

Evolution of the biosphere

## Chronological Relationship of Pliocene Deposits in Fluvial Plains between the Prut and Southern Bug Rivers

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**Abstract** – Deposits of three Pliocene fluvial plains between the Prut and South Bug rivers were studied in order to reconsider their disputed age determinations and chronological relations. Different ages of these deposits have been established, and their correlation with the Eastern Paratethys stratigraphic scale and magnetochronologic and stratigraphic scales of West European continental deposits have been established. The oldest deposits of the Stol'nicheny Formation are dated as the early Kimmerian (magnetic Chron 5). On a continental scale, they are close to the boundary between the Turolian and Ruscinian. The Kuchurgan Gravel is dated as the terminal early and middle Kimmerian (middle part of the Gilbert Chron) and also as the terminal early Ruscinian (MN zone 14). The Karboliya Beds correspond to the late Kimmerian (the end of Gilbert Chron) and to the late Ruscinian (MN zone 15).

Neogene continental deposits are widespread in the area between the Prut, Dniestr, and South Bug rivers. Their formation was initiated at the end of the middle Sarmatian. At that time, the sea regressed from the Galician Bay far to the south and left a wide depression covered with marine sandy and clayey deposits of the middle Sarmatian. As the marine basin regressed the original fluvial plain gradually progressed to the south. In the middle Pontian, this plain covered the entire territory of Moldova and southwestern Ukraine. Its deposits were composed of cyclic gravel, sandy, and clayey sediments of fluvial, lacustrine, and deltaic origin. This continental sequence is subdivided into two major parts: the Miocene (Balta Formation) and Pliocene. Deposits of older fluvial plains, containing "Carpathian pebbles" (jaspers, silified argillites, and others) and alluvium from the higher terraces of the Prut, Dniester, and Danube rivers are referred to the Pliocene (Khubka, 1981; Bukatchuk *et al.*, 1983).

Deposits of Pliocene fluvial plains are preserved on the most elevated watershed areas. Only in the south of the Prut region are they submerged below the sea level. There are three fields of old fluvial deposit occurrences (Fig. 1). These are areas between the South Bug and Dniester rivers ("Kuchurgan Gravel"), between the Dniester and Prut rivers (Stol'nicheny sequence), and between the Prut, Danube, and Yalpug rivers, where deposits bear mammals of the "Moldavian Roussellion" (Bilinkis, 1987). The latter have been named differently by different authors as the lower Porat Alluvium (Konstantinova, 1967), the Karboliya

Beds (Roshka and Khubka, 1964), etc. Here, we use the term "Karboliya Beds". Old fluvial deposits have been studied to varying extents. The Stol'nicheny Alluvium is so far the least known. There are different opinions concerning the chronological relationships of the above three sequences as well as their correlation with the regional stages of the Eastern Paratethys and the continental zonation scale of P. Mein (1990).

Stratigraphic relations between the Kuchurgan Alluvium and the Karboliya Beds are interpreted in two different ways. First, the Kuchurgan deposits are assumed to be older than the Karboliya Beds (Schevtschenko, 1965; Konstantinova, 1967; Korotkevich, 1988; Topachevskii, and Nesin, 1989). According to the second viewpoint, these deposits are synchronous (Lungershausen, 1938; Chepalyga, 1967; Khubka, 1982; Gabuniya *et al.*, 1986; Bukatchuk, 1986; Bilinkis, 1987; and others).

The Stol'nicheny deposits are considered either older than the Kuchurgan deposits and Karboliya Beds (Gabuniya *et al.*, 1986; Khubka, 1987) or synchronous with them (Bilinkis, 1987).

The goal of the present study is to refine the stratigraphic position of the three sequences under consideration.

### KUCHURGAN ALLUVIUM

We studied Kuchurgan deposits in the right bank of the Kuchurgan River valley in the natural outcrops and in the quarries near the villages of Novaya Andria-

