NEW FAUNAL ELEMENTS FROM THE LATE CRETACEOUS (MAASTRICHTIAN) CONTINENTAL DEPOSITS OF SEBEŞ AREA (TRANSYLVANIA)

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Introduction

From a paleontological point of view, the Sebeş area (SW Transylvania) became recently known due to the rich vertebrate assemblages of late Cretaceous (Maastrichtian) age, discovered in numerous sites of continental facieses. However their discovery goes back in time till the end of the XIXth century, a true recognition and wider application comes very late on the last decade. From geological point of view however, the recent studies concerning the various continental deposits and their fossil record, is of critical importance for (re)dating of certain stratigraphic units as well as for wider correlative basis of the syn-orogenic molasse deposits of the Carpathian region linked to the early stages of the Laramidian uplift, further geotectonic evolution, and also the paleogeographic reconstruction of the Late Cretaceous/Early Tertiary Transylvanian landmass. On the other hand, the local paleoenvironmental reconstruction due to palaeontological, taphonomical and stratigraphical analysis shows a large variety of facieses, a dynamic landscape evolution, reshaping the long-term modeling of the Transylvanian island.

A secondary aspect concerns the fossil assemblages, particularly the vertebrates represented mainly by various dinosaurs. From paleobiological point of view, the vertebrate faunal series recovered from a wide time-span, starting with the lower Maastrichtian (cca. 69 Ma) till possibly the K/T boundary (cca 65 Ma), is of a great importance as well, showing close connections to other Carpathian and Alpine domains and also intercontinental links. In this respect the paleogeographic evolution of the whole central-East European region and eastward connections can be outlined. Recent results obtained in the Carpathian domain clearly shows that the "confined" faunal assemblages of the central-East European archipelago were in close relation in a wide geographic area, and faunal interchanges often took place during the whole late Cretaceous.

The present study is intended to contribute to a better understanding of both the geological-stratigraphical as well as paleontological particularities of the Sebeş area late Cretaceous terrains.

Geological setting

The studied area is located in the south-western part of the Transylvanian sedimentary basin formed by a series of superimposed late Cretaceous-Neogene basinal structures developed on the top of Mid-Cretaceous nappes.[1] Following the Maastrichtian tectonically induced regression,[2] extensive continental sedimentation started along the realm of the Apuseni and Şureanu Mountains, however in certain sub-basins, deep-marine sedimentation continued late into the Paleocene.[3] All these units lying on the folded structures of the ophiolites bearing Transylvanides (right flank of the Mureş valley) or the mainly igneous Supragetic nappe (left flank of Mureş Valley), were deposited subsequent to the latest Cretaceous (Laramidian) orogenetic phase that produced the earliest remnants of the Carpathians and correspond to one of the oldest molasse deposits related to this main tectonic event.[4]

Late Cretaceous fossiliferous continental deposits have been known in Romania since the description of the classic dinosaur fauna of the Haţeg Basin.[5] Recent explorations have determined that late Cretaceous fossil-bearing continental deposits are widely distributed spatially, across the western and northern margin of the Transylvanian Basin and also within several small, intermountain basins, from Rusca Montană in SW up to Şimleul Silvaniei in NE.[6] The most productive vertebrate localities are distributed along the south-western realm of the Transylvanian Basin in Sebeş area and in the Haţeg Basin, where several lithostratigraphic units have been identified.[7]

In Sebeş region (**fig. 1**), and particularly on the left flank of Mureş valley along the Sebeş river (**fig. 2**), the continental sequence corresponding

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[1] Krézsek, Bally 2006.

[2] Transition from the Rift extensional megasequence to the late Cretaceous-Paleocene Sag megasequence (for details see Krézsek, Bally 2006).

[3] Filipescu, Kaminski 2008.

[4] Săndulescu 1984; Willinghofer *et alii* 2001; Krézsek, Bally 2006. Relict Santonian molasse continental and marine-coastal deposits are known in Sebeşel-Pianu area.

[5] Nopcsa, 1900; Nopcsa 1902; Nopcsa 1905 and Nopcsa 1923.

[6] For a recent review see Codrea *et alii* 2009. A new Maastrichtian dinosaur bearing site was recently investigated in Şimleul Silvaniei basin as well, which extends further north-west the exposure of the late Cretaceous continental depositional setting.

[7] Codrea *et alii* 2009; Grigorescu 2010.

to the Maastrichtian Sebeş formation (SBF afterwards), conformly overlaps the Campanian-lowermost Maastrichtian flyshoid Bozeş formation (Petreşti area), or locally directly the igneous basement of the Supragetic nappe (Săscior-Dumbrava-Deal area). It is worth to mention the presence of an older coal-bearing continental sequence ("Sebeşel strata"), however not very well developed (cca. 50 m in thickness), exposed in several creeks in Pianu de Sus - Sebeşel area. The age is considered Santonian, being sandwiched between the igneous basement of the Supragetic nappe and the base of the Campanian Bozeş formation. Plant remains and incarbonised-silecified tree logs and branches are abundant within red or grayish conglomerate and bluish-gray sandstone bodies.

From structural perspective, both the Bozeş and the overlying SBF are slightly folded forming couples of E-W oriented synclines and anticlines, associated with numerous NW-SE oriented imbricate-reverse or hinge faults, suggesting a compressional geological setting.

The continental beds exposed in the Sebeş area, were considered belonging to several distinct lithostratigraphic units. Their age had been reported to be either Oligocene-Miocene or Late Cretaceous.[8] Until recently, few studies had intended to solve the stratigraphical problems. Two recent papers[9] proposed a new stratigraphical scheme, and accordingly two Late Cretaceous (Maastrichtian) continental formations can be recognized in the area, both of them yielding vertebrate remains: the underlying spatially restricted unit is represented by the *Vurpăr* formation (VPF)[10] which is Early Maastrichtian, while the overlying unit is represented by the *Şard* formation (SDF)[11] dated as Maastrichtian up to Priabonian. In addition two other red continental formations were redefined in Alba Iulia and Sebeş area: the *Bărăbanţ* formation (BTF)[12] Oligocene in age exposed N-NW of Alba Iulia; and the *Sebeş* formation (SBF)[13] dated as Late

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[8] For a historic overview see Therrien 2005; Codrea, Dica 2005 and Codrea *et alii* 2008.
[9] Codrea, Dica 2005; Codrea *et alii* 2009.
[10] Included before in the top of the *Bozeş* formation belonging to the Mures nappe*,* a very thick shallowing upward flyshoid series with locally developed mollasic sequences on the top. The Vurpăr formation of rather restricted spatial extension represents a distal deltaic sequence characterized by yellowish-brown sand, sandstone and conglomerates.
[11] First defined by Koch (1894) as "*Sárd-Borbánd red clays*" of supposedly Oligocene age. The Şard formation represents a medio-proximal fluviatile sequence dominated by fine to coarse channel fills and relictual overbank deposits and paleosol interbeddings.
[12] Corresponding to the upper section of Koch's "*Sárd-Borbánd red clays*."
[13] Named by Loczy L. (1912) as "*Roteberg schichten*" or "*Vörösmarti rétegek*" meaning "*Râpa Roşie strata*." The SBF is characterized by medium to coarse channel fills and occasional lacustrine muds and extensive over bank deposits.

Oligocene to Middle Miocene[14] and well developed between Teleac and Sebeş localities on the left flank of Mureş valley.[15]

In the light of recent field investigations and new data-acquisition, this current stratigraphic model also requires revision, in particular regarding the relationship between the Maastrichtian VPF-SDF complex, and so called "Oligocene-Miocene" SBF. Extensive mapping and investigation of new outcrops that yielded well preserved autochthonous vertebrate fossils indicate, in contrast to all previous opinions, a Maastrichtian age for SBF as well.[16]

As discussed, the age of SBF was rather controversial, until recently no conclusive evidences being presented to sustain any chronostratigraphic assertement. However Nopcsa F. was the first who correctly interpreted its late Cretaceous age,[17] all later studies indicated an Oligocene or even Miocene age. The main debate was concentrated around the autochthony vs. allochtony of the vertebrate (mainly dinosaurs) fossils found at Râpa Roşie stratotype, but the general view pointed to reworked faunal elements, derived from much older (Cretaceous) formations.[18] Supposedly Oligocene fresh-water mollusks (*Helix* cf. *deplanata*, *Lymnaeus* cf. *pachygaster*)[19] and nummulitid bearing limestone pebbles were reported from the mid-upper section of the formation, indicating a late Oligocene up to early Miocene (post-Priabonian but pre-Badenian) age. In the last years, more paleontological and stratigraphical evidences were gathered, clearly pointing to Nopcsa's early conclusion. None of the above mentioned evidences were demonstrated: the freshwater mollusk assemblage identified at Lancrăm, is undoubtedly Maastrichtian in age, being associated with autochthonous dinosaur remains and dinosaurian foot-prints.[20] The Priabonian limestone pebbles and boulders found at Râpa Roşie, originates from the reworked conglomeratic basal unit of the middle Miocene trasgressive marine

[14] Grigorescu 1987; Grigorescu 1992; Codrea, Dica 2005; Codrea *et alii* 2008.

[15] Actually the extension of SBF can be followed in south and south-west direction to Deal-Săsciori-Cacova, Cioara and Vinerea in Cugirului Valley (north of Şureanu Mountains).

[16] Vremir *et alii* 2009; Csiki *et alii* 2010.

[17] Nopcsa 1905; Nopcsa 1909. The red clays of this unit, were first interpreted as late Cretaceous (Halavats 1904), but in a later study an early Miocene (Aquitanian) age was proposed (Halavats 1906), in accordance to Koch's oppinion (Koch 1894; Koch 1900).

[18] Grigorescu, 1987, 1992; Codrea, Vremir 1997; Jianu *et alii* 1997a; Codrea, Dica 2005; Codrea *et alii* 2008; Codrea *et alii* 2009.

[19] Telegdy Róth 1904.

