Brief report

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The first finding of *Mimomys* in the Russian Far East

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A new species of the *Mimomys* is described from the Far East Russia (the Medvezhyi Klyk cave, Sikhote-Alin). Layer 7 of the Medvezhyi Klyk cave (1.08–1.18 m) was dated to be 13 790–14 200 BP. *Mimomys chandolensis* sp. nov. was found in a deeper layer (2.63–2.68 m) and therefore assuming there was no redeposition of the remains and that the accumulation proceeded gradually, the molar specimen we found is 30–50 kyr old. Due to the extent of the preservation we observed in the molar and the structure of the cave, the specimen does not seem likely to have been redeposited. Our hypothesis is that due to the warm and wet climate of the region, the vole, which became extinct more than 600 kyr ago, had been extant there by the Late Pleistocene period. The new species is hypsodont, with a few cement, a lack of enamel isle or prismatic fold; tangential and lamellar layers of enamel ultrastructure are poorly expressed.

Introduction

The genus *Mimomys* Forsyth-Major, 1902 includes voles with rooted molars that possess cement in the re-entrant angles of the teeth. This genus emerged in the Palearctic zone during the Pliocene period and eventually spread to the Nearctic regions. In both of these biogeographic regions the juvenile odontologic traits were preserved, with the roots forming later and the teeth becoming more hypsodont. All of the Recent subtribes and genera of the tribe Arvicolini (Kretzoi 1954) have emerged independently from different representatives of the genus *Mimomys*, and Arvicolini (Gray, 1821) have passed in parallel through the *Allophaiomys* organizational level (Martin and Tesakov 1998; Golenishchev and Malikov 2006). Presently it is difficult to recognize which specific lineage of the genus *Mimomys* led to the development of the Recent Arvicolini tribe groups. While the developmental lines of Palaearctic *Mimomys* that led to the Recent genera *Microtus* Schrank, 1798 and *Terricola* Fatio, 1867 are recognizable, the data on the *Mimomys* that are ancestral to the Far East voles of the genus *Alexandromys* Ognev, 1914 are fragmentary. The fossil record of *Mimomys* is known from Transbaikalia (Buryatia) and China (Erbaeva 1973; Bazarov et al. 1976; Bazarov 1986; Zheng and Li 1986; Alexeeva and Erbajeva 2005; Erbajeva et al. 2006; Zhang et al. 2008; Kawamura and Zhang 2009) (Fig. 1).

The fossil remains of mammals in the South Far East have been found mainly in caves and archaeological sites. The abundant remains of small mammals were discovered in the Holocene and Late Pleistocene deposits of the Bliznets Cave, which is known as the richest paleontological site of its type in the south of the Russian Far East (Tiunov 1976; Alexeeva 1986; Alexeeva and Golenishchev 1986; Tiunov et al. 1992; Alexeeva 2007). The other site that is of equal interest is the Medvezhyi Klyk cave (Tiunov and Panasenko 2007), where tens of thousands of amphibian, reptilian, avian and mammalian fossil remains were collected between 2005 and 2009 (Panasenko and Tiunov 2010; Tiunov and Panasenko 2010) including a single tooth of *Mimomys* that is a subject of this paper.

Institutional abbreviations.—GIN, Geological Institute, Russian Academy of Sciences, Moscow, Russia; ZIN, Zoological Institute, Russian Academy of Sciences, Saint Petersburg, Russia.

Other abbreviations.—ASD, anterosinuid; HSLD, hyposinulid; L, length; Lant, anteroconid length; Lbas, basal length; OIS, Oxygen Isotope Stages (= MIS, Marine Isotope Stage); R, radial enamel; SDQ, Schmelzband-Differenzierungs-Quotient (= enamel differentiation index); W, width; Want, anteroconid width.

Geological setting

The Medvezhyi Klyk cave is situated in the Lozovyi Mountain Chain at a height of 465 m above sea level (43°01'43" N, 133°01'23" E), which is in the southern spur of Sikhote-Alin (the Partizanski Region of the Primorsky Krai) (Fig. 1). This cave is a karst cavity with a downward, vertical inlet (Panasenko and Tiunov 2010) (Fig. 2).

The excavation revealed that the sediments were divided into 13 layers, which were described in Fig. 2. All the layers are similar in composition of small mammal species, but different in their quantitative ratio. Within all layers the most abundant were *Sorex caecutiens* and *Craseomys rufocanus*.