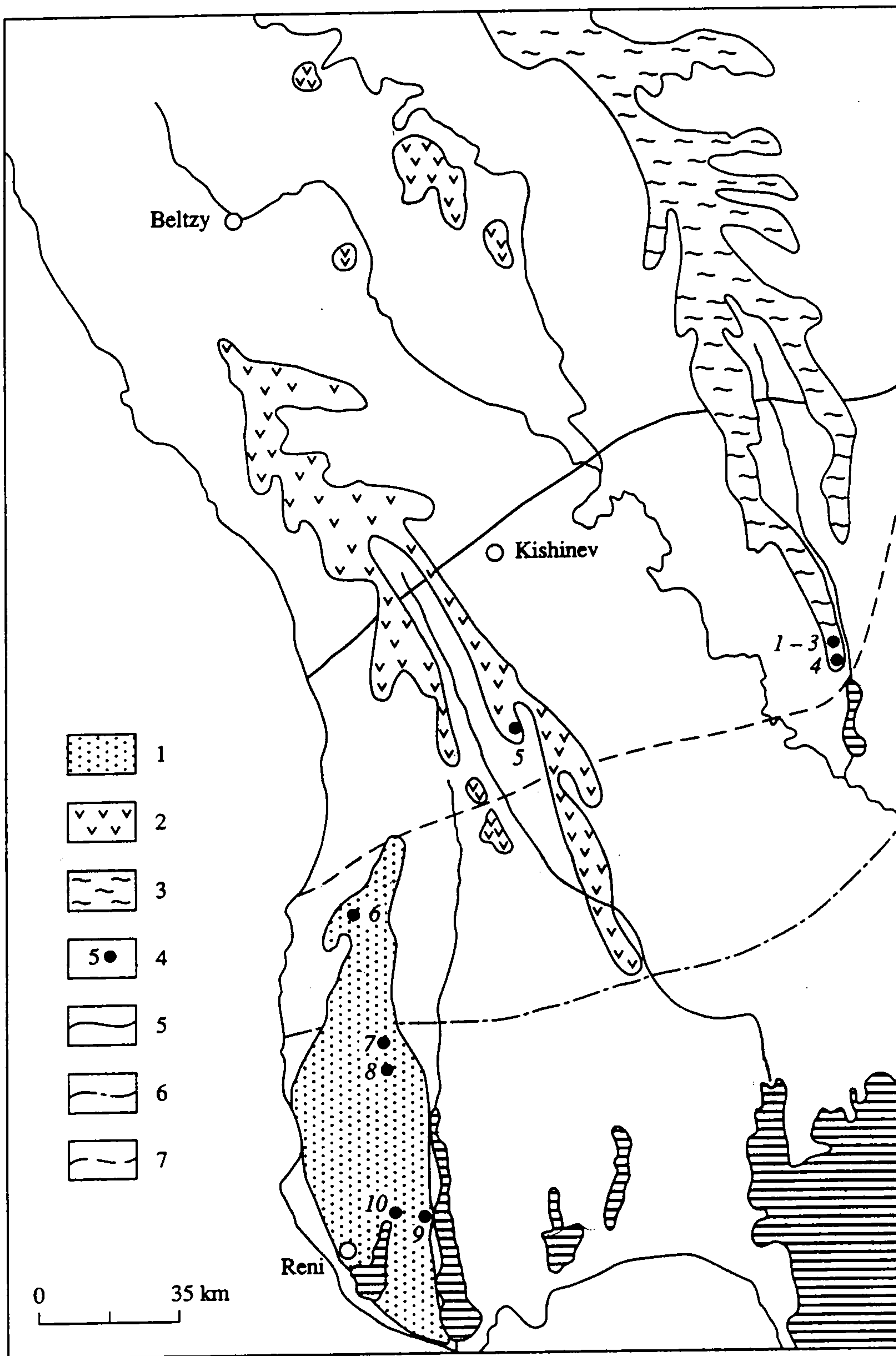


Fig. 1. Distribution of deposits of Pliocene fluvial plains between the Prut and South Bug rivers.

1 - Karboliya Beds, 2 - Stol'nicheny Alluvium, 3 - "Kuchurgan Gravel", 4 - Localities of fossil mammals: 1 - Grebeniki, 2 - Nikol'skoe, 3 - Uytunoe, 4 - Novaya Andriashivka, 5 - Mugureny, 6 - Lucheshty, 7 - Budei, 8 - Musait, 9 - Kotlovina, 10 - Novaya Etuliya.

Inferred coastlines for: 5 - Late Sarmatian Sea, 6 - Meotic Sea, 7 - Early Pontian Sea.

Distribution of fluvial formations after Bilinkis (1987).

shevka, Uyutnoe (Konstantinovka), Slavyano-Serb-skaya, Velikaya Ploskaya, Anastasievka, Novopetrovka (the stratotype of the Kuchurgan faunal assemblage), and Stoyanovo, and also in quarries near the villages of Savchenskoe, Voinichevo, and Ivanovka on the left bank of the Kuchurgan Valley.

In all the sites mentioned, the Kuchurgan deposits overlie various horizons of the Balta Formation. They have a thickness of 10 to 15 meters and are represented by medium- to fine-grained sands with common lenses of gravel and pebbles of Carpathian origin and rare clay lenses. The deposits often yield remains of larger and smaller mammals and rare shells of freshwater mollusks.

Small mammal remains were collected in quarries near the villages of Novaya Andriashevka and Grebe-

niki. They were also collected in smaller amounts in quarries near the villages of Nikol'skoe and Uyutnoe (Konstantinovka) (the table).

*Grebeniki 2.* The sand quarry of this locality is on the right bank of the Kuchurgan Valley, Grebeniki village (Odessa region), two km from the center of the village of Grebeniki near a cattle-breeding farm. The Kuchurgan Alluvium consists of medium-grained sands and gravels. They occur above the fine-grained clayey sands of the Balta Formation. The exposed thickness is up to 14 meters. The quarry bottom is almost at the top level of the Balta deposits. However, the contact between the Kuchurgan and Balta deposits has not been observed. Mammal remains were collected from a meter-thick lens of poorly sorted gravel, one or two meters above the quarry's bottom.

List of small mammals from the studied localities

List of forms	Mugureny	N. Andriashevka	Grebeniki 2	Nikol'skoe	Uyutnoe	Musait 7	Budei	List of forms	Mugureny	N. Andriashevka	Grebeniki 2	Nikol'skoe	Uyutnoe	Musait 7	Budei
<b>RODENTIA</b>								<i>Tamini indet.</i>		2	3				
<i>Promimomys</i> sp. 1	1							<i>Pliopetaurista</i> sp.	3	6	1				2
<i>Promimomys</i> sp. 2		1						<i>Blackia polonica</i> Mein		2					
<i>Promimomys insuliferus</i> (Kowalski)		45						<i>Miomimus</i> sp.		2					
<i>Promimomys moldavicus</i> (Kormos)			20	2	1		31	<i>Glis minor</i> Kowalski		1					
<i>Promimomys</i> sp. n.						12		<i>Eliomys</i> cf. <i>intermedius</i> Friant						1	2
<i>Promimomys</i> ex gr. <i>occitanus</i> (Thaler)							2	<i>Castor</i> ex gr. <i>fiber</i> L.					1		1
<i>Trilophomys</i> sp.						1		<i>Trogontherium</i> cf. <i>minus</i> Newton	3	1	4	4			
<i>Epimeriones</i> sp.			1					<b>LAGOMORPHA</b>							
<i>Pseudomeriones</i> sp.		1						<i>Ochotona antiqua</i> (Argiropulo et Pidoplitshka)	1	60	65	5	2	1	9
<i>Kowalskia polonica</i> Fahlbusch		6	1					<i>Ochotona</i> cf. <i>eximia</i> Chomenko		16	8	1	1		4
<i>Kowalskia</i> cf. <i>magna</i> Fahlbusch		5						<i>Pliolagomys</i> cf. <i>gigas</i> (Argiropulo et Pidoplitshka)						2	
<i>Kowalskia</i> sp.	1							<i>Prolagus</i> cf. <i>michauxi</i> Lopez	1	3	8				
" <i>Cricetus</i> " aff. <i>kormosi</i> Schaub		12	7					Leporidae indet.							1
" <i>Cricetus</i> " sp. (large form)							7	<i>Alilepus</i> sp.		1			1		
<i>Odessamys simionescui</i> (Kormos)						1	27	<i>Trischizolagus dumitrescuae</i> Radulesku et Samson		4	12	4	1		2
<i>Prospalax</i> sp.	4	8	3				1	<i>Hypolagus</i> sp.	2						
<i>Nannospalax macovei</i> (Kormos)	5	25	13	1	3	4	47	<b>INSECTIVORA</b>							
<i>Occitanomys adroveri</i> (Thaler)		10						Soricidae indet.	1		7	1			5
<i>Occitanomys</i> sp.							1	Blarini indet.		2					
<i>Apodemus</i> cf. <i>dominans</i> Kretzoi		5	1			4	1	Soriculini indet.		2					
<i>Apodemus</i> sp. 1		2	2					<i>Amblicoptus</i> sp.	1	2					
<i>Apodemus</i> sp. 2		8						<i>Talpa</i> sp.	4	2	2			2	
Muridae indet.	1							<b>Total</b>	28	233	158	18	10	28	143

