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STUDY OF THE UPPER EOCENE-LOWER OLIGOCENE CONTINENTAL FORMATIONS FROM NORTHWESTERN SIDE OF THE TRANSYLVANIAN DEPRESSION – BIOSTRATIGRAPHY AND PALEOENVIRONMENTAL RECONSTRUCTIONS BASED ON LAND VERTEBRATE ASSEMBLAGES

ABSTRACT OF PH.D THESIS

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CONTENT

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INTRODUCTION

In Paleogene, at the Eocene/Oligocene boundary, both floral and faunal assemblages in the whole Europe recorded the consequences of changes occurred in paleogeography, induced on their turn by climatic changes. This event was long time ago already observed in Western Europe, mainly in "sudden and deep" changes occurred in vertebrate assemblages – especially mammals. The Swiss paleontologist Stehlin named the event *"La Grande Coupure"* ("*The Great Break*"), just due to the amplitude and dramatic changes.

Such changes occurred however, differentially, each floral or animal group reacting faster or slower to the environments challenges. Compared to the Western Europe or to Asia, the Romanian areas yielded until now only poor data on the land Paleogene biota. When available, such data referred mostly to restricted exposures and outcrops, yielding only few taxa. In such circumstances, the correlations both to Western Europe or Asia remained rather faint. Therefore, the data concerning Romania were punctiform, with uneven knowledge of the different taxa: molluscs or nannoplankton were sometimes intensely studied, while other groups remained poor investigated (e.g. phytocoenosis, mammals, birds etc) or not studied at all (e.g. microvertebrates).

In this Ph.D. thesis I appreciated that a more detailed approach for vertebrate faunas around the Eocene/Oligocene boundary in northwestern Transylvania could be of interest both for Romanian as well as for foreign paleontologists. I succeeded in finding several new vertebrate localities, some of them rich in fossils. This region has the advantage of convenient outcrops, showing continuous fine sedimentary successions, allowing correlations on wide distances. The data issued are proving successive immigration waves, with newcomers originating mainly from Asia, but also from other directions. Some of them, after crossing Transylvania, succeeded in reaching the Western Europe, while others failed, ending their trip before. Such a fossil record gives to our country its own peculiarity.

On such arguments, this study intends to point out at better resolution possible the succession of these bioevents, preserved in the Paleogene sedimentary record. This research tries to find out an answer to several problems raised by the succession and evolution of some faunal taxa, as well as their living specific environments.

The results allow better correlations between Western Europe and Asia. The recent discoveries from Georgia, Asia Minor or Bulgaria are justifying the continuation of such researches in our country too. In this manner, the vertebrate localities from Transylvania will be better taken into consideration worldwide.

CHAPTER I. „*LA GRANDE COUPURE*" main geological event in the northern hemisphere

The Middle Eocene - Early Oligocene interval, extended on 10 M.y., seems had been a critical phase in the geological history of the Earth. The decrease of annual mean values induced by the cooling tendency put an imprint on flora and fauna assemblages, recorded mainly by terrestrial taxa.

Two cooling phases can be distinguished by floristic studies. The first one followed the warm Middle Eocene (41-40 M.y.); with ca. 10º C drop of annual temperature mean value, and the second one, which followed the Upper Eocene warming (33-32 M.y.), with at least 13º C drop. This entire climatic cooling interval called by Woolfe (1971) the "Oligocene deterioration", and later by the same (Woolfe, 1978), the "Terminal Eocene Event" (abbreviated T.E.E.).

As a consequence, there are two low temperatures phases leading on an aridity increase: the first at the top of the Middle Eocene; the second one covered the Eocene/Oligocene boundary extending to the Early Oligocene (Berggren & Prothero, 1992).

The *causes* invocate for these major climate changes are in connection with the tectonic events, which affected the global oceanic circulation of waters, splitting apart Australia from Antarctica and Norway from Greenland (Prothero, 1985). The opening of the passage between Antarctica and Australia established the occurrence of the Antarctic "ice sheet" (Kennett et al., 1975), the first such event ever recorded in Cenozoic. According to Hooker (2000), this "ice sheet" would be responsible for the sea level drop. Unfortunately, the first moment of the ice sheet installation remain still unclear. Consequently, the first cooling phase is still waiting for an explanation. Bartek et al. (1992), proposed a pattern, which explains the development of the Antarctic "ice sheet" as a consequence of the evaporation and precipitation of waters conveyed towards Antarctica from the equatorial regions of the Pacific Ocean.

The changement of the Paleogene paleogeography putting apart Australia from Antarctica, facilitated the development of Circum-Antarctic stream, which is responsible for the Antarctic glaciation (Kennett, 1977).

The consequences of the climate cooling radically altered the evolution of the flora and fauna from the Northern Hemisphere.

Land flora and fauna changement in Europe

Flora changements. The palynological analyses (Collinson, 1992) suggested for the Eocene a general turnover in the flora composition. The floristic studies indicated a transition from dominantly tropical vegetation in Middle Eocene to subtropical vegetation in Late Eocene. The climatic deterioration continued even in Early Oligocene, marked by mixed deciduous and evergreen forests, indicating the presence of warm temperate and seasonal climate.

The vegetal transition from the tropical to the subtropical and warm temperate evolved in paralell with an increase in aridity. The well represented *Ephedra* from the Late Eocene is a hard evidence, besides the increased frequence of silcrets and calcretes (Daley, 1989), or the mammals indicating wide open areas (Hooker, 1992).

In this manner, from the exuberant Middle Eocene forests, in the Early Oligocene one can record a lot of areas with a more attenuate vegetation, involving open grassy areas interropted by clusters.

Faunal changements. „*La Grande Coupure*" (LGG) is a concept first time introduced by Stehlin (1909), studying the Paleogene mammal assemblages from Paris Basin (France). He observed a sudden disappearance of the Eocene European endemic taxa and the occurrence in Oligocene of several representatives originating from Asia. The name introduced by Stehlin is extremely suggestive, indicating the abruptness of the faunal turnover recorded mainly by European vertebrates at Eocene/Oligocene boundary.

In Europe, the data concerning flora and fauna changes referred to LGC in the different regions are very uneven. The details are usualy missing because of rarity of convenient exposures recorded in the field.

In Eocene, Europe looks like an archipelago. On its shores, the marine sequences interbedded with the terrestrial ones (Berggren & Prothero, 1992). However, LGC is well marked on a lot of Western Europen Paleogene sections that alloowed adequate calibrations for biostratigraphy.

The Lower and Midle Eocene European faunas are dominated by archaic taxa as: multituberculates, „adapiform" primates, creodonts, „insectivors", archaic ungulates, pantodonts and tillodonts (Berggren & Prothero, 1992). Among Perissodactyls one can enumerate paleotheres and lophiodonts, while among Artiodactyls: choeropotamids, xiphodonts, mixtotheriids, cebochoerids, anoplotheriids, dacrytheriids, cainotheriids and amphimerycids.

A turnover top, associated to the Bartonian-Priabonian event (Hartenberger, 1984) lead to major extinction of Perissodactyls. These ones was replaced by *Palaeotherium* representatives with a peculiar dentition adapted to coarse-browsing. Than, one can record the decrese of: tree-dwellers taxa, mainly among apatemyids and primates, the insectivores and the small mammals (Collinson & Hooker, 1987). The rodent fauna ballance betwen pseudosciurids and theridomyids.

Beginning with the Oligocene, the Turgai Strait became a passageway, so that the insularity of Europe had gone (Wang, 1992). The track, from an immigration center located in SW Asia, followed the Balkan archipelago towards the Alps highs already outlined after the Upper Cretaceous tectogenesis (Heissig, 1979). In this respect, one can suspect several ways of immigration from Asia towards Europe, the Anatolian/Balkan one beeing just one of them.

On these land bridges, a lot of representatives of various asiatic groups as: Lagomorphs, Cricetids, Rhinocerotidae, Zapodidae, Chalicotheriidae, Entolodontidae etc was able to immigrate in Europe. The post-„LGC" fauna involves: hares, evolved carnivors (especially amphicyonids, viverids, mustelids, ursids, procyonids and nimravids), theridomyid rodents, evolved artiodactyls (anthracothers, entelodonts, leptomerycids and tayassuids), as well as perissodactyls (chalicothers and rhinocerotoids). It worth to be mentioned the dominance of large-sized mammals and the extinction of tree-dwellers, besides the first ocurrence of seed eating rodents.

The newcomers were nothing else but the ancestors of modern faunas. Their success has to be explained by the extinction of the old endemic groups, unable to adapt to this new constraint (Hartenberger, 1983).

If outlining a review of fauna preceding the great LGC immigration, one can point out that these are poor and low diverse (Hartenberger, 1983). Compared to the Eocene, in Oligocene one can notice several new aspects as: 60 % impoverishment of land vertebrates; significant decrease of mammal sizes; the occurrence at the beginning of the Oligocene of 13 new mammal families arrived from Asia (Brunet, 1977; Cavelier, 1979; Russel et al., 1982). All these changes can be interpreted as a consequence and answer to paleoclimate and paleogeography mutations issued in this time span.

This famous faunal turnover was extremely well represented in Western Europe. It is mainly a bioevent related to Europe: in Asia, as well as in North America, there are much more interesting bioevents, as the ones from Chadronian/Orellan (= Bartonian/Priabonian) boundary or the ones occurred along all the Orellan (= Early Oligocene; Hooker, 2000).

CHAPTER II. Evolution of knowledge of the Paleogene continental formations in NW Trasylvania

1700-1900 EPOCH: A series of interesting informations occurred in several ancient publications from the early XVIIth century. Unfortunately, a lot of them are bibliophile rarities, difficult if not impossible to be found in the Romanian libraries: *e.g.* Köleseri (1717), Fridwalzky (1767), Ignatz von Born (1774) (*fide* Hauer & Stache, 1863). In these circumstances, one can consider that the first modern and wrought mentions concering the Paleogene from Transylvania belong to Fichtel (1780). After Fichtel, the following mentions concerning the Paleogene formations belong to Beudant (1822). Other mentions on the Paleogene from the Transylvanian Basin as a consequence of journeys in this region belong to Boué (1831) and Lilienbach (1833).

In these circumstances, one can consider that the first monographic work related to the topic is the one of Hauer & Stache (1863). It was done at Bielz suggestion, who was member of the Natural Science Society from Sibiu (Hermannstadt). It square up to in a much more structured systematic manner the summum of informations already accumulated.

Complementary data on the Paleogene from the Transylvanian Depression belong to Pávay Elek, charged in 1869 by the Hungarian Ministry of Industry and Research to study the geology of Cluj and Remetea areas. The data related to the geological investigations served to the construction of the railway linking Cluj from Oradea. The results of the geological study, the annexed maps and numerous sketches, a lot of them outlining new details, formed the base for two papers, published in 1871 and 1872.

Interpreting the geologic data, Pávay tried to sketch a stratigraphic division of the deposits (sometimes, erroneously), corresponding to three epochs of the Eocene (lower, middle and upper) also known from the Paris Basin.

Essential is the fact that he provided a lot of paleontological data, with a special interest on mammals. In this manner, he enriched the list of taxa known from Transylvania. Such an example refers to the large mammal mentioned from the site of Rădaia, assigned to *Palaeotherium* genus (later described as a new species by Böckh, 1876, as *Brachydiastematherium transsylvanicum* BÖCKH & MATYASOVSKY, 1876). On this evidence, the red sandstone deposits from Cluj vicinity were assigned to the Early Eocene.

Later contributions for the Paleogene formations from Transylvania belong to well-known geologists as Koch and Hofmann. Their field data published in long series of papers (between 1876-1900), offer valuable geologic informations, subsecvently reiterated as refferable elements by different students. Because the topics investigated by these two scientists were often in common, we considered appropriate to present in parallel the evolution of their results.

In a juvenilia, redacted with the collegial help of some curators, Koch (1876) succeed to draw up a large and laborious repertory of fossils collected previously to the beginning of his career, curate in different museums, adding also several personal informations concering Transylvania. He accorded a special attention to the Eocene mammals (from Rădaia, from the outcrops located at Mănăştur or Cluj, at Jebuc or Rodna at Valea Vinului), arguing on this basis the existence of the Paleogene into the area. The list contains the name of 89 sites where the fossil vertebrates originated from, specifying the remains (bones or teeth), the names of students involved in the studies and the collections where the fossils were curate (mainly in the museums located in the most importantant Transylvanian cities: Braşov, Sebeş, Târgu-Mureş, Cluj etc).

The Paleogene formations from Trasnylvania were presented in two wide monographs issued in 1894 and 1900. The data contained in is based also on the previous publications belonging to Hofmann (1879, 1881, 1883, 1887, 1888), Pávay (1871, 1872), Böckh (1876). In the section concerned to the Paleogene formations, Koch sketched a series of correlations (based mainly on lithology) with Paris Basin. In discerning the stratigraphic units, Koch used some data belonging to Hofmann, an outstanding geologist who worked mainly in Sălaj district. After more than a century from their research, the data aquired was used thenceforth by a larger number of geologists involved in the investigation of the Transylvanian Basin. Even now, Koch's two monographs still represent a basic reference for the geology of Transylvania.