[20] Vremir 2001; Vremir, Codrea 2002.

sequence unconformly overlapping the SBF.[21] Well preserved autochthonous dinosaur and other reptilian fossils where found in various depths of the whole section, clearly demonstrating a Maastrichtian age for most of the SBF.[22]

As regarding the base of SBF, the best exposed transition from the flyshoid Bozeş formation to the overlying continental deposits, is represented by the Petreşti section (**fig. 4**), located north from Petreşti village along the Sebeş River. The late Campanian - lowermost Maastrichtian neritic-infralitoral sequence is followed by a thin brackish-estuarine sequence corresponding to the Top of Bozeş formation.[23] Besides a rich marine and brackish invertebrate assemblage and inwashed plant remains, a single vertebrate fossil is recorded, represented by a limb-bone fragment, belonging to a giant pterosaur, regarding its size- most likely an Azhdarchid. Based on the faunal assemblage, for this transitional sequence a lower Maastrichtian age is proposed. The occurrence of *Pachydiscus neubergicus* index ammonite, indicate the lowermost part of the Maastrichtian stage (first occurrence), up to the base of the upper-lower Maastrichtian, corresponding to the *Belemnella sumensis* belemnite zone.[24] The same age for the Top Bozeş formation in the right flank of Mureş valley (Metaliferi area) was also established, based on nannoplancton assemblages.[25] In Petreşti section, the dark colored sandy-silty argillaceous brackish-estuarine sequence is conformly[26] overlapped by mainly reddish occasionally coarse alluvial deposits and well developed overbank and pedogenetic horizons, representing the base of SBF, from where several dinosaur remains were collected. A similar transition is described from Stăuini (Cheia valley) on the right flank of Mureş near Vinţu de Jos.[27] The basal section of the Vurpăr formation from where the *Sabal major* Unger palm species was described, from lithological point of view is represented by red claystone, grayish sandstone and conglomerate with numerous incarbonised tree-logs and stumps, and scarce vertebrate remains (crocodylomorphs, dinosaurs). This

[21] The ex-situ nummulite bearing winnowing pebbles and boulders are to be found mainly on south-eastern basal section of the outcrop, below the middle-Miocene (Badenian) conglomeratic unit well exposed on the hill-top (Plesii hill).
[22] Vremir *et alii* 2009; Csiki *et alii* 2010.
[23] Codrea *et alii* 2009 considers the brackish-estuarine sequence within the Petreşti section belonging to the "extremely condensed Vurpăr formation."
[24] Christiensen *et alii* 2000; Jagd, Felder 2003; Niebuhr, Esser 2003.
[25] Chira *et alii* 2004.
[26] Without apparent unconformity, however a hidden short-term interruption is not excluded.
[27] Pálfy 1900; Pálfy 1902.

unit overlaps a brackish-paralic sequence of carbonaceous claystone from where over 20 invertebrate species were described. Besides the mollusks, frequent plant remains, leaf imprints, fruits and incarbonised tree fragments are known, without any strict marine faunal influence as seen in Petreşti section.

In the studied area between Petreşti and Oarda de Jos, the SBF represents a thick succession of mostly alluvial deposits of dark bluish or gray mudstone, red, dark-brown or yellowish-brown claysone, red silty-clay, medium sized to coarse poorly sorted conglomerate with reddish or grayish mostly cross-laminated sandstone interbeds. The deposition took place in various conditions, from proximal alluvial fans to medium and distal facieses of fluvial systems, showing locally developed lacustrine, forrested-swampy, short evaporitic stages, also extensive pedogenised floodplain deposits. While the lowermost (Petreşti, Sebeş-Glod) and some of the middle sections (Secaş in part and Oarda de Jos) shows a suite of more or less stable environment successions, the mid-upper one (Secaş in part, Lancrăm, Râpa Roşie, Râpa Lancrăm, Feţilor Hill) was a more dynamic and aggressive erosional/depositional stage, characterised by frequent reactivations and flow-direction changes in a high sinuosity fluvial system. These major faciesal variations were probably related to the changing subsidence rate, geotectonic evolution of source-area heights, and long term climatic variations.

The roughly 450 m thick[28] continental SBF is unconformly overlapped by transgrading middle Miocene (Badenian) marine deposits, well exposed on the major hill-tops, particularly on Râpa Roşie, Râpa Lancrămului and Gruiul Lupului sections. There is no evidence yet for the presence of the K/T boundary or Cenozoic depositional continuity, however the uppermost section completely devoid any vertebrate remains which not necessarily implies taphofaciesal biases. More complex geochronologic and magneto-stratigraphic dating are required to establish both the K/T boundary and the temporal extension of this very important continental depositional event.[29]

In this respect a sole early Maastrichtian possibly up to Paleocene(?) continental formation-complex have to be considered, comprising the recently (re)defined[30] and roughly coeval "Vurpăr", "Şard" and "Sebeş"

[28] Thickness calculated in the type-section area (between Petreşti and Lancrăm), however a greater vertical extension is not excluded towards north (Oarda de Jos-Hăpria-Teleac sector).
[29] Therrien *et alii* 2002.
[30] Codrea, Dica 2005.

formations, developed in the same depositional setting, however with two different source areas.[31] The tentatively named "*Sebeş-Vurpăr complex*" is correlative to the Jibou formation (north-west Transylvanian basin), respectively to the Sânpetru and Densuş-Ciula formations (Haţeg Basin).[32]

Late Cretaceous vertebrate sites of Sebeş area

Over a dozen late Cretaceous (Maastrichtian) vertebrate bearing localities are known in Sebeş area on the left flank of Mureş Valley, most of them delivering only scattered fossil remains.[33] The most important outcrops discussed below, are exposed along the Sebeş and Secaş rivers and the south-western slopes of Pleşii and Viilor hills, between Petreşti and Oarda de Jos.

Petreşti: this site (coded PT) exposes more than a 100 m of the lowermost profile of SBF, and the transitional marine-brackish sequence from the Top Bozeş formation (**fig. 4**). It is dominated by red (occasionally calcaretic), dark red and bluish-gray clay and silty-claystone of moderately well drained floodplain deposits, interbedded with fine to medium size mostly cross-laminated sandy-gravelly channel fills, belonging to a moderate sinuosity anastomosed fluvial system. This environment was characterized by large and stable flood-plain areas, crossed by interconnected strait to sinuous channels. Up to now, very few vertebrate fossils were recorded in the basalmost section of SBF as well as in the transitional estuarian sequence. Based on a fragmentary 2nd wing-phalange shaft, the presence of a giant pterosaur (most probably an Azhdarchid) can be documented in the estuarian facies. Other fragmentary vertebrate fossils belonging to ornithopods and indeterminate dinosaurs were collected from the basalmost flood-plain deposits.

Sebeş-Glod: a suite of restricted outcrops (coded SbG/A-D), located 1.5 to 3.0 kilometers north of Sebeş town, downstream and along the Sebeş River. A 40-45 m section is exposed from the lower part of SBF, roughly 100 meters above the conformable contact with the underlying marine-transitional Bozeş formation and approximately 350 meters below the major

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31 The Vurpăr and Șard formations source area is located in the southern part of the Metaliferi Mountainsm while the main source area of the Sebeş formation is situated in the Şureanu Mountains (the Supragetic nappe), between them forming an embayment along the present day Mureş valley (main suture zone), and gravitating toward north-east (in present coordinates) to one of the main late Cretaceous sub-basins (Alămor or even Târnave).

32 Grigorescu 2010.

33 Grigorescu 1987; Codrea,Vremir 1997; Jianu *et alii* 1997a; Vremir 2001; Vremir *et alii* 2009; Codrea *et alii* 2008, Codrea *et alii* 2009.

mid-Miocene unconformity that caps the SBF at its stratotype locality (Râpa Roşie). The stratigraphic position of the locality within the local geological framework suggests that it is probably late early Maastrichtian in age. This section (**fig. 3**) is dominated by coarse, mainly cross-bedded channel deposits (gravel, sandy gravel, cross-laminated sandstone), with occasional interbeds of finer grained red or brownish-red overbank and floodplain deposits (fine laminated sandstone, silty-claystone, mudstone) of a high sinuosity river. Contact between the floodplain deposits and the channels is often erosional. Several calcrete-bearing red silty-claystone horizons (up to 2 m thick), are identified as well drained moderately mature calcic paleosols. During the last decade a large number of vertebrate fossils have been found. Most are fragmentary or isolated bones, some referable to dinosaurs: *Zalmoxes* sp., hadrosauroidae, titanosaurids, velociraptorine theropods (*Balaur bondoc*), but also turtles (*Kallokibotion bajazidi*; *Muehlbachia npocsai*), small crocodylomorphs, pterosaurs (large sized Azhdarchid), and possibly birds.[34] However, the pedogenetically modified red mudstone occasionally yields more complete specimens and partial skeletons the sedimentologic and taphonomic evidence suggests a general attritional taphofacies of largely isolated and evenly distributed bone fragments and splinters. The bones suffered long term subaerial biodegradation, disarticulation and prefossilization weathering, including occasional insect related surficial modifications.[35] Episodic flood-related fine sediment input covers the inwashed partially rotted carcasses, characterizing a proximal floodplain environment.

Secaş-Feţilor Hill: this site (coded SFH/A-C) is located around the Sebeş and Secaş river-junction, and exposes more than 65 m from the lower-middle section of SBF in stratigraphic continuity above the SbG profile (**fig. 5**). The section is dominated by coarse, mainly cross-bedded channel deposits (medium to coarse bar-conglomerates), with interbeds of fine grained red overbank deposits and occasional dark greenish-brown or bluish-gray, often calcareous ponded deposits (silty claystone, mudstone) and thin evaporites. Toward up-section, thick (up to 6 m) red silty claystone and paleosol horizons occur with mostly cross-laminated sandstone and microconglomerate interbeddings, marking the transition to the upper section of SBF outcropping in Râpa Lancrămului. From lithologic and faciesal point of view, the lower section is very similar to that exposed at

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34 Vremir 2001; Codrea *et alii* 2009; Csiki *et alii* 2010.

35 Vremir 2009. Most insect related bone-modifications are associated to coleopterans (Dermestidae?) and isopterans (termites), pointing to long-term subaerial exposure, low water table, not densely vegetated environment, relatively dry conditions, etc.

