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MIOCENE VERTEBRATES REWORKED IN QUATERNARY DEPOSITS IN MOLDAVIA

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Abstract. In the Quaternary deposits of the Moldavian and Scythian platforms between the Eastern Carpathians and Prut, one can collect sometimes rather rich Pleistocene and Holocene vertebrates, mainly large herbivores as woolly mammoth, *Mammuthus primigenius* (Blumenbach, 1799) or woolly rhinoceros, *Coelodonta antiquitatis* (Blumenbach, 1807). Apart such fossils, in same deposits one can collect also Miocene vertebrate remains reworked from older, underlying deposits. They refer mainly to perissodactyls as three toed horses (hipparioninae), rhinoceros, but also cetaceans (as various Sarmatian dolphins). Apart the vertebrate remains, Middle and Upper Miocene invertebrates were reworked too. All these fossils can be easily recognized, showing reworking marks and a different fossilization. But, in spite of their specific features, sometimes they led to confusions concerning the geological age of the Quaternary deposits, presumed to be older than they were in fact. It is also interesting to notice that the areal distribution of these fossils follows a rule in accord with the geological evolution and tectonic pattern of the platforms. In the northern area, the single Miocene vertebrates expected to be reworked could refer to marine mammals, as long as the Lower Sarmatian (Volhynian) deposits are exclusively marine and the few Badenian (Middle Miocene) deposits are marine too. The single terrestrial such vertebrates could originate exclusively from the areas nearby the Eastern Carpathians, where in Volhynian fluvial-lacustrine environments occurred. In the southern areas, the reworked Miocene vertebrates are by far more diverse, as the source areas are of more various geological ages, including the Upper Sarmatian, Meotian or Pontian ones. Sometimes, such reworked fossils can bring additional data from systematic viewpoint, filling gaps in the knowledge of the terrestrial Miocene vertebrates, where some representatives are missing *in situ*. Case studies are herein exposed: the Simila open-pit and Movileni Quaternary outcrops (both in Vaslui County).

Keywords: Miocene vertebrates, reworked status, Quaternary, Moldavia, Romania.

REZUMAT. Vertebrate miocene remaniate în depozite cuaternare din Moldova. În depozitele cuaternare din platformele Moldovenească și Scitică, între Carpații Orientali și Prut, pot fi uneori

colectate eșantionaje destul de bogate de resturi de vertebrate pleistocene și holocene, îndeosebi de mamut, *Mammuthus primigenius* (Blumenbach, 1799) sau rinocer lânos *Coelodonta antiquitatis* (Blumenbach, 1807). În afara unor astfel de fosile, din aceleași depozite pot fi de asemeni colectate resturi de vertebrate miocene, remaniate din depozitele aflate dedesubtul celor cuaternare. Acestea se referă îndeosebi la perissodactyle precum caii tridactili (hipparioninae), rinoceri, dar de asemeni la cetacee (îndeosebi delfini sarmațieni). În afara resturilor de vertebrate, au fost remaniate de asemeni nevertebrate miocen medii-superioare. Toate aceste fosile pot fi cu ușurință recunoscute, prezentând semne clare de remaniere și fosilizări distincte, dar în pofida acestor evidențe, uneori au condus la confuzii legate de vârsta geologică a depozitelor cuaternare, presupuse ca fiind mai vechi decât erau de fapt. Este de asemeni interesant de semnalat că distribuția areală a acestor fosile urmează o regulă în concordanță cu evoluția geologică și structura tectonică a platformelor în discuție. În sectoarele nordice, singurele vertebrate miocene remaniate se pot referi la mamifere marine, atâta timp cât depozitele sarmațian inferioare (volhiniene) sunt exclusiv marine, la fel ca și cele badeniene (Miocen Mediu), cu puține apariții în aflorimente. Totuși, vertebratele terestre volhiniene ar putea proveni din remanieri având arii surse în imediata vecinătate a Carpaților Orientali, acolo unde sunt semnalate depozite fluvio-lacustre. În sectoarele sudice, vertebratele miocene remaniate sunt de departe mai diverse, ariile surse referindu-se la vârste geologice mai diverse, care includ și Sarmațianul Superior, Meotianul sau Ponțianul. Uneori, astfel de fosile remaniate pot aduce date adiționale sub aspect sistematic, completând lacunele de cunoaștere a vertebratelor miocene, unde astfel de taxoni nu au fost descoperiți deocamdată *in situ*. Studiile de caz prezentate aici: cariera Simila și aflorimentele cuaternare de la Movileni (ambele localități în jud. Vaslui).