1900-2000 EPOCH: In the first half of the XXth century, the Paleogene from Trasylvania was less studied if compared with the previous decades. The majority of geologists involved in this topic dealt with details only, or they tried to improve the stratigraphic schema drawn by Hoffman and Koch. Such an example is the revision published by Haug (1920).

Another study on the Paleogene was carried on by Szádecky-Kardoss (1930). He define the so-called „Transylvanian basin", resulted in his oppinion trough the plunge of the „Trasylvanian land" during the Mediterranean. The exposures of the Paleogene formations is indicated in two areas (basins), different from the facies viewpoint. The first one is located in NW and SW (Țicău, Jibou, Cluj-Napoca and Alba Iulia), and the second one in S and SE (Porceşti, Lueta). A „large and durably threshold" represented by „a land" separed these two areas.

Mateescu studied the NW part of the Transylvanian Basin, focusing mainly his interest on the geology and physiography of the Huedin Depression (1925, 1926) or the facies variations of the Paleogene deposits reported to the Moigrad fault (1938).

Another outstanding student involved in the study of the Trasylvanian Paleogene was Popescu-Voiteşti (1926), who drawn the first paleogeographic synthesis of the Eocene from Romania. He considered that the median Carpatian axis functioned as a „border" between two biologic provinces: one corresponding to the Transylvanian Depression, and the second one in the Getic Depression and Dobroudja. Later, Bombiță (1963) disagreed with this pattern.

Other data concerning the Paleogene are related to some field mission repports: Ferenczi (1950), Májzon (1950), Mihaltz (1950), Reich (1950), Pătruț (1952), Joja (1956), Răileanu & Saulea (1954, 1956), Dumitrescu (1957), Barbu (1956, 1962), Bombiță (1957, 1963 a, b, 1984 a, b), Mészáros (1957, 1959, 1961), Niță Pion (1966), Petrescu (1968, 1970, 1971, 1972, 1987), Popescu (1976, 1978), Rusu (1967, 1970, 1977, 1989, 1995), Tătărâm (1963, 1984). Some thesis had been done too in these areas, as the ones of Petrescu (1969), Şuraru (1970), Moisescu (1975), Rusu (1977), Codrea (1995), Baciu (1999) etc.

CHAPTER III. The Paleogene continental formations from NW Transylvania

The Paleogene deposits from the area are corresponding to the filling of a foreland basin that evolved post-Laramie tectogenesis, in the convergence area between the Preapulian and Getic cratons (Hosu, 1999). In Eocene, the stratigraphic succession indicates a rhythmic sedimentation, evidence by land ("lower variegated series" and "upper variegated series") and marine ("lower marine series" and "upper marine series") formations, interbedded (Răileanu & Saulea, 1956). The alternance of these two deposit types and the more advanced investigations in marine deposits, allowed to establish the geological ages for the land formations too.

Three sedimentation realms are distinguished: Gilău, Meseş and Preluca (Rusu, 1970; Popescu, 1978). Their related flora and faunal assemblages involved a large diversity of taxa, some of them being excellent stratigraphic and environmental markers, hard evidence for a succession of bioevents. The most interesting ones refer to the Eocene/Oligocene boundary.

The region has continuous, fair preserved sedimentary successions, laterally expanded on several kilometers. The formations of interest for the land vertebrates are in majority non-marine. They evolved either in fluvial, or lacustrine environments. However, there are scarce land mammals records even in marine environments, in near shore realms.

Valea Nadăşului Formation (Popescu, 1978; Early Priabonian). Excepting some restricted areas, this formation expanded mainly in Gilău and the northern side of Preluca (Chioar subzone) areas, sandwiched between two marine formations: Viştea Limestone (downward) and Jebucu (upward). The lithology concerns two main kinds of deposits: arenaceous in base and siltic clay interbedded by lens-like accumulations of green clay, sand or microconglomerate to the formation top (Popescu, 1978).

Rădaia fossil locality (Cluj district). This formation is the first one that documents the first doubtless immigration wave originating from Asia, trended to Europe. In Transylvania, it happened before the classic "*Grande Coupure*" bioevent known in Western Europe (Codrea & Fărcaş, 2002). The mammals already found since long time ago in Rădaia, nearby Cluj-Napoca, concern the titanothere *Brachydiastematherium transsylvanicum* BÖCKH & MATYASOVSKY, 1876 as well as the archaic rhinocerotoid *Prohyracodon orientale* KOCH, 1879. If the titanother geographic origin still remains obscure in spite of over a century of research, the rhinocerotoid was well documented in Asia, wherefrom it dispersed until Europe (Codrea, 2000).

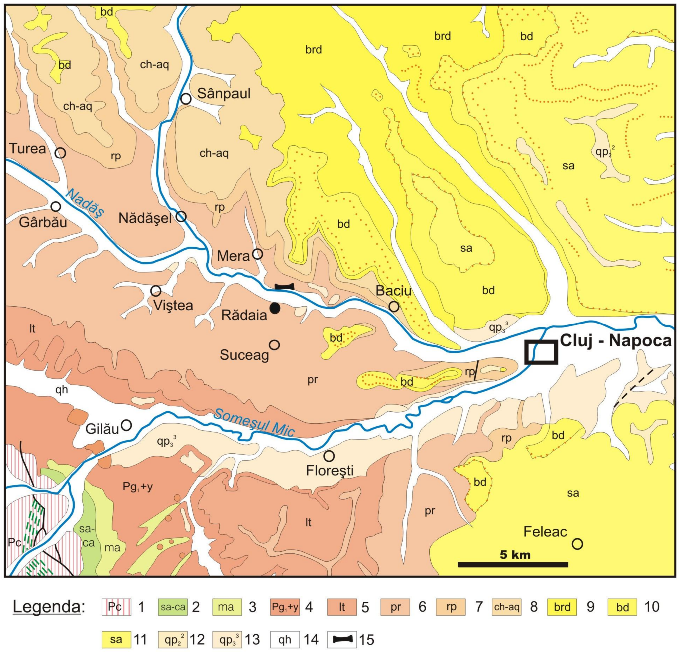

Fig. III. 1. Geological map of the Rădaia fossil locality, Cluj district
(after the geological map of the Geological Institute of Romania, 1:200.000, modified).
1: Proterozoic, 2: Cretaceous (Santonian-Campanian) 3: Cretaceous (Maastrichtian), 4: Paleogene (Paleocene-Ypresian), 5: Eocene (Luteţian), 6: Eocene (Priabonian), 7: Oligocene (Rupelian), 8: Oligocene/Miocene (Chattian-Aquitanian), 9: Miocene (Burdigalian), 10: Miocene (Badenian), 11: Miocene (Sarmatian), 12,13,14: Quaternary, 15: Fossil vertebrates.

Morlaca fossil locality (Morlaca locality, Cluj district). Morlaca (village at 10 km west of Huedin, has a long history since its first report belonging to Szadeczky (1915), renewed by several contributions as the ones of Mateescu (1926), Mészáros & Tămaş (1963), Petrescu & Mărgărit (1987), Mészáros et al. (2001), Baciu (2003).

In Morlaca, there is a marine evolution beginning with the Eocene „lower marine series” and continuing with the Cluj Limestone. In Valea Nadasului Formation I observed two vertebrate bearing levels that I named Morlaca 1 and Morlaca 2.

Morlaca 1 is Lower Priabonian coally clay 0.20 m thick, meaning paralic evolution, bearing *Sphaerochara* cf. *labellata* as well as *Chara* (Baciu, 2003). Among vertebrates, only crocodiles can be mentioned, probably *Diplocynodon*.

Morlaca 2 refers to a channel filling, with sand and soft balls. Several large vertebrates have to be mentioned, as large herbivores or turtles.

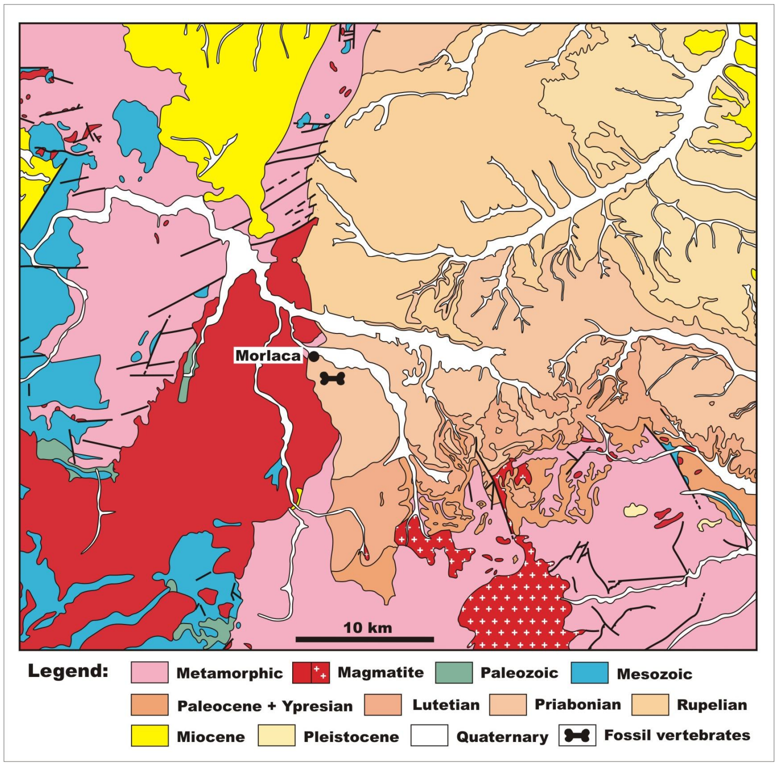

Fig. III. 2. Geological map illustrating Morlaca locality, Cluj District
(according the geological map 1: 200000 of the Geological institute of Romania, modified)

Turbuța Formation (Hofmann, 1879; Early Priabonian)

Turbuța Formation is a lateral correspondent of Valea Nadășului Formation. These two formations share the same sedimentary environment (flood plain), but Turbuța Formation is more flooded compared with Valea Nadășului Formation.

Turbuța Formation is exposed mainly on the Meseş area, with a lesser extension in Preluca, and is sandwiched between two marine formations, well documented by nannoplankton and mollusc assemblages (Mészáros, 1991): bellow, the Racoți and Viştea formations belong to NP 18 zone, and Jebucu Formation, located above, to NP 19. As a consequence, Turbuța Formation is Priabonian.

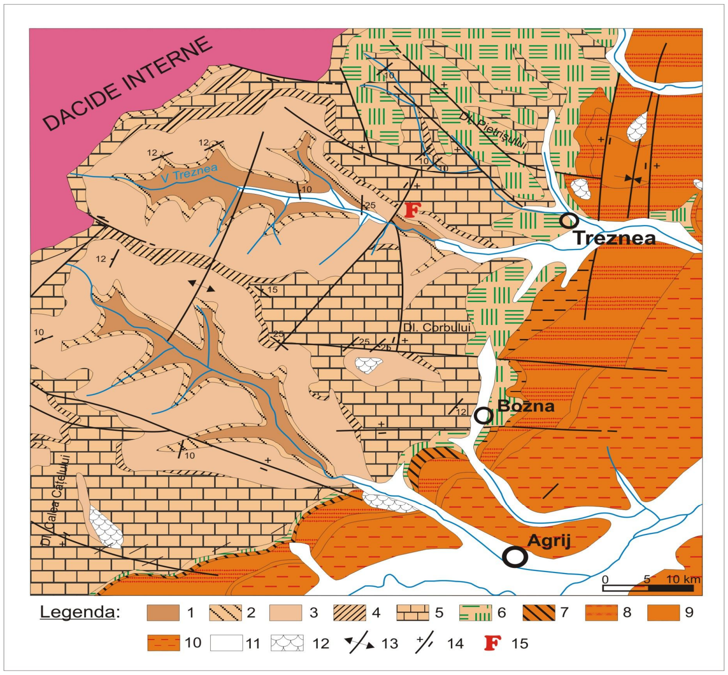

Fig. III. 3. Geological map of the Treznea 1 locality, Sălaj distict,
(according the geological map 1: 50000 of the Geological Institute of Romania)
1: Mortănuşa Formation, 2: Racoţi Sandstone, 3: Turbuţa Formation, 4: Jebucu Formation,
5: Cluj Limestone, 6: Brebi Formation, 7: Curtuiuş Formation, 8,9: Moigrad Formation,
10: Post-Moigrad Formation, 11: Quaternary alluvial deposits, 12: Landslides, 13: Anticline,
14: Rised-lowered tectonic blocks, 15: vertebrate fosile.

Treznea 1 fossil locality (Treznea locality, Sălaj district). An illustrarive outcrop may be observed near Treznea (Salaj District) 80 km NW from Cluj-Napoca. I named this site Treznea 1, on the left bank of Şanţului Valley.

The second marine series into the Paleogene succession fall on the **Turea Group** (Rusu, 1995), also known as the "upper marine series" (Răileanu & Saulea, 1956). Like in the previous marine series, in spite of the marine sedimentary environments, some land vertebrates are also known from these deposits, originating from the emerged areas bordering the Paleogene Sea.

Jebucu Formation (Bombiţă, 1984; Priabonian)

This formation marks the continental/marine transition occurred immediately after the Lower Priabonian land episode. It concerns mainly gypsum exposed in Gilău sedimentary area. In Meseş, it is included into Turbuţa Formation, while in Preluca area is completely missing.