Lancrăm, characterised by superposed coarse channel deposits containing oriented inwashed silecified/incarbonised tree-logs and stumps. The paleocurent orientation shows mostly north-north east (in present coordinates) flowing direction, of a high energy shallow gravel-bed river, which in time toward the top, substantially increase in sinuosity. Besides various plant-remains and invertebrates, a few vertebrate fossils were collected, belonging to fresh-water turtles (*Muehlbachia*) and various dinosaurs.

Lancrăm: an almost continuous series of outcrops (coded Lc/A-D), situated 0.5-0.8 km downstream from the Secaş-Sebeş river junction, exposing a 40 m profile of the lower-middle section of SBF (**fig. 6**). Well correlable with the previous profile, the section is dominated by coarse, mainly cross-bedded bar-conglomerates, with tabular or cross-laminated sand and sandstone interbeddings, greenish-brown or bluish-gray lacustrine mudstone in the base and occasional reddish overbank fines on top. The coarse channel deposits contain dozens of oriented silecifiated or incarbonised tree logs and stumps, some of them 16-18 m in length with diameters up to 1.5 m. As their distribution and orientation indicates, such megafossils accumulated during periodic heavy floods. The dominant paleocurent directions points towards a north and north east flowing direction of a high energy brided river. The vertebrate fossil material is represented by hydrodinamically sorted para-autochtonous skeletal elements, mainly massive limb-bones belonging to various dinosaurs. Besides a few turtle (*Kallokibotion, Muehlbachia*) and crocodylomorh (*Allodaposuchus*) remains, most of the specimens are represented by titanosaurs (cf. *Magyarosaurus*) and ornithopods (*Telmatosaurus, Zalmoxes*), accumulated in medium to coarse channel deposits.[36] In the basalmost lacustrine mudstone, frequent plant remains, occasional gastropods and microvertebrates (disarticulated fish-bones) occur. In the lower section of LcB, a dinoturbated layer was identified, the relatively well preserved foot-prints being allocated to *Hadrosaurichus* ichnotaxon, probably related to *Zalmoxes* iguanodontian dinosaur.[37] A swampy streamside gallery-woodland and patchy forested interchannel overbank environment can be reconstructed, where the rich vegetation attracted a large number of sauropod and ornithopod dinosaurs.

Oarda de Jos: several outcrops (coded Od/A-C) are known next to the village, on the right bank of Sebeş, 0.5 to 1.0 km upstream from the Sebeş-Mureş river junction. This profile corresponds to the middle section

[36] Vremir 2001; Codrea *et alii* 2009.
[37] Vremir, Codrea 2002.

of SBF, being characterized by laterally extensive sandy channel fills of a meandering fluvial system, silty crevasse splays, locally developed ponded calcareous mudstones with thin coal layers, and brownish-red fine overbank deposits (**fig. 7** and **8**). While OdA and OdB profiles are dominated by fluvio-lacustrine facieses, OdC situated above, exposes an extensive overbank succession, with restricted channel deposits of cross-laminated sandy-pebbly intebeddings. The dominant paleocurrent orientation indicates north-east to east flowing direction. Numerous leaf imprints, fruits (*Mastyxia*) and incarbonised tree fragments are recorded especially on the bottom section in the lacustrine and fine channel facieses. Aquatic invertebrates are also numerous, represented by fresh-water snails and crayfish chelipeds. The mostly isolated vertebrate fossils, occurs especially in the overbank deposits. Lenticular micro-vertebrate bone-accumulations are known from shallow abandoned channels and crevasse-splays, also calcareous ponded deposits (a very particular bioturbated egg-shell coquina limestone). Very few associated and/or articulated skeletal parts were recovered (ornithopod hind-limb elements; partial lizard skeleton), exclusively from the reddish overbank facies. The vertebrate assemblage includes fish (*Lepisosteus*), allocaudatan amphibians (*Albanerpeton*), indeterminate lizards, crocodylomorphs (*Allodaposuchus precedens*), pleurodiran and cryptodiran turtles (*Muehlbachia nopcsai, Kallokibotion* sp.), various dinosaurs (*Telmatosaurus*, *Zalmoxes*, titanosaursids, dromeosauridae indet.), enantiornithid birds, multituberculate mammals (Kogaionidae), also a huge accumulation of avian eggs and egg-shells (associated with embryonic, hatchling and adult skeletal elements). Other egg-shell fragments recovered by screen-washing documents the presence of *Pseudogeckoolithus?* and *Megaloolithus* types.[38]

Râpa Roşie: the stratotype locality (coded RR), exposing an approximately 220 m thick profile of the mid-upper section of SBF. While the lower part is dominated by extensively developed red overbank deposits with occasional coarse channel-fill interbeddings, the middle part is characterized by numerous superimposed massive or cross-laminated reddish sandy-gravelly channels. Towards the top-section, a fining-upward tendency can be noticed, with predominant loose sandy-pebbly deposits and a series of thin silty-claystone interbeddings in the uppermost section. The dominant large scale broad and shallow channel bodies with sheet-like geometries observed in the middle section are commonly derived from brided stream deposits with repeated erosional events. The fining upward trend observed in the upper part of the profile indicates a greater

[38] Codrea *et alii* 2009.

stratigraphic completeness of progressive abandonment and lateral migration in a high sinuosity low-gradient fluvial system. Vertebrate fossils are common trough the whole section, however more complete or well preserved specimens are to be found in the lowermost and mid-upper section of the profile mostly in sandy channel deposits. The vertebrate assemblage includes very rare crocodylomorphs (*Allodaposuchus,* cf. *Doratodon*), turtles (*Kallokibotion, Muehlbachia*), pterosaurs (giant Azhdarchid), and various dinosaurs, represented by titanosaurid sauropods (including a large-sized form), ornithopods (*Zalmoxes, Telmatosaurus*), ankylosaurs (*Struthiosaurus*?) and a medium-sized theropod. Taphonomic characteristics indicate scattered and transported (even moderately rounded) and weathered bone fragments/splinters, and occasional autochthonous, less transported complete specimens, including extremely fragile skeletal elements.[39]

Râpa Lancrămului: a smaller outcrop (coded RL) located on the south-western slope of Viilor Hill, exhibits an over 100 m profile of the upper section of SBF. The lithology is similar to that of Râpa Roşie outcrop with large scale superimposed sandy-pebbly cross-bedded channel bodies, and occasional silty-claystone interbeddings. The top section however is characterized by extensive overbank deposits, with thick (up to several meters) pedogenised red calcretic claystone of a well drained overbank environment. Vertebrate fossils are less commonly recorded, partly because the limited accessibility. Para-autochthonous turtle (*Kallokibotion*) but also titanosaurids and euornithopod (*Zalmoxes*) dinosaurian bones are imbedded in the medium to coarse channel-lag deposits. As in Râpa Roşie outcrop, the most frequent identifiable skeletal elements are represented by massive titanosaurid long-bones and various vertebral corpuses, which were less affected by the fluviatile transport. Most bone fragments exhibits extensive longitudinal or mosaic crackings, which indicate a long-term subaerial exposure (weathering stage 3-4) prior to burial, and some degree of intraformational reworking, sustaining the repeated erosional and redepositional processes within a large brided fluvial system.

Paleontology

The Maastrichtian vertebrate assemblages identified in Sebeş area, are very similar to those described from the Maastrichtian of Haţeg basin, Sânpetru and Ciula-Densuş formations.[40] In both areas, all major groups are well represented, including fish, amphibians, lacertilians, crocodilians, turtles,

[39] Vremir *et alii* 2009.

[40] Therrien 2005; Codrea *et alii* 2009; Benton *et alii* 2010; Grigorescu 2010.

pterosaurs, dinosaurs, birds and mammals, demonstrating the extant of "Haţeg Island" towards north-east. Due to the more extensive research-work done in Haţeg area,[41] over 60 micro- and macro-vertebrate taxa are identified, out of which, only one third is known from Sebeş region.

Despite the great similarities observed between the two faunas, in the recent years new elements were identified or described from Sebeş area too. Such "exotic" discoveries can be related to particular or unique taphofaciesal conditions or even age-differences between sites or certain stratigraphic units. Also the observable different relative abundance of taxa can be traced back to ecological factors as well, rather than implying a biogeographical pattern. As recently demonstrated,[42] some of these new faunal elements, subsequently were identified in the Haţeg basin too (their true recognition was impossible before), once more demonstrating close connection between the two provinces.

New faunal elements in the Maastrichtian deposits of Sebeş area, includes fresh-water pleurodiran turtles (Dortokidae), various pterosaurs (Azhdarchidae), theropods (Velociraptorinae) and birds (Enantiornithinae).

A special attention is given to several redated outcrops (namely Râpa Roşie and Râpa Lancrămului) exposing the uppermost section of SBF, supposedly of early-late up to late Maastrichtian in age. If true, the vertebrate assemblage identified here, can add more information regarding the faunal composition at the end of the Maastrichtian stage, yet unknown in the Haţeg basin. Besides the already identified turtle (*Kallokibotion*), euornithopod (*Zalmoxes*), titanosaurid (*Magyarosaurus*), ankylosaur, and theropod dinosaurs[43], new elements are represented by two crocodylomorphs (the eusuchian cf. *Allodaposuchus* and a ziphosuchian cf. *Doratodon*), fresh-water turtles (Dortokidae cf. *Muehlbachia*), pterosaurs (Azhdarchidae), hadrosaurs (*Telmatosaurus*) and a peculiar large-sized titanosaurian sauropod.

REPTILIA
CROCODYLOMORPHA (Walker 1970)
CROCODYLIFORMES (Hay 1903)
EUSUCHIA (Huxley 1875)
cf. Allodaposuchus (Nopcsa 1928)

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[41] Csiki, Grigorescu 2007; Grigorescu 2010.

[42] Vremir, Codrea 2009; Codrea *et alii* 2009; Csiki *et alii* 2010.

[43] Grigorescu 1987, Grigorescu 1992; Jianu *et alii* 1997; Codrea, Vremir 1997; Codrea *et alii* 2008.

A complete cervical osteodermal scute documents the presence of a large-sized crocodylomorph in the upper section of Râpa Roşie (RR) outcrop.

