

Magnetostratigraphical age assignments of Middle and Late Sarmatian Mammalian localities of the Eastern Paratethys

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with 6 figures and 3 tables

Abstract. The chronological sequence of Middle and Late Sarmatian fossil mammalian localities of Ukraina, Moldova, and Transcaucasus is presented. The stratigraphic position of the localities is indicated within the substages of the Eastern Paratethys and within the magnetostratigraphical scale.

The localities of the Bessarabian substage date to the second half of the polarity Chron 11 and first half of Chron 10. The fauna of these localities corresponds to that of the Early Vallesian (MN9). The localities of the Khersonian substage date to the second half of Chron 9 (Anomaly 5) and the beginning of Chron 8. The fauna is correlated with that of the Late Vallesian (MN10).

The lower boundary of the Vallesian is close to the base of the Bessarabian. The MN9/MN10 boundary is not older than the boundary between the Bessarabian and the Khersonian substages. The upper boundary of the Vallesian nearly coincides with the boundary between the Sarmatian and the Meotian.

Kurzfassung. Es wird eine chronologische, mittel- bis spät-sarmatische Abfolge von Säugetier-Lokalitäten der Ukraine, Moldaviens und des Trans-Kaukasus vorgestellt. Die stratigraphische Position der Lokalitäten wird entsprechend den Unter-Stufen der östlichen Paratethys und der Magnetostratigraphie angezeigt.

Die Lokalitäten, die in die Unter-Stufe des Bessarabium fallen, gehören in die zweite Hälfte von Chron 11 und die erste Hälfte von Chron 10. Die Fauna dieser Lokalitäten entspricht der des frühen Vallesium (MN 9). Die Lokalitäten, die in die Unterstufe des Khersonium fallen, gehören in die zweite Hälfte von Chron 9 (Anomalie 5) und den Beginn von Chron 8. Die Fauna ist korreliert mit der des späten Vallesium (MN 10).

Die untere Grenze des Vallesium ist nahe des Bessarabium. Die MN9/MN10-Grenze ist nicht älter als die Grenze zwischen den Unter-Stufen des Bessarabium und des Khersonium. Die obere Grenze des Vallesium stimmt nahezu überein mit der Grenze zwischen dem Sarmatium und dem Meotium.

Introduction

In south-eastern Europe there are about three dozen fossil mammalian localities in marine deposits of the Middle (Bessarabian) and Late (Khersonian) Sarmatian age. They are important for a direct correlation of marine and continental deposits. The joint occurrence of fossil mammals and of marine molluscs unambiguously refers a locality either to the Bessarabian or the Khersonian substage. However, the precise position of these fossiliferous beds and their

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Table 1 Position of mammal localities within substages of the Sarmatian after different researches.

	KOROTKEVICH, 1988	LUNGU, 1990	This paper
Khersonian	Staraya Kubanka	Raspopeny	Kajnary, Raspopeny Poksheshty, Berislav, Staraya Kubanka, Tiaginka, Yurievka Krivoy Rog
	Berislav, Tiaginka, Yurievka, Krivoy Rog	Staraya Kubanka, Poksheshty, Kajnary, Yurievka, Tiaginka, Krivoy Rog	
Bessarabian	Varnitsa, Sevastopol	Varnitsa, Buzhor 2, Gritsev, Sevastopol Klimentovichi	Sevastopol Gritsev, Klimentovichi, Varnitsa, Buzhor 2
	Kalfa, Buzhor 1, Lapushna, Zheltokamenka	Kalfa, Buzhor 1, Lapushna	Kalfa, Zheltokamenka, Buzhor 1, Lapushna
	Gritsev, Klimentovichi	Zheltokamenka	

chronological order within regional substages are defined differently by different authors. (Table 1).

The aim of this study is to determine the position of some reference localities with fossil mammals situated on the northern coast of the Black Sea, within the stratigraphic scale of the Eastern Paratethys and the magnetic polarity scale. We utilize data on the paleogeography of the Sarmatian basin and paleomagnetic data to specify the precise position of the localities within each of the regional substages.

The localities Gritsev, Klimentovichi, Zheltokamenka, and Sevastopol in Ukraine and Buzhor 1 and 2, Lapushna, Kalfa, and Varnitsa in Moldova, are situated in coastal marine deposits of the Bessarabian substage (Fig. 1). The localities Berislav, Tiaginka, Yurievka, Staraya Kubanka, and Krivoy Rog in Ukraine, and Kajnary in Moldova, are situated in marine deposits of the Khersonian substage (Fig. 2). The Khersonian locality Eldari is in Transcaucasia (Fig. 3).