Bociu fossil locality (Bociu locality, Cluj district). The site is on the top of this formation, at Bociu. It means cca. 5 cm thick brown clay, very rich in charophyte, as well as in vertebrate remains. The vertebrate fossils are not numeorus, but very interesting.

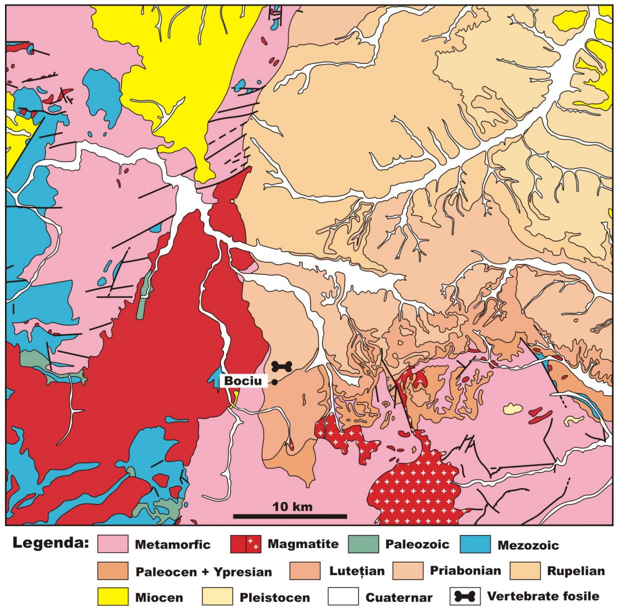

Fig. III. 4. Harta geologică a punctului fosilifer – Bociu, judeţul Cluj
(preluată şi prelucrată după harta geologică a Institutului Geologic al României, 1:200.000

Dâncu Formation (Rusu, 1972; Rupelian; MP23 or MP24)

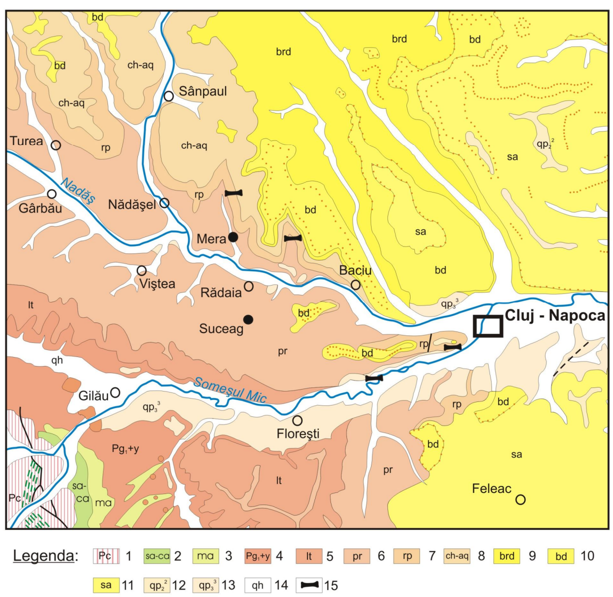

Fig. III. 5. Geological map of the fossil localities: Cetăţuia Hill (Cluj-Napoca locality), Suceag and Mera, Cluj district (after the geological map 1: 200000 of the Geological Institute of Romania)
1: Proterozoic, 2: Cretaceous (Santonian-Campanian) 3: Cretaceous (Maastrichtian), 4: Paleogene (Paleocene-Ypresian), 5: Eocene (Luteţian), 6: Eocene (Priabonian), 7: Oligocene (Rupelian), 8: Oligocene/Miocene (Chattian-Aquitanian), 9: Miocene (Burdigalian), 10: Miocene (Badenian), 11: Miocene (Sarmatian), 12,13,14: Quaternary, 15: Fossil vertebrates.

This formation represents just the terminal part of the former „Ticu Beds”, *sensu* Koch. In Gilău area, these deposits are cropping out as a long, but narrow stripe. Several land vertebrate localities had been already reported: Cluj-Napoca, Suceag, Mera, Aghireş (Codrea & Fărcaş, 2002).

The flora from Cetății Valley contains 25 taxa, with 16 families and 19 genera, with *Rumohra recentior*, *Osmunda lignitum* (formă autohtonă), *Sequoia abietina*, *Pinus* sp. *Alnus gaudini*, *Quercus lemoignei*, *Berchemia dacica*, *Sideroxylon salicites*, *Poacites* sp. etc. Givulescu (1997) mentioned a warm and wet temperate climate.

The vertebrate-bearing levels are situated towards the formation top, where fluvial and lacustrine deposits are widespread and two coal beds – called Francisc and Rozalia – had been once mined in Aghireșu (Codrea & Fărcaş, 2002). The vertebrates document either MP 23, or MP 24 units, including fish as *Enoplophthalmus* sp. *Hemitrichas* sp., *Dapalis transylvanicus* n. sp., *Dapalis* sp. (Reichenbacher & Codrea, 1999), reptiles as Squamate – *Anguidae* indet., *Serpentes* indet.; turtles – *Trionyx* sp., *Chinemys strandi*; crocodiles – *Diplocynodon* sp.; birds: Charadiimorphae - *Rallicrex kolozsvarenis*; Anserinae indet. (Kessler et al., 1998); mammals: Insectivora indet., Rodentia - ? *Paracricetodon* sp.; Pantolestidae – *Kochictis centennii*; entelodons – *Entelodontidae* indet., *Entelodon* aff. *deguilhemi*; anthracothers – *Elomeryx crispus*, *Anthracotherium* sp.

The Asian originating representatives already dominate the Dâncu Formation fauna. For example, the antracothere described by Rădulescu & Samson (1989), is similar with the ones reported in SE Asia. Several immigrating waves of anthracothers had crossed this region towards Western Europe, in Oligocene.

Cetățuia Hill fossil locality (Cluj-Napoca locality, Cluj district). The outcrop is located on the meridional slope of the Cetățuia Hill.

Suceag-Cipcheş Valley (Suceag locality, Cluj district). The fossil bearing site is located on the left bank of the Cipcheş Valley (left tributary of Nadașului Valley).

Mera fossil locality (Mera locallity, Cluj district). The fossil bearing site is located on the left bank of Berecoaia Valley. In the last years, the site changed due to landslides.

CHAPTER IV. Description of vertebrates from the studied area

IV.a. Gear and methods of study

The first step in studying the Paleogene terrestrial vertebrate assemblages, more exactly the ones occurred around the Eocene/Oligocene boundary, concerned several field surveys in order to locate the vertebrate localities of interest. Part of the studied localities was mentioned long time ago – as the ones reported by Koch in his monograph on the Paleogene from Transylvania in 1894 – while others were discovered by our own research, due to field survey in Cluj and Salaj districts.

After locating the levels of interest, I followed the specific classical ways for collecting the samples. A first direction of study concerned the macro-fossils. The majority had been collected from the Eocene localities Morlaca, Radaia or Treznea, as well as the Oligocene ones Cluj-Napoca and Suceag. In all these places we found exclusively small and medium sized teeth or bones, as isolate items, devoid of anatomical connections.

The fossils were extracted from their rock matrix using the chisel and the small hammer (the classical method used worldwide, in all laboratories), but also a pneumatic device. In some circumstances, when the fragility of teeth and bones was too high, the fossils were impregnate *in situ* by a professional glue (rodopaste or mowillite) solved in acetone or alcohol.

The description of fossils collected was based on direct observation of the samples. The measurements were taken with several calipers, depending on fossil sizes.

Photographs were taken with a Sony camera (8.1 Megapixels, convenient for fair resolution and details on each sample), after processing the photographs with Adobe Photoshop CS2 in order to obtain the plates for this thesis.

Finally, for systematic assignment for each fossil I used various professional references, using the comparison method. These references were mentioned in each chapter (in the abstract, there are only some selected references).

The main part of the vertebrate localities referred the micro-vertebrates. For locating the convenient levels, I followed several sedimentary successions, looking in detail at each rock sample where the small bones or teeth were observed with the pocket lens in the field. Where we have to deal with promising signs, a restricted sample of sediment was dried and washed in the field, for an initial evaluation.

As none of these levels was a favorable location (enough water, fair environment for washing etc) for processing directly the sediment in the field, we carried the sediments to the laboratory. In this manner, we scarified the quantities in order to obtain a better quality of concentrate. However, we succeeded in processing the following quantities of sediment: 400 kg in Bociu, 500 kg in Treznea, 500 kg in Cluj-Napoca Cetățuie, 700 kg in Suceag, about 250 kg in Mera.

The sediment originating from each locality was dried by the sun, on tarps, in the courtyard of Babes-Bolyai University in Cluj-Napoca, as well in winter time inside the laboratory, in stoves. The dryness degree is essential for a fair processing.

After drying, the sediment was washed in concentrated hydrogen peroxide, washed again in water in plastic recipients, than washed on thieves 0.3 and 0.5 mm of stainless mesh. The concentrate obtained was dried again and stored for sorting.

The sorting was hand done, under the binocular eyeglass, in order to collect the fossils. The fossils were washed with hydrogen peroxide, then impregnated with the above mentioned glue.

The SEM photos of the teeth were made in National Natural Science Museum in Paris (France) or in the Royal Institute of Natural Sciences in Bruxelles (Belgium).

CHAPTER IV. Description of the vertebrates from the studied area

IV.b. Upper Eocene and Lower Oligocene localities

<u>Systematic paleontology</u>

Class Pisces

Family Lepisosteidae Cuvier, 1825

Lepisosteidae **indet.**

The Eocene gar fishes from Treznea seem to continue the much older presences in Transylvania, from Late Cretaceous (Maastrichtian), when such fish assigned to *Lepisosteus* genus lived in abundance inside the rivers and lakes of the Hateg Island (Grigorescu et al., 1999; Codrea et al., 2001, 2009), as proved by hundreds of scales and teeth collected in Oarda de Jos (Alba district).

Class Amphibia
Proteidae
Mioproteus **sp.**

LOCALITY AND FORMATION: Suceag, Dâncu Formation, Cluj district;
GEOLOGICAL AGE: Early Oligocene (= Rupelian, Kiscelian);
SAMPLE: dentary (2 bones), vertebrae (12 fragmentary pieces), humerus

Latonia **sp.**

LOCALITY AND FORMATION: Formațiunea de Dâncu, Suceag, județul Cluj;
GEOLOGICAL AGE: Early Oligocene (= Rupelian, Kiscelian);
SAMPLE: maxillae (5 pieces), illium (4 pieces)

Lissamphibia HAECKEL, 1866
Anura MERREM, 1820
Palaeobatrachidae COPE, 1865
***Albionbatrachus* MESZOELY, SPINAR & FORD, 1984**
Albionbatrachus oligocenicus **VENCZEL, CODREA & FĂRCAȘ** /in print/

LOCALITY AND FORMATION: Suceag, Dâncu Formation, Cluj district;
GEOLOGICAL AGE: Early Oligocene (= Rupelian, Kiscelian; MP 23-24);
SAMPLE: TYPE SPECIMEN UBB V 442, complete frontoparietal of a mature specimen; the right postero-lateral side slight damaged; across a transverse fissure, the anterior lobe is moved upward and to the right; several fissures of minor significance may be observed on the anterior and rear surfaces.
OTHER ASSOCIATE BONES: two fragmentary front-parietals (UBB V 443; 444); a fragmentary spheno-ethmoid (UBB V 445); two maxillae fragments (UBB V 446; 447); three fragmentary angulo-splenials (UBB V 448 - 450); six distal humeral fragments (UBB V 451 - 456), two fragments of iliac (UBB V 457; 458).

Fig. IV.b.1. Fronto-parietal of *Albionbatrachus oligocenus* – upper, ventral and lateral views (Suceag –Dâncu Formation). It worth to underline the ornamented skull roof, diagnostic feature for the taxon

Ranidae

Pelophylax sp.

LOCALITY AND FORMATION: Suceag, Dâncu Formation, Cluj district;
GEOLOGICAL AGE: Early Oligocene (= Rupelian, Kiscelian);
SAMPLE: iliac (2 pieces).

From paleobiogegraphic viewpoint the occurrence of *Mioproteus* is important: until now it was reported only starting with the Early Miocene of Europe. *Albionbatrachus* was firstly described from Headon Hill 2 (England; Meszoely et al. 1984). A taxon close to this genus was reported until now in Europe only in the Late Oligocene (MP 30) at Oberleitersbach (northern Bavaria), described as *Palaeobatrachus* sp. (aff. *Albionbatrachus wightensis*) by Böhme (2008).

The remaining fauna was rarely reported from the European Oligocene. The richness of herpetofauna remains in the localities belonging to Dancu Formation proves the values of these sites for the knowledge of this fauna in Europe.

Class Reptilia

Anguidae

Anguidae indet.

LOCALITY AND FORMATION: Suceag, Dâncu Formation, Cluj district;
GEOLOGICAL AGE: Early Oligocene (= Rupelian, Kiscelian);
SAMPLE: various osteoderms

Aniliidae

Eoanilius sp.

LOCALITY AND FORMATION: Suceag, Dâncu Formation, Cluj district;
GEOLOGICAL AGE: Early Oligocene (= Rupelian, Kiscelian);
SAMPLE: vertebrae (5 pieces)

Boidae

cf. *Bransateryx* sp.