Cuvinte cheie: vertebrate miocene, remanieri, Cuaternar, Moldova, România.

INTRODUCTION

From structural viewpoint, in northeastern Romania two platforms may be outlined: the so-called “Moldavian” Platform and to south, the Scythian Platform. Concerning the first one, Săndulescu (Săndulescu, 1984) outlined since decades ago that the “Moldavian” Platform is nothing but just a local name for the southwestern sector of the Oriental Europe Platform. The Scythian Platform still keeps unclear knowledge about the sole, but this detail is not relevant for the topic of this study. The most important aspect concerns the fact that both platforms share the last sedimentary cover (mega-sequence, or “sedimentary cycle” in Ionesi, 1994). In both units this one starts by Middle Miocene (Late Badenian) deposits (Ionesi, 1994), but while in the Moldavian Platform the last deposits exposed are Meotian, in the Scythian the last ones are Pliocene-Quaternary, in fluvial-lacustrine environments. Such a regional specific distribution of deposits is due to the tectonic control: both platforms are dipping on NW-SE direction. In this manner, due to erosion, the oldest deposits are exposed in the northernmost areas, while the youngest are in south.

The Quaternary evolution and mainly the Late Pleistocene one refers to a fluvial system that developed several river terraces. These deposits are of interest from paleontological viewpoint, primarily for the Quaternary vertebrate remains. The most common fossils are the large herbivores as woolly mammoth, *Mammuthus primigenius* (Blumenbach, 1799) or woolly rhinoceros, *Coelodonta antiquitatis* (Blumenbach, 1807), frequently recorded in a lot of localities

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(Simionescu, 1990; Codrea, 2005). They are of interest in establishing the geological age of the river terraces, but also for reconstruction of the Upper Quaternary terrestrial environments.

Apart the Quaternary fossils, often one can collect from the same rocks Miocene vertebrate remains too. They are completely different, exposing heavy reworking marks as well as a different, more advanced fossilization. At first glance, they have not high value, but a closer look indicates that they can add details about the systematic diversity of the Miocene taxa, some of them missing in the Miocene localities records *in situ*. Such reworked fossils are the subject of this paper.

In order to illustrate the reworks, several dozen of fragments of Miocene vertebrates were collected, mainly from two Upper Pleistocene localities, Simila and Movileni, both in Vaslui County (Fig. 1).

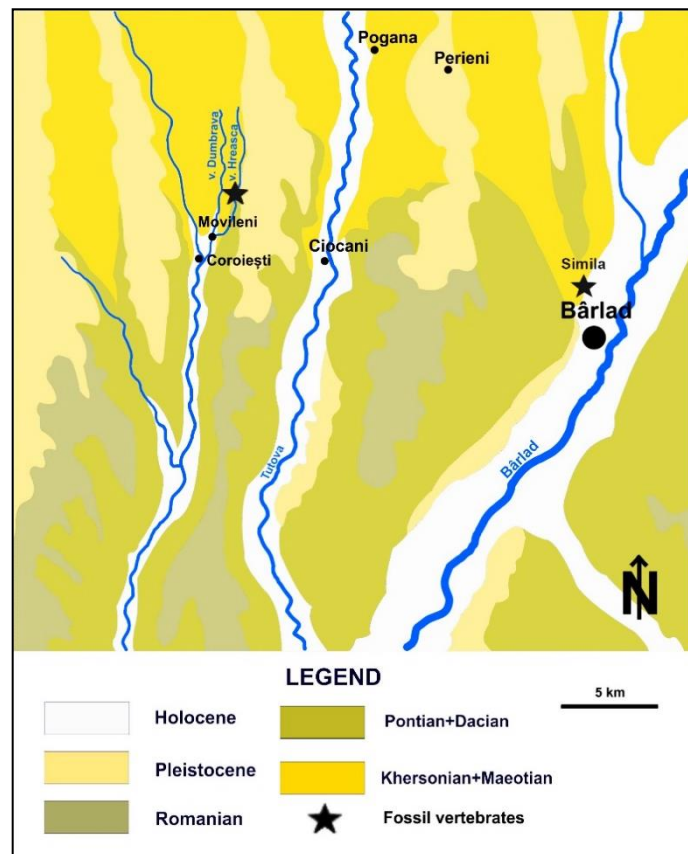


Figure 1 - Location of Simila open-pit and Movileni outcrops on the geological map.

