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MIDDLE PLEISTOCENE SMALL MAMMAL FAUNAS OF EASTERN AND WESTERN EUROPE: CHRONOLOGY, CORRELATION

ABSTRACT. Many new very important Middle Pleistocene small mammal localities of Europe were discovered during the last decades. These new data permit to divide the Middle Pleistocene geological sequences of Eastern and Western Europe and carried out the correlation between them. However, there are some difficulties connected with the incongruity of mammal appearance in different parts of Europe. In this paper we would like to discuss all these problems using Middle Pleistocene small mammal data and to present the possible biostratigraphical scheme for the whole Europe.

KEY WORDS: small mammals, Middle Pleistocene, Europe, correlation

MATERIALS AND METHODS

In this article we use the Western European stratigraphical scheme. According this scheme the beginning of the Middle Pleistocene corresponding to the boundary of palaeomagnetic epochs Matuyama–Brunhes (~0.8 mln. yrs. BP) and the end of Middle Pleistocene falls to the beginning of Eemian (=Mikulian) Interglacial (about 0,135 mln. BP). The Early and Middle Neopleistocene of the Russian stratigraphical scheme correspond to the Middle Pleistocene of Western European stratigraphical scheme.

Eastern Europe

Dniester, Danube and Prut basins. One of the most complete sections of the Middle Pleistocene is the Kolkotova Balka section near the Tiraspol town (Moldova, Dniester basin). The deposits corresponding to the whole Middle Pleistocene are opened up in this outcrop. The several layers with mammal faunas were discovered here: the lowest 3 layers with small and large mammal fauna were found in the fluvial deposits of different facies. The fauna of these fluvial layers describe as the stratotype of Tiraspolian mammalian complex [Alexandrova, 1976; Pleistocene of Tiraspol, 1971] which correspond to the Il'inkian Horizon of Russian stratigraphical scheme with *Mimomys savini, Prolagurus posterius – Lagurus transiens, Microtus (Stenocranius) hintoni-gregaloides*, *Microtus arvaloides, Microtus ratticepoides (=oeconomus)* and others; 2) above the fluvial deposits of the Dniester River underlies the horizon of the Vorona fossil soil with small mammal fauna which is correlated with the Muchkap Interglacial. Fauna includes *Lagurus transiens* (archaic morphotype), *Microtus gregalis* and others; 3) uppermost the loess deposits lie covered the horizon of the Inzhava fossil soil, synchronous to Likhvin Interglacial with *Lagurus transiens – L. lagurus*, *Microtus (S.) gregalis*, *Microtus* ex gr. *agrestis* и др.

[Mikhailesku, Markova, 1992; Markova, 2007]. So the faunas of this key section reflected the natural events of the most part of the Middle Pleistocene (Fig. 1). These faunas expressed the significant evolutional changes in different phylogenetic lines of Arvicolidae: *Prolagurus – Lagurus, Microtus (Stenocranius) hintoni-gregaloides – M. (S). gregalis* and others. The different taphonomy of Kolkotova Balka main horizons (fluvial deposits and fossil soils) didn't permit to reveal the transition between the rooted voles of *Mimomys* genus (the ancestral form of water vole *Arvicola*) and the un-rooted voles of *Arvicola* genus. All localities with *Mimomys* were found in fluvial older deposits. The different fossil soils overlying the fluvial deposits didn't include the remains of water voles *Arvicola* (or its ancestor form *Mimomys intermedius*) what could be explained by their taphonomy.

There are several other very principal Middle Pleistocene small mammal localities situated on the south-west of the Russian Plain in Prut and Danube River basins. The faunas were described in Nagornoe, Suvorovo, Ozernoe, Plavni and many others localities. These localities as a rule characterize only one stage of Middle Pleistocene: Il'inka Interglacial, Muchkap Interglacial, Likhvin Interglacial and Kamenka Interglacial. Most of them include the fauna of the Likhvin Interglacial. The significance of these materials for stratigraphy also is very high. All of these localities were found in the liman and lake deposits and include not only mammal remains but also brackish-water mollusks what permits to carry out the straight correlation between the continental and marine deposits of the Russian Plain and the Black Sea [Mikhailesku, Markova, 1992].

Dnieper basin. There are several Middle Pleistocene localities of small mammals are known from the Dnieper basin, mostly from the middle part of basin. They are connected with the fluvial deposits of IV terrace of Dnieper. The localities Gunki and Pivikha are situated on the left bank of Dnieper; the Chigirin locality is situated on the right bank [Markova, 1982] (Fig.1).