According to the degree of preservation of fossil remains all the layers lying above the layer 7, were considered as Holocene. They are very similar in composition of species as well as their quantitative ratio. The brown bear bone from layer 7 (1.08–1.18 m) was ^{14}C-dated to ca. 12 140 BP.

In the Pleistocene layers there are more remains of the species, which nowadays range much further north (*Alexandromys oeconomus*, *A. maximowiczii*, *Lemmus amurensis*) or west (*A. mongolicus*, *Myospalax psilurus*) from the Medvezhyi Klyk cave.

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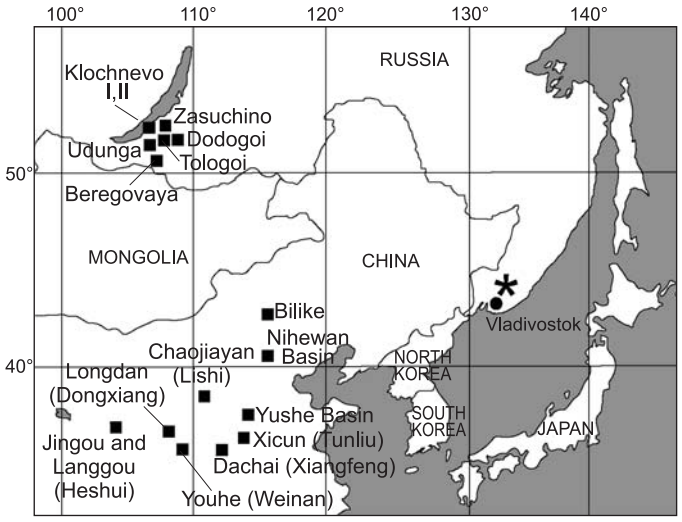

Fig. 1. Localities of fossil *Mimomys* in Transbaikalia, Primorye, and China. Asterisk indicates the location of the Medvezhyi Klyk Cave.

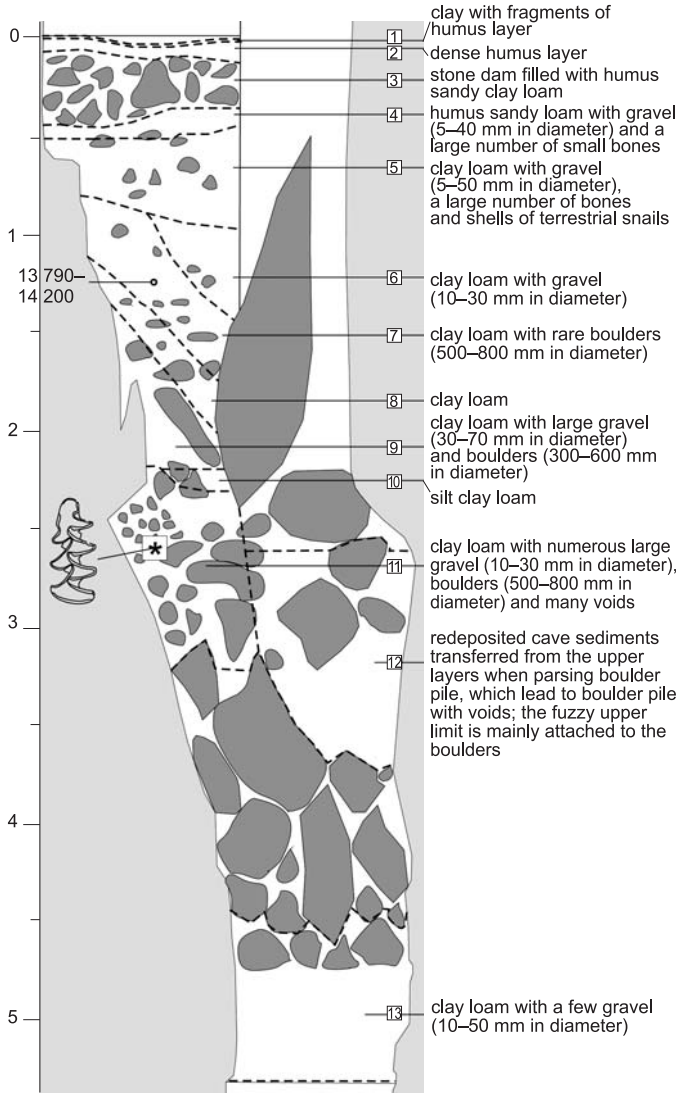

Fig. 2. Diagrammatic picture deposits of the southwestern wall of the excavation pit in the Medvezhyi Klyk Cave. Asterisk indicates the site of *Mimomys chandolensis* sp. nov.