The quadrilateral slightly enlarged-massive scute has a length of 33 mm and maximal width of 42 mm, showing a well marked slightly elongated rounded crest on midline (**fig. 9**). Regarding its large size and morphology, the dermal plate most probably belongs to the eusuchian *Allodaposuchus*, commonly identified in the lower-middle section of SBF, particularly at Oarda de Jos locality,[44] and also in various sites of Haţeg basin.[45]

Remarks: the species *Allodaposuchus presedens* Nopcsa 1928 is defined on the basis of cranial and few vertebral and apendicular postcranial elements, the dermal scutes not being properly known.

ZIPHOSUCHIA (Ortega *et alii* 2000)
cf. Doratodon (Seeley 1881)

Based on a recently collected left lower-dentary fragment, a small-sized crocodylomorh is also documented in the upper-most section of Râpa Roşie (RR) outcrop. The specimen represents the mid-posterior part of the dentary, exhibiting five roughly same sized and equidistant alveoli (5-9?), preserving compressed bulbous and antero-posteriorly enlarged roots, having a preserved length of 59 mm, and hights of 15-19 mm (**fig. 10**-**11**). The longitudinal depression on the lateral surface of the dentary extending parallel to the ventral mandibular margin (typical Sebecosuchian synapomorphy) and the apparent homodont mandibular tooth-row indicate a Ziphosuchian appartenance. Regarding its size and slender dentary profile, with a slight concave arching (waving), a great resemblance with *Doratodon carcharidens* Seeley, 1881 species can be noticed. The profuse ornamentation observed on the lateral side of the dentary indicate a mature individual, with absolute size between *D. carcharidens* and *D. ibericus*. The genus *Doratodon* is known from the Campanian of Europe,[46] and also from the Maastrichtian of Haţeg basin,[47] being the first Gondwanian sebecosuchian-like crocodylomorph in the late Cretaceous of Europe.

Remarks: both *Doratodon carcharidens* (Campanian of Muthmannsdorf, Austria) and *D. ibericus* (Campanian of Valencia, Spain) were defined on

[44] Delfino *et alii* 2008; Codrea *et alii* 2009.
[45] Martin *et alii* 2006.
[46] Company *et alii* 2005.
[47] Martin *et alii* 2006. Besides the eusuchian *Allodaposucus* and ziphosuchian *Doratodon*, the a small-sized alligatoroid *Acynodon* and the highly specialized *Theriosucus* was also identified.

cranial and mandibular elements including dentaries. A detailed morphological analysis and comparison is needed for a more precise taxonomic identification.

TESTUDINES (Linnaeus 1758)
PLEURODIRA (Cope 1864)
MEGAPLEURODIRA (Gaffney Tong and Meylan 2006)
DORTOKIDAE (Lapparent de Broin and Murelaga 1996)
Muehlbachia nopcsai (Vremir, Codrea 2009)

A new Upper Cretaceous fresh-water dortokid pleurodiran turtle had been reported from the continental deposits of Sebeş area and Haţeg Basin.[48] Scarce but rather well preserved specimens were collected from the upper-lower Maastrichtian sites of Oarda de Jos, Secaş, Sebeş-Glod and Râpa Roşie.

This small-sized (shell-length up to 20 cm) pleurodire turtle, exhibits a mixture of endo- and exoskeletal morphological features, placing it between the late Cretaceous (Campano-Maastrichtian) south-west European genus *Dortoka* and the Romanian latest Paleocene (Thanetian) genus *Ronella* (**fig. 12-13**).

In *Muehlbachia nopcsai*, the decoration consist of sharp, close and more or less parallel crests on neurals and costals on the proximal third (anterior) or proximal half (posterior). Pitted surface is sometimes present on plastral and carapacial elements, a feature probably related to fungal infections. The basic ornamentation type is strong and much closer to *Dortoka*, than to *Ronella*.

The pleural scute 1 has the same length or shorter than in *Dortoka*, longer than in *Ronella*, being just excluded from costal 2 like in *Dortoka*. Pleural scute 2 is enlarged posterolaterally (like in *Dortoka*) reaching the antero lateral border of costal 5. *Muelbachia* has strong axillary process like *Dortoka* and it covers 1/3 up to 1/2 of the costal 1, (variability due to sexual dimorphism shell elevation and plastral concavity). The axillary process does not reach the 2nd thoracic rib or the scar marginally touches the costal 2 (like *Ronella*). The nuchal plate (Nu) is wider and slightly shorter than in *Dortoka*. The vertebral 1 is narrow posteriorly not overlapping the lateroposterior corners of the nuchal (*Dortoka* like). Neurals 1 and 2 are elongated, rectangular or oval in shape (like *Ronella*). Mid-neurals are slightly elongated and equally narrow, hexagonal in shape with long postero-lateral sides (like *Ronella*). The wide and triangular iliac scar on costal 8 is anteriorly enlarged

[48] Vremir 2004; Vremir, Codrea 2009.

and extends or is in contact with costal 7 (like *Ronella*), excluded from the peripheral (like *Dortoka*) but slightly prolonged onto suprapygal. The pygal plate is small and rectangular-square shaped, much shorter than in *Dortoka*, very similar is shape and scute configuration to *Ronella*.

Muelbachia nopcsai has a long and relatively narrow plastron; the anterior plastral lobe being longer than in *Ronella*, close to *Dortoka*. The pectorals medially overlap the entoplastron (*Ronella* like) or eventually reaches the entoplastral point and well anterior laterally on the hyoplastron. The entoplastron is more elongated and rhomboid in shape than in *Ronella* and it is closer to *Dortoka*, but the humero-pectoral suture is situated in the mid-section of the plate (slightly advanced than in *Ronella*). A short and elongated-oval pubic scar lies exclusively on the xiphiplastron (like in *Dortoka*) and does not prolong onto the hypoplastron. The femoro-anal suture is always situated well on the anterior half of the xiphiplastron (*Ronella* like), which has a narrow aspect with parallel margins in the posterior half and a relatively wide anal notch.

Dortokids however are considered an endemic European clade, they have a wide stratigraphic and geographic distribution. The family is known from the early Cretaceous (Barremian) of Vallipon in Spain and late Cretaceous (Campanian-Maastrichtian) of northern Spain and southern France.[49] Recently, dortokids were identified in the late Cretaceous (Santonian) of Hungary, Campanian of Austria, respectively Maastrichtian of Romania. The latest occurrence is recorded in the late Paleocene (Thanetian) and possibly early Eocene (Ypresian) of Jibou and Giurtelecu Şimleului in Transylvanian Basin.

Remarks: based on certain more primitive characters observed in *Ronella* in respect to *Dortoka,* they had been placed in two different lineages, separated early as the Latest Jurassic/Early Cretaceous.[50] *Muehlbachia nopcsai* combine a mosaic of "primitive" and more "derived" characters found in both *Dortoka* and *Ronella*, a state which shows a more complex evolutionary history within the group. A series of characters observed on the Santonian and Campanian specimens of Iharkut (Hungary) and Muthmannsdorf (Austria), also indicate that certain rather ambiguous than distinctive generic diagnostic features, actually are related to individual or intraspecific variations. In order to clarify this question, a reevaluation of the whole paleontologic material, including more complete specimens (associated complete carapace and plastron, also appendicular elements) is in progress.

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49 For an overview see Lapparent de Broin *et alii* 2004.
50 Lappaernt de Broin *et alii* 2004.

PTEROSAURIA (Kaup 1834)
PTERODACTYLOIDEA (Plieninger 1901)
AZHDARCHOIDEA (Nesov 1984 ; Unwin 1992)
AZHDARCHIDAE (Nesov 1984 ; Padian 1986)
***Gen. et sp. indet.* (giant form A - RR specimen)**

An almost complete cervical vertebra of a giant pterosaur was recently recorded from the upper section of SBF at Râpa Roşie (RR) outcrop,[51] of supposedly late Maastrichtian age. The specimen was found in situ, associated with other well preserved vertebrate remains, including turtles, crocodylomorphs, hadrosaurians, euornithopods and titanosaurid dinosaurs.

The cervical vertebra is largely complete and distinguished by its very large size (**fig. 14**-**16**). The remarkably thin cortical bone and general anatomy of the specimen clearly demonstrate that this is a pterosaur vertebra and comparison with other late Cretaceous pterosaurs,[52] indicate that it is most likely the third cervical. The specimen is uncrushed and largely undistorted, but lacks the dorsal tip of the neural spine, the terminus of the left prezygapophysis, the entire left postzygapophysis and the condylar region. The neural spine appears to have been robust, but relatively low and divided into anterior and posterior portions by a distinct mid-length gap. The zygapophyses are short and remarkably stout. The prezygapophysial facet is oval, gently convex and faces dorsally and somewhat anteriorly. The postzygapophysial facet is more sub-circular and faces posteriorly and slightly ventral. The neural arch is confluent with the centrum throughout its length. The transverse foraminae are well developed and enclosed ventrally by vestigial cervical ribs. These are completely fused to the centrum indicating that this individual had reached osteological maturity. The neural canal consists of an ossified tube suspended within a cancellous network. The anterior opening of the neural canal is flanked on either side by a circular pneumatic foramen. The general similarity of this vertebra to the third cervical of azhdarchids and the presence of characters unique to (confluency of the neural arch and centrum), or almost exclusive to Azhdarchidae (pneumatic foraminae flanking the neural canal, neural spine subdivided into cranial and caudal portions) provide strong support for the assignment to this family.[53]

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51 Vremir *et alii* 2009.
52 *Phosphatodraco* (Pereda-Suberbiola *et alii* 2003); *Azhdarcho* (Nessov 1984; Bakhurina, Unwin 1995) and *Zhejiangopterus* (Cai, Wei 1994).
53 Witton, 2007; Witton, Naish 2008.