LOCALITY AND FORMATION: Suceag, Dâncu Formation, Cluj district;
GEOLOGICAL AGE: Early Oligocene (= Rupelian, Kiscelian);
SAMPLE: vertebrae (10 pieces).

Order Chelonii Brongniart 1800 (Latreille, 1800)

Gen *Mauremys* Gray 1869 (= *Clemmys* ; = "*Chinemys*")

LOCALITY AND FORMATION: Turbuța, Șanțului Valley, Treznea 1, Sălaj district;
GEOLOGICAL AGE: Late Eocene (= Early Priabonian);
SAMPLE: several carapace and plastron fragments

Suprafamily Trionychoidea Fitzinger, 1826

Family Trionychidae Fitzinger, 1826

Genus *Trionyx* Geoffroy Saint-Hilaire, 1809

***Trionyx clavatomarginatus* Lörenthey, 1903**

LOCALITY AND FORMATION:Cluj Limestone Formation, Cluj-Napoca and Baciu, Cluj district;
GEOLOGICAL AGE: Late Eocene (= Early Priabonian);
SAMPLE: several carapace and plastron fragments.
LOCALITY AND FORMATION: Rădaia, Valea Nadășului Formation, Cluj district;
GEOLOGICAL AGE: Late Eocene (= Early Priabonian);
SAMPLE: small carapace fragment.

Trionichids are rarely reported in Late Eocene in Transylvania. That is the reason why I mention now a small carapace fragment recorded in Valea Nadasului Formation, at Radaia. It fairly preserves a peculiar ornamentation. It occurred in the same locality that yielded the notorious *Prohyracodon orientale* fossils (type locality of this species).

Order Crocodylia GMELIN 1788

Suborder Eusuchia HUXSLEY 1875

Family Alligatoriade KALIN 1940

Alligatoridae **indet.**

LOCALITY AND FORMATION: Turbuța, Șanțului Valley, Treznea 1, Sălaj district;

GEOLOGICAL AGE: Late Eocene (= Early Priabonian);

SAMPLE: several isolate teeth.

Superorder Crocodylomorpha Walker, 1968

Order Eusuchia emend. Huxley, 1875

Genus *Diplocynodon* Pomel, 1847

Diplocynodon **sp.**

LOCALITY AND FORMATION: Cluj-Napoca Cetatuie and Suceag, Dancu Formation, Cluj district;

GEOLOGICAL AGE: Early Oligocene (= Rupelian, Kiscelian);

SAMPLE: various cranial or post-cranial bones (mandible fragment, cervical, thoracal, tail vertebrae, rib fragments, humerus, inominate bones, femora, tibia, phalanx, osteoderms).

Diplocynodon occurred in Europe and North America since the Middle Eocene (Berg, 1966; Ginsburg & Bulot, 1997; Böhme, 2003). Earlier reports, as the one from Jibou (Paleocene, Jiboub Formation) are not for instance enough documented by fair fossils. They could be rather resulting of mistaken determination based on scarce sample, without enough diagnostic characters. However, we mention that there are paleontologists with different viewpoints. According them, the occurrence could be earlier, in Late Paleocene (Thanetian; Vasse, 1997).

The origin of these crocodiles is a still debated subject. After some interpretations, their origin should be in Asia, migrating toward Europe only after the opening of some terrestrial bridges (Kotsakis et al., 2004). The migration track seems to be the one formed by the archipelago raised by the folded structures of the orogene. The Transylvanian representatives could follow such track.

In other opinions (Vasse, 1993), this genus could be of European origin. From Europe, it could migrate in North America at dawn on Eocene. Therefore, the geographic area of origin remains for instance an open discussion, which is in need of additional studies, as Buscalioni et al. (1992) pointed out.

The evolutionary history of the genus seems to be a long and successful one, as far as the last European representatives survived until the end of Miocene. Obviously, in Oligocene this genus was widespread in Transylvania. In Central Europe, these crocodiles were extinct in Middle Miocene (MN 6), 13.5-14 M.y. ago, together with chameleons and giant tortoises, warm loving taxa. The extinction occurred gradually, with an extinction gradient. In this manner, such crocodiles could survive in southern Europe until more recent times. For example, if in France the last record is in Sansan (MN 6; Ginsburg & Bulot, 1997), on Iberian area it was mentioned also in MN 9 unit, cca 9.7 M.y. ago

(Antunes, 1994). In Bulgaria, the survival was longer, until the end of Miocene (Huene & Nikolov, 1963).

In Romania, the last record seems to be in Middle Miocene at Subpiatra 2/1 (MN 6), near Alesd (Borod Basin; Hir & Venczel, 2005). Inside Subpiatră assemblage, the crocodile occurs besides numerous representatives of *Rana*, varans, all reptiles that became extinct in the later Subpiatră 2/2 (MN 7+8).

Class Aves

Order Ardeiformes WAGLER, 1831

Genus *Eostega* LAMBRECHT, 1929

***Eostega lebedinskyi* Lambrecht, 1929**

LOCALITY AND FORMATION: Cluj Limestone Formation, Cluj-Napoca former Manastur open pit, Cluj district;

GEOLOGICAL AGE: Late Eocene (= Early Priabonian);

SAMPLE: mandible fragment.

This fossil is a rarity, such remains are extremely few in Paleogene, as: *Masillastega rectirostris* described by Mayr (2002) at Messel (MP 11), which Mlíkovský considers in same genus with Cluj bird; *Mergus ronzoni* Gervais, 1848-1852 from French Lower Oligocene (Ronzon, MP 21) or the younger *Sula arvernensis* Milne-Edwards, 1867, from Late Oligocene (MP 30) at Gannat (France).

Supraorder Charadiimorphae HUXLEY 1867

Family Rallidae VIGORS 1825

***Rallicrex* LAMBRECHT 1933**

***Rallicrex koloszvarensis* LAMBRECHT 1926**

LOCALITY AND FORMATION: Cluj-Napoca Cetatuie, Dâncu Formation, Cluj district;

GEOLOGICAL AGE: Early Oligocene (= Rupelian, Kiscelian);

The diagnosis of this genus remains for instance rather confusing (Jurcsák & Kessler, 1973), but Caroll (1988) accept its validity. As the name is showing this bird has a mixture of characters both from *Rallus* and *Crex*. Such a combination is indicating a bird close to *Rallus aquaticus* Linne 1758, but with less advanced aquatic abilities, preserving also some features close to *Crex crex* Linne 1758.

Class Mammalia LINNAEUS, 1758

Subclass Theria PARKER & HASWELL, 1897

Infraclass Eutheria GILL, 1872

Order Marsupialia

***Peratherium lavergnense* CROCHET, 1979**

LOCALITY AND FORMATION: Turbuța, Șanțului Valley, Treznea 1, Sălaj district;

GEOLOGICAL AGE: Late Eocene (= Early Priabonian);

SAMPLE: several isolate teeth and mandible fragments.

This species was firstly described from Lavergne (France), its type locality, one among the Quercy phosphates.

Treznea 1 is for instance the single locality bearing Pleogene marsupials in our country. The species' stratigraphy concerns the FAD at Grisolles, in Marinesian (Late Eocene). Starting with level, the species is present in levels as Fons4, Perrière and La Débruge. After, it became rare, but it could be present in San Cougat, Etampes, or even in Early Oligocene at Hoogbutsel (MP 16-21 units). Apart these type localities, in other regions it was found in Aubrelong 1 and 2, Lascours, Bouffie, Les Clapies, Pradigues, Malpérié, Perière, Les Sorcières, Sossis, Le Bretou, Salème (Crusafont, 1967; Crochet, 1978, 1979, 1988; Remy *et al*., 1987; Checa & Casanovas, 1989-1990).

In Treznea 1, these marsupials are among the most frequent small mammals. In this locality, a single species seems to be present.

Order Insectivora

Family Erinaceidae FISCHER VON WALDHEIM, 1817

?Neurogymnurus sp.

LOCALITY AND FORMATION: Cluj-Napoca Cetatuie, Suceag, Mera, Dâncu Formation, Cluj district;

GEOLOGICAL AGE: Early Oligocene (= Rupelian, Kiscelian);

The Rupelian insectivores from northwestern Transylvania obviously belong to archaic European echinosoricidae, *Neurogymnurus* being besides *Tetracus.* Such mammals are rather rare in the different European assemblages, becoming extinct in Late Oligocene (MP 30; Antunes & Mein, 1992). The genus could be present in the Early Oligocene from Dětaň, but the fossils originating from this locality are fragmentary (Fejfar, 1987).

Order Rodentia BOWDICH 1821

Family Cricetidae MURRAY 1866

Genus *Atavocricetodon* FREUDENTHAL 1996

Atavocricetodon cf. *atavus* **(MISONNE 1957)**

SPECIES BELONGING TO GENUS: *Cricetodon murinum* SCHLOSSER 1884; *C. huberi* SCHAUB 1925; *Eucricetodon nanus* Pelaez-Campomanes, 1995; *Atavocricetodon hugueneyae* Freudenthal 1996, *A. nanoides* Freudenthal 1996, *A. minusculus* Freudenthal 1996.

STRATIGRAPHY AND GEOGRAPHIC RANGE: Europe Late Eocene-Early Oligocene.

LOCALITY AND FORMATION: Turbuța, Șanțului Valley, Treznea 1, Sălaj district;

GEOLOGICAL AGE: Late Eocene (= Early Priabonian);

SAMPLE: several isolate teeth.

Genus *Pseudocricetodon* THALLER 1969

cf. *Pseudocricetodon* sp.

SPECIES BELONGING TO GENUS: *P. montalbanensis* THALER 1969, *P. thaleri* HUGUENEY 1969.

STRATIGRAPHY AND GEOGRAPHIC RANGE: Europe Late Eocene-Early Oligocene.

LOCALITY AND FORMATION: Turbuța, Șanțului Valley, Treznea 1, Sălaj district;

GEOLOGICAL AGE: Late Eocene (= Early Priabonian);

SAMPLE: several isolate teeth.

There are different viewpoints related to the early hamsters from Central Europe. According Baciu & Hartenberger (2001), the older cricetid occurred in Late Eocene in Möhren 6 (*Atavocricetodon atavus*). Dienemann (1987) mentioned however, that this taxon is documented only by a single tooth, probably allochtonous.

The track followed by the migratory mammals related to "*La Grande Coupure*" there are some various scenarios. After Vianey-Liaud (1979), the immigrants arrived in Europe from regions located eastward from Ural Mountains, crossing the Turgai Strait. Heissig (1979) and Hellmund & Heissig (1994), agreed rather a way following the land bridge emerged between Asia and Europe due to the rise of the Alpine orogene. In their scenario these faunas migrated from Kazachstan by Georgia and Turkey to Bulgaria and Transylvania. As arguments, they mentioned the earlier presence of these mammals in the Oriental Europe. This hypothesis was also renewed by Uhlig (1999 a, 1999 b), who mentioned that the Upper Eocene *Prohyracodon orientale* from Romania has close relationship to *Eggysodon*.

The discovery of the Upper Eocene hamsters in Romania, which have close affinities both with the Oligocene cricetids from Central and Western Europe and from the Late Eocene from Asia, supports also Heissig's scenario.

Subfamily Paracricetodontinae Mein & Freudenthal, 1971

Genus Paracricetodon Schaub, 1925

Paracricetodon sp.

SPECIES BELONGING TO GENUS: type species *Cricetodon spectabilis* Schlosser, 1925; *P cadurcensis, P. confluens, P. dehmi, P. walgeri, P. kavakderensis, P. kodjazarmensis*.

The representatives of this genus are now reported firstly in Romania from the Rupelian localities from Gilau sedimentary area, in order of richness in such fossils at Cluj-Napoca Cetățuie (the richest locality), Suceag (lower and upper: Sci and Scs) and Mera (lower and upper: Mri and Mrs). Te west, such fossils are missing, but it would however, possible to find them perhaps at Aghires. If so, they would be present in the entire area with coal deposits.

Superorder Paraxonia MARSH 1884

Order Artiodactyla OWEN 1848

Superfamily Anthracotherioidea Gill 1872

Genus *Elomeryx* MARSH 1894

***Elomeryx borbonicus (*GERVAIS 1848-1852)**

SPECIES BELONGING TO GENUS: type species *Elomeryx crispus* (GERVAIS 1849), with subspecies *E. crispus crispus* (GERVAIS 1849) and *E. crispus cluai* (DEPERET 1906). STRATIGRAPHY AND GEOGRAPHIC RANGE: In Europe, *Elomeryx* occurred in Late Eocene (MP 18, La Debruge), probably as result of an immigration from Asia, lasting until the Early Eocene (MN 1, Fornant 11, Pyrimont-Challonges, Wischberg; Hellmund, 1991).

DATA ON DISCOVERIES FROM TRANSYLVANIA. The first fossils of small anthracotheres were unearthed in 1917 at Cluj, by Janos Tulogdi, at Cetățuie, in Dâncu Formation deposits. The place where Tulogdi dug was located under the actual cross monument from this hill. Now, it vanished due to the works against landslide tendencies carried out on the hill slope. The fossils recovered by Tulogdi finally reached two collections: the majority of teeth are in the MAFI collection (Geological Institute) in Budapest, while the post-cranial bones remained in Cluj University. Probably the teeth were sent in Budapest for systematic assignation, but they never returned in Transylvania.