The layer 11 is characterized by abundant occurence of hermophilic species (*Sorex mirabilis*, *Crocidura shantungensis*, *C. lasiura*, *Myospalax psilurus*) which point out to warmer climatic conditions most likely related the MIS 3when broadleaved and mixed conifer-broadleaved forest was the main type of vegetation (Korotky et al. 2005). Still, the most abundant within that layer, as well as within all the other ones, were *Sorex caecutiens* and *Craseomys rufocanus*, which are dominant taxa throughout the section. In the layer 13 the dominant taxa are associated by *S. minutisimus* and *Sorex* indet. (shrews similar in size to *S. unguiculatus* or *S. isodon*).

There were 11 species of small mammals found within layer 11. In this layer, as well as within other layers, the most abundant representatives of Arvicolinae were sylvestral species, such as *Craseomys rufocanus* and *Myodes rutilus*, and among the grey voles, we found *Alexandromys maximowiczii* and *A. fortis* (Haring et al. 2015). In the same layer we found a single first lower molar (m1) of *Mimomys* vole (Tiunov et al. 2011), which is described in this paper.

Material and methods

We allocated 13 lithological layers in the Medvezhyi Klyk cave with a total excavation depth of 5.3 m. Each lithological layers was excavated with a several conditional horizons of 5–10 cm. The sediment samples were washed in running water using a 1 mm mesh screen.

According to the radiocarbon dating, the age of the humerus of the brown bear GIN-13479 found in layer 7 (1.08–1.18 m) is determined as 13 790–14 200 BP.

The standard m1 measurements were made (Fig. 3) (according Tesakov 2004). In addition to these measurements, the enamel ultrastructure of the m1 specimen was analyzed using an electron microscope (Quanta 250).

Systematic palaeontology

Order Rodentia Bowdich, 1821

Family Cricetidae Fischer, 1817

Subfamily Arvicolinae Gray, 1821

Tribe Arvicolini Kretzoi, 1954

Genus *Mimomys* Forsyth-Major, 1902

Type species: *Mimomys chandolensis* sp. nov.; see below.

Mimomys chandolensis sp. nov.

Figs. 3, 4.

Etymology: After type region of Lozovyi Ridge (formerly Chandolaz).

Holotype: Left m1 (ZIN 101600) the anterior enamel edging of both of the outward lingual angles is slightly damaged.

Type locality: Cave of Medvezhyi Klyk, Mountain Chain of Lozovyi (465 m above sea level), the southern spur of Sikhote-Alin, the Partizanski Region of the Primorski Krai, Primorye, Russia.

Type horizon: MIS 3, Late Pleistocene.

Material.—Holotype only.