Magnetostratigraphy

The sections containing fossil mammalian localities are usually incomplete. This makes it difficult to interpret their paleomagnetic data. Localities in marine deposits are much easier to correlate with the magnetic polarity time scale. The most complete sections of the marine Neogene deposits of the Eastern Paratethys have been studied paleomagnetically and correlated with the magnetochronological scale (PEVZNER & CHIKOVANI 1978, PEVZNER & VANGENGHEIM 1984, VANGENGHEIM & al. 1988).

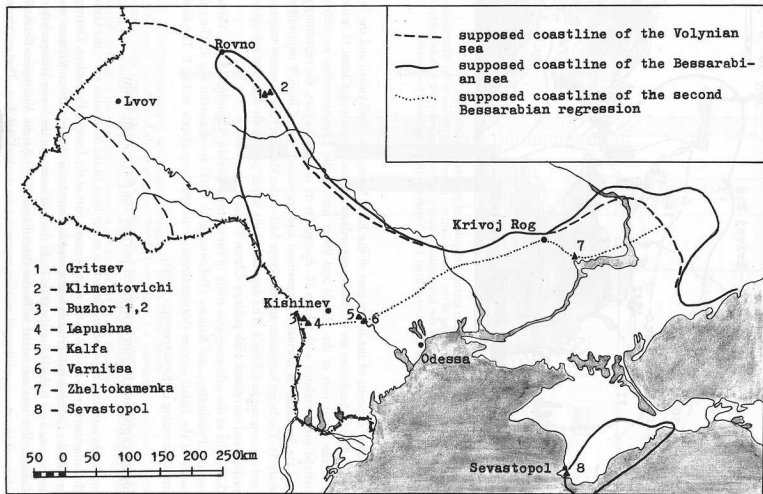


Fig. 1. Distribution of Volhynian and Bessarabian marine deposits and Bessarabian mammalian localities.

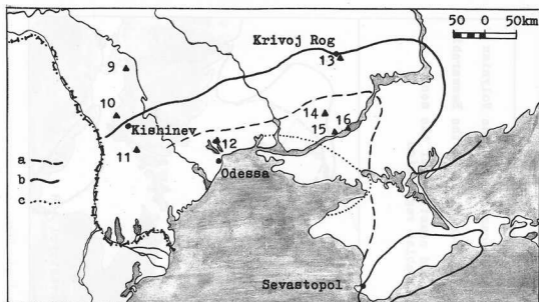


Fig. 2. The distribution of Khersonian marine deposits and mammalian localities.

a – presumed coastline at the beginning of the Khersonian; b – presumed coastline of the Khersonian sea; c – presumed coastline at the end of the Khersonian. Localities: 9 – Raspopeny; 10 – Poksheshty; 11 – Kajnary; 12 – Staraya Kubanka; 13 – Krivoj Rog; 14 – Yurievka; 15 – Tiaginka; 16 – Berislav.

The marine deposits of the upper part of the Early Sarmatian (Volhynian) and the lower part of the Middle Sarmatian are normally magnetized and correlated with Chron 11, whereas those of the upper part of the Middle and lower part of the Late Sarmatian are reversely magnetized and correlated with Chron 10. Except for its uppermost part, the remaining part of the Late Sarmatian is normally magnetized and correlated with Chron 9 (equivalent of Anomaly 5). The latest Sarmatian and the lower half of the Meotian have reversed magnetization and correspond to Chron 8. The deposits of the upper part of the Meotian are normally magnetized and correlated with polarity Chron 7.

The results of the paleomagnetic study of the sections Buzhor, Lapushna, Kalfa, Varnitsa, Raspopeny, Poksheshty, and Kajnary (PEVNER & al. 1987) are shown in Fig. 4. The paleomagnetism of the Eldari section (VANGENGEM & al. 1989) are shown in Fig. 3. The Gritsev section is according to KOROTKEVICH (1988).