Gunki locality was studied by the several methods (geological, pedological, palynological, malacological methods). Also the palaeomagnetic investigation of deposits had been done [Velichko et al., 1982]. This outcrop includes the deposits of second part of the Middle Pleistocene and the Upper Pleistocene. The Dnieper (=Zaalian) till is registered here. The Romny and Kamenka paleosols were described below the Dnieper till. Fluvial thickness occurred below the loess-paleosol sequence. The fluvial deposits of IV terrace are correlated with the Likhvin Interglacial by the palynological and mammalian data. The small mammal remains were discovered in the 3 facieses of alluvium close by age. The rich fauna didn't include the teeth of rooted voles *Mimomys* and *Borsodia*. There are no also remains of archaic voles (with "pitymys" triangles) such as *Microtus (Terricola) arvaloides* and *Microtus (Stenocranius) gregaloides*. Steppe lemmings are presented by the remains of *Lagurus* genus with *Lagurus transiens* morphotypes (which are more abundant) and *Lagurus lagurus* ones. The *Microtus* genus includes the voles *Microtus arvalis, M. oeconomus* and *M. (S.) gregalis*. The palynological data indicate the Likhvin age of the deposits [Gubonina, 1982]. Malacological materials show on Early Euksinian age of mollusk fauna. Gunki section is a unique one by the completeness of the palaeontological data [Markova, 1982]. The localities Pivikha and Chigirin include similar small mammal faunas by the species composition [Markova, 2006].

Don and Desna basins. The complicated mammalian succession was described by the materials of Middle Pleistocene small mammal faunas from Don and Desna basins. The earliest of them are correlated with the beginning of Middle Pleistocene, the latest is referred to the Dnieper (=Saalian) Glaciation [Agadjanian et al., 2008; Markova, 2007]. The small mammal materials related as well as to the interglacials so to the glaciations (Don Glaciation, Oka Glaciation and Dnieper Glaciation).

In last years the small mammal faunas with archaic *Arvicola* were found in the deposits related to interval, which follows Muchkap interglacial and cooling which is next after

STRATIGRAPHY		PALAEOMAGNETIC	MIS	Biostratigraphy					
				Western Europe			Eastern Europe		
				Glaciations, Interglacials	Stages	Small mammal localities	Glaciations, Interglacials	Loesses, paleosols	Small mammal localities
PLEISTOCENE	LATE MIDDLE PLEISTOCENE	BRUNHES	8	Volstonian (=Saalian) Glaciation	Cold Interval	Ussel Armagier Plaidter-Hummerich I Ariendorf 2 Ariendorf 1	Dnieper Glaciation	Dnieper loess	Berezovo, Chekalin (Fl. deposits), Alpatievo, Pavlovka0na-Desne
							Romny warming.	Romny paleospol	
							Cooling	Loess	
			9		Hoogoven (=Reinsdorf) Interglacial	**Schöningen (Reinsdorf) Kärlich H**	Kamenka Interglacial	Kamenka paleosol	Priluki, Uzunlar, Rasskazovo, Plavni
			10		Cooling		Cooling	Borisoglebsk loess	Topka
			11	Hoxnian (=Holsteinian) Interglacial	Holsteinian Interglacial	**Schöningen (lower layer)** Niide	Likhvin Interglacial	Inzhava paleosol	Chekalin, Gunki, Chigirin, Pivikha, Ozernoe, Rybnaya Sloboda **Kolkotova Balka (Inzhava soil)**
	EARLY MIDDLE PLEISTOCENE		12	Anglian (=Elsterian) Glaciation			Oka Glaciation	Oka till	Mikhailovka 2
			13	«Cromerian complex»	Interglcial IV	Boxgrove, Mauer, Miesenheim Westbury-sub-Mendip	Ikoretsk Interglacial	Optimum	Mastyuzhenka, Shekhman **(first appear.of *Arvicola cantianus*)**
			14		Glaciation C			Cooling	
					Interglacial III	**Kärlich G**	Muchkap Interglacial		
								Cooling	
			15			Mosbach, Izernia **(first appear.of *Arvicola cantianus*)** Little Okley, Süssenborn, Pakefield			
								Cooling.	
								Konakhovka warming	Posevkino, Perevoz, **Kolkotova Balka (Vorona paleosol),** Konakhovka loc. and others
								Cooling	
								Glazovo warming	Illovaisky Kordon
			16		Glaciation B	**Kärlich F**	Don Glaciation	Don till	Bogdanovka, Zmeevka Troitsa I
			17		Interglacial II	**Kärlich C-F** West Runton	Il'inka Interglacial	Il'inka paleosol complex	**Kolkotova Balka (fluvial dep.)** Novokhopersk Uryv 4, Il'inka
			18		Glaciation A				
		Matuyama	19		Interglacial I	**Kärlich B**	Petropavlovka cooling	Loess	Karai-Dubina Petropavlovka

Fig. 1. Middle Pleistocene biostratigraphical scheme of Europe

Muchkap (Mastuzhenka, Ikorets, Shekhnan-1 localities) and Oka glaciation.