After, on the same hill, several fossils were collected by a student in 1957. But, he found only turtle remains, and no anthracothere fossils. The turtles were studied later by Mlynarsky & Mészáros (1969). The site with turtle remains is on a western location compared to Tulogdi's site. From the last site, in 1997 the geologist student Matei Vremir, under supervision of Prof. dr. Vlad Codrea, collected some more vertebrate remains, but they concerned only crocodiles and not anthracothere. This was the site where we dug in the last years.

MATERIALS: in *MAFI* collection: right and left mandible fragments (initially assigned to „Hippopotamus"), inv. Ob 3383; phalanx, Ob 3987; astragalus, Ob 3389; damaged calcaneum, Ob 3390; palate of a juvenile, with milk teeth, Ob 3391; half-mandible of a juvenile, with d2-d4 şi m1 in eruption.

- *in Cluj university collection*: right femur, with proximal part damaged (CT1 1); two fragments, proximal (CT1 2a) and distal (CT1 2b) of a left femur; two rotulae: right fragmentary (CT1 3), left complete (CT1 4), of same individual; two tibias (CT1 5 and CT1 6); left astragalus (CT1 7); two calcaneum (CT1 8 and 9); Mc III (CT1 10), as well as fragmentary metapodials (CT1 11-14, 15-20); three phalanx (CT1 23-25); inominate fragments (CT1 26-27); two omoplate fragments (CT1 28-29); distal fragment of left humerus (CT1 30); proximal ulna fragment (CT1 31); ten fragmentary incisors (CT1 32-41); fragment of mandible with dp3 (CT1 42); p 4 (CT1 43); six vertebrae (CT1 44-49); tibia fragment (CT2 1); metapodial fragment (CT2 2); right p2 (SgC 1) and right p3 of same specimen (SgC 2).

LOCALITY AND FORMATION: Cluj-Napoca Cetatuie, Suceag, Dâncu Formation, Cluj district;

GEOLOGICAL AGE: Early Oligocene (= Rupelian, Kiscelian);

Order Perissodactyla OWEN 1848

Parvorder Ceratomorpha WOOD 1937

Superfamily Rhinocerotoidea OWEN 1845

Genus *Prohyracodon* KOCH 1897

Type species: *Prohyracodon orientale* **KOCH 1897**

SPECIES DIAGNOSIS: in Codrea (2000)

SPECIES BELONGING TO GENUS: *P. orientale, P. meridionale, P. ?parvus, P. obrutschewi*.

STRATIGRAPHY AND GEOGRAPHIC RANGE: ?Middle and Late Eocene and Early Oligocene, in Asia and Oriental Europe.

DISCUSSIONS. The single find of *P. orientale* from Europe is the one from Rădaia, on the left bank of Nadăşului Valley, in Valea Nadăşului Formation. The last observations belonging to Codrea (2000) are enough detailed for the older fossils curate in Babeş-Bolyai University collections in Cluj, therefore I do not renew these discussions. It worth mention the probable synonymy between *P. orientale* and *P. meridionale* (the last one, on its turn, synonym with *P. progressa*), as Codrea already underlined.

Superfamily Rhinocerotoidea Owen, 1845

Family Amynodontidae Scott & Osborn, 1883

Genus *Sharamynodon* Kretzoi, 1942

Sharamynodon sp.

SPECIES BELONGING TO GENUS: The problem concerning this genus' species is extremely disputed (for details see Wall, 1989). It is presumable that the number of species would be high, if genera as *Lushiamynodon* or *Sianodon* are synonyms of *Sharamynodon*. Because of this situation as well as the impossibility of direct comparison with specimens from Asia, we stopped the determination at genus level.

STRATIGRAPHY AND GEOGRAPHIC RANGE: ?Middle and Late Eocene and Early Oligocene, in Asia and Oriental Europe.

LOCALITY AND FORMATION: MORLACA, Valea Nadasului Formation, Cluj district;

GEOLOGICAL AGE: Late Eocene (Priabonian);

MATERIALS: right tooth row (M1 – M3) in maxillary; right mandible fragment preserving ?m1 or m2

The tooth row is originating from a mature old individual, with advanced wearing of molars, which eliminate several characters. However, some details may still be observed.

Infraorder Titanotheriomorpha HOOKER, 1989

Superfamily Brontotherioidea MARSH, 1873

Family Brontotheriidae MARSH, 1873

***Brachydiastematherium* BÖCKH & MATYASOVSKI, 1876**

Brachydiastematherium transilvanicum **BÖCK & MATYASOWSKI 1876**

SPECIES BELONGING TO GENUS: *Brachydiastematherium* is a valid genus, monospecific.
STRATIGRAPHY AND GEOGRAPHIC RANGE: Late Eocene (Priabonian), Europa, Romania.
LOCALITY AND FORMATION: Rădaia, Valea Nadăşului Formation, Cluj district;
GEOLOGICAL AGE: Late Eocene (Priabonian);
MATERIAL DE REFERINȚĂ: The single titanothere ever reported from Transylvania is *Brachydiastematherium transilvanicum* (discovered in 1871 by Alex Pavay, at Rădaia, near Cluj-Napoca, Osborn, 1929). The single piece described in a publication refers to an anterior fragment of mandible preserving al incisor series, the first two right premolars and the complete left cheek teeth series including m1 (measurements in Osborn, 1929). The fossil was found when the road Cluj-Zalau collapsed at Rădaia, in the second half of 19th century.

Apart this fossil, in Cluj university collection there are also some additional items, post-cranial bones. Their size fit with the mandible; therefore, they could belong to same mammal. These bones were never published. Such bones may offer an idea about the animal size, probably reaching 2 m at shoulder.

? *Brachidiastematherium transylvanicum* **Böckh & Matyasovski, 1876**

LOCALITY AND FORMATION: Morlaca, Valea Nadăşului Formation, Cluj district;
GEOLOGICAL AGE: Late Eocene (Priabonian);
MATERIAL: Upper right molar

After more than a century, it is the single such find in Transylvania. Morlaca is a new Upper Eocene locality bearing large mammals.

Fig. IV.2. Upper right molar
? *Brachidiastematherium transylvanicum* **Böckh & Matyasovski, 1876,**
oclusal view

CHAPTER V. Paleogeography

The Upper Eocene-Lower Oligocene time span recorded major changes in Earth paleogeography. Apart from changes induced by the plate tectonics already mentioned, it worth to look closer Eurasia and its peculiar evolution.

For the area on interest we can underline a series of events, mainly tectonic, which controlled the evolution of the region and the balance marine vs. continental. We refer mainly to the so-called Lower Oligocene Pyrenean tectogenesys (more precise, in Merian; Rusu, 1988). These movements were preceded in Late Priabonian by the pre-Pyrenean tectogenesys (Mészáros & Dudich, 1968). Basically, all these movements are part of the Alpine orogenesis, but they didn't led to folded and/or thrust structures, but had large influence on the distribution of the immerged and emerged regions. The Pyrenean movements were associated in some interpretations to the genesis of the so-called early (initial) Paratethys (Rusu, 1988). Anyhow, in Gilau sedimentary area we may underline the following: tilting and emersion of large areas in northwestern Transylvania that formed the continental Valea Nadăşului and Turbuța Formations. This emersion wasn't a long lasting one, because soon after the marine realm regained the region, with the Foidaş anhydrite and the Cluj Limestone Formation deposits. Brebi Formation recorded the maximum deep of the sea in this area. However, in Rupelian, Gilau area lifted again: in Merian there is already marine/terrestrial interleaving fairly cropping out on Berecoaia Valley at Mera. This continentalisation is more obvious to the top of Mera Formation, near the boundary with Moigrad Formation. From this level there are reported plat remains, indicative for the Rupelian climate.

The first continental sequence concern Valea Nadăşului and Turbuța formations. In a larger basin overview, this episode lasted longer in other areas: The Sard Formation from the Metaliferi sedimentary area documents this assertion (Codrea & Dica, 2005), but the age of its tot is still unclear (Codrea et al., 2010): it could correspond to a sedimentation including the Eocene, or the whole basal Paleogene could be missing, due to the erosion occurred between the Latest Cretaceous and Priabonian. In any case, it's obvious that the southwestern side of the Basin of Transylvania acted in that time span as a land area, without any marine influences. This is proving that both Valea Nadăşului and Turbuta formations were nothing but a north-northwestern extension of an emerged area that included Pannonia, Apuseni Mountains, extending over the Southern Carpathians to the Moesian Platform, continuing in Bulgaria, Turkish Trakia and Asia Minor. To east, it was a marine realm, including the flysch sedimentation from Eastern Carpathians Moldavides and the post-tectonic cover of Bucovinids. It is important to point out that to east, the continental area couldn't communicate with the large lands from Eastern Europe due to this peculiar paleogeography. This detail is essential: all the eastern migrants could reach Transylvania only from southeast, and not from east or north.

Such a scenario is finding hard evidence in the Upper Eocene vertebrates found in Bulgaria (Nikolov et Heissig, 1985) that refers to taxa of clear Asian origin as some archaic rhinocerotoids as *Prohyracodon*, or titanotheres close to the one from Radaia, in Transylvania.

Moreover, Codrea (2000) underlined since a decade ago that resemblances could be advanced to a similitude between some mammals from Transylvania, Bulgaria and even Oriental Asia (Yunnan). Codrea's arguments are enforced by the presence of the oldest hamsters from Europe in the Late Eocene from Transylvania. The taxa only mentioned by Baciu & Hartenberger (2001) were retrieved both in Bociu or in Treznea 1. Their Asian origin was never contested by any paleontologist. After their arrival, they co-existed with a fauna probably of European origin (didelphid marsupials). This confirm Heissig's pattern, the German paleontologist sketching a more rich way the Eocene paleogeography, compared to the more rigid pattern published by Baldi (1984), who was thinking about continuous land bridges between the Moesian Platform and Caspian realm, as well between the Rodop Mountains and Anatolia and Caucasus. Such paleogeographical reconstructions are almost every time based on the high standing eustatism of the ocean, and are not consider the low eustatism, when the emerged area gain more extension.

Would be possible an intrusion of Asian mammals from North in Transylvania? Such a scenario was proposed by paleontologist as Vianey-Liaud, who presumed the closure of the Turgai Strait. This closure opened a way for the terrestrial Asian faunas to septentrional Europe. A closer look shows that this wide area could communicate with the Romanian regions, due to Mazury-Mazowsze uplift (Odrywolska-Bienkova, et al., 1978). In our opinion, the Asian intrusion could follow these both tracks.

It is very obvious that the Asian migrations occurred before the Eocene/Oligocene boundary, more exactly in Priabonian, or possibly even earlier (for older times, Transylvania recorded only marine realms). We should presume a migration gradient, with earlier presences of some mammals compared to Western Europe. Such tendency was controlled by a specific paleogeography, related to climate change. The regression of seas opened new land bridges.

In Early Oligocene (Dâncu Formation), the paleogeography was deeply changed, both local and continental. Locally, one may take into consideration the invasion of the marine realms happened in Late Eocene, starting with the anhydrite facies (Foidas Formation), followed by a carbonate platform (Cluj Limestone Formation), evolving gradually to a deeper basin (Brebi Formation, where the Eocene/Oligocene boundary is located in northwestern Transylvania). It was a transgression, developing a distinct marine cycle in Late Eocene and earliest Oligocene. This tendency was not strict local, because we can find it in other areas of the Basin of Transylvania too, like in Metaliferi area or on the northern margin of the Southern Carpathians.

In Metaliferi area, the marine transgression begins with the Ighu Formation, its basal section being correspondent of the top of Cluj Limestone and the marls with *Nummulites fabianii* (Băluță, 1987; Codrea et Dica, 2005 with all mentioned references) The marine Eocene from Alba district is lying in unconformity the red beds of the Sard Formation, which the geological age of the top remains unclear, but the base in obviously Maastricthian. Even the Sard Formation is completely devoid of any Paleogene term, a gap and erosion during the basal Paleogene are proving the emerged status of the area. It means a different evolution compared to Cluj-Sălaj-Maramureş region.

On the northern margin of Cindrel and Fagaras mountains, the Paleogene is clearly documented by the marine deposits from the notorious outcrops from Turnu Roşu (= Porceşti, Sibiu), where both Lutetian and Priabonian are present (Bucur & Ianoliu, 1987), but only in marine facies, mainly rich in limestone. Several lithostratigraphic units were outlined in this area: Valea Satului Formation (Cuisian), Strada Muntelui Formation (Luteţian-Priabonian) and Valea Nişului Formation (Priabonian-Early Oligocene; Mészáros, 1996). Unfortunately, a refined definition for these formations, even after more than a decade since the death of Professor Nicolae Mészáros, is still undone: the type sections as well as the limits of these formations are rather figured in the table and some details are not mentioned at all. But these Paleogene exposures are not the single in the area. Of same interest are the ones located westward, on Rodului Valley in Apoldu de Sus, which are Middle Eocene (Mészáros et al., 1977).