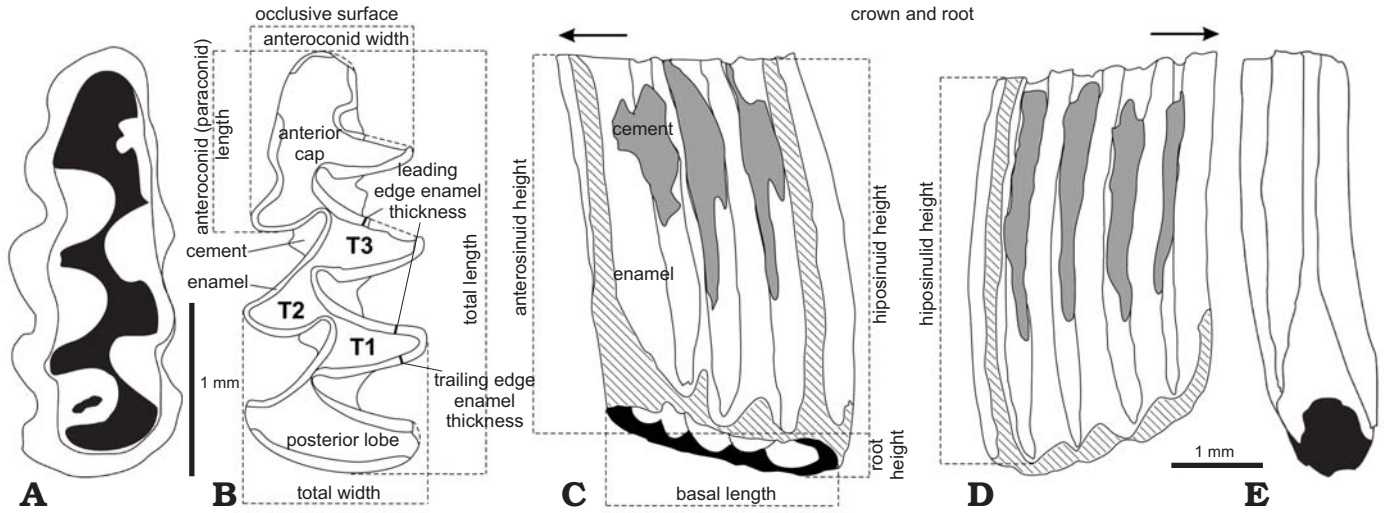

Fig. 3. Left m1 of a vole *Mimomys chandolensis* sp. nov. from Primorsky Krai, Russia, Late Pleistocene (MIS 3); ZIN 101600 in root (**A**), occlusal (**B**), buccal (**C**), lingual (**D**), and anterior (**E**) views. T1–3, the triangles of the occlusal suface; dentine tracks and fields of lateral sides are hatched; arrows mark the anterior direction. Terminology and measurements modified from van der Meulen (1973), Rabeder (1981), Tesakov (2004), Lozano-Fernández et al. (2013).

Diagnosis.—Hypsodont, with little cement, without enamel isle or prismatic fold, tangential and lamellar layers of enamel ultrastructure—poorly expressed.

The crown height/occlusive length ratio is 1.83 and the extent of cementation is mild. Unlike in *M. gansunicus,* which is characterized by a high extent of cementation, in our specimen, the buccal inward angles of the occlusive surface is one third filled with cement, while the lingual angles are halfway filled. There is some cement in the paraconid inward fold as well. There is no enamel isle or a *Mimomys*-type prismatic fold. The specimen is smaller than all of the other molars found in the East Palearctic. Our molar has a m1 length and width of 2.42 mm and 1.05 mm, respectively, while for the holotype of *M. gansunicus*, those measurements are 2.97 mm and 1.25 mm, respectively (Erbajeva 2005). On the ultrastructural level, the layer of radial enamel prevails; the tops of the inward and outward angles are covered with only radial enamel. The lamellar and tangential layers are no more than one third of the total enamel width.

Table 1. The basic measurements: mean value and range (in mm) of m1 of *Mimomys chandolensis* sp. nov. from Medvezhyi Klyk cave, being compared to some other species of *Mimomys*. SDQ, enamel differentiation index.

Species	Length	Width	SDQ	Reference
Mimomys chandolensis sp. nov.	2.42	1.05	128	this paper
Mimomys gansunicus	2.97 (2.76–3.18)	1.37 (1.23–1.51)	137 (126–147)	Zheng and Li 1986
Mimomys youhenicus	2.71	1.28	125	Zheng and Li 1986
Mimomys banchiaonicus	3.90	1.92	137	Zheng and Li 1986
Mimomys peii	3.64 (3.47–4.01)	1.67 (1.46–1.76)	129 (114–137)	Zheng and Li 1986
Mimomys tigliensis	2.59	1.10		Tesakov 1998
Mimomys savini (Gran Dolina, TD 4B)	3.34 (3.25–3.6)	1.44 (1.31–1.52)	149.6	Lozano-Fernández et al. 2013

Measurements (in mm).—L, 2.42; Lant, 1.03; W, 1.05; Want, 0.94; Lbas, 2.30; ASD, 3.95; HSLD, 4.23; R, 0.34; SDQ, 128.

Description.—The level of preservation of this *Mimomys* molar is consistent with other arvicoline remains found in the same layer. The tooth was weakly mineralized, with light yellow enamel and slightly darker yellowish dentine. The basic measurements and morphology of this molar are presented in Table 1 and Fig. 3.