*Novaya Andriashevka.* The old, weedy quarry on the right bank of the Kuchurgan Valley is situated between the villages of Frunze and Pervomaisk, 0.5 km south of the steep road from the plateau to the village of Novaya Andriashevka. Here, there is an exposure of fine- and medium-grained quartz sands (4 or 5 meters thick) with gravel lenses. Remains of small mammals were collected from the gravel lens in the section's middle part.

*Nikol'skoe.* The sand quarry in the eastern outskirts of the village of Nikol'skoe exposes the Kuchurgan Alluvium consisting of fine- to medium-grained quartz sands with rare gravel lenses. The exposed thickness is 5 to 6 meters. There is no visible contact with underlying deposits of the Balta Formation. In a ravine situated south of the quarry, the Balta sands rest on upper Sarmatian deposits with marine molluscan fauna. Mammal remains were collected from a gravel lens two meters above the bottom of the quarry.

*Uyutnoe (Konstantinovka).* The sand quarry of the village of Uyutnoe is situated two kilometers south of the Nikol'skoe Village quarry, between the villages of Uyutnoe and Konstantinovka on the plateau surface. There is an outcrop about 3 meters thick of medium- to coarse-grained sands with pebble and gravel lenses. Mammal remains were collected in the middle part of the exposure. The pelvic bone of a mastodon was also found here.

#### STOL'NICHENY ALLUVIUM

Comprehensive descriptions of these deposits have been presented by Khubka (1982) and Bukatchuk (1985).

We inspected fluvial deposits of the Stol'nichehy Formation together with Moldavian geologists P.B. Bukatchuk, I.V. Blyuk, P.E. Guivan, and A.N. Lungu in a number of outcrops and quarries in the middle and central parts of the distribution area. The exposures are situated near the villages of Viveritsa, Leordoe, Pitushka, Gaureny, Kabaeshty, Selishte, Stol'nichehy, Zloti railway station, Novye Kirkaeshty, Sagaidak, Mugureny (Surik), and Troitskoe. The deposits are mainly composed of fine- to medium-grained quartz sands with lenses of clays, silts, gravel, and pebbles containing Carpathian material. The Stol'nichehy Alluvium occurs above various horizons of the Balta Formation. It overlies marine deposits of the lower Pontian only in the south. Its maximum thickness is to 40 - 50 m (Bukatchuk, 1985).

Bukatchuk (1985) distinguished several levels composed of the Stol'nichehy Alluvium that represent heterochronous (within the Kimmerian regional stage) terraces of the paleo-Prut and paleo-Dniester rivers. Bilinkis (Bukatchuk *et al.*, 1983) considers all these deposits as synchronous but "displaced to various hypsometric levels by Pleistocene neotectonic movements" (p. 39).

Mammal remains are extremely scarce in the Stol'nichehy Formation. This is a problem when trying to resolve different viewpoints concerning the age of its various parts that occur at different hypsometric levels.

We were able to collect some materials representing small mammal remains from the Mugureny sequence (the table) located in an old but sometimes used sand quarry on the right bank of the Skunosa River, which is the left tributary of the Kogil'nik River between the villages of Mugureny (Surik) and Sagaidak. The observed thickness of the deposits is 5 - 6 m. Mammal remains were collected in a gravel lens in the middle part of the section.

#### KARBOLIYA BEDS

The history of the research, occurrence conditions, lithology, and faunal characteristics (freshwater mollusks and mammals) of the Karboliya Beds have been thoroughly discussed (Khubka, 1982, 1987; Bilinkis *et al.*, 1987). Thus, we will be brief in our description of these deposits.

The Karboliya Beds rest on red weathering crust that developed after sandy and clayey deposits of the lower Pontian. In some places the weathering crust is eroded, and the Karboliya Beds rest directly upon the Pontian deposits. All the sequences dip southwest. For example, near the village of Tatareshty, the top of the Pontian has an absolute elevation of +158 - 160 m, but +140 m near the village of Lucheshty, +80 - 85 m in the vicinity of the village of Musait (Bilinkis, 1987), and -20 m near the village of Etuliya (Khubka *et al.*, 1983).

We observed the Karboliya Beds overlying the Pontian weathering crust near the villages of Dermenzhi (16th km of the Chumai-Tatareshty road), Budei (11th and 13th km), and Musait (5th to 6th km).

In the north, the Karboliya Beds are overlain by younger loesslike deposits or by red and brown buried soils of different age. In the south, they are overlain by younger deposits of fluvial plains containing shells of sculptured Unionidae (the upper Poratian, according to Konstantinova and Poratian after Khubka) or by fluvial deposits of Pliocene and Quaternary terraces of the Prut and Danube rivers. The maximum thickness of the Karboliya Beds is 60 m in the north and 110 m in the south (Valeny Village) (Khubka, 1982).

The Karboliya Beds represent constrictive alluvium, sometimes including lacustrine facies. Up to eight alluvial cycles are recognized within them (Khubka, 1982, 1987 and others).