Simila concerns a still active open pit (Codrea et al., 2013), where large amounts of sand and gravel were recently mined for the works carried out for the

road E581 linking Bârlad town to Huși. The second locality, Movileni is located northwest to Bârlad town. There, the Quaternary deposits are exposed on Hreasca Creek, streamed on north-south direction (Codrea & Ursachi, 2010, Ursachi et al., 2011), where sand is in dominance.

MATERIALS AND METHODS

The samples of Miocene vertebrate fragments reworked in the Quaternary rocks yielded in these two localities were collected by usual paleontological survey in the field. As all concern large vertebrates, these fossils were directly extracted from the different beds with geological hammer and chisels, both in Simila and Movileni. In Movileni, the fragments were found already extracted from the rock matrix, reworked into the actual alluvia of the Hreasca Creek.

But not all these fossils are useful for study. Some of them are as fragmented as they do not preserve any diagnostic feature of interest for a systematic assignation. Therefore, they were removed away from the sample and will be not registered in the inventory. The others are housed in the paleontological collection of the Museum “Vasile Pârvan” Bârlad, Natural Science Branch (hereafter, abbreviated as VPM).

As the fossilization is an advanced one, none of these fossils needed a special treatment with professional polymers (e.g. mowilite), in order to strengthen it. Never the matrix rock was too cohesive to the fossilized bone and/or teeth. It was removed simply by mechanical means, usually directly in the field.

The systematic assignation was based on references and on comparative material from various collections, in our country or abroad.

The photographs capture was done with Nikon Coolpix P520 with NIKKOR 42X Wide Optical Zoom ED VR 4.3 - 180 mm 1:3-5.9, than processed on Adobe Photoshop CC.

RESULTS

The Miocene vertebrates reworked in the Quaternary deposits from Simila and Movileni, belong to the following taxa:

Superclass Osteichthyes Huxley, 1880
Class Actinopterygii Klein, 1885
Infraclass Teleostei Müller, 1845
Teleostei indet.
(Pl. 1, Fig. 1)

A single fragment of a vertebra was found in Simila open pit (VPM C 5584). This fragment offers too scarce possibilities for a systematic assignation, but it worth to be mentioned that until now, Miocene fish in the platforms from Eastern Romania are extremely scarce. Same rule seems to act in the fossil record in

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Republic of Moldova, where a more consistent fish list documents various taxa in localities as Būzhor 1 (= Bujor 1; Bessarabian, in the opinion of Lungu & Rzebik-Kowalska 2011, MN 9 unit) or Poçşeşti (“middle late Sarmatian s.l.” and “MN 10” according Kovalchuk et al., 2014; MN 9, according to Vangengeim & Tesakov, 2013). We can suppose that this vertebra is documenting a fresh water fish either Late Sarmatian or Meotian. The centrum is high and short. The estimated size of the articular facets diameter is around 13 mm.

Class Mammalia Linnaeus, 1758
Order Proboscidea Illiger, 1811
Suborder Elephantiformes Tassy, 1988
Clade Elephantida Tassy & Shoshani, 1997
(Pl. 1, Figs. 2a, b)

A single fragment documents the proboscideans among the reworked fossils (VPM C 5585). It refers to a portion of a mastodon cheek tooth, more specifically the mesial wall of the first ridge of a left lower molar. This part of the crown is extremely worn by attrition, as it frequently happens (e.g. in Schlesinger, 1917). The mesial cingulum can be fairly observed, but reworking marks are obvious, the pearl-like enamel ornamentation of the cingulum being hardly eroded. This process is also responsible for the nearly complete erosion of the mesial pressure mark, this one being now only faintly distinguishable. The enamel is thick, about 3.4 mm. The maximum breadth of the preserved part of this anterior ridge is 67 mm. According these sizes, we can presume that the fragment could originate from a left m2, possibly of the mastodon *Tetralophodon longirostris* (Kaup, 1832).

Order Perissodactyla Owen, 1848
Family Equidae Gray, 1821
Genera *Hipparion* De Christol, 1832/ *Hippotherium* Kaup, 1832.
(Pl. 1, Figs. 3, 4a-b)

The three toed horses are frequently recorded in the fossil record of the Simila open-pit, but the remains are usually hard reworked, keeping marks of a rather long transport. If considering the whole sample already collected, probably a part of these fossils can be related to the genus *Hipparion*, other part to *Hippotherium*, depending on their source areas. The lower molar illustrated in figs. 4 a-b is a right m1, very similar in size and sharing few morphological features with *Hippotherium primigenium* (von Meyer, 1829) (“*Hipparion platygenis* Gromova, 1952”, in Trelea & Simionescu, 1985, or “*Hipparion sarmaticum* Lungu, 1973” in Lungu & Simionescu, 1993, Lungu et al., 1993) from Scheia, in the Repedea Formation (Bessarabian). But our, has more folded enamel.