Further to west, there are mentioned Eocene limestone blocks bearing nummulites, reworked by the Badenian transgression, at Dobârca (Maxim, 1965). Recently, this Badenian reworking, was renewed by Solomon et al. (2010). They pointed out that these blocks are exclusively Lower and Middle Eocene, as it can be seen in Râpa Roşie, near Sebeş. They concern limestone rich in alveolineae and nummulites. Such blocks could not originate from the Apuseni Mountains margin from Alba area, where only Priabonian deposits are for instance known. For this reason, a thick pile of Paleogene deposits should once exists on the northern margin of Southern Carpathians, eroded by the Paratethys Sea, in Badenian. This erosion was very aggressive and eliminates for large areas the Paleogene deposits. The original Eocene succession cannot be reconstructed now, because we have to deal with a real puzzle, reworked in the Badenian deposits. Anyhow, during the Early and Middle Eocene, there was a carbonate platform that evolved in shallow marine waters. When this platform accumulated, the emerged areas where located to west and south, where the vertebrates were able to cross to northwestern Transylvania.

The Paleogene marine realm is important for the knowledge of the continental evolution due to the vertebrate remains, fortuitous burred in the marine rocks. It concerns the remains from Jebucu gypsum, or the ones collected during the mining of the Cluj Limestone, once very intense.

The Oligocene paleogeography was completely changed. It is obvious that the emerged areas extended and their influence in the marine record, too. The first signs toward a continental evolution can be observed in our area of interest only in Merian (Mészáros et al., 1989; Ghergari et al., 1989), therefore pre-Kiscelian (Rupelian). The top of the type section of Mera Formation from Berecoaia Valley at Mera, already bears a flora apparently rich in Lauracee, the taxa including: *Daphnogene cinnamomea,* cf. *D. cinnamomifolia, Laurophyllum obovatum, Laurophyllum* sp., *Neolitsea palaeosericea,* as well as Fagaceae - *Dryoplhyllum furcinervis* and Rhamnaceae - *Zizyphus zizyphoides* (Mészáros & Petrescu, 1967). From same formation, at Fildu de Sus (Sălaj) is reported the oldest indricothere from Transylvania, probably related to *Urtinotherium* (Codrea & Şuraru, 1995; Codrea, 2000), as well as the single report of *Ronzotherium* (Codrea, 2000).

In Moigrad Formation, the continental environments are very obvious, documented by the red beds. Unfortunately, in these red beds the fossils are extremely rare: they are isolate and are originating from fortuitous finds, as the one of *Entelodon* aff. *deguilheimi* (Brunet, 1979; Rădulescu & Samson, 1989) –, which Kretzoi (1941) considered as a distinct species, *E. hungaricum*, but Brunet put in synonymy with the fore mentioned species -, or some poor preserved indricothere fossils found at Dâncu (Vlad Codrea, *personal communication*). This emerged status of the area continued for a rather long span in Rupelian, when fluvial deposits accumulated in Gilau and Meses areas. Such a process was not only local, because at this level one can observe that land bridges opened, giving free access to Europe to several large mammals, as the indricothers. Such giant rhinos are indicative for open environments, where the forests became rarer and the areas covered by herbs gained richer extension. Indricothers are large mammals obviously arriving from Asia (Codrea, 2000). However, their success was rather restricted, if thinking that their westernmost presence ever documented is in Ivangrad (Montenegro).

The end of the marine domain arrived to the top of Dâncu Formation, when the basin is gradually re-gained by the marine realm. This process began with fluvial-lacustrine deposits recorded in Gilau area, very unequal as vertical extension: thicker at Ticu-

Tămaşa, becoming thinner and thinner to east, as in Cluj-Napoca at Cetatuie, or with a more severe thinning just some kilometers further, as in the well FH2 Transgex, between 53,6-54 m (therefore, only forty of cm.), with fish fauna: *Dapalis transylvanicus, D. angustus*, „*Lesuerigobius*" sp. (original data, unpublished by Petrescu et al., 2002). There are some of the same species published by Reichenbacher & Codrea (1999) at Berecoaia at Mera, or Cipcheş at Suceag.

The presence of some taxa occurred in Dâncu Formation is indicative for the continuation of immigrations from Asia. Among such vertebrates, the anthracotheres are a good example. Among them, we can note a large sized form („*Anthracotherium* sp. large size", Rădulescu & Samson, 1989), close to *A. monsivalense* de Zigno, 1888 from the Italian Lower Oligocene. The resemblance of this anthracothere with the one from Czechia (Detan-Dverce; Fejfar, 1987) or even from the Extreme Orient (Ducrocq, 1995), is probably indicative for a distinct evolving line, with representatives of success in their radiation. The second form of anthracothere is *Elomeryx*, which belongs to the small size category, with less clear origin. Nikolov & Heissig (1985), reporting such mammals from the ?Late Eocene from Burgas (Bulgaria) are arguing for an Asian origin vs. a south or western European origin, earlier supported by Heissig (1979), or more recently by Ducrocq (1995). In our opinion, if Burgas deposits really belong to Late Eocene, it could prove Asian origin, as the ones from Trakia, in Turkey. The geological ages of some formations from Oriental Europe are continuing to be mistakenly related by some paleontologists from Western Europe. For example, Ducrocq (1995) considers Dâncu Formation as Late Eocene (*sic!*), basing exclusively this assertion of the morphology of anthracothers cheek teeth, ignoring at all the additional data, including the marine deposits already dated sandwiching Moigrad and Dancu formation. In such situation, we just recall that Dancu Formation belongs to NP 23 (upper part) and NP 24 (lower part; Mészáros & Moisescu, 1991). If we relate this formation to ELMA ages or the MP units, it is Suevian, MP 23.

Practically, just above these levels, begun the evolution of the brackish-marine Gruia Formation and its lateral correspondent, Ileanda Formation, the last one typical for rocks formed in anoxic environment. At this level we stopped our study, because the remaining formations are too far from the Eocene/Oligocene boundary.

CHAPTER VI. Paleoenvironmental evolution around Eocene/Oligocene boundary in Transylvania

An event as „*La Grande Coupure"* that was induced and controlled by the climate change has as result –among other consequences- changes in Upper Eocene and Lower Oligocene environments. These changes refer to re-configuration of the terrestrial environments, as well as the all biota. As we already mentioned, the climate became colder, influencing firstly the flora, then the fauna.

The climate reconstruction for the Cenozoic in Transylvania was mainly based on marker plant assemblages originating from various localities (Petrescu & Balintoni, 2002). As a lot of tentative, it is weakened by the scarcity of data for some time spans, probably bollixing the climate short events. The general trend of the climate curve is fair, in concordance with the other European regions (for details, Petrescu, 2005). But, some events as the Barthonian crisis, could not be recorded: between Morlaca (in our opinion, misplaced in Luteţian) and Treznea, other localities yielding data are completely missing, as well as between Treznea and Bizuşa (Rupelian) it is a same situation.

In same situation are the interpretations based on terrestrial vertebrates. The data refer to localities too long separated in the geological time. This situation is due to the peculiar geological evolution of the Basin of Transylvania in Paleogene, with too many marine invasions, when the data coming from continental realms, are few or even missing.

I will expose further data that could be useful for the ancient environment reconstructions. The key in this tentative is obviously yielded only by the marker-taxa. The time span of interest refers to Late Priabonian-Rupelian. For the pre-Priabonian evolution, the data related to continental realms are extremely few (e.g. Codrea & Vremir, 2003 c).

The first continental sequence refers to Valea Nadăşului and Turbuţa formations. If the first one is already notorious for its large mammal remains, the second one yielded a very interesting microvertebrate fauna. I will begin with the last ones.

The fishes were collected exclusively from Treznea Formation. As I exposed in the systematic section, all such fossils are documenting the gar-fish. They are indicative for fresh waters (rivers with high debit or lakes). Some of the actual representatives are able to record episodic intrusions in brackish or even marine water. But at Treznea, such a situation was missing, because the remaining taxa are clearly indicate, fresh water (charophyte, turtles etc). Such fish may be extremely attired by stagnant water environments (Treznea sediments, black and rich in organic matter is such a deposit). Ferocious carnivorous, they hunted other fishes as well as carcasses of small mammals (hamsters and marsupials), including probably the aquatic dwellers too, turtles or possibly small birds.

The Treznea 1 turtles are also indicative for pond environment, in water invaded by plants. They could be the prey of gar-fish or crocodiles, but such a tropic relationship could never be documented by bite marks on the carapace or plastron. An interesting taphonomic detail concerns the fragmentary status of the bones. No entire carapace or plastron was ever found, in thwart of a stagnant water environment where anatomical connections could be expected.

The mammal assemblage is dominating by the didelphid marsupials belonging to *Peratherium*. The ecological exigencies of the actual didelphids concern the tropical to temperate forests, bush areas, prairies interrupted by rare forests, sometime in wet environments, pampas or even the arid areas, with desert tendencies. The climatic barriers are related to the climatic regime in general, or to the altitude, these mammals not exceeding 3,400 m in Equatorial area. In spite of such cosmopolitism, their main preference is related to the dense tropical forest. These marsupials are in predilection arboreal, but they may to be terrestrial or even excellent swimmers too (*Chironectes*), with the adaptation of their foot extremities. The diet is very diverse, hunting small mammals (at Treznea1 the hamsters could be such a prey), small birds, lizards, eggs, insects, various carcasses, but also plants, seeds and fruits, fish, frogs, crustaceans. The majority of the actual representatives are nocturne, sometimes twilight, but also active at dawn (Crochet, 1979).

In Early Eocene, the paleogeography of the Western Europe was high peculiar, with an endemic, insular evolution, an archipelago-like system surrounded by marine waters. The coastal areas were covered by dense forests, with swamps, of tropical-type. Such close environments are documented by several large mammals, very specific for the whole Western European region.

The arid tendency occurred in Ludian was not an abrupt one, but probably evolved gradual. Therefore, some European areas still remained rich in forests, of close type. Such an environment may be presumed at Treznea, with swampy tendencies, documented by turtles, amphibians, fishes. As for the evidences offered by plants, such documents in the fossil record are not too numerous. They could refer to the microflora published by Petrescu & Mészàros (1987), renewed by Petrescu (2003). On the other hand, it is the climatic curve figured by Petrescu & Balintoni (2004). In the list of taxa from Treznea, on Santului Valley, the possible marker taxa indicative for the Ludian crisis (Cupressacee and Taxodiacee), either are completely missing (the first of these groups), are are very rare (the second one). But, other taxa are well documented, as palms, *Taxodium*, beeches, exotic nut trees (Juglandaceae) or *Nyssa* trees, proving a subtropical to tropical climate (means temperatures 20º C and rainfall around 1,200 mm/year). Unfortunately, as in majority of studies achived in Transylvania, the environmental information is just punctual, the climatic short events being ignored. Between the Lutetian and the base of Priabonian there is no intermediary locality, that meaning around 10 My of data gap. Such penury of data is characteristic for other European regions too, for the same time span. We may presume that in Transylvania, in Priabonian, the climate wasn't so spoiled as in other European regions.

Before the Early Eocene, the marsupials were missing from the fauna of Europe, or anyhow, there is no evidence to support their presence. The didelphids have to be considered as arrived in Europe at the beginning of the Early Eocene (Russell, 1975). The marsupials arrived from North America, when the land connection between these two continents was still in function, that explaining the common taxa in both continents (Crochet, 1979). Concerning the track followed by the marsupials from North America to Europe, two ways can be considered: by Asia, or by North Atlantic. The first one is less plausible and is now completely obsolete, due to the long existence of Turgai Strait, eastern from Ural Mountains. The second track, crossing the North Atlantic (so-called Geer passage: Greenland-Spitzberg-Scandinavia) is more credible, the marsupials arriving in Europe just before the endemic epoch at dawn of Eocene. In this manner, the marsupials from Treznea should be considered as European representatives arrived in Transylvania from the Western Europe, probably during a low stand episode. *Peratherium* was in Priabonian there an autochthonous representative, of European origin.

So, the Treznea 1 vertebrate fauna may bring some additional details. We can consider that some taxa could had evolved in place, since the Paleocene, evolving to endemic representatives (but such endemic tendency, was never proved). *Peratherium* is a marker-taxon for the Upper Eocene faunas, in localities as La Debruge, Perrière or San Cugat, all Priabonian.

The problem of the access in this region begins simple if thinking that the majority of the paleogeographic maps are sketched on data issued from transgression times. The regressive events are very rare taken into consideration. The possibility of faunal changes with Western Europe was clear demonstrated by Gheerbrant et al. (1999) in the Paleocene of Rona-Jibou. The hamsters seem to document immigrations from Asia, but for certitude a larger sample of fossil is needed.

Anyhow, it is enough clear that at least for our country, the faunal migration events forego "*La Grande Coupure*", i.e. the faunal drastic change recorded in Western Eocene at Eocene/Oligocene boundary.

As for the large mammals, until now they were known only from the single locality Rădaia. Now, we are adding the new locality Morlaca 2. The single interpretation for the environement of these mammals concerns the same fluvial deposits, both in Rădaia and Morlaca. All the bones are devoid of anatomical connections, being carried by water streams before the burial. In Morlaca, several superposed channels can be observed in the outcrop that yielded the fossil bones. One can even presume a water selection, because the small bones as well as the microvertebrates are missing. As main environmental marker, one may consider the amynodont, which is associated to the titanothere. Their Asian origin is more than evident.

The finds from Bociu are extremely scarce and document only the hamsters. The lagoon environment is proved by the peculiar lithology, rich in anhydrite. The hamster remains are present in the levels where fresh water fingerprint can be noted.