In sequences situated along the Bol'shaya Salcha Valley, the Karboliya Beds can be subdivided into two parts. The lower one predominantly includes horizontally stratified sandy and clayey deposits with rare layers of gravels mainly consisting of clayey pebbles and carbonate concretions. The upper part is substantially sandy and cross-bedded with a large number of layers and lenses of pebbles and gravels containing a considerable amount of Carpathian material. Some studies have used fluvial cycles to correlate distant sections. This practice is incorrect because a number of cycles can vary even in different walls of the same ravine.

Freshwater mollusks are rare in these deposits but evenly distributed throughout the sequence. Shells of the following smooth and plicated Unionidae have been found here (Khubka, 1987): *Potomidae saratae* (Teiss.), *P. pannonica* (Neum.), *P. sibirica* Pen., *P. stoliczkai* (Neum.), *P. sanderbergeri* (Neum.), *P. bogatscheevi* (Gr.-Beres.), *Eulimnium sturzae* (Cob.), and *Plicatibathia flabelliformis* (Mikh.) This fauna enabled Andreescu (1975), Khubka (1987), and other scientists to correlate the Karboliya Beds with deposits of the lower Romanian (the *Viviparus bifarcinatus* Zone NSM<sub>10</sub>) occurring on the right bank of the Prut River and in the Dacian basin.

Mammal remains occur throughout the sequence, though the main finds are from the upper part.

We studied the Karboliya Beds along the valley of the Bol'shaya Salcha River. The deposits are exposed in a number of ravines along the right bank of the valley, between the villages of Vinogradovka (Vulkaneshty district) and Tatareshty (Kagul district) of Moldova. Mainly small mammal remains were collected near the villages of Budei and Musait.

**Budei.** The studied ravine is located on the right bank of the Bol'shaya Salcha Valley near the northern outskirts of the village of Budei. The road leading from Chumai to Tatareshty crosses it at the 13th km. Here, the lower Pontian deposits have a visible thickness of about 50 m. Above these deposits, there is a 3-m-thick red weathering crust. The lower sequence of the Karboliya Beds occurs above the weathering crust. It is represented by white and light yellow fine-grained quartz sands with rare gravel lenses. They have a visible thickness of 17 - 18 m. The upper part of the section is covered with talus. Small mammal remains were collected in gravel lenses located 1.5 to 5 m above the base of the Karboliya Beds.

In a similar geological setting fauna of small mammals was discovered by Alexandrova (Sadchikova *et al.*, 1986) in the southern outskirts of the village of Musait at the 5th km of the Chumai - Tataresty road (Musait 5).

**Musait 7.** The right bank of the Bol'shaya Salcha valley near the village of Musait is dissected by a complex ramifying system of ravines. In the center of the village at the 7th km of the road there is a junction of three major ravines.

The Karboliya Beds are represented here more completely than in sections near Budei and in the southern outskirts of the village of Musait (5th and 6th km of the road). The deposits rest here upon an eroded surface of the lower Pontian and are overlain by red and brown paleosols. The thickest sequence of the Karboliya Beds is exposed to the right of the above-mentioned ravines. The lower member is 25 - 30 meters thick, and the upper one has a thickness of 15 - 17 meters. In places, they are divided by eroded red and brown buried soil. Remains of small mammals were collected in a gravel lens in the middle part of the upper member, 10 m below the top of the Karboliya Beds.

## PALEONTOLOGICAL MATERIALS

A list of forms from the studied localities is given in the table.

In order to solve stratigraphic problems, most of our attention was paid to the study of voles. Most important in estimating the evolutionary advantages of Arvicoline species are the following features: differentiation of the anterior part of M<sub>1</sub> and posterior part of M<sub>3</sub>, degree of development of the enamel islets, number of molar roots, and the degree of hypsodonty quantitatively correlated with the height of dentine tracts.

Collections from Musait 5 and Lucheshty VII of Alexandrova (1989), from Etuliya of Shushpanov (1985), and from Kotlovina (lower beds) of Topachevsky and Nesin (1989) were studied for comparison.<sup>1</sup> We also used the material collected in the lower Pontian deposits of the Vinogradovka locality, the Bolgrad district, and the Odessa region (collection GIN No. 1093).

Below, we present a description of voles from the localities studied.

**Mugureny.** The single first lower molar (M<sub>1</sub>) of *Promimomys* sp. (Fig. 2, 1) from this site is a rather worn tooth that had already lost an enamel islet and has extremely low dentine tracts.<sup>2</sup> The sum of three tracts (C), namely the outer tract of the anteroconid and the outer and inner tracts of the posterior lobe is equal to 0.23 mm. Thus, the hypsodonty degree of the form is more advanced than that of *Promimomys* sp. from the Vinogradovka locality (C = 0.1 mm).

**Novaya Andriashévka.** The *Promimomys insuliferus* (Kow.) (Fig. 2, 2) from this locality is distinctly more evolved than the Mugureny form. The two forms are apparently separated by a considerable time interval. The sum of the tracts in the first lower molar ranges here from 0.52 to 0.7 mm ( $n = 5$ ), with a mean value of 0.62 mm versus 0.23 mm measured in the case of the vole from Mugureny. This form has a somewhat more differentiated M<sub>1</sub> anterior part than the type forms from Podlesice in Poland and the southern Russia localities of Antipovka and Chugunovka (Agadjanian and Kowalski, 1978). This may indicate the slightly younger age of the former.

It is important to note that, apart from quite numerous remains of *P. insuliferus*, a single M<sub>3</sub> of a larger vole was encountered in the locality. The dimensions of the tooth lie beyond the variation range corresponding to teeth of *P. insuliferus*, and the dentine tracts are also very low.

**Grebeniki 2.** Two forms of voles were found here. The smaller one, *Promimomys* sp., is comparable in size to *P. insuliferus*, but unfortunately its remains are very

<sup>1</sup> We mean the bone-bearing bed from the seventh fluvial cycle of the Lucheshty section, according to Alexandrova (1989).

<sup>2</sup> Height of dentine tracts was measured from the conventional line drawn at the crown base normal to the long axes of the synclinal folds through the lowermost point of the enamel in the posterior external synclinal fold.