The measurements are the following ones (in mm): crown length - 20.6, maximum breadth - +10.4, height of crown - 28.

Order Artiodactyla Owen, 1848
Suborder Ruminantia Scopoli, 1777
Family Cervidae Goldfuss, 1820
Genus *Procapreolus* Schlosser, 1924
?Procapreolus sp.
(Pl. 1, Fig. 6)

The artiodactyl remains are among the most frequent Miocene fossils found in the studied localities. At Simila, such fossils were found mainly in the channel fills represented by pebbles and sands, while in Movileni the remains had been found exclusively in the recent alluvia of the Hreasca Creek. One may presume either reworks from Quaternary deposits, or directly from the Miocene ones, exposed upstream. They refer mainly to antler and horn core fragments, rarely to teeth fragments (Pl. 1, Fig. 5). Even present, these last ones never allowed clear systematic assignments, being heavily rolled before their burial into alluvia.

Concerning the antler fragments, they clearly document the presence of cervids. In spite of their rather high frequency, the antlers are usually as fragmented as they are useless for taxa assignments. However, a fragment breaks this rule and offers some useful elements for assignments. It is a fragment preserving a long and thin pedicle (MVP C 5589), a burr heavily worn by reworking and the basal part of the antler (ca. 30 mm) with deep vertical grooves. The transverse section of the antler is sub-circular (Pl. 1, Fig. 6). In this preserved portion, there is no sign of ramification. This kind of pattern could be indicative for a representative of *Procapreolus* genus (Croitor, 2014).

Cervidae indet.
(Pl. 1, Figs. 5, 7-8)

The other antler fragments offer to scarce diagnostic features for clear assignments. However, some of them are very near in shape to the antlers of the genus *Euprox* (VAC personal observation, in the Meteorkrater Steiheim Museum collection, Germany), belonging probably to young individuals. This deer is reported in Sarmatian deposits in Republic of Moldova (Lungu & Rzebik-Kowalska, 2011), but its presence could be presumed also later, in Meotian (Gentry et al., 1999).

Family Bovidae Gray, 1821
Subfamily Antilopinae Gray, 1821
Genus *Gazella* Blainville, 1816
(Pl. 1, Fig. 9)

The fragmentary horn core illustrated was found in Movileni. It is illustrative for the genus *Gazella* (Korotkevitsch, 1970) marked by deep, narrow vertical grooves, visible on the sub-circular cross section too.

DISCUSSIONS

In spite of the extremely scarce data on the Middle-Late Miocene fish from Moldavia, one may expect richer samples in the future field missions. The fluvial continental deposits should preserve such fossils and some deposits like the ones from Pogana could yield fish remains. For instance, the Miocene fish remains reworked in the Quaternary deposits are extremely rarely encountered and the vertebra fragment from Simila open-pit is rather the exception, not the rule.

The mastodons are more frequent recorded in Moldavia, either in Sarmatian or in Meotian. Such mastodon localities are Draxeni (Codrea & Ursachi, 2007, Late Bessarabian, MN 9, according Vangengeim & Tesakov, 2013), Crețești 1 (Ursachi et al., 2015, Late Sarmatian, MN 9) or Tanacu and Șișcani-Vaslui (Macarovici, 1978, Meotian, MN10-12). The mastodon systematics for the fossils collected from this region is still far to be clear, because some assignments are still needing reassessments or more precise stratigraphy (Țibuleac, 2014). The mastodon tooth fragment from Simila open pit is too small and too incomplete to be useful for an assignment. It should originates from a rather far locality, if thinking to the reworking marks, indicative for a long transport, perhaps in the Sarmatian or the nearer Meotian deposits, that Bârlad River washed in Quaternary. It could belong to the mastodon species mentioned above.