Between the continental sequence already mentioned and the Rupelian, in northwestern Transylvania we have to deal exclusively with marine rocks. The continental influence is usually faint, with allochthonous fossils. The most interesting such deposit is the Cluj Limestone. From this limestone, among other continental vertebrates there are some soft shell turtle remains related to genus *Trionyx*. Its representatives concern fresh water turtles, with possibilities of adaptation to brackish water too, indicating subtropical-tropical rivers with high debits, lakes, large ponds or swamps. The majority is carnivore, eating fish, crustaceans, snails or amphibians, sometimes even birds or small mammals. Their long neck allow the breath at surface, even when the body is underwater, hidden by the mud or sand (the olive color of the carapace offer a fair mimetic). Part of respiration is trough the skin, allowing long immersion time. The legs end by three claws, characteristic for this genus.

For Cluj Limestone, formed in a pure steno salt environment (Codrea et al., 1997), these fossils are allochthonuous for the taphocoenosys. These turtles originated from the continental surrounding areas, carried into the marine basin by the rivers, as carcasses. They were buried into the limy mud. Their pre-burial history is rather long, indicative for a long transport of the carcass. A putrefaction of the soft tissues should be taken into consideration, as long as no legs, neck or cranium bone was in connection. In all known situations the plastron is missing, documenting this scenario. The high dynamic of sea water spread the bones, as it happen with other vertebrates, this time marine, as the sirenians, with similar taphonomy (*personal observation*).

For the small fragment found in Radaia, such presence is easier to explain in a fluvial environment. There, they are autochthonous elements in the vertebrate assemblage.

In Romania, the fossil trionichids are not very frequent. To the Paleogene representatives already from northwestern Transylvania already mentioned by Koch (1894), it worth to add the one of Peters' (1855) from the "Middle Eocene" at Turnu Rosu (Porcesti), which is the oldest report of the group in our country. Apart from these Paleogene representatives, there are also younger ones, as in the Corus Formation at Coasta Mare, near Cluj Napoca (Early Miocene) or in the type locality, Corus (Fuchs, 1962; Vremir & Codrea, 1997), in Middle Miocene at Minisu de Sus (MN 7-8; Vremir et al., 1997) or Reghiu (Vrancea; ? MN 10; Macarovici & Motaş, 1965), or even from younger deposits, at Căpeni (Baraolt) or Borsec (Mlynarsky, 1966).

If we compare the paleoenvironments, one may underline the following: the presence of trionichids in the Corus Foamation is similar as strict local paleogeographyb to

Cluj Formation, that meaning same allochthony of fossils. Hoever, at Minis there are several differences, because the brackish-marine Sarmatian waters were replaced for short episodes by fresh water, probably due to occasional inputs, documented by specific diatoms or silicoflagelates (Codrea & Barbu, 1996; Barbu & Codrea, 2002; Codrea et al., 2007). The climate there was subtropical-warm temperate, with specific flora (Givulescu et al., 1995, 2002), or fauna (Codrea, 1992, 1996; Codrea et al., 1991 a,b). The trionichids from Reghiu appeared in a fluvial environment occurred near the Eastern Carpathians in the so-called "Milcov Beds", around the Kersonian/Meotian boundary. The last representatives form Baraolt and Borsec would show the adaptability of these turtles to resist until annual mean temperature around 14-15° C. As de Broin (1977) showed, this genus was extinct in Europe in Pliocene, surviving in Africa or Oreint (Israel).

Interesting are also the tentative of reconstructions for the Eocene of Cluj region. Several times they are represented on land, a rather unusual aspect for this group.

From same Cluj Formation is originating the *Eostega* remains. The actual representatives are cosmopolite, in all climates, excepting the Arctic. However, their main affinities are trended to tropical or subtropical zones, even if in temperate regions there are dense colonies too. The actual representatives are middle sized birds, with wingspan between 140-175 cm, with wing extremities long and sharp. Their peculiar ethology refers to the capacity to plunge in the ocean water directly falling from high distance, for catching the fish or marine invertebrates. They are not true pelagic birds, being more coastal dwellers, as it probably was the case on the Cluj Limestone environment. To the isolate islands it seems that they arrived only during the storms, carried by the strong air currents. As the find in Cluj refers to just a single isolate fossil, it is difficult to prove the existence of a colony, but such possibility could not be excluded.

The Rupelian, recorded the true terrestrial environment only in Moigrad Formation (the top of Mera Formation bears only weak signs of such a process).

The Moigrad Formation is dominating by fluvial red beds. Such deposits are extremely scarce in fossils. The few ones had been already published by Rădulescu & Samson (1989), but we may now add some indricohere scarce remains too, at Dancu (original observation).

In such a situation, more substantial data are originating from Dancu Foarmation (Rupelian), where the fossil record is rich. This formation is fluvial, with lacustrine and swamp tendencies, which developed coal strata of low economic value (lignite). The coal beds thickness is decresing from west to east, at Cluj Napoca the coal being extremely thin, until vanishing just east to Cluj. On the opposite direction, the coal beds are thicker and thicker, once being mined at Aghireş-Tămaşa), ceea reflecting differences between the input and fossilization of the organic matter.

Among the most relevant fossils one may underline the freshwater turtles (Mlynarski, M., & Mészáros, M., 1963), very frequent especially at Cluj-Napoca – Dl. Cetățuie-, where they are the dominating fossils. They are indicative for the margins of the fres water streams, lakes or ponds. However, the actual representatives are tolerating also brakish environments, for short episodes of thei life, as in lagoons or marine swamps. In is interesting to note that they never were mentioned at Ticu-Tămaşa, in Suceag or Mera being rare. The actual representatives are able either to estivate into the mud when the water is scarce, or on the opposite, to hibernate in northern regions.

Besides these turtles, the crocodiles of the genus *Diplocynodon* mean a marker for same environments. Their adaptations for brackish environments are well known for the actual representatives. In fossil records, such tendencies are known in juvenile populations (Karl & Müller, 2008). *Diplocynodon* should also to be noted as warm lover element , dweller with river and lake margins, which avoided the deep water.

The Suceag herpetofauna involves 7 taxa: *Mioproteus* sp., *Latonia* sp., *Albionbatrachus* sp., *Pelophylax* sp., Anguidae indet., *Eoanilius* sp., cf. *Bransateryx* sp., adding the new paleobatrachid *Albionbatrachus oligocenus*. This fauna is indicating a taphonomic context related to a lake or swamp, where the specific taxa are mixed with strictly terrestrial elements.

Among birds, *Rallicrex koloszvarensis* is indicating a representative living hidden in the plants covering the margins of the ponds, swamps or water streams. It is a small sized bird (22-28 cm, with 38-45 cm wingspan, and around 190 g in wight). It has a gracile body, with strong legs and short wings. It is almost runner and not a flyer. When flying, it does on short distances, hidden by the vegetation.

The mammals are bearing a message very cler: anthracothers – either the small sized ones as *Elomeryx borbonicus*, or large – all are indicative for swamps, with coals. Besides them, we can note small mammals as hamsters, didelphids marsupials, perhaps the presence of dipodids (still to less documented in the fossil record), others marsupials (in same situations). However, it is evident after processin several hundreds of kilograms of sediment, is the scarcity of glirids (only a couple of cheek teeth). Such a fact excludes a too dense forest around the Rupelian waters at Cluj. It is not surprisingly: the frequence of glirids is not exceptional in other regions regions in Oligogene too, as it happen in Anatolia (Turkey; de Bruijn et al., 2003). But oviously, insects were numeorous, as the insectivore remains are enough frequent.

The marker taxa are extremely important in tentative of environmental reconstructions. The majority of them are new for the Romanian paleontology.

CHAPTER VII. Biostratigraphy of the continental formations around the Eocene/ Oligocene boundary in Transylvania

The Paleogene sedimentary succession in Transylvania concerns as already I mentioned, continental/marine-brackish interleavings. The transitions between these environements are not involving in the majority of cases sedimentary gaps, but they are gradual. The sedimentary gaps, when present, are not long and not too geographically extended. Such an evolution in convenient for dating the terrestrial sequences, because the marine formations sandwiching the continental ones are easily datable by various fossils (nannoplankton, foraminifers, molluscs etc). Another way, is to consider the terrestrial own fossils, as the mammals or other vertebrates.

The Upper Priabonian land sequence represented by Valea Nadasului end Turbuta formations has in its base, depending the specific sedimentation area, either the Vistea Limestone (in Gilau and Meses areas), or the siliciclastic deposits of Rakoczy Sandstone (in Meses, but especially in Preluca). In Preluca and Gilau, the land deposits are laterally replaced by the siliciclasts of the comprehensive Stejerea Formation; Rusu, 1987). The Vistea Limestone is notorious in this region, firstly mentioned by Koch (1894) as the “lower rough limestone” by analogy with the Basin of Paris, in France. Other names were also used, as Leghia Limestone (Bombita, 1963 a). Its Lower Priabonian age is based on large foraminifers (nummuites, alveolines; Bombiță, 1984 a), molluscs, sea oursins, but also nannoplankton, (NP 18; Mészáros & Moisescu, 1991). The Rakoczy Sandstone is coeval, bearing nearly same fossils.

Over the continental sequence is lying the marine sequence of the Turea Group (Rusu, 1995). In its base, on a restricted area in Gilău and Preluca areas, but extended in Meseş, there are exposed the Jebuc Formation gypsums, which are including also paralic coals and even fresh water intercalations (Mészáros & Tămaş, 1963). On wider uniformity, there is the Cluj Limestone Formation. This limestone disspears to northeast inside the thick Cozla Limestone Formation. The Cluj Limestone (= the upper rough limestone, *sensu* Koch, 1894). It is well dated by foraminifers, molluscs, sea oursins, and the nannoplankton is indicating the NP 20 unit (Late Priabonian; Mészáros & Moisescu, 1991). Therefore, the Priabonian age for the continental sequence is more than obvious.

More much interesting is the analysis of the continental faunas. Such datation should refer firstly to MP units of the European Paleogene (Schmidt-Kittler et al., 1987). The Eocene/Oligocene boundary is located between MP 20/21 units.

For Valea Nadăşului Formation, none of the large mammals is a marker taxon for biostratigraphy. There is a simple explanation: the mammal units are based on taxa nearly exclusively by vertebrate localities from Western Europe, which was in Eocene still an island area, evolving in endemicity. The marker species are to found among the large herbivores, as paleotheres, anoplotheres or other mammals completely absent in Transylvania. On the other hand, in Western Europe are missing large mammals as titanotheres or amynodonts. Therefore, we have to accept that in Oriental Europe (Transylvania included) some immigration from Asia occurred before the Eocene/Oligocene boundary. The Upper Eocene faunas reveal specificities for this province, where successive arrivals of Asian mammals can be observed. So, the Ludian faunas from Eastern Europe are different from the western representatives. For the large mammals from Transylvania should rather be looked for in Asia. Such correspondents can be found in Sharamurunian faunas (Russell & Zhai, 1987), where titanotheres as *Sivatitanops* or *Rhinotithan* are recorded, hyracodonts as *Prohyracodon*, or various amynodonts like *Sharamynodon*. The main disadvantage in Asia is related to the too rough datings, where equivalents of the MP units are missing. In these circumstances, of better utility are the mammals presumed to be of European origin, as the didelphid marsupials as the ones from Turbuța Formation, of Treznea 1. *Peratherium lavergnense* has a rather short stratigraphic range: FAD in MP16 Robiac (end of Bartonian), LOD in MP17 Fons 4. *I consider the Treznea marsupials as belonging to the last of these levels, such an interpretation being in concordance with the datings of the marine neighbouring formations.*

Others microfaunal elements of eventual utility originating from the same level are the hamsters. If considering *Atavocricetodon atavus,* this was mentioned in Western Europe beginning with MP21 Soumaille. If this species is present in Transylvania, it means that here it occurred earlier. Such a situation is raising same questions as Legendre’s (1987a), who questioned the contemporaneity of migrations during Grande Coupure in all parts of Europe. He underlined that some rodent assemblages are younger in France than in Germany. I’m agreeing with this viewpoint, considering that the Eastern Europe offers arguments for **migration gradients**, Transylvania being inaded earlier by the Asian immigrants by the Anatolia and Balkans trak.

The second continental sequence yielding mammals is the Suevian (Rupelian) one. Excluding the isolate and fortuitous finds from Mera and Moigrad formations, too scarce for consistent data I will focus this discussion on Dâncu formation.

Dissimilar to the Late Eocene, in Suevian we can note sedimentary gaps in Gilau area, reported by Rusu (1989), associated by Mészáros & Dudich (1968) to the pyrenian tectogenesis. Under the Moigrad Formation in Gilau area (the only of interest for our study) there are deposits belonging to Mera Formation. Their geological age was coined based on molluscs (Rusu, 1989) and nannoplankton (NP 22 and 23; Mészáros & Moisescu, 1991) to the Rupelian. Over Dâncu Formation there are Gruia Formation tempestites, belongiong to NP 23 and base of NP 24 units.

Concerning the vertebrates, we can point out that some taxa are useful for dating the sediments. For Moigrad Formation, the entelodon *Entelodon deguilheimi* is indicative for the Asia immigrants, this species being indicative in Western Europe for MP22 Villebramar unit.