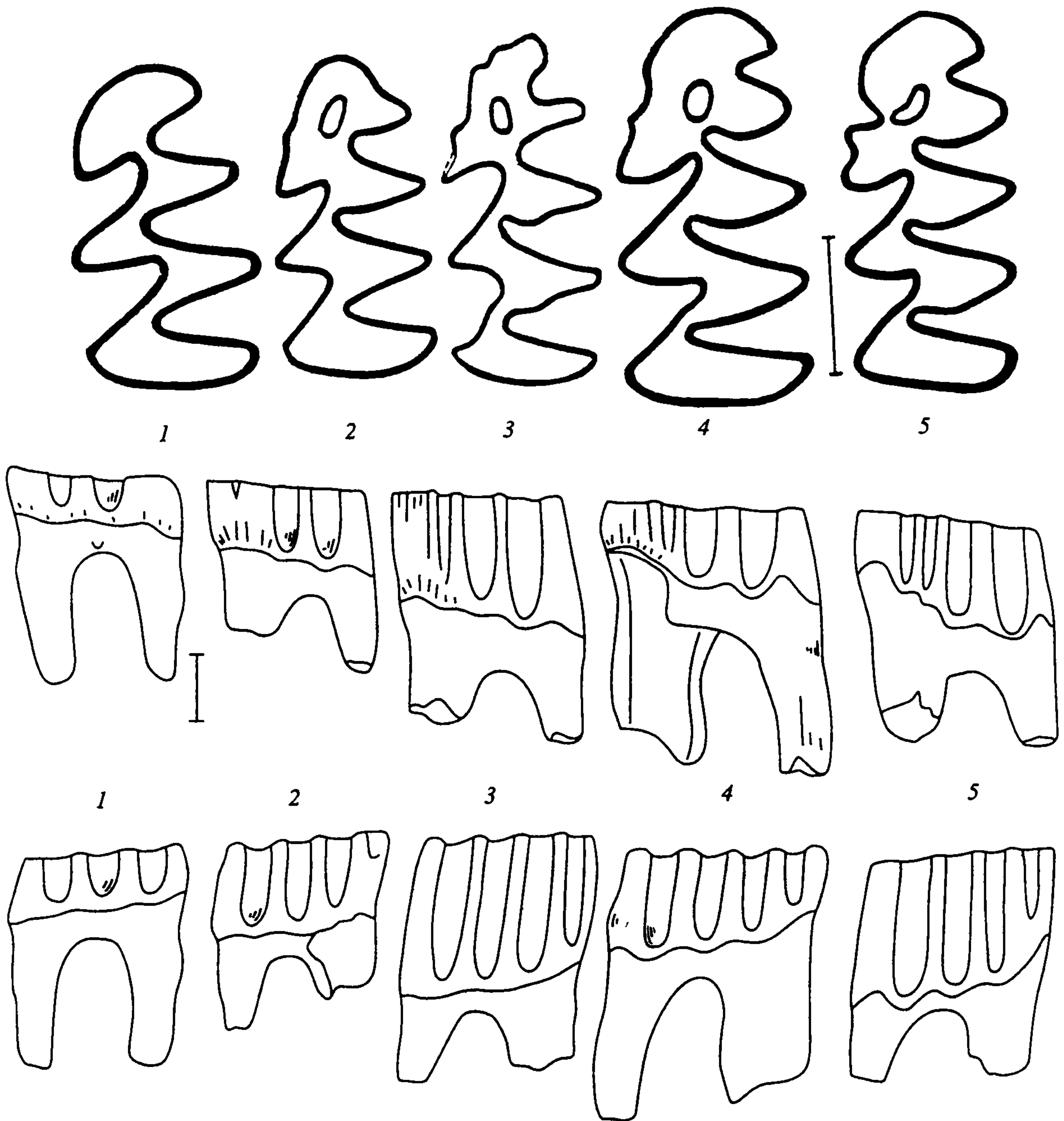


Fig. 2. Arvicolid molars of the *Promimomys* genus.

(1) *Promimomys* sp., Mugureny; (2) *P. insuliferus*, Novaya Andriashevka; (3) *P. moldavicus*, Grebeniki 2; (4) *P. moldavicus*, Budei; (5) *P. sp. nov.*, Lucheshty VII. Upper row – occlusial surface, middle row – external view, lower row – internal view. Scale bars – 1 mm.

fragmentary. The form is slightly more hypsodont than the species from Novaya Andriashevka. The other, larger vole, *Promimomys moldavicus* (Kormos) (Fig. 2, 3), already has a well differentiated  $M_1$  anterior part; however, its tracts are still low ( $C = 0.7, 1.0, 1.2$ ). This form is most similar to *P. moldavicus* from the Romanian locality Malusteny. Voles from Nikol'skoe and Uyutnoe represent the same stage of evolution.

**Budei.** Material from this locality contains remains of two Arvicolines. *Promimomys moldavicus* is smaller

(Fig. 2, 4). It is somewhat more hypsodont ( $C = 1.2, 1.3$ ) than *P. moldavicus* from Grebeniki 2 and more similar to forms from the Ptolemais 3 locality in Greece (van de Weerd, 1979; Fejfar *et al.*, 1990) and the Calta locality in Turkey (Sen, 1977). A similar form was described by Alexandrova (1986) from the Musait 5 locality. Remains of the larger vole are fragmentary. They are arbitrarily attributed to *P. ex gr. occitanus*.

**Musait 7.** The locality yielded remains of *Promimomys* sp. nov. (Fig. 2, 5). It is more hypsodont than

the Budei form and is identical to voles from the lower and middle fossiliferous beds of the Etuliya locality (Shushpanov, 1985), lower beds of Kotlovina (Topachevsky and Nesin, 1989), and Lucheshty VII (Alexandrova, 1989). The sum of the  $M_1$  tracts varies from 1.5 to 2.1 mm. In its level of evolution, the form is very close to voles from the Weze locality in Poland (Sulimski, 1964), Czarnota 2 in Hungary (Kretzoi, 1962), and Orrios 3, 7 in Spain (Fejfar *et al.*, 1990).