Paleogeography of the northwestern part of the Sarmatian basin

During Volhynian and Bessarabian time, two major bays of the Sarmatian sea – the Galician and Boristhenian bays – existed in the northwestern part of the Eastern Paratethys. During the Volhynian the Galician bay extended as a narrow zone from the latitude of Kishinev to the northwest, reaching Central Europe (Fig. 1). In the southeast – in the lower Dnieper region – the Galician bay was connected with the Boristhenian bay. At the Volhynian-Bessarabian boundary, there was a southward marine regression in the Galician bay. The sea retreated

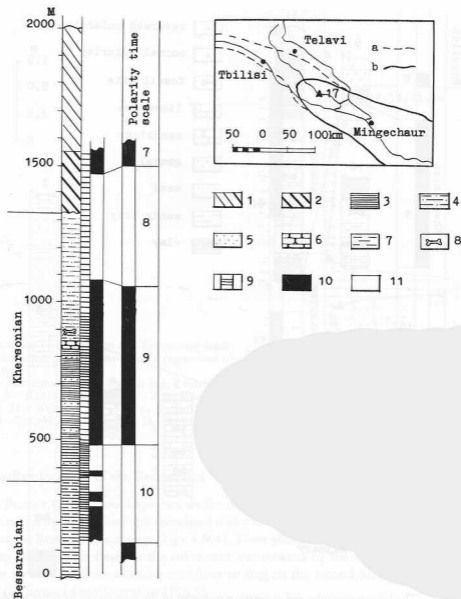


Fig. 3. The lithostratigraphy and magnetostratigraphy of the Eldari section (17).

1 - gray sands and clays of the continental Shirak Formation; 2 - variegated sands and clays of the continental Eldar Formation; 3 - clay; 4 - sandy clay; 5 - sand; 6 - sandstone; 7 - marl; 8 - bone-bearing horizon; 9 - position of the paleomagnetic samples; 10 - normal polarity; 11 - reversed polarity; a - presumed coastline of the Bessarabian; b - presumed coastline of the Khersonian.

approximately to 49° N and became considerably freshened. Subsequently, a transgression extended northward to the latitude of Rovno. The Galician bay shifted to the east with respect to the Volhynian basin boundaries. The Crimea formed an island during the Volhynian and Bessarabian. In the mid-Bessarabian time a new regression began; its presumed coast-lines are

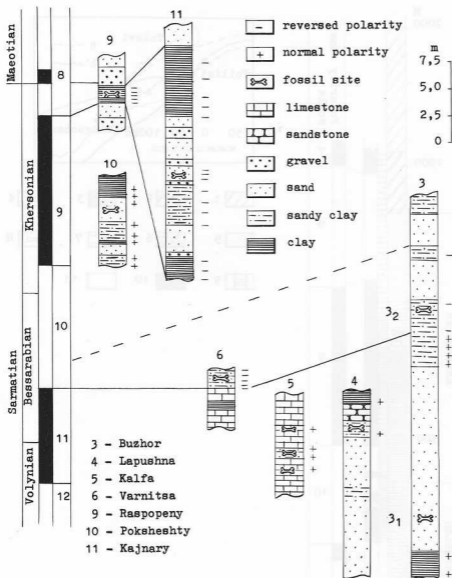


Fig. 4. The lithostratigraphy and magnetostratigraphy of the mammalian localities of Moldova.

shown in Figure 1. Later, a northward transgression again reached the latitude of Rovno. During a subsequent regression at the end of the Bessarabian, the Galician bay was drained (Fig. 2). In spite of a new northward transgression during the Khersonian, the Borysthenian bay decreased substantially compared to its Bessarabian extension. After a strong regression at the end of the Khersonian, it disappeared completely.

Figure 1 shows the shoreline of the second Middle Sarmatian regression according to DIDKOVSKY (1986), emended for Moldova by the authors. The rest of the Sarmatian coast-lines is drawn after KOLESNIKOV (1940).

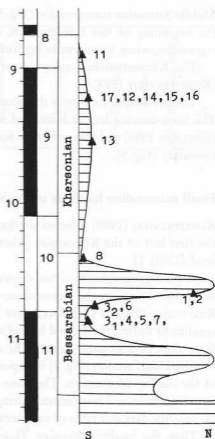


Fig. 5. The position of Bessarabian and Khersonian mammalian localities relative to transgressions and regressions of the Galician bay.

1 - Gritsev; 2 - Klimentovichi; 3₁ - Buzhor 1; 3₂ - Buzhor 2; 4 - Lapushna; 5 - Kalfa; 6 - Varnitsa; 7 - Zheltokamenka; 8 - Sevastopol; 11 - Kajnary; 12 - Staraya Kubanka; 13 - Krivoj Rog; 14 - Yurievka; 15 - Tiaginka; 16 - Berislav; 17 - Eldari.