The horse fossils, although frequent are often heavy marked by reworking and the teeth, always isolated. The only horse ever reported from the Late Badenian of Moldavia is *Anchitherium aurelianense* (Cuvier, 1825), found in marine deposits at Miorcani (Gheorghiu et al., 1967). In Sarmatian, the paleontological record is richer only since the "Hipparion Datum" (Berggren & Van Couvering, 1974; 11.5 Ma according Bernor et al., 1988; basal Vallesian, MN 9 unit according Mein, 1999) documenting the migration of these horses from Asia to Europe. Apparently, the oldest hipparioninae record in Moldavia and Romania is in the Bârnova Formation (Cochior & Nechita, 1993), but still harder evidence are in the Repedea Limestone Formation (Trelea & Simionescu, 1985, Codrea et al., 1992, Lungu et al., 1993) as long as these fossils were found *in situ*, while in the first situation the exact level which the tooth originated from, remains rather doubtful. In our opinion, "*Hippotherium sarmaticum*" (Lungu & Rzebik-Kowalska, 2011) could be hardly distinguishable from *H. primigenium*, being rather a junior synonym of this late one species.

As Bernor and Armour-Chelu (Bernor & Armour-Chelu, 1999) noticed, the first hipparioninae dealt with "subtropical to warm temperate forest-to-woodland contexts", with "large percentage of browse into their diet" (p. 195). But Lungu (Lungu, 2008), mentioned for the "Complex of the faune of Calfa", "climate aridity and extension of open land areas, as savannah are" (p. 182). Such environments are

hardly credible if thinking about the rather lower crowned cheek teeth of this horse, as Lungu and collaborators (Lungu et al., 1993) themselves agreed.

After the first wave of migration, these horses recorded various species in Moldavia (Lungu & Simionescu, 1993), but the validity of some of them needs stronger arguments, based on richer and more diagnostic samples.

The even toed representatives offer usually a rich sample in the Middle-Upper Miocene terrestrial faunal assemblages from Eastern Europe, as it happened often either in Ukraine (Korotkevich, 1970) or Republic of Moldova (Lungu, 1984, Lungu & Rzebik-Kowalska, 2011). But this situation is not the same in Moldavia, where these taxa are rather rarely reported. In Moldavia, no representative was ever reported in Middle Miocene (Badenian). In Early Sarmatian the reports are still extremely scarce (Țibuleac & Codrea, 1997, Hir et al., 2017). This situation is logical if one think about the paleogeographical evolution of this region in Miocene. The last tectogenesis that erected a thrust nappe in Eastern Carpathians occurred in Early Sarmatian (Volhynian). Even after this geological event, the largest part of the platforms remained still covered by the Paratethys Sea (Popov et al., 2004), excepting the proximal Eastern Carpathian marginal areas of the new emerged lands, where piles of gravels and sands are indicative for a strong sedimentary input from western and northwestern source areas (Miclăuș, 2001, Rățoi, 2013). In these fluvio-lacustrine environments, coal forming facies are recorded (Țibuleac, 1999), where terrestrial vertebrates can be mentioned, as the small deer antler fragments reported from (Țibuleac & Codrea, 1997). In our opinion, this find marks rather the high potential of these deposits in yielding vertebrate remains, until now not valued by enough field works. Similar records are in the basal most Late Miocene, the number of localities that yielded terrestrial vertebrates being extremely low. Apart Draxeni (Late Bessarabian; Codrea & Ursachi, 2007) and Crețești 1 (Kersonian; Ursachi et al., 2015), all the other reports concern fortuitous finds and not systematic diggings.

Draxeni documents a regression tendency occurred to the end of the Middle Sarmatian, the terrestrial fossils being present just consequence of the rivers and other fresh water streams actions, mainly during the flood events. The vertebrate fossils are isolated and strongly marked by the water action (waves and currents), often fragmented. Even in such circumstances, this fossil record is of high value for Moldavia. But, the artiodactyls are extremely poor represented.

Crețești 1 is a completely different site from environmental viewpoint. It documents a fluvial plain, where in flood events the vertebrate bones and teeth formed fossil-bearing “pockets”. A group of six terrestrial turtles huddled into a pile, drowned together during a flood, preserving in anatomical articulation their limb bones (including even the protecting bony plates) and sometimes, the cranium. However, the even toed herbivores are scarcely represented, the largest number of fossils in this locality referring to Perissodactyls (Codrea et al., 2017, in print).

The Meotian deposits are also scarce in artiodactyl remains, the most numerous being the gazelles (Macarovici, 1978, and references therein).