### COMMENTS ON SYSTEMATICS

In the last few years, it has been suggested that the boundary between the early and late Ruscinian be placed at the replacement level of *Promimomys moldavicus* (Scm.) by *Mimomys davakosi* van de Weerd (Fejfar and Heinrich, 1990). It was believed that these forms constitute a phyletic line. Radulescu and Samson (Radulescu *et al.*, 1989) consider them to be identical, with *Mimomys davakosi* being a synonym of *Promimomys moldavicus*.

In our opinion, the type materials on both species as well as the *Mimomys occitanus* Thaler are members of the same *Promimomys* genus of brachiodont rooted voles with an anterior enamel islet in  $M_3$ . Moreover, the discrimination of *P. moldavicus* from *P. davakosi* is questionable and requires specific evidence. At the moment, it is impossible to compare both forms in detail. In spite of adequate revisions (Radulescu *et al.*, 1989; Fejfar *et al.*, 1990), different measuring systems and inevitable size distortions in published illustrations make it difficult to compare dentine tract heights. Nevertheless, the structure of the  $M_1$  anteroconid confirms that "*Mimomys*" *davakosi* is more advanced than *Promimomys moldavicus*. At the same time, the heights of the dentine tracts in  $M_1$  of *M. davakosi* (van de Weerd, 1979; Fejfar *et al.*, 1990) and *P. moldavicus* (Radulescu and Samson, 1989) range from 0.8 to 1.2 mm. These values are close to those of *P. moldavicus* from Grebeniki 2. Thus, we are faced with the difficulty of discriminating *P. moldavicus* from *P. davakosi*. It is possible that they are conspecific. The most recent species in the *P. moldavicus* phylogeny is the form from the Musait 7, Luchesty VII, Etuliya (lower and middle beds), and Kotlovina (lower beds) localities. This form may warrant a separate specific name.

Summarizing the available data on voles from the considered sites, we may conclude that they represent sequential evolutionary stages as follows: primitive *Promimomys* sp. from Mugureny; *P. insuliferus* from Novaya Andriashevka; *P. moldavicus* from Grebeniki 2; slightly more advanced *P. moldavicus* from Musait 5 and Budei; *P. sp. nov.* from Luchesty VII, Etuliya (lower and middle beds), Kotlovina (lower bed), and Musait 5. A vole from the lower Pontian site Vinogradovka precedes all these forms.

Noteworthy is the presence of a second *Promimomys* form along with *P. insuliferus* already at the

level of Novaya Andriashevka. Likewise, *P. ex gr occitanus* occurs together with *P. moldavicus* in the Budei locality. This indicates the existence of several Arvicoline lines starting at a rather early stage in the group's history.

### FAUNAL ASSEMBLAGES OF SMALL MAMMALS

Faunal groups accompanying various *Promimomys* forms undergo certain changes through time, in both quantitative ratios of different groups and the appearance or disappearance of certain species and even genera.

The quantitative relations between small mammals from the Mugureny locality is difficult to evaluate because of limited material. Most remains belong to mole rats, while other forms are almost equally represented. Noteworthy is the presence of the *Kowalskia* genus among them.

The diverse fauna of Novaya Andriashevka includes 26 species of 22 genera and 12 families. As noted, according to the evolutionary state of *Promimomys*, this fauna is separated from the Mugureny assemblage by a long time interval. At this stratigraphic level, the dominating *Ochotona* genus (34%) deserves attention. The second in abundance is the *Promimomys* genus (19%), and the amount of mole rats is significant (14%). Among hamsters, there are *Pseudomeriones* forms and two species of *Kowalskia*. Fauna of Muridae (10%) are represented by at least four species, including *Occitanomys adroveri*.

Faunas of Grebeniki 2, Nikol'skoe, and Uyutnoe with *Promimomys moldavicus* are similar to the fauna of Novaya Andriashevka in taxonomic composition but somewhat less diverse. The presence of *Epimeriones* is noted. These faunas are also similar to each other in quantitative proportions of species, though, in Grebeniki 2, Nikol'skoe, and Uyutnoe, the amount of pikas is higher (51%), but the abundance and diversity of Muridae is lower (6% and only two species, respectively).

Faunas of Budei and Musait 5 substantially differ from preceding assemblages in quantitative proportions of forms. Pikas cease to be dominant (9%), being replaced by mole rats *Nannospalax macovei* (33%) and voles *Promimomys* (23%). There are also some differences in taxonomic composition: remains of *Kowalskia* forms are absent, and along with remains of large "*Cricetus*," bones of the small hamster *Odessamys simionescui* are met.

The youngest fauna of the Karboliya Beds with a very advanced species of *Promimomys* is known in the Musait 7, Luchesty VII, Etuliya (lower and middle beds), and Kotlovina (lower beds) localities. In addition to dominant forms of *Promimomys*, it is characterized by the appearance of the *Pliomys* and *Dolomys* genera. The assemblage from Musait 7 includes *Pliolagomys* and *Trilophomys* forms, encountered for the first time.

Three stages in fauna development during the time interval under consideration can be recognized according to the quantitative proportions and taxonomic composition of small mammals. The earliest one is tentatively recognized only in the fauna of the Mugureny locality. It corresponds to the time of the formation of the Stol'nicheny Alluvium. The stage is distinguished by almost equally represented groups except Spalacidae, but additional data is necessary to define the time limits of this stage. The second stage coincides with the formation time of the Kuchurgan Alluvium (Novaya Andriashevka, Grebeniki 2, Nokol'skoe, and Uytnoe localities). A significant role of *Ochotona* forms, which became absolutely dominant at the end of the stage, is typical of the second stage.

In the Budei, Musait 5 and 7, Lucheshty VII, Etuliya, and Kotlovina localities, the Karboliya Beds were formed during the third stage. The stage began with the inversion of the Lagomorpha to Arvicolidae ratio forms. At the end of this time, interval the latter group became completely predominant. The lower boundary of the third stage is also marked by an extinction of the *Kowalskia*, *Prolagus*, and *Epimeriones* genera. In the middle of the stage, there is another distinct event: the appearance of the new genera *Pliomys* and *Dolomys* of the Arvicolinae.