Fossil mammalian localities of the Bessarabian

The localities Buzhor 1, Kalfa, and Lapushna are the oldest considered here. The bone-bearing sediments are normally magnetized and correlated with the end of polarity Chron 11 and with the first half of the Bessarabian substage (Figs. 4 & 6). These sediments were not formed at the very beginning of the Bessarabian, as the entire area was covered by the sea. The regressive pattern of the sections of these localities enable us to suggest the second Middle Sarmatian regression as the time of their formation (Fig. 5).

The locality Zheltokamenka seems to be chronologically close to the localities above. Like Kalfa, Lapushna, and Buzhor 1, Zheltokamenka is situated near the coast-line of the lowest sea level of the second Middle Sarmatian regression (Fig. 1).

The localities Varnitsa and Buzhor 2 are stratigraphically slightly younger. The fossiliferous beds are reversely magnetized and were dated at the beginning of Chron 10.

The bone-bearing clays of the locality Gritsev are reversely magnetized and contain shells of Middle Sarmatian molluscs (КОРОТКЕВИЧ 1988). These clays fill karstic fissures in the Middle Sarmatian limestones which they overlie. The reversely magnetized sediments of this site suggest its correlation with the second half of the Bessarabian. Gritsev is close in age to Buzhor 2 and Varnitsa and may be slightly younger, as it was formed at the end of the last

Middle Sarmatian transgression (Fig. 5). The localities Varnitsa and Buzhor 2 were formed at the beginning of this transgression, or during the climax of the second Middle Sarmatian regression, when karst was being formed in the Gritsev limestones.

The Klimentovichi locality is correlated with Gritsev because of their faunal similarity (KOROTKEVICH 1988).

The Sevastopol locality is the youngest of the Middle Sarmatian localities considered here. The bone-bearing lens is associated with the upper part of the Middle Sarmatian limestones (GABUNIA 1959) and was probably formed during a regression at the Bessarabian-Khersonian boundary (Fig. 5).

Fossil mammalian localities of the Khersonian

KOROTKEVICH (1988) referred the localities Berislav, Tiaginka, Yurievka, and Krivoj Rog to the first half of the Khersonian substage. LUNGU (1990) placed Starya Kubanka at the same level (Table 1).

A paleogeographic analysis shows that these localities (except for Krivoj Rog) were covered by the sea at the Bessarabian-Khersonian boundary and during the first half of the Khersonian (Fig. 2). Therefore, these localities could have been formed only under regressive conditions during the second half of the Khersonian. The locality Krivoj Rog is the oldest of these sites. It is situated close to the coast-line of the maximum extension of the sea.

The Eldari section (Fig. 3) is important as it is one of the most complete and thick sections of the marine Khersonian. The bone-bearing bed is situated in the upper half of the marine Late Sarmatian and was formed during the Khersonian regression. Its age, inferred by magnetic polarity data and rates of sedimentation, is about 9.2 Ma (VANGENGIM & al. 1988, 1989).

Thus, the localities Berislav, Tiaginka, Yurievka, Staraya Kubanka, and Eldari are correlated with the second half of the Khersonian. All localities are associated with the regressive stage of the development of the Sarmatian basin. At present, we cannot precisely establish the relative stratigraphic position of these localities and therefore place them at the same stratigraphic level.

The Poksheshty locality belongs to this group, judging by its mammalian fauna. The site is associated with terrestrial deposits of the Balta suite superposed on the marine Middle Sarmatian. The bone-bearing bed is normally magnetized (Fig. 4) and correlated with Chron 9 (PEVZNER & al. 1987).

We refer the Kajnary site to the very end of the Khersonian. The locality contains reversely magnetized sediments with shells of Late Sarmatian molluscs. On the basis of the magnetic polarity of the sediments, the locality can be referred either to the beginning (late Chron 10) or the end (early Chron 8) of the Khersonian, as reversed magnetization is characteristic only for these Late Sarmatian intervals. However, if we consider the regressive structure of the section, its formation at the end of the Khersonian can be inferred. The site is younger than the upper boundary of Chron 9, but older than the normal polarity event of Chron 8. The locality Raspopeny is referred to the same stratigraphic level. It is in continental deposits of the Balta suite. The fossiliferous bed is reversely magnetized (Fig. 4). Its correlation with the end of the Sarmatian can be inferred by the presence of one of the latest representatives of the (sub)genus *Acbtiaria* (see below).