The occlusive surfaces include the posterior loop, the 3 alternating triangles and the anteroconid area (Fig. 3). The second and third triangles are the most widely fused. Thus, there are 4 isolated dentine fields: the posterior loop, the first triangle, the second and the third triangles, and the anteroconid. On the buccal side there are 2 deep inward folds filled with cement and a slightly developed anteroconid fold. On the lingual side there are 4 inward angles filled with cement. The anteroconid includes widely fused plates of the fourth and fifth triangular prisms and the plate of the anterior loop. The enamel islet is absent and there is no rudimentary evidence of it. On the buccal side of the tooth there is a slightly developed *Mimomys*-type ridge. The enamel edge of the m1 occlusive surface possesses two disjunctions at the posterior and one disjunction at the buccal anteroconid loop. The enamel is of a differentiated thickness. The thinnest enamel is in the deepest sites of the inward angles, but the enamel edge of the posterior loop and posterior sites of the prisms is comparatively thicker; a finding that is typical for *Mimomys.* Additionally, the front enamel in some prisms is also thickened. The enamel differentiation quotient, the rear/front enamel thickness ratio in the main triangles SDQ (enamel differentiation index) is 128. The SDQ was calculated as:

$$SDQ = [\Sigma (teet \times 100/leet)]/N$$

where N refers to the number of dentine fields of the studied

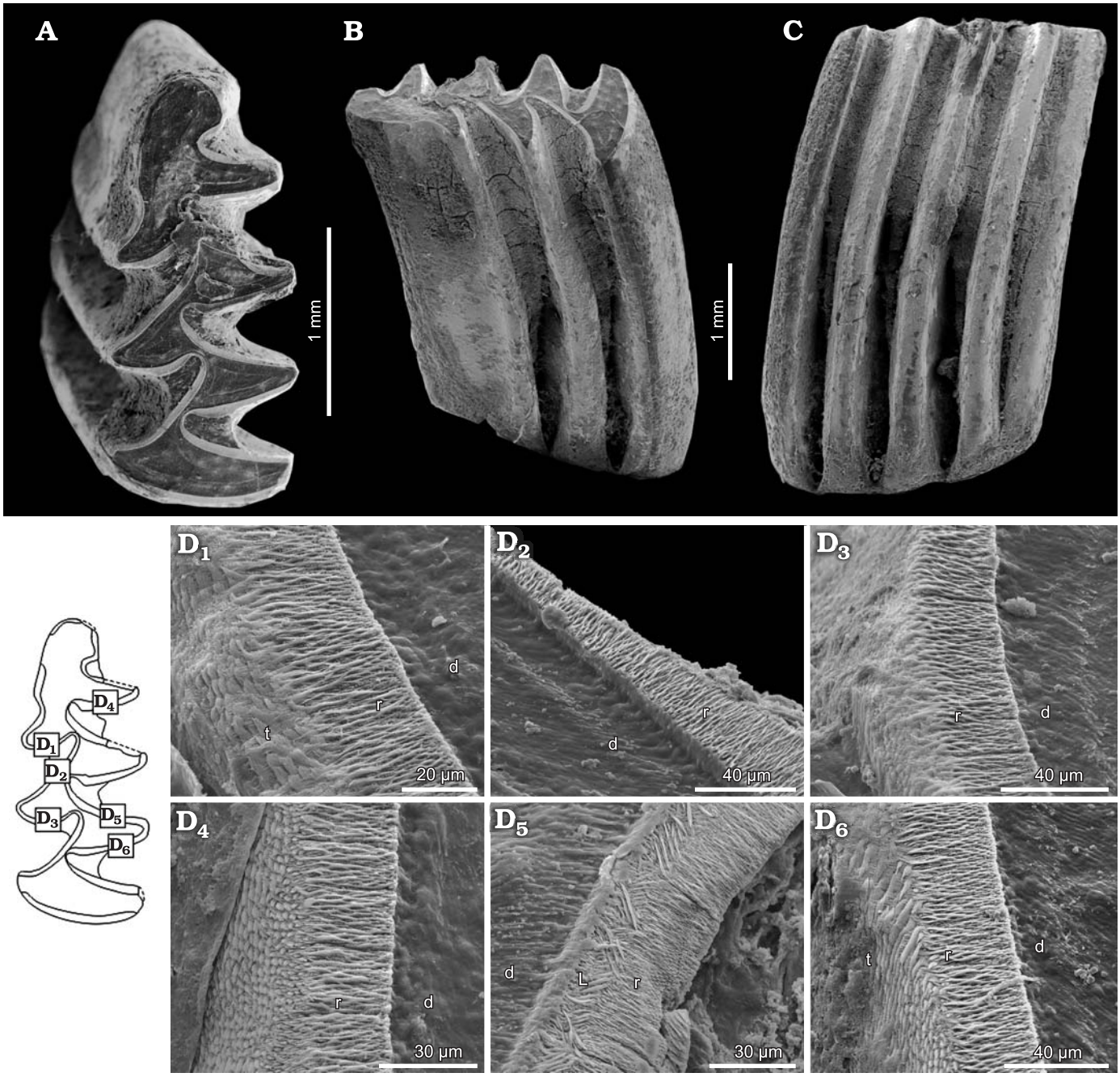

Fig. 4. Vole *Mimomys chandolensis* sp. nov. (ZIN 101600) from Primorsky Krai, Russia, Late Pleistocene (MIS 3). Left m1 in occlusal (**A**), buccal (**B**), and lingual (**C**) views, and photographs of the enamel ultrastructures (**D**). Positions of D_1–D_6 indicated on the drawing. Abbreviations: d, dentine; L, lammelar enamel layer; r, radial enamel; t, tangential enamel.

tooth; teet (trailing edge enamel thickness) refers to the maximum thickness of the posterior enamel loop; and leet (leading edge enamel thickness) refers to the maximum thickness of the anterior enamel loop (Heinrich 1978; Lozano-Fernandez et al. 2013).

The molar is hypsodont and the root development is in the initial (merorhiz) stage because the inward prismatic folds do not penetrate the basal surface of the tooth (indicating an underdeveloped molar neck). The tracks are stretched up to the occlusal surface, and the track on the buccal side of the anteroconid is narrow and without the *Mimomys*-type barb.

The enamel ultrastructure of the *Mimomys* sp. nov. m1 (Fig. 4) is somewhat different from that of the other known representatives of the genus (Koenigswald 1980). The tangential and lamellar layers are underdeveloped. On the buccal side of the molar, the tangential layer appears only at the limited sites of the posterior edges of the triangles, whereas the lamellar layer is observed only at the anterior edge of the hypoconid and forms a mere third of the total enamel thickness. On the lingual side, both pattern types are present within the enamel edging of all the outward angles and tapers to complete absence towards the tops of the inward angles.