Remarks: with an estimated original length of 30 cm and a maximum width, measured across the prezygapophyses, of 23 cm, this is the most massive vertebra known for any pterosaur. Preliminary comparative studies[54] suggest that it was substantially larger than either of the giant individuals of *Quetzalcoatlus* and *Hatzegopteryx*,[55] which have an estimated wing-span of around 10-11 m.[56] Actually the width of the anterior articular facet is at least two-times larger than in any recorded giant form, the general proportions, size and morphology indicating a very robust more mobile and possibly shortened neck. This shows that the RR specimen was anatomically quite different from other azhdarchids, suggesting much more anatomical/morphological and ecological diversity than previously realized.[57] Regarding the bone-wall thickness and internal structure, a great resemblance with other skeletal elements of *Hatzegopteryx* can be noticed, however the lack of overlapping skeletal parts makes any morphological comparison impossible. Despite the absolute size difference and time-span between the two finds (erly or early-late Maastrichtian for *Hatzegopteryx*, late or possibly latest Maastrichtian for RR specimen), is possible that the RR cervical belongs to a much larger individual of *Hatzegopteryx*.

AZHDARCHIDAE? (Nesov 1984; Padian 1986)
Gen. et sp. indet. **(giant form B - PT specimen)**

A fragment of presumably wing phalange shaft[58] was recently collected from the earliest Maastrichtian Top Bozeş formation, from Petreşti (PT) site. The specimen (**fig. 17**-**18**) was found ex-situ in a brackish-estuerine sequence and part of the bone surface is broken being eroded.

The preserved bone-shaft is pneumatic, forming a very thin-walled tube, and based on the rather unusual shape of the cross-section, probably represents a mid-proximal shaft segment the of a pterosaurian 5th digit second phalange. Based on its size and particularly the bone shaft width and wall thickness proportion, the specimen most likely belongs to a giant azhdarchid. However slightly compressed, the maximum available shaft width is 40 mm, while the wall thickness is between 1.8 and 3.4 mm, with an average shaft width/wall thickness ratio of 16.3. Comparing the bone

54 Vremir *et alii* 2009; D. Unwin, personal observations.
55 Lawson 1975; Langston 1981; Buffetaut *et alii* 2002; Buffetaut *et alii* 2003.
56 Witton, Naish 2008.
57 D. Unwin, written communication (2009).
58 D. Unwin, written communication (2010).

proportions with other azhdarchids,[59] the restored length of the whole bone, probably reached 80 cm or more (the estimated length of wp2 in *Quatzalcoatlus northropi* is 65 cm, while in *Arambourgiania philadelphiae* is 74 cm), indicating a wing-span exceeding 10 m, same as *Hatzegopteryx thambema* from the Maastrichtian of Haţeg basin.[60]

AZHDARCHIDAE (Nesov 1984, Padian 1986)
Gen. et sp. indet. **(medium-large form - SbG specimen)**

A partial-articulated skeleton of a medium-large pterosuar was recovered from Sebes-Glod (SbG) outcrop, from red overbank deposits. The specimen includes three articulated cervical vertebrae (most probable C3-5), partial articulated wing exhibiting the proximal, distal and medial carpals, the 4th (wing) metacarpal, the first wing phalange, and some other yet unsituated fragmentary bones.[61] Certainly is one of the most complete European late Cretaceous pterosaur specimen found to date.

The extremely thin walled pneumatic bones (particularly the wing-bones) are slightly crushed, preserving great part of the bone surface and the internal molds. The most distinctive azhdarchid characters are given by the neck region, showing very elongated cervicals (**fig. 19**), with extremely reduced neural spines, confluent neural canal with centrum and apparent lack of lateral pneumatic foramen on the centrum. Degree of cervical elongation (sensu Unwin 2003) shows length/min width ratio of 4.3 (C4), respectively 5.3 (C5). The preserved length of the first wing phalange is 26 cm (restored length approxinmatelly 28 cm), suggesting an estimative wing-span of 4.0 m, roughly same size-class as *Azhdarcho lancicollis* (wsp 3.5-4.0 m) from the late Turonian of Uzbekistan, *Bakonyodraco galaczy* (wsp 3.5-4.0 m) from the Santonian of Hungary, *Zhejiangopterus linhaiensis* (wsp 3.5 m) from the Campanian of China, *Bogolubovia orientalis* (wsp 3.0-4.0 m) from the Campanian of Penza region, Russia, but smaller than *Alanqa saharica* (wsp>5.0 m) from the Cenomanian of Aferdou, Morocco and *Phosphatodraco mauritanicus* (wsp 5.0 m) from the Late Maastrichtian of Ouled Abdoun, Morocco.[62]

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59 The azhdarchid wing-bone proportions, particularly the wing phalanges and wing phalange/ulna ratio, are highly variable, making difficult any comparative wing-span estimation.

60 Buffetaut *et alii* 2002, 2003.

61 The specimen was retrieved in September 2009, and its preparation has not been completed yet.

62 Bucharina, Unwin 1995; Ösi *et alii*, 2005; Averianov *et alii* 2005; Pereda-Suberbiola *et alii* 2003; Watabe *et alii* 2009; Ibrahim *et alii* 2010.

Remarks: the preliminary analysis of SbG specimen clearly shows an azhdarchid affinity, however the unfinished restoration did not allowed yet a more complete comparison with other late Cretaceous species.

Other late Cretaceous pterosaur finds from Romania:
Late Cretaceous (Maastrichtian) Romanian pterosaur finds are extremely rare. Besides the above described specimens from Sebeş area, a few small sized Ornithocheirid-like remains (notarium, several teeth and unidentified "hollow bones") were first reported from the Maastrichtian of Sânpetru in the Haţeg basin.[63] Additional pterosaurian materials (notarium, fragmented humerus and femur) collected from the same site, were identified as possibly belonging to a small Pteranodontid.[64] The pterosaurian notarium mentioned by Nopcsa, was recently reviewed, and most likely represents a maniraptoran theropod sacrum.[65] Several teeth presumably belonging to an Ornithocheirid were also recorded from various sites of Haţeg basin, however their affinity is still not clear, probably belonging to sauropod dinosaurs.[66]

The giant (wsp 10-11 m) azhdarchid *Hatzegopteryx thambema* from the early or early late Maastrichtian of Vălioara in Haţeg basin was described on the basis of palatal fragment, occipital skull and a proximal articular humerus. A second specimen represented by a large femora shaft (restored length 40 cm), was described from Tuştea dinosaur nesting-site as well.[67] A possibly third specimen was recently refound in the Bucharest University Paleontological collection, being identified as a fragmentary anterior mandibular symphysis.[68]

Three recently collected Maastrichtian specimens are represented by an incomplete small sized wing-phalange (wp 2?), recovered from the same formation at Boiţa in north Hateg basin,[69] an almost complete large sized (wsp 4.5-5.0 m) coracoid from Vadu (central Haţeg basin), most probably belonging to a subadult individual of *Hatzegopteryx*, and a medium sized (wsp 3.5 m) scapula from the coeval continental deposits of Pui (eastern Hateg basin).

All together, the Romanian Maastrichtian pterosuarian finds shows a grater morphological and taxonomical diversity as previously thought, with

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[63] Nopcsa 1914.

[64] Jianu *et alii* 1997b; for an overview see Buffetaut *et alii* 2003.

[65] Ősi, Özy 2007.

[66] Csiki *et alii* 2009; Csiki, verbal communication.

[67] Buffetaut *et alii* 2002 ; Buffetaut *et alii* 2003.

[68] Vremir M., personal observation.

[69] Vremir *et alii* 2009.

three or even four different taxa, ranging from the small sized Ornithocheirid-like forms, small Pteranodontids, up to various large and gigantic Azhdarchids.

DINOSAURIA (Owen 1842)
ORNITHISCHIA (Seeley 1887)
ORNITHOPODA (Marsh 1881)
HADROSAUROIDEA (Sereno 1986)
***Telmatosaurus* sp.** (Nopcsa 1898)

A partial medio-proximal right femur (**fig. 20**) documents the presence of this taxon, within the uppermost section of Râpa Roşie outcrop. The bone is well preserved without any abrasion marks or syndepositional brakes, being found associated with a large sauropod dorsal vertebra, a giant azhdarchid cervical vertebra and various mainly dinosaurian skeletal elements.

The proximal epyphysis is completely preserved with a well developed rounded-hemispherical femoral head projected horizontally. The broad grater trochanter is less elevated being separated from the head by a well developed-wide depression. The anterior trochanter is also well developed, broad and flattend, separated by the grather trochanter by a deep rather wide cleft. The lower-anterior edge shows a vertical elevated tuberosuty of muscle attachment. The shaft is massive and strait, slightly compressed in antero-posterior direction with a subrectangular cross section. The fourth trochanter is partially preserved, broad and rounded proximally, being probably situated above the midshaft. Several large tooth-marks can be noticed both on the shaft and apophyseal region, suggesting predation or scavenging related disarticulation and dispersal prior to burial in fine channel-fill deposits. Regarding its size, the bone had an original length of approximately 440 mm, a midshaft width of 61 mm, and a proximal width/depth of 102/76 mm, indicating an adult individual.

Telmatosaurus transsylvanicus Nopcsa represents the only hadrosaurian species known from the Maastrichtian of Romania well represented in the Haţeg and Transylvanian basins. Small sized (dwarf) hadrosaurian remains are common in the lower and middle section of SBF (Oarda de Jos, Lancrăm, Sebeş-Glod),[70] but till now unknown from the uppermost section of SBF and from Râpa Roşie or Râpa Lancrămului outcrops.

[70] Vremir 2001; Therrien 2005; Codrea *et alii*, 2009.

Remarks: as previously suggested[71] this species most probably represents a basket taxon, which actually could include a variety of hadrosaurians. The ontogenetic development of long bones studied on the Tuştea nesting-site, shows a series of variations during growth.[72] But certain differences are observed also in adult specimens, indicating variations related to sexual dimorphism as well.

SAURISCHIA (Seeley 1889)
NEOSAUROPODA (Bonaparte 1986)
TITANOSAURIA (Bonaparte, Coria 1993)
TITANOSAURIDAE (Lydekker 1893)
***Gen. et sp. indet.* (large size - RR specimen)**

A largely complete medio-posterior dorsal vertebra (**fig. 21**-**22**) belonging to a large size titanosaurid sauropod was most recently recovered from the uppermost section of Râpa Roşie outcrop.

