon, including sites Chokurcha I (cultural layer IV), Starosele (horizons 3 and 4), comes from the first half of the Middle Valdai or Vytachiv Interstadial (MIS 3). Species of open steppe areas were widespread in that period, represented for example by rodent species *C. migratorius*, *E. talpinus* and *L. lagurus*. *Microtus arvalis obscurus* was a constant component of the faunas of that period, and was the dominant species. At the same time, both the small and large mammals did not include representatives of forest fauna (except red deer). The faunas from sites Kabazi V (III/5, III/4), Starosele 1 and 2, Karabi Tamchin III, represent the next stage. Based on radiocarbon dating, the sites are correlated with the Hengelo interphase. Besides the dominant steppe forms, representatives of forest fauna (*A. flavicollis*, *Sorex araneus*) appear in these sites. Faunas from the sites Kabazi V (III/3, III/2) and Buran Kaya III (C) are associated with the cold phase, which followed the Hengelo interphase. The deposits of these sites show dominance of steppe forms with constant presence of forest-associated species. Only steppe forms were found in Buran Kaya III, C. The faunas from Syuren I (Fb2, Ga, Gb1), Buran Kaya III (B), Kabazi V (III/1-III/1A, II/4A-II/7) Karabi Tamchin II/2 are associated with the upper Vitachiv or Bryansk (= Denekamp) interphase, the end of MIS 3 interstadial. The large and small mammal faunas from these sites are dominated by species of open areas and steppes, with constant presence of forest-dwelling species.

Faunal assemblages of upper part of EBK Ba2 site: units F, E, and D, which probably should be correlated with Bug stadial (late Pleniglacial, MIS 2) (Gerasimenko, 2007) have no analogues in the faunistic assemblages of Chokurcha I, Starosele 1 and 2, Karabi Tamachin, Kabazi V and Suiren I. The Holocene assemblages represented by extant fauna of units C, B, and A are similar to assemblages described from several Mesolithic and Neolithic sites in Crimea (Benecke, 1999).

7. Conclusions

Deposits of Emine-Bair-Khosar Cave, excavated between 2006 and 2010, yielded diverse and abundant vertebrate fauna (more than 50 taxa in total), especially in the Ba2 site. The locality provides evidence for faunal changes in MIS 3 (Vytachiv interglacial) of the last glaciation (units H and lower part of G) and after a long gap lasting ca. 20 ky (MIS 2, Bug stadial), for the Late Glacial (sediments from the upper part of unit G, F) and the Holocene (units E–A). The local chronostratigraphical synthesis is based on radiometric chronology and faunal studies. During MIS 3, the Crimean fauna at higher elevations was more or less stable up to the end of Late Glacial (unit F?). The most specific feature of MIS 3 and Late Glacial fauna assemblages is the dominance of remains of steppe or open-country species. The majority of the typically steppe mammals (e.g. *C. cricetus*, *L. lagurus*, *E. luteus* and *B. priscus*) appeared in unit E for the last time, and only *S. tatarica* is still found in the Holocene units. However, boreal species were also well represented. The common vole (*Microtus arvalis obscurus*) and the red deer (*C. elaphus)* were dominant mammal species in every unit. Typical Holocene units C, B, and A contained similar faunal assemblages, including exclusively species occurring at present in the Crimean peninsula.

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