Table 2 continued.

	Gritsev	Klimentovichi	Buzhor-1	Lapushna	Kalfa	Buzhor-2	Varnitsa	Zheltokamenka	Sevastopol
	1	2	3 ₁	4	5	3 ₂	6	7	8
<i>Chalicotherium</i> sp.	+								
<i>Aceratherium simorreense orientalis</i> Lungu			+		+	+		sp.	
<i>Dicerorhinus</i> sp.					+		+		
<i>Chilotherium zernovi</i> Boriss.							+		+
<i>Microstonyx antiquus</i> (Kaup.)					+				
<i>Schizochocerus vallesiensis</i> Crus. et Lavoc.					+				
<i>Lagomeryx flerovi</i> Lungu	+	+	+	+	+	+	+		+
<i>Euprox</i> aff. <i>furcatus</i> (Hens.)	sp.	sp.	+		+	+			
<i>Achtiaria expectans</i> Boriss.				+			+	+	+
<i>A.</i> sp.				+					
<i>Tragocerinae</i> gen.?			+						
<i>Miotragocerus pannoniae</i> (Kretz.)			+		+				
<i>M.</i> aut <i>Protragocerus leskevitschi</i> (Boriss.)							+	sp.	+
<i>M. borissiaci</i> Korotk.									+
<i>Moldoredunca amalthea</i> Lungu							+		
Reduncini gen.?									
<i>Hippotraginae</i> gen.?	+								

Fossil mammalian faunas

Faunal lists (Tables 2 & 3) of the localities considered here are according to LUNGU (1990), PEVNER & al. (1987), KOROTKEVICH (1988), SEMENOV (1989), and VANGENGEIM & al. (1988).

The fauna of the Bessarabian substage (Table 2) is characterized by the presence of *Progonomys cathalai*, *Machairodus* ex gr. *aphanistus*, *Hipparion* ex gr. *primigenium*, *Achtiaria expectans*, *Microstonyx antiquus*. The end of the stage is marked by an apparent ecological differentiation of the hipparions with two forms of the genus occurring in some localities. In addition, several Astaracian relics are present, e.g. *Amphilagrus*, *Crusafontina*, *Proctictitherium*, *Aceratherium* (*Alicornops*), *Euprox*, *Lagomeryx* (particularly numerous). The locality Zheltokamenka has yielded a proximal phalanx of *Anchitherium*, but its rolled state of preservation leaves open the question whether this genus is actually present in the Beassarabian fauna.

The fauna of the Bessarabian is very close to the Early Vallesian faunas of Western Europe and is referred here to zone MN9.

The Khersonian fauna (Table 3) contains considerably less Astaracian elements than the Bessarabian one. Noteworthy is the adaptive radiation of the (sub)genus *Achtiaria*, which was later replaced by the (sub)genus *Palaeotragus*. Late members of *Achtiaria* are distinguished by a high degree of specialization (GODINA 1979). A characteristic peculiarity of the fauna is the abundance of chiloteres, which sometimes reach a subdominant level. *Adcrocuta* and a number of open landscape forms, such as *Gazella*, *Procapra*, and *Graecoryx*, appear. A very

Table 3 List of Khersonian mammals.