For Dâncu Formation, *Elomeyx borbonicus* is a marker taxon for MP24 Heimersheim. This datation seems to be in contradiction with the age coined on fish fauna (Reichenbacher & Codrea, 1999), which is MP23 Itardies. Unfortunately, there are not other dating arguments, because among the micromammals some taxa as *Blainvillimys* or *Theridomys* are missing in Transylvania. Therefore, *I consider this foirmation as belonging both to MP 23 and MP 24 units.*

At the end of this section consecrate to biostratigraphy I want to deal with an aspect concerning all the continental formations from Transylvania. Some charts already published are referring to "the lithostratigraphic units from Transylvania" (e.g. Filipescu, 2001). But, in reality, all are concerning only northwestern Transylvania ant not all this basin. Paleogene continental formations are also exposed on soutywestern area (Codrea & Dica, 2005), as well as between in southern areas, between Dobârca and Porcesti. *Therefore, I made a new chart, including all these formations.*

It is extremely obvious that in southwestern part of the basin, the Bărăbanț Formaiton in Oligocene (Codrea & Dica, 2005), due of the relationships with basal and underlying deposits. But, these continental beds never yielded any vertebrate remain.

On south, the age of the red beds from Dobârca that yielded the amynodon *Cadurcodon zimborensis* is enough clear. At Turnu Roșu (= Porcești), near Sibiu, the continental formations are are practically missing, but for the marine ones one should take into consideration the stratigraphy made by Mészáros (1996).

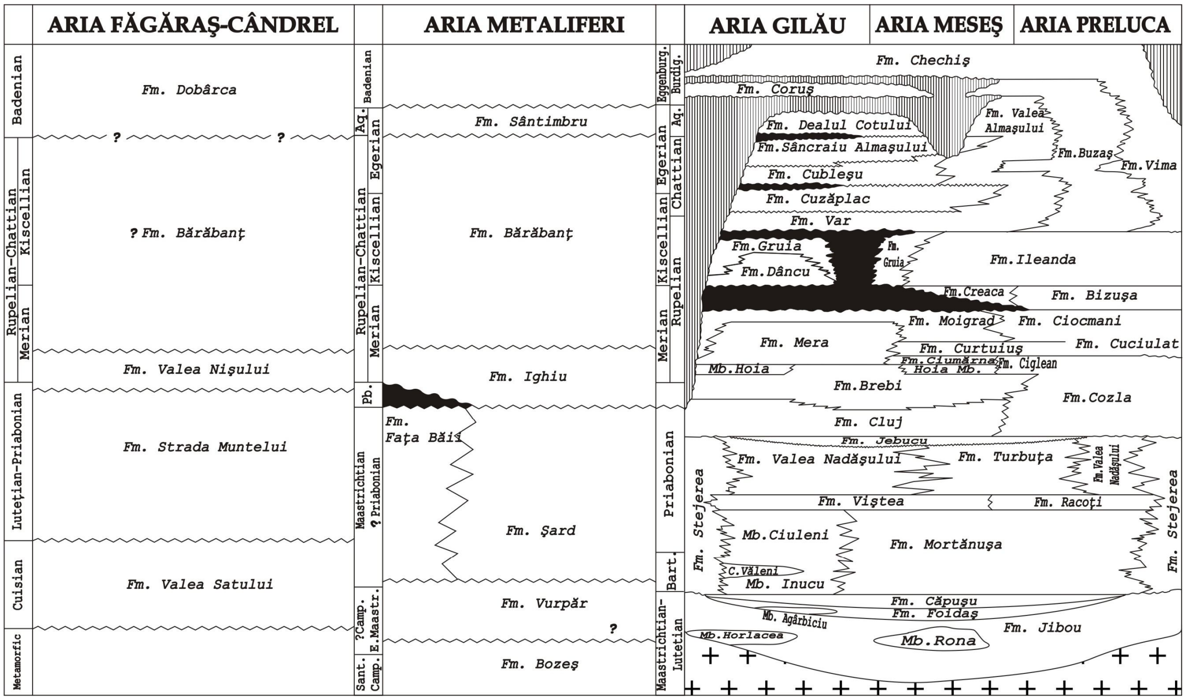

Fig. VII.1. Paleogene formations in Transylvania

CHAPTER VII. CONCLUSIONS

The northwestern area of the Paleogene Basin of Transylvania is the most illustrative part for the climatic events happened at Eocene/Oligocene boundary. To this region, one can add the southwestern area too, but there the Paleogene message is less rich and clear.

As in other regions of the northern hemisphere, mainly in Eurasia, the consequences of such events led in the marine realms eustatic fluctuations, on regressive trend. In the emerged areas, changes in all bios occurred, as occurrence of new plant taxa in several areas, as well as new geographical distributions of vertebrate taxa due to the land bridges opened.

For understanding these messages of the Eocene evolution, I surveyed a series of continental formations outcrops, but also of some marine ones that are preserving terrestrial elements arrived fortuitous in the marine basins. In the first category there are Valea Nadăşului and Turbuța (both Priabonian). For interpreting their environments, I used the data already aquired as sedimentology (Hosu, 1999), plants (Petrescu & Balintoni, 2004) or vertebrates (Codrea, 2000), adding on my turn results issued by my own research. Practically, this terrestrial sequence as the whole Priabonian (that begin with Vistea Limestone Formation) means nothing else but a transition from the climatic optimum from the Middle Eocene to the colder Lower Oligocene („*Oligocene icehouse*"), due to the Antarctic glaciation expansion. The cooling from the Early Oligocene (Pomerol & Premoli-Silva, 1986; Zachos et al., 1996; Salamy & Zachos, 1999; Prothero, 2006) had effects on the environments from the Basin of Transylvania too.

The lithology and sedimentology at the trasition between Vişţea Limestone Formation from the Gilău sedimentary area and the fluvial red siltic clay of the Valea Nadăşului Formation are usually very sharp, as it can be observed in Vişţea. At Morlaca, at the boundary between the Vişţea Limestone and Valea Nadăşului Formation, there are thin paralic coally beds, as I observed on Răoasă Valley, which N. Mészáros (*personal communication*) associated to the base of the continental formation, *viewpoint I kept in this work too*. Petrescu & Mărgărit (1987) associated these sequences to Vişţea Limestone. It is true it is difficult to agree one or another of these interpretations, as this thinn coally sequence occur just at the limit between the limestone and the red deposits. But, very evident is the mistaken position of Morlaca in Lutetian (Petrescu & Balintoni, 2004). Therefore, the climatic curve made by these two geologists is slightly deformed. Morlaca is a younger locality, belonging to the base of the Priabonian. It is probably confusion because in other older works Petrescu (2003) considered this locality as Late Eocene. The microflora from Morlaca (Petrescu, 2003), dominate by exotic Fagacee as *Castanopsis*, including also palms or *Nipa*, could be indicative according this author for mesophytic forests, completed by environments as “savanna with palms” or with mangroves, in “tropical-subtropical” climate, with “low rainfall due to local causes” (pag. 53).

From this level, the vertebrates are not for instance too numerous. From the coal sediments I washed and sieved several ten of kilograms of sediment, but a single crocodile tooth assigned to *Diplocynodon*. It could be an alligator-like coming from the epoch following the Bartonian climatic crisis. This genus representative survived in Europe until the Miocene. Such a success was due to its cosmopolitism, adapting both to brackish as well as to the fresh water, in various climates (Vasse, 1993). Even a single one, *this tooth is documenting this genus for the first time at this level.*

From Valea Nadăşului Formation few large herbivores found in the last two centuries at Rădaia, notorious being *Brachydiastematherium transylvanicum* and *Prohyracodon orientale*. I did not insist on these mammals, because recently Codrea (2000) developed a detailed discussion. To these mammals *I add a soft-shell turtle remain at Radaia*, an additional evidence for the fluvial origin of the red beds. For this formation one can presume open environments, if thinking to the cursorial rhino. In such environments is illustrated in some tentative of reconstruction (e.g. Heinrich Harder). Probably, the forests were present near the river streams. *Prohyracodon* had a very wide geographic range form Transylvania, Bulgaria to China (Yunnan; see details in Codrea, 2000).

To the notorious locality Rădaia, *I add the new locality Morlaca*, belkonging to the same formation. It yielded titanothere remains (*Brachydiastematherium* size), amynodon (*Sharamynodon*), antracothere (possibly *Prominatherium*), turtles. ***It is the single report of a titanothere in the last century, because in Radaia it was never found again, the first report of an Eocene amynodonin Romania, and the first mention of their association with anthracothers. Morlaca is now the richest large vertebrates' locality in Transylvania and from the whole southeastern Europe.***

Conclusive results I obtained also from the coeval Turbuța Formation. This formation evolved also in fluvial environment, but more flooded compared to Valea Nadăşului, which developed ponds and small lakes as it may be observed in localities as Buciumi, Stâna, Treznea or even in the type locality, Turbuța. If at Stâna or Buciumi we found only lacustrine fish (Ambasiidae), at Treznea the fauna is larger, including apart the fishes frogs, lizards, turtles, crocodiles or mammals. The most interesting representatives are the mammals, as the didelphid marsupials *Peratherium*, or the oldest hamsters from Europe, *Atavocricetodon* and *Pseudocricetodon*. For marsupials I proposed an European origin, because in Asia the first ones are from the Early Oligocene (Gabunia et al., 1984). Probably they arrived at Treznea following an archipelago, *step-by-step*. On the opposite, the hamsters arrived from Asia. ***One should accept migration gradients.*** The first immigration waves arrived in southeastern Europe, spreadinfg gradually to west. The second trak colud by on northern side of the continent, immediately after the closure of the Turgau Strait. Probably both tracks are credible and were followed by these mammals. ***If the hamsters were already reported by Baciu & Hartenberger (2001), the remaining representatives of Treznea assemblage are firstly reported now.***

The majority of Upper Eocene mammals from Transylvania are missing in Western Europe. This fact is normal if thinking to the peculiar evolution of Western Europe as archipelago in Eocene. ***However, based on marsupials in association with the archaic hamsters, I proposed to relate the consinetal sequence from Transylvania to MP 17 (Fons 4) or eventually to MP 16 (less probably) units.***

Between the Priabonian continental episode and the first similar Rupelian one, in all the sedimentary areas from northwestern Transylvania there are exclusively marine formations: Jebucu, Cluj, Brebi, Hoia, Mera, Culmea Cozlei. For the continental influences, they all are not of high interest. However, in Jebucu Formation some hamster remains are also reported.

The Cluj Limestone bears some fossils originating from terrestrial representatives (turtles, birds etc) carried into the basin by the river streams. The Cluj Limestone environment was the one of a carbonate platform covered by shallow waters, with high dynamic waters (waves, currents). For short episodes, restricted areas were emerged, developing carst.

In Oligocene, continental sequences occur only at the top of Mera Formation, or in its lateral corresponding Curtuiuş Formation. For Mera we can note only a scarce plant assemblage (Petrescu, 1972), dominate by Lauracee and exotic oaks, besides warm loving plants as palms. It was interpreted as being “subtropical monsson type” climate, with mean temperatures around $+19^0$ - $+20^0$C, and rainfall 2.000 mm/year. In Mera Formation there are recorded Asian immigrants as primitive rhinos (*Ronzotherium*) or giant rhinoceros, perhaps *Urtinotherium* (Codrea, 2000). Even too few, such mammals could support the MP 21 (Soumaille) unit. However, no Western Europe representative was mentioned until now from this formation.

The continental fauna from Moigrad Formation is also scarce, recovered from fluvial red beds similar to the ones of Valea Nadasului. Remains of *Entelodon* aff. *deguilheimi* at Huedin, or indeterminate indricothers at Dâncu are already known. The giant facoccers are of Asian origin, being indicative in Western Europe for MP 22 (Villebramar) unit.

The environment for such cursorial mammals was the open land, where forests were rare, as indicate also by indricothers. That is pleading for the reducing areas covered by forest and expansion of grassy surfaces.

I was able to bring a more consistent contribution for the environments of the Dâncu Formation. In thesis I exposed in a detailed manner the studied outcrops, pointing out the thinning recorded in the Transgex well.

From this level, a very rich fauna was described, including fishes (Reichenbacher & Codrea, 1999), reptiles (Mlynarski & Mészáros, 1963), birds (Lambrecht, 1929, 1933; Kessler, 1996). **As result of the new research, the list was enriched with small reptiles and frogs (*Mioproteus* sp., *Latonia* sp., *Pelophylax* sp., Anguidae), including a new paleobatrachid species (*Albionbatrachus oligocenus*), crocodyle (*Diplocynodon*) and mammals: the small anthracothere *Elomeryx borbonicus*, hamsters (*Paracricetodon*), gliridae, insectivors. All are new for Romania.**

The environment concern swamp areas, drained by river streams with high debits, possibly estuarian areas at Suceag and Mera, where brackish influences can be seen. Such environments were preferred by the *Diplocynodon* crocodile, or some fishes that are rich represented. Surprinsingly, only few plant remains had been described. The single such mentions concern few Lauraceae imprints collected on Cetatuia Hill at Cluj Napoca (Răzvan Givulescu, *personal communication*). At this level, there is a dominance of hamsters among the micromammals, indicating open spaces, covered by herbs. The glirids are extremely rare. The consequences of „*La Grande Coupure*" were present.

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