The slightly elongated and dorso-ventrally compressed corpus (length = 150 mm; width = 110 mm; height = 80 mm), is strongly opistocelous with convex hemispherical condyle and a larger concave caudal cotyle. On the lateral side, the centrum bears a deep and large slightly elongated eye-shape pleurocoel. The verticalised and very high neural arch is partially preserved (height = 150 mm), exhibiting damaged praezygapophysis, incomplete diapophysis, complete postzygapophysis, broken neural spine and the mostly well preserved laminar structure, including a pair of accessory anterior centroparapophyseal lamina, strong posterior centrodiapophyseal lamina, a well developed postzygodiapophyseal lamina and centropostzygapophyseal lamina. The neural duct is 30 mm wide and 40 mm in height. Both diapophyses are broken close to their base and a steep almost vertical orientation can be noticed. Apparently the hyposphene-hypantrum structure is missing. The internal structure of the bone is spongy with large air-sacs.

This specimen bears clear titanosaurid characters, and the missing hyposhene-hypantrum structure suggests a basal position within the clade. Some particular features are represented by the very large size (by Transylvanian standards), elongated corpus bearing a large pleurocoel, very high neural arch, more derived characters being represented by the accessory anterior centroparapophyseal laminae and a well developed postzygdiapophyseal lamina.

71 Dalla Vechia 2006; Dalla Vechia 2009.

72 Grigorescu, Csiki 2006.

In the Maastrichtian continental deposits of Haţeg basin, at least three titanosaurian sauropod taxa were distinguished.[73] Besides the well known small sized *Magyarosaurus dacus* species (including "*M. transsylvanicus*"), a second small to medium sized taxon was recently proposed (*Paludititan nalatzensis*), substantially differing from the genus *Magyarosaurus*.[74] A third and comparalively larger taxon is represented by the less known "*Magyarosaurus*" *hungaricus* species which probably represents a third yet undefined genus. In Sebeş region, sauropod fossils are rather common, represented by scattered limb bones and vertebrae allocated to the genus *Magyarosaurus*. At Râpa Roşie locality, a small caudal vertebra corpus was identified as belonging to *Magyarosaurus*.[75]

Remarks: regarding its size and morphology, the above described vertebra indicate the presence of a particular large-size titanosaurid taxon (body length well over 10 m), differing from both "small" (*Magyarosaurus dacus*) or small to medium sized (*Paludititan nalatzensis*) forms known from the Haţeg basin, possibly belonging to "*M.*" *hungaricus* the only relatively large-sized form known so far from the Maastrichtian of Romania.

THEROPODA (Marsh 1881)
COELUROSAURIA (Huene 1914)
MANIRAPTORA (Gauthier 1986)
DROMEOSAURIDAE (Matthew, Brown 1922)
Balaur bondoc (Csiki *et alii* 2010)

A new velociraptorine theropod was recently discovered in Sebeş-Glod (SbG) vertebrate locality. The specimen represents an associated and partially articulated skeleton of a mature/near-mature individual (**fig. 23**). The preserved elements include: one anterior and seven more posterior and articulated dorsal vertebrae, the sacrum (made up of at least 4 sacrals) in articulation with the pelvis (including incomplete ilia preserving only the circum-acetabular region, pubes and ischia, all preserved in life position), one caudosacral, five anterior caudals, fragmentary right and left scapulacoracoids, complete right and almost complete left forelimbs, left distal hindlimb in articulation (tibiotarsus, metatarsals and complete digits) and right tarsometatarsus. The ossified, paired sternal plates are partially preserved. Additionally, several incomplete dorsal ribs (pertaining to the posterior dorsal vertebrae), gastralia and indeterminate bone fragments were

[73] Csiki *et alii* 2007; Stein *et alii* 2008.
[74] Csiki *et alii* 2009.
[75] Codrea *et alii* 2008.

also found. No cranial bones, cervical vertebrae, distal caudal vertebrae and femora were recovered yet.

A general description was recently published,[76] pointing out the most striking morphological features: pneumatic foramina extend throughout the dorsal column, and broken surfaces reveal extensive internal cavities in the neural arches. The ossified sternal plates preserved mostly as molds, are separate and the scapula and coracoid are fused. The coracoid has an extensive ventral process and is inflected medially relative to the scapula. The sigmoidal humerus is marked by a deep groove on the posterior surface distal to the deltopectoral crest. Unusually, the radial condyle is located on the anterior surface of the distal humerus. The bowed ulna is D-shaped in cross section, due to a flat anterior surface that is bisected by an autapomorphic longitudinal ridge. The manus (**fig. 24**) is extensively modified relative to other theropods, especially in regards to fusion and differential development of the digits. The carpals and three metacarpals are fused into a 'carpometacarpus'. The distal condyles of metacarpals I and II are do not extend onto the plantar surface, indicative of more limited manual extension. Digit III is atrophiated and non-functional. Phalanx III-1 is reduced to a small nubbin that is much smaller than the phalanges of digits I and II. The well developed ungual phalanges are present on digit I and II. Pelvic bones are fused and the pubis and ischium are so extremely retroverted that they nearly parallel the long axis of the ilium. The pubis is oriented at most 45 degrees relative to horizontal. The hindlimb exhibits extensive fusion: the tibia and fibula are fused with the proximal tarsals to form a tibiotarsus, the distal tarsals are fused onto the metatarsals, and metatarsals II-V are fused to each other across most of their lengths. The stout tarsometatarsus is less than twice as long proximodistally as wide mediolaterally, and is much wider than the tibiotarsus, reflecting a shortened distal leg optimized for power instead of speed. The most remarkable feature of the hindlimb is the enlarged and functional first digit. Metatarsal I remains a small, wedge-like element that articulates at idpoint of metatarsal II, as is normal for tridactyl theropods, but the two phalanges of digit I are enlarged, nearly the size of the phalanges of digit II. The second pedal ungual is the largest in the foot and exhibits modifications for extreme extension. All of the appendicular bones possess a heavily sculptured vermiculoid external surface.

Phylogenetic analysis identifies *Balaur* as the sister taxon to *Velociraptor*, supported by a fused scapulocoracoid, a cuppedicus fossa rim that is nearly confluent with the acetabular rim, fused distal tarsals, and a

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[76] Csiki *et alii* 2010.

muscle attachment flange on metatarsal IV. However, the closest relatives of *Balaur* are mostly Asian and North American taxa of similar or slightly older age, whereas contemporary (or near contemporary) South American species, and older Laurasian taxa, are placed elsewhere on the phylogeny. This indicates that faunal interchange between the European archipelago and Asia persisted deep into the Cretaceous, and the Haţeg Island was not solely an endemic refugium for primitive taxa, but its fauna was also shaped by dynamic interchange with the Laurasian mainland.

Taphonomic remarks: the specimen was found partially articulated (**fig. 25**) and slightly dispersed, in fine grained red to brownish-red floodplain deposit. The red silty-claystone overbank deposits, frequently yield evenly distributed and mostly fragmented bones, splinters and chips showing a long subaerial exposure (weathering stage 3-5), indicating an attritional trempled taphofacies. In certain levels more complete specimens and partial skeletons occur indicating episodic flood-related fine sediment imput characterizing a proximal floodplain environment. Two such levels were identified (80 cm apart), the lower one containing the theropod skeleton, while the upper one yielding partial pterosaur (azhdarchid) and semiterrestrial turtle (*Kallokibotion*) skeletons. Other associated faunal elements are represented by various dinosaurs (*Zalmoxes*, *Telmatosaurus*, and titanosaurids), crocodylomorphs, turtles (*Muehlbachia*) and possibly birds. The partially rotten theropod carcass (probably still bearing ligamentar tissues or skin) was transported in a low energy current during such a waning flood, then at least some parts were for a short time subaerially exposed (weatherin stage 1-2), partially disarticulated and buried due to additional sediment input.

As indicated by the detailed quarry-map, site-map and sedimentological analysis, more extensive excavations at the quarry-site can lead to the recovery of remaining skeletal parts, particularly hindlimb elements and the distal caudal series. As indicated by a small long-bone shaft fragment collected from another layer (roughly 70 cm above) and bearing the characteristic sculptured vermiculoid external surface, the presence of other *Balaur* specimens is not excluded.

AVES

ORNITHOTHORACES (Chiappe 1996)

ENANTIORNITHES (Walker 1981)

Gen. et sp. indet.

A huge accumulation of colonial avian eggs, egg-shells and associated skeletal parts of embryonic, hatchling and adult birds were recently recovered from Oarda de Jos (OdA) vertebrate site. A preliminary analysis based on several less fragmentary bones of adult specimens, indicate an appartenance to a small sized enantiornithid bird. Besides numerous axial, appendicular and rare cranial elements, these include a scapula (**fig. 28**) and a partial humerus (**fig. 27**) which exhibits enantiornithid characters.[77]

The scapula is rather robust and strait with a well developed acromion. The scapular blade is strait, flattened with a subequal width, bearing a distinct longitudinal groove on the medial margin, and a longitudinal depression on the lateral surface. Proximally, the acromion is robust and subtriangular-rounded with a semilunate surface on the craniomedial area. The acromion is separated from the humeral and coracoideal articular surfaces by a robust neck, bearing a deep excavation. The humeral articular surface is large and concave representing half of the proximal width.

The proximal end of the humerus is enlarged, showing a well developed and flat deltopectoral crest. The humeral head is elongated, concave cranially and convex caudally, being separated by the bicipital crest by a deep and wide ligamental groove. The bicipital crest is robust and rounded, laterally projected bearing a distinct pneumotricipital fossa and also a minute pneumatic foramen. The presence of a pneumatic foramen indicates the incipient pneumatization of the humerus, known in neornithes birds, being rarely found within enantiornithes.

The association of skeletal elements and well-preserved eggs is also important, being the most relevant such association of ootaxonomic and osteotaxonomic avian entities found in the late Cretaceous of Europe.