The faunas of this evolutional level were described earlier in Western Europe (Mosbach, Miesenheim, Kärlich Kä G and others). These faunas don't' contain the remains of *Mimomys* genus, but include the representatives of archaic un-rooted voles of *Arvicola* genus. The Ikoretzk Interglacial was described by these new materials from the Russian Plain [Iosifova et al., 2009].

Volga basin. The small mammal fauna, similar by the species composition to the numerous faunas of the Likhvin Interglacial from other river basins of the Russian Plain (Danube, Prut, Dniester, Dnieper and Don basins) was found by Dr. V.P. Udartsev in the fluvial deposits of Rybnaya Sloboda section situated near the mouth of Kama River (right tributary of Volga) [Markova, 2004]. The Kamenka fossil soil is located higher in this section. The Rybnaya Sloboda fauna includes *Arvicola cantiana, Lagurus transiens-lagurus, Clethrionomys rufocanus* and others. In lower Volga basin (Chernyi Yar locality) more evolved fauna was described with more progressive *Arvicola* and *Lagurus* [Alexandrova, 1976]. Similar fauna of small mammals was found near Spasskoe village in the middle Volga basin [Markova, 2007].

Western Europe

The Central and Western European small mammal record is from a number of geographically scattered, in many cases isolated localities. Rich, well-known early Middle Pleistocene assemblages are from localities such as Voigtstedt (Gemany) and West Runton (England) [Maul, Parfitt, 2010]. Long sequences are almost non-existent. An exception is the Kärlich sequence, exposed in a quarry located in the Neuwied Basin (Germany), with on top of the Tertiary clays Quaternary deposits gravels of the Rhine and Moselle rivers and an alternation of loess, loess-like, and slope deposits and tephras (ashes, pumices) which originate from extinct volcanoes located in the neighbouring East Eifel volcanic field dating from the late Early Pleistocene to the Holocene [Boenigk, Frechen, 2001]. Several stratified mammalian faunas, within which the *Mimomys – Arvicola* transition occurs, were collected from the Pleistocene sequence (Kärlich main section – Kä A – H) exposed in the Kärlich pit. The older faunas Kä C – F are characterised by the presence of *Mimomys savini*; the oldest representatives of the water vole, *Arvicola terrestris cantiana*, were recovered in the rich fauna from Kä G. The faunal assemblages from the Kärlich sequence together with the faunas from the same region (Miesenheim I and Ariendorf) form a reference for the early Middle Pleistocene faunal history to which faunas such as Mauer and Mosbach (Germany) can be correlated [van Kolfschoten, 1990].

Both the *Microtus (Stenocranius) hintoni-gregaloides – M. (S). gregalis* and the *Microtus (Terricola) arvaloides – Microtus arvalis* lineage as well as the *Mimomys-Arvicola* lineage offer the possibility to correlate the Eastern and the Central European faunas. The faunal sequences indicate that in Central Europe, *Mimomys savini* occurs in the earliest Middle Pleistocene faunas and that the *Mimomys – Arvicola* transition occurs long before the Elsterian (=Oka Glaciation). The loess deposits of Kärlich F correlated with the Don Glaciation is the uppermost unit with *Mimomys* remains. Two *Arvicola* faunas (Kärlich G and Miesenheim I) are referred to two different interglacials with a pre-Elsterian age.

Central European faunas dating to the Elsterian (Oka) Glaciation are poorly known. The same applies to the Holsteinian (Likhvin) faunas. The Schöningen locality (Germany) yielded an extensive collection of small mammal remains dated to post-Elsterian age [van Kolfschoten, 2012]. The oldest assemblage from this site most probably has a Holsteinian age; however, this assemblage is rather poor. The mammal fauna from the so-called Reinsdorf Interglacial (locally defined), the second interglacial after the Elsterian, is very rich. This fauna is characterised by the presence (in a low quantity) of early Middle Pleistocene relicts (*Talpa minor* and

Drepanosorex) as well as rather primitive water vole *Arvicola* molars indicating that the age of the fauna predates many well-known late Middle Pleistocene faunas such as Weimar-Ehringsdorf (Germany) and Maastricht-Belvédère (The Netherlands) [van Kolfschoten, 1985] with a more advanced *Arvicola* record and with relicts.