#### POSITION OF FLUVIATILE SEQUENCES IN THE MAGNETOCHRONOLOGIC SCALE

There is no serious disagreement regarding the position of the Karboliya Alluvium in the magnetochronologic scale. It is correlated with the upper part of the Gilbert Chron. Differences lie in the fact that some scientists place the lower boundary at the top of the Kochiti Subchron (Alexandrova, 1989), and others place it inside it (Khubka *et al.*, 1983). The upper boundary is considered to either coincide with that between the Gilbert and Gauss chrons (Alexandrova, 1989) or to coincide with the lowermost part of the Gauss Chron (Sadchikova *et al.*, 1983; Khubka *et al.*, 1983).

Paleomagnetic data is available for five sequences of the Karboliya Alluvium. In three of them (Tatareshty, Baimakliya, and Novaya Etuliya), a zone of normal polarity is registered in the lower part of the Karboliya Beds. It is correlated with the second half of the Kochiti Subchron. Accordingly, the lower boundary of the Karboliya Beds was placed inside the subchron (Khubka *et al.*, 1983). The reversely magnetized fossiliferous beds in the Musait 5 sequence (Sadchikova *et al.*, 1986) does not contradict this dating. In the uppermost parts of the Lucheshty (Sadchikova *et al.*, 1986) and Tatareshty sequences (Khubka *et al.*, 1983), a zone of normal polarity was distinguished. It corresponds to the beginning of the Gauss Chron. These normally magnetized deposits, however, lack paleontological characteristics. Whether they belong to the Karboliya Beds or to the overlying upper Poratian (Konstantinova, 1967)

or Poratian deposits (Khubka, 1987) is a question that needs to be studied more thoroughly.

Hence, it follows that the Karboliya fluvial deposits may occupy an interval of the paleomagnetic scale from the middle part of the Kochiti Subchron to the end of the Gilbert Chron (Fig. 3).

There is no paleomagnetic data for the Stol'nicheny and Kuchurgan fluvial deposits. The position of these sequences in the paleomagnetic scale can be indirectly inferred by comparison with evolutionary stages of *Promimomys* forms in sections correlated with the magnetochronologic scale.

The vole from Grebeniki 2, i.e., from the upper part of Kuchurgan deposits, is very close to the type form *Promimomys moldavicus* described from the Romanian Malusteny locality. The latter is dated as the earliest Romanian and corresponds to the beginning of the Kochiti Subchron.

The position of the Novaya Andriashevka and Mugureny sections within the magnetochronologic scale was determined by interpolating sum values of Arvicolina dentine tracts between corresponding values for voles from Grebeniki 2 and Vinogradovka (the latter site is dated as the beginning of magnetic Chron 6). Taking into consideration the exponential increase of the hypsodonty of *Promimomys* molars from the older to the younger forms, we estimated that the Novaya Andriashevka locality, that is, the lower boundary of the Kuchurgan Alluvium, falls in the middle part of the Gilbert Chron between the Nunivak and Sidufial subchrons. The Mugureny site (Stol'nicheny Alluvium) is placed within the magnetic polarity Chron 5.

#### POSITION OF FLUVIATILE SEQUENCES IN THE STRATIGRAPHIC SCALE OF THE EASTERN PARATETHYS

An analysis of published papers shows many different ideas on how to correlate the considered fluvial sequences with regional stages of the Eastern Paratethys. The Stol'nicheny Alluvium is placed at various stratigraphic levels ranging from the middle Pontian to the late Kimmerian, inclusive; the Kuchurgan Alluvium is placed from the early Kimmerian to the early Akchagylian; and the Karboliya Alluvium is placed from the early Kimmerian to the middle Akchagylian.

Using inferred magnetochronological intervals for the deposits in question and the fact that the Kimmerian ranges from the end of Chron 6 to the end of the Gilbert Chron (Semenenko and Pevzner, 1979), we may conclude that the Stol'nicheny Alluvium was deposited in the early Kimmerian, while the Kuchurgan Alluvium and Karboliya Beds were formed in the middle and late Kimmerian, respectively (Fig. 3).

We emphasize that our inference on the age of the Stol'nicheny and Kuchurgan alluviums cannot be applied to the entire area in which these deposits occur.