Taphonomic remarks: the fossil material is preserved in a peculiar egg-shell coquina ponded flood-plain limestone microfacies (**fig. 26**), within the basal fluvio-paludal sequence of the outcrop (**fig. 8**). The ground-nests were washed together in a small and shallow pond during a flood event. The lenticular sheet-like accumulation showed certain zonation of thin concave-up tight shell-supported layers, while in the upper part, more complete eggs and chaotically oriented egg-shell and bone melange occur, indicating a primary hydrodinamic deposition. Following a very short transport, the bird carcasses and eggs were concentrated and mixed into fine calcareous-muddy sediment, and subsequently were disarticullated and bioturbated by a large number of saprophagous insects (coleopterans), possibly crayfish and other necrophagous organisms, which consumed mainly the soft tissues and

[77] Chiappe, Walker 2002.

feathers, the bones remaining unaltered.[78] As indicated by the perfect preservation of the tiny bones, the calcareous mud layer was in short time covered by fine sediments in a low pH water-loged environment. Similar microtaphofaciesal conditions are world-wide rarely recorded, one such example being described from the early-late Maastrichtian of Nălaţ-Vad vertebrate site in the Haţeg basin.[79]

Noi elemente faunistice din depozitele continentale Cretacice superioare (Maastrichtian) din zona Sebeş (Transilvania)

(Rezumat)

Formaţiunile continentale Cretacice superioare din zona Sebeşului, sunt cunoscute încă de la începutul secolului al XIX-lea. Acestea aparţin la câteva formaţiuni distincte, recent definite, a căror vârstă a fost îndelung dezbatută. Cele mai recente cercetări indică o vârsta Maastrichtian-posibil Paleocenă atât pentru depozitele care aflorează pe malul drept al Mureşului între Vinţu de Jos şi Şard, cât si pentru cele din stânga Mureşului, unde apare la zi formaţiunea de Sebeş (bine expus în aflorimentul tip de la Râpa Roşie).

Câteva aflorimente ne-au livrat un valoros material paleontologic care a contribuit la redatarea acestor depozite continentale. Resturi de vertebrate în general disjuncte (majoritatea aparţinând dinozaurilor) apar în siturile de la Petreşti, Sebeş-Glod, Secaş-Dealul Feţilor, Lancrăm, Oarda de Jos, Râpa Roşie şi Râpa Lancrămului.

Noile elemente paleofaunistice pentru zona Sebeşului sunt reprezentate printr-un un nou gen de ţestoasa-pleurorira de talie mică (*Muehlbachia nopcsai*), cel puţin două forme de pterosaurieni din familia Azhdarchidelor (o formă de talie medie-mare nedefinită şi două specimene gigantice posibil aparţinând genului *Hatzegopteryx*), un dinoyaur theropod velociraptorin, reprezentat printr-un nou gen şi specie (*Balaur bondoc*) şi, respectiv, păsări primitive din grupul enantiornithelor. În ceea ce priveşte aflorimentul de la Râpa Roşie, s-au identificat aici câteva elemente noi pentru acest stratotip, printre care un crocodilian-ziphodont de talie mica (cf. *Doratodon*), un crocodilian-eusuchian de talie mare (cf. *Allodaposuchus*), un hadrosaurian (*Telmatosaurus*) şi un sauropod titanosaurian de talie mare, distinctă de genul *Magyarosaurus*, bine cunoscut atât din fauna Maastrichtiană din Haţeg, cât şi din câteva aflorimente din zona Sebeşului.

Explicaţia figurilor

Fig. 1. Harta geologică a zonei Sebeş.
Fig. 2. Secţiune geologică de-a lungul râului Sebeş între Petreşti (sud) şi Oarda de Jos (nord).
Fig. 3. Profil stratigrafic de la Sebeş-Glod.
Fig. 4. Profil stratigrafic de la Petreşti.
Fig. 5. Profil stratigrafic de la dealul Secaş-Feţii.
Fig. 6. Profiluri stratigrafice de la Lancrăm.

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78 Vremir 2009.
79 Van Itterbeeck *et alii* 2004.

Fig. 7. Profiluri stratigrafice de la Oarda de Jos.
Fig. 8. Profil stratigrafic detailat al aflorimentului de la Oarda de Jos-OdA.
Fig. 9. Placă osteodermică cervicală de *Allodaposuchus* de la Râpa Roşie.
Fig. 10. Fragment dentar din mandibula stângă de *Doratodon* de la Râpa Roşie-vedere laterală.
Fig. 11. Fragment dentar din mandibula stângă de *Doratodon* de la Râpa Roşie-vedere laterală – vedere mediană.
Fig. 12. Reconstrucţia unei carapace compozite de pleurodiran *Muehlbachia nopcsai*.
Fig. 13. Reconstrucţia platoşei compozite de *Muehlbachia nopcsai*.
Fig. 14. Vertebra a 3-a cervicală a unui pterozaur azhdarchid gigant de la Râpa Roşie – vedere dorsală.
Fig. 15. Vertebra a 3-a cervicală a unui pterozaur azhdarchid gigant de la Râpa Roşie – vedere ventrală.
Fig. 16. Vertebra a 3-a cervicală a unui pterozaur azhdarchid gigant de la Râpa Roşie – vedere dorsală şi craniul.
Fig. 17. Fragment al falangei? a 2-a aparţinând unei aripi de pterozaur azhdarchid gigant de la Petreşti – vedere laterală.
Fig. 18. Fragment al falangei? a 2-a aparţinând unei aripi de pterozaur azhdarchid gigant de la Petreşti – vedere transversală.
Fig. 19. Vertebra a 5-a cervicală a unui pterozaur azhdarchid de talie medie de la Sebeş-Glod – vedere ventrală.
Fig. 20. Partea proximală a unui femur drept de *Telmatosaurus* de la Râpa Roşie – vedere anterioară.
Fig. 21. Vertebra posterioară dorsală a unui titanozaur de talie mare de la Râpa Roşie – vedere laterală.
Fig. 22. Vertebra posterioară dorsală a unui titanozaur de talie mare de la Râpa Roşie – vedere caudală.
Fig. 23. Holotipul unui velociraptor terapod *Balaur bondoc* de la Sebeş-Glod – distribuţia elementelor scheletice.
Fig. 24. Membrele anterioare ale *Balaurului bondoc*.
Fig. 25. Membrul anterior drept al *Balaurului bondoc* în poziţie naturală.
Fig. 26. Ouă aviare în cochină de la Oarda de Jos.
Fig. 27. Humerus proximal al unei păsări enantiornitine de la Oarda de Jos.
Fig. 28. Omoplatul unei păsări enantiornitine de la Oarda de Jos.

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Cuvinte-cheie: paleontologie, geologie, Transilvania, zona Sebeşului, fosile.
Keywords: paleontology, geology, Transylvania, Sebeş area, fossils.

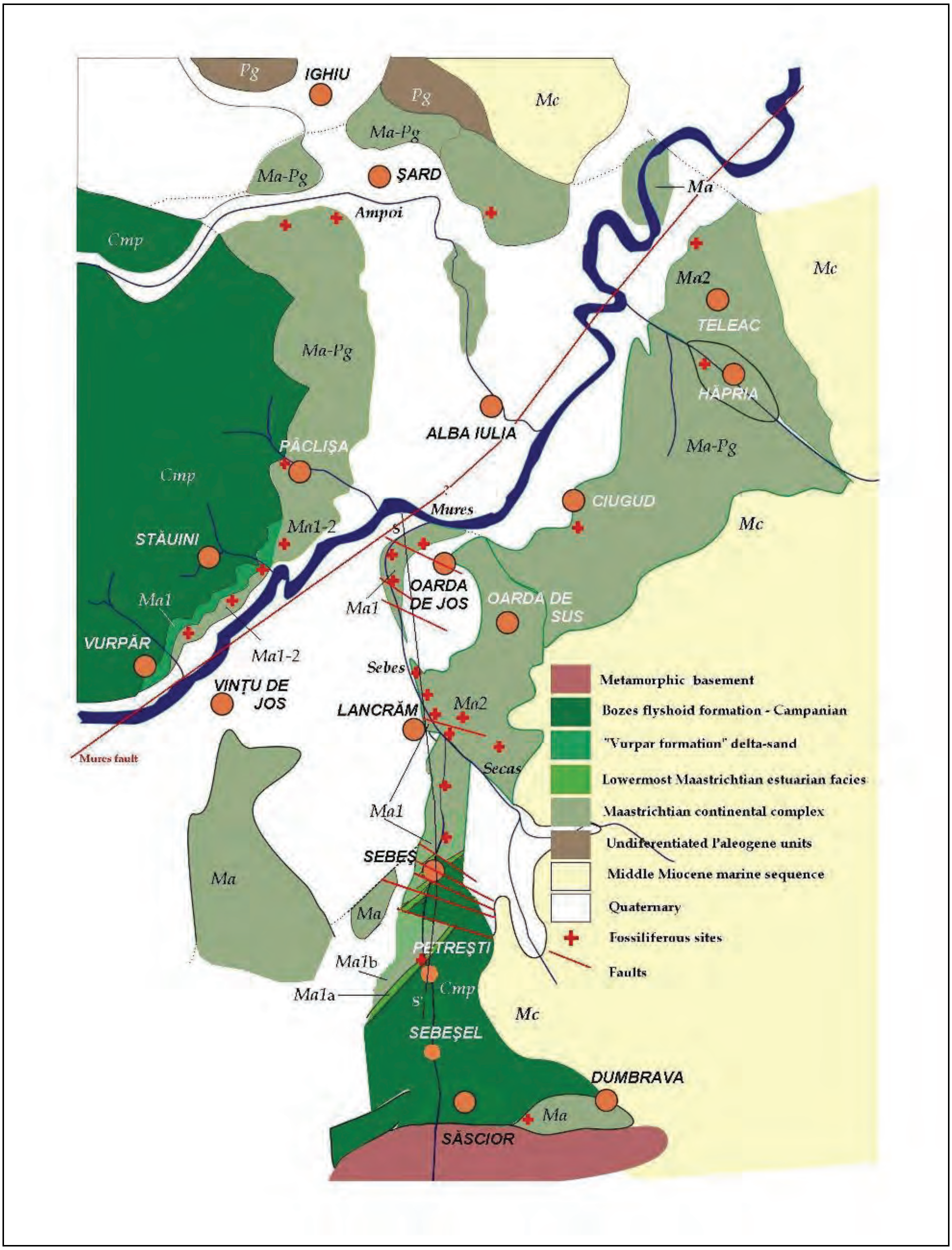

Fig. 1. Geological map of Sebeş area

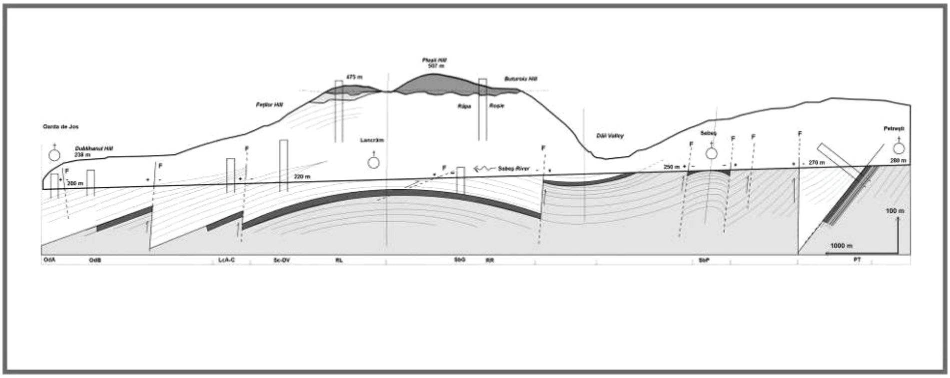

Fig. 2. Geological cross-section along the Sebeş River between Petreşti (south) and Oarda de Jos (north)