In these circumstances, the antler fragment that could document the presence of *Procapreolus* is important for Moldavia. Valli (Valli, 2010) made an overview on the occurrence and stratigraphic distribution of this genus in Europe, underlining that it was present since Late Miocene (MN 10) until Pliocene (MN 16). Lungu and Rzebik-Kowalska (Lungu & Rzebik-Kowalska, 2011) reported in Republic of Moldova this deer since Middle Bessarabian of Otovaska 1 (MN 9; however, this could be a wrong assignation) and later at Leordoaya in “Early Pontian” (= Leordoia, MN 13). The antler we are discussing here is originating from Movileni, on Hreasca Creek. Either it was bore in the Upper Pleistocene deposits, or if it was directly reworked in the alluvia of the creek, one may presume that it could originates from Meotian deposits, as the specific geology of this region reflects (Hreasca Creek upper stream is not incising Sarmatian exposures; Macarovici, 1960). In such circumstances, one even may presume the presence of the species *Procapreolus ucrainicus* Korotkevich, 1974 known from Berislav (MN 10).

The gazelle remains often occur in the Middle-Late Miocene of the Republic of Moldavia (Lungu & Rzebik-Kowalska, 2011), but only in the so-called “*Hipparion* fauna localities”. In Moldavia, Macarovici listed “*Gazella deperdita* Geravis, 1847” and “*G. brevicornis* (Roth & Wagner, 1848)” in the Meotian localities Zorleni and Giurcani (both in Vaslui County).

CONCLUSIONS

The Miocene fossils reworked into the Quaternary deposits - mainly river terraces - can be sometimes in high amounts. In some situations, they lead to wrong interpretation of the geological ages of such rocks (e.g. Miocene vs. Quaternary in Simila open-pit, based on the Miocene mollusks reworked; Bejan et al., 2012).

For the systematic of the Upper Miocene vertebrates, the finds of reworked fossils can bring additions to the biodiversities, as the possible presence of the genus *Procapreolus* herein reported. Many other vertebrate taxa could be added to the paleontological lists concerning the Middle-Upper Miocene of Moldavia. But such work is often a difficult task as long as these fossils are always very fragmented and worn by the long transport happened before their burial into the Quaternary sediments. This rule is illustrative for the fossils herein described, collected in Movileni and Simila.

The Badenian (Middle Miocene) outcrops from Moldavia can yield terrestrial vertebrates only by lucky finds, as long as these deposits are marine. The discovery of *Anchitherium* at Miorcani (Gheorghiu et al., 1967) is an illustrative example.

One may expect the oldest terrestrial Miocene vertebrates mainly from the Volhynian (Early Sarmatian s.l., Middle Miocene) fluvial-lacustrine deposits cropping out on the eastern margin of the Eastern Carpathians. These areas, at the contact between the Carpathians and the platform areas of Moldavia, were the first ones emerged after the last tectogenesis occurred in the Eastern Carpathians

(Săndulescu, 1984). These Volhynian environments, with swampy tendencies were ideal places for vertebrate communities. For instance, extremely few data are known about them, the finds (Țibuleac & Codrea, 1997, Codrea & Țibuleac, 2000, Hir et al., 2017) being rather fortuitous, than results of systematic works in the field. Apart these areas very promising for terrestrial vertebrates, in the whole northern Moldavia one may expect only marine vertebrates, as whale and dolphin remains (VAC, personal observation).

Since Middle Sarmatian s. l. (Bessarabian) the emerging lands enlarged and fluvial-lacustrine environments are often recorded. These tendencies lead to more promising microvertebrates potential levels. As a rule in Moldavia, one may expect richer finds of terrestrial vertebrates in the Moldavian and Scythian platforms, as one look for these fossils towards the southernmost areas. It should be the main target for the next years to come.

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PLATE 1 - Reworked Miocene vertebrates in Quaternary deposits at Simila and Movileni (Vaslui County). Fig. 1 - Fish vertebra fragment (VPM C 5584), Simila; Figs. 2 - Mastodon lower cheek tooth (MVP C 5585), Simila, a: crown view, b: mesial view; Fig. 3 - Hipparioninae incisor (MVP C 5586); Fig. 4 - Hipparioninae right m1, Simila, a: lateral view; b: crown view; Fig. 5 - Artiodactyla indet., upper cheek tooth (MVP C 5588), Simila, crown view; Fig. 6 - ?*Procapreolus* basal antler fragment (MVP C 5589), Movileni; Fig. 7 - Deer antler fragment, *Euprox*-like (MVP C 5590), Movileni; Fig. 8 - Deer antler fragment (MVP C 5591), Simila; Fig. 9 - *Gazella* sp. horncore fragment (MVP C 5592), Simila. Scale bar: 10 mm.