DISCUSSION

The phylogenetic lines *Microtus (Stenocranius) hintoni-gregaloides – M. (S). gregalis, Microtus (Terricola) arvaloides – Microtus arvalis* and *Mimomys – Arvicola* are the base for the correlation of Eastern and Western Pleistocene small mammal faunas. The analysis of the Middle Pleistocene mammalian sequence of Central and Western Europe indicates that *Mimomys savini* was discovered in earliest Middle Pleistocene faunas. The *Mimomys – Arvicola* transition was found in Western Europe long before the Elsterian (=Oka) Glaciation. The loess deposits of Kärlich F are correlated with the Don Glaciation of Eastern Europe and are the latest sediments with *Mimomys* remains (Fig. 1).

Two localities with archaic *Arvicola* (Kärlich G and Miesenheim I) are referred to two different interglacials. Both of them are related to pre-Elsterian time. The faunas, synchronous to the Elsterian Glaciation, are practically unknown in Western Europe. The faunas of the Holsteinian (=Likhvin) Interglacial are very rare in this part of Europe.

Schöningen locality (Germany) includes the rich collection of small mammal remains corresponding to post-Elsterian deposits. The earliest layer with small mammal remains in Schöningen, possibly related to Holsteinian Interglacial. Unfortunately this locality contains only few small mammal bones.

The rich strata with small mammals in Schöningen is synchronous to the Reinsdorf Interglacial (this Interglacil was distinguished only in this region). This fauna corresponds to the younger Interglacial then Holsteinian warm phase. Possibly it could be synchronous to the Kamenka Interglacial of Eastern Europe. The Reinsdorf fauna includes few relics of the first half of Middle Pleistocene – *Talpa minor* and *Drepanosorex* and also archaic *Arvicola cantianus*. That permits to conclude that this fauna are earlier then late Middle Pleistocene faunas of Weimar-Eringsdorf (Germany) and Maastricht-Belv@édère (the Netherlands) with more progressive water voles [van Kolfschoten, 1990].

Thus, we can reveal the evolutional succession of small mammal faunas in Western and Eastern Europe during Middle Pleistocene based on the morphological changes in the different phylogenetic lines. These transformations have the similar trends in the different parts of Europe. The revealed succession of small mammal faunas indicates significant similarities of the Middle Pleistocene faunas belonged to the large stratigraphical divisions in different European regions. Unfortunately now only few full Middle Pleistocene sections with the significant succession of heterochronous mammalian faunas are known both on the Russian Plain and in Western Europe. The fullest picture was revealed to the Dniester and Don River basins of the Russian Plain and also for the Neuwied and Rhine River basins of Central Europe.

Unfortunately the mammals of the one of the most important phylogenetic line *Prolagurus – Lagurus*, which gives a lot of information about the stratigraphical position of the Eastern European faunas, are absent in Western Europe. So, we need to base only on *Mimomys – Arvicola* and *Microtus* members.

We need to mention some differences in the first appearance of new small mammal taxa in Western and Eastern Europe. So, there are un-known Central European faunas with *Mimomys* remains which correspond to the complicated interval between the cold stage synchronous to the Don Glaciation and the Elster Glaciation. Only archaic water voles *Arvicola cantianus* were discovered in these faunas. On the contrary there are several important well-known mammal localities

in Eastern Europe (in the Dniester and Don basins) with evolved *Mimomus (M. savini)* which related to the Muchkap Interglacial. This Interglacial took place between the Don and Oka Glaciations. The first un-rooted water voles *Arvicola cantianus* appeared only in the very end of this complicated interval during the Ikoretsk Interglacial. Till now this phase was revealed only in the Don basin.

The future studies of small mammal faunas from the different regions of Europe and also the correlation of main stratigraphical horizons with mammal localities permit to establish most reliable correlations of Middle Pleistocene small mammal faunas of Eastern and Western Europe.

Described analysis of the Middle Pleistocene small mammal faunas could help to reconstruct and to date the natural events of Middle Pleistocene for the territory of whole Europe and to reveal the similarities and un-similarities in Arvicolidae evolution in the different parts of Europe. ■

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