	Rasopeny	Poksheshty	Kajmary	St. Kubanka	Krivoj Rog	Yurievka	Tiaginka	Berislav	Eldari
	9	10	11	12	13	14	15	16	17
<i>Anurosores kormosi</i> Bachm. et Wils.			+						
<i>Petenya dubia</i> Bachm. et Wils.			+						
<i>Proochotona kalfina</i> Lungu			+						
<i>P. sp.</i>	+	+	+						
<i>Alilepus sp.</i>			+						
<i>Monosaulax kainarensis</i> Lungu			+						
<i>Myomimus dehmi</i> (Bruijn)			+						
<i>Sarmatosminthus kainarensis</i> Lungu			+						
<i>Progonomys woelferi</i> Bachm. et Wils.			+						
<i>Parapodemus lugdunensis</i> Schaub			+						
<i>Kowalskia cf. fablbuschi</i> Bachm. et Wils.			+						
<i>K. sp.</i>			+						
<i>Plesiogulo aff. brachygnathus</i> (Schloss.)			+						
<i>Promeles sp.</i>			+						
<i>Parataxidea sp.</i>				+					
<i>Ictitheriini</i>									+
<i>Percrocuta gigantea</i> (Schloss.)			+						+
<i>P. sp.</i>			+						
<i>Machairodus sp.</i>			+		+				
<i>Metailurus sp.</i>			+						
<i>Deinotherium giganteum</i> Kaup	+				+			sp.	+
<i>Turicius turicensis</i> (Schin.)					+				
<i>Tetralophodon longirostris</i> Kaup			+						+
<i>Choerolophodon pentelici</i> (Gaud. et Lart.)								+	+
<i>Hipparion cf. verae</i> Gab.			cf.			+	+	+	
<i>H. giganteum</i> Grom.	cf.	cf.		+					
<i>H. eldaricum</i> Gab.									+
<i>H. sp.</i>			+						+
<i>Chilotherium eldaricum</i> Zisk.									+
<i>Ch. aff. zernovi</i> (Boriss.)									+
<i>Ch. kowalevskii</i> (Pavl.)	+	+							
<i>Ch. sarmaticum</i> Korotk.							+	+	
<i>Ch. schlosseri</i> (Weber)				+					
<i>Ch. sp.</i>					+				
<i>Diceros gabuniai</i> Zisk.									+
<i>Microstonyx antiquus</i> (Kaup)								cf.	+
<i>M. sp.</i>	+								
<i>Euprox sarmaticum</i> Korot.					+				
<i>Cervavitus sp.</i>	+	+							
<i>Procapreolus ukrainicus</i> Korot.									+
<i>Achtiaria berislavicus</i> Korot.			+					+	
<i>A. moldavicus</i> Godina	+								
<i>A. borissiaki</i> Alex.									+
<i>Samotherium sp.</i>				+			+	+	
<i>Miotragocerus leskevitschi</i> (Boriss.)			+						
<i>Mirabilocerus eldaricus</i> (Gabaschv.)									+
<i>Protragelaphus sp.</i>				+					
<i>Gazella gracile</i> Korot.	+	+						+	+
<i>Graecoryx cf. valenciennesi</i> (Gaud.)								+	+
<i>Procrapra capricornis</i> (Wagn.)				+		+		cf.	

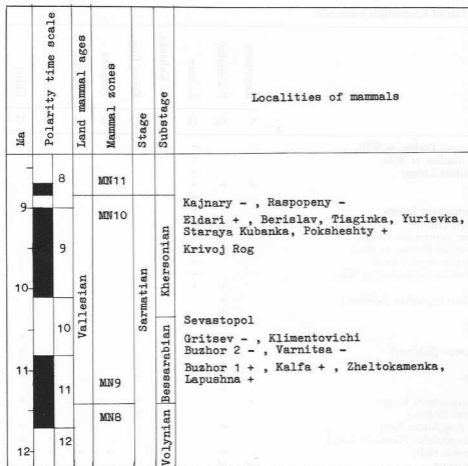


Fig. 6. The position of mammalian localities in the magnetostratigraphic scale of the Eastern Paratethys.

characteristic association of the two hipparions *H. verae* and *H. giganteum* probably survived into the Meotian.

Unfortunately, there are very few small-mammal localities. Therefore, the Kajnary locality is particularly interesting. Its fauna resembles closely that of Kohfidisch in Austria. The latter is referred to the terminal Vallesian (MEIN 1990). *Progonomys woelferi* and *Parapodemus lugdunensis* are present both at Kohfidisch and Kajnary. We refer all the Khersonian localities considered here to the Late Vallesian (MN10).

Conclusion

On the basis of the geologic position of the bone-bearing beds in sections of marine deposits of the Late and Middle Sarmatian, in combination with paleogeographic and magnetic polarity data, the sequence of reference fossil mammalian localities and their position within substages

of the Eastern Paratethys stratigraphic scale and within the magnetic polarity time scale have been established (Fig. 6).

The Bessarabian localities were deposited in the second half of polarity Chron 11 and first half of Chron 10. The fauna of these localities corresponds to that of the Early Vallesian (MN9).

The mammalian localities of the Khersonian were formed during the second half of Chron 9 and beginning of Chron 8. The fauna is correlated with that of the Late Vallesian (MN10).

The lower boundary of the Vallesian is close to that of the Bessarabian. However, a more accurate definition of its position requires further studies. The MN9/MN10 boundary seems to be not older than the boundary between the Bessarabian and Khersonian. We cannot determine its precise position, as there are no localities from the first half of the Khersonian in the studied region. The upper boundary of the Vallesian nearly coincides with the boundary between the Sarmatian and the Meotian.

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