Remarks.—Among the known Eurasian and North American hypsodont *Mimomys*, *M. gansunicus* and *M. haplodentatus– M. tornensis–M. tigliensis* appears to be the most similar to the molar we found (Zheng and Li 1986; Tesakov 1998, 2004; Zhang et al. 2010; Tesakov and Kolfschoten 2011); the comparison with the latest representatives of *Mimomys–M. savini* (Fejfar et al. 1998; Lozano-Fernández et al. 2013) was also carried out (Table 1). The latter occurred to be considerably larger, than our specimen. Because our specimen differed from all the other representatives of the genus in most of the m1 characteristics measured, we describe this as coming from a new species. The differential diagnosis was made in comparison with *M. gansunicus,* as the closest one both geographically and morphologically.

Stratigraphic and geographic range.—Type locality and horizon only.

Concluding remarks

In Eurasia, the voles of the genus *Mimomys* have been extinct more than 600 thousand years ago (Fejfar et al. 1998). Layer 7 of the Medvezhyi Klyk cave (1.08–1.18 m) was dated to be 13 790–14 200 years old. *Mimomys chandolensis* sp. nov. was found in a deeper layer 11 (2.63–2.68 m) and therefore assuming there was no redeposition of the remains and that the accumulation proceeded gradually, the molar specimen we found is 30–50 thousand years old. Due to the extent of the preservation we observed in the molar and the structure of the cave, the specimen does not seem likely to have been redeposited. It should be also mentioned, that in almost all the layers, except the uppermost ones the remains of zokor (*Myospalax psilurus*) were found. That is why, opposite to Korotky et al. (2005), we consider, that open forest-steppe and steppe landscapes were more abundant in this area in the Late Pleistocene and Holocene. It is worth to mention that bone remains of forest species are predominant in the layers where bone fossils of the zokor were found. This fact means that open landscapes were not predominant but were rather abundant at least along the river valleys and southern slopes of mountains. The presence of bone fossils of the zokor in units corresponding both to warm and cold periods of the Late Pleistocene indicates that the previously existing ecosystem was stable. In the Late Pleistocene layers of that cave the abundant remains of the grey voles of the genus *Alexandromys,* which inhabit the open landscapes, were also registered (Voyta et al. 2011; Haring et al. 2015). Nowadays it is only *Alexandromys fortis*, that inhabits that area. We conclude, that species of *Mimomys* managed to exist here much longer, than anywhere else, owing to some specific environmental conditions in the South-Eastern part of the mammoth fauna geographic range.

This conclusion about existence of that form of *Mimomys* in Late Pleistocene requires further collecting effort with precise dating.

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