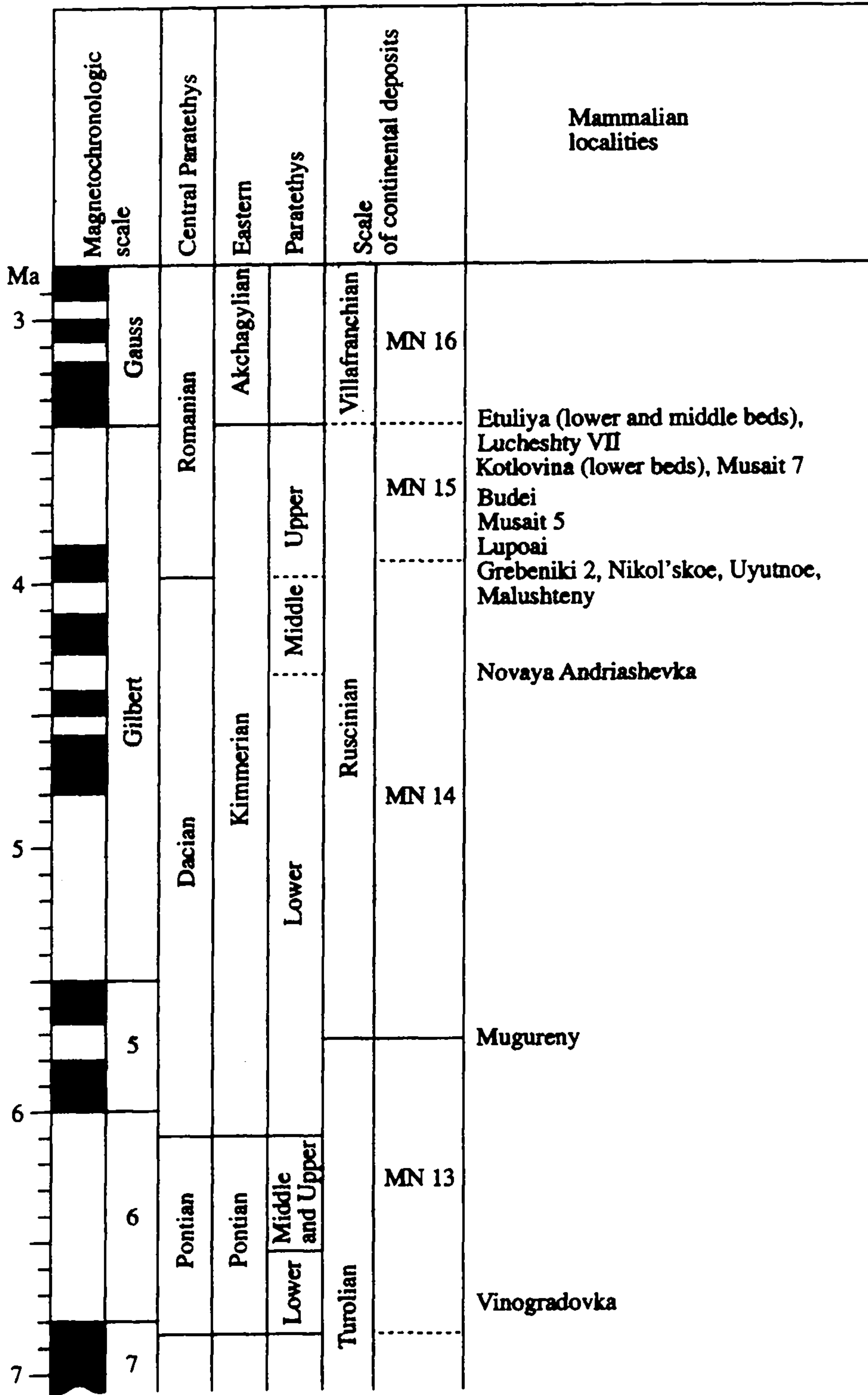


Fig. 3. Position of fossil mammal localities versus magnetostratigraphic and stratigraphic scales.

It is not improbable that further to the north they include some units considerably older than the Kimmerian.

As already noted, one of the main criteria of the subdivision of the supra-Sarmatian continental deposits into the Miocene and Pliocene parts was thought to be the

appearance of "Carpathian" pebbles in the sequences. The time of this event in continental deposits of Moldova and South Ukraine has already been debated for several decades. Some Moldavian geologists suggested that the event occurred during the post-Pontian age (Bukatchuk

and Burdenko, 1969). There is some evidence, however, that the "Carpathian" pebbles had appeared in Moldavian territory already in pre-Kimmerian time. For example, in Stol'nicheny deposits with "Carpathian" pebbles near the village of Lozovo, a mandible of *Choerolophodon* sp. was found (Gabuniya *et al.*, 1986). This form of mastodon survived only until the end of the Meotian (Korotkevich, 1988). Therefore, the fossiliferous deposits are certainly pre-Pontian.

#### POSITION OF MAMMALIAN LOCALITIES IN THE CONTINENTAL DEPOSITS SCALE

The evolutionary level of the Arvicoline form from the Mugureny locality (Stol'nicheny Alluvium) strongly suggests that the fauna is not younger than the first half of the early Ruscinian, because the vole is more primitive than *Promimomys insuliferus*. The latter is typical for the second half of zone MN 14 (Mein, 1990). The lower time limit of this fauna is problematic. But if correlation of the Mugureny locality with the middle part of the magnetic polarity Chron 5 is correct, then the fauna is close in age to the boundary between the Turolian and Ruscinian (Pevzner and Vangengeim, 1986).

The co-occurrence of *Promimomys insuliferus* and *P. moldavicus* similar to the type form in the Kuchurgan Gravel allows us to date it as the second half of the early Ruscinian (zone MN 14).

The boundary between zones MN 14 and MN 15 in Western Europe corresponds to the replacement level of *Promimomys moldavicus* by "*Mimomys*" *davakosi* (Fejfar and Heinrich, 1990). As was noted, it is extremely difficult to morphologically discriminate between these forms. That is why we cannot use paleontological criterion in the correlation of late Ruscinian faunas of Eastern and Western Europe and must use other methods, in particular, the magnetostratigraphic method.

The Karboliya Beds occupy a magnetostratigraphic position similar to that of the upper Alfabrian of Spain, i.e., to zone MN 15, between the Kochiti Subchron and the Gilbert - Gauss chrons boundary (Moissenet *et al.*, 1990). Thus, the fauna from the Karboliya Beds corresponds to zone MN 15 in its chronological range, as defined by Moissenet *et al.* The Musait 5 and Budei localities can be attributed to the basal part of zone MN 15, and the Musait 7, Lucheshty VII, Etuliya (lower and middle beds), and Kotlovina (lower beds) localities can be attributed to the upper half of this zone (the Csarnotian of M. Kretzoi zonation as indicated by the appearance of the genera *Pliomys* and *Dolomys*).

#### CONCLUSION

The conducted study revealed different ages for deposits of three fluvial plains occurring between the South Bug and Dniester and the Dniester and Prut rivers.

Deposits of the Stol'nicheny Alluvium were formed during the early Kimmerian in the studied territory. On the continental scale, they correspond to the boundary interval between the Turolian and Ruscinian. On the magnetostratigraphic scale, the Stol'nicheny deposits correlate to the middle part of magnetic Chron 5. The Kuchurgan Gravel was probably deposited at the very end of the early and in the middle Kimmerian, and is equivalent in age to the second half of the early Ruscinian (MN 14) of the continental scale. On the magnetostratigraphic scale, these deposits correspond to the middle part of the Gilbert Chron. The Karboliya Alluvium was formed in the late Kimmerian and correlates to the late Ruscinian (MN 15) on the continental scale, and with the time interval from the Kochiti Subchron to the upper boundary of the Gilbert Chron.

It should be noted that further studies are required to discover the paleontological criteria that could indicate the lower and upper boundaries of the early Ruscinian, as the available data is insufficient to correlate East and West European faunas.

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