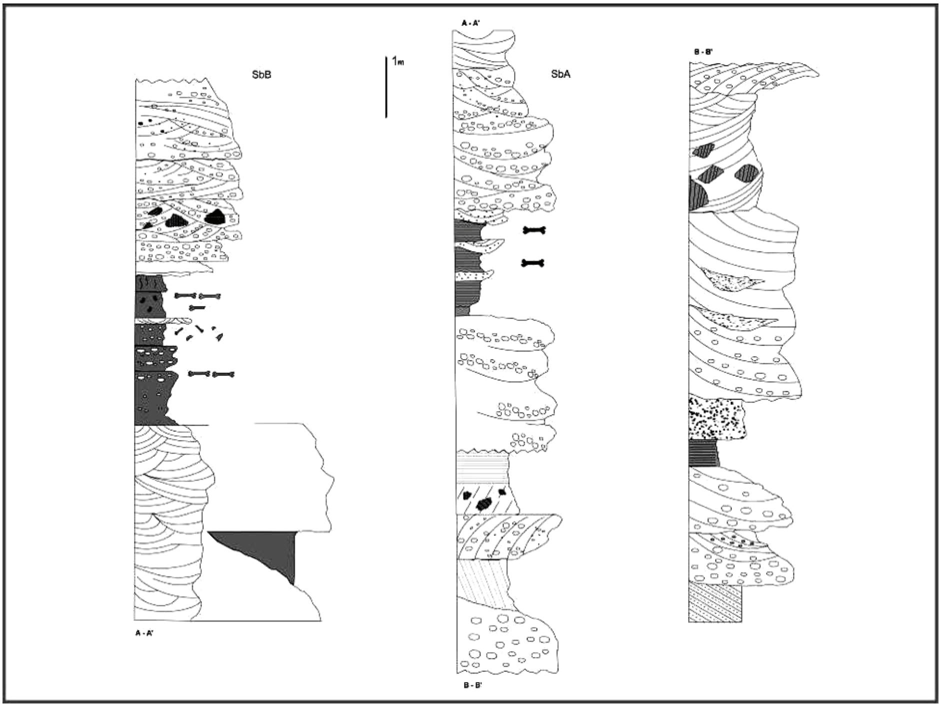

Fig. 3. Stratigraphic log at Sebeş-Glod (SbG/A, B) locality

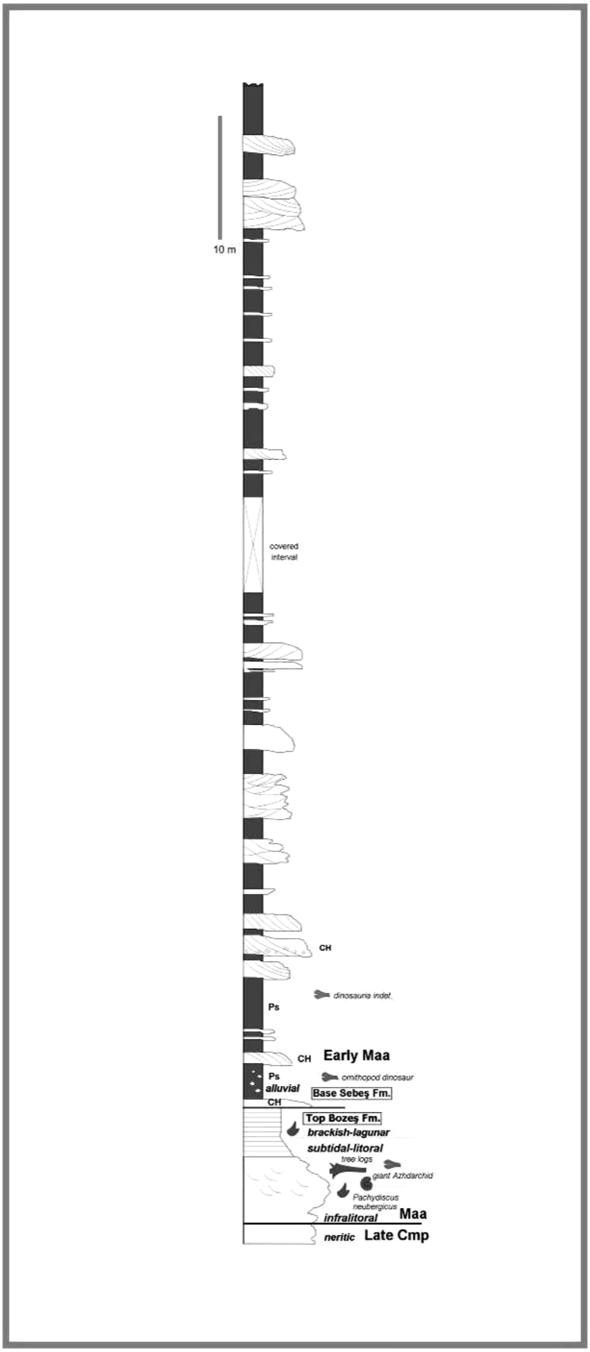

Fig. 4. Stratigraphic log at Petreşti (PT) locality

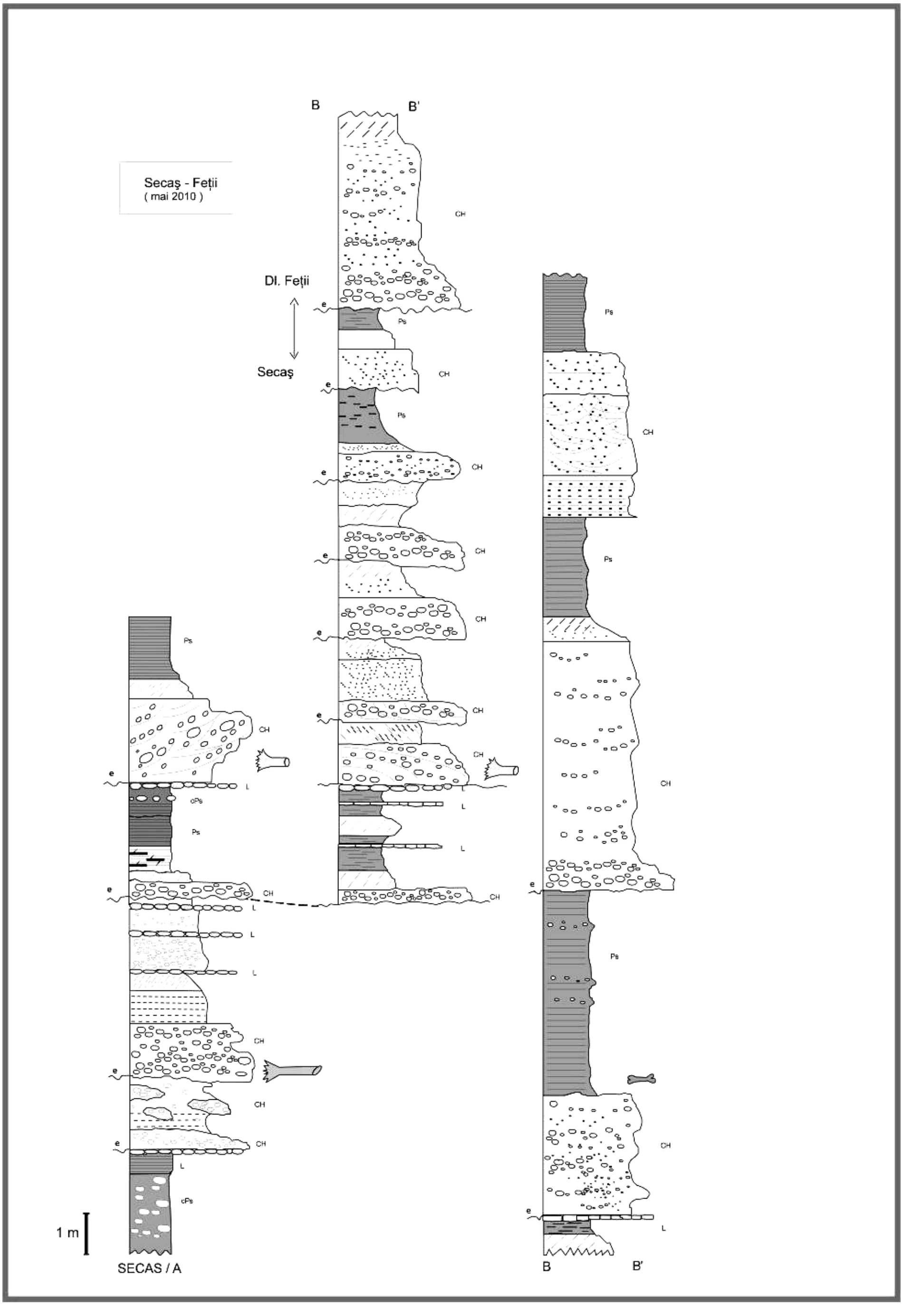

Fig. 5. Stratigraphic log at Secaş-Feţii Hill (SFH/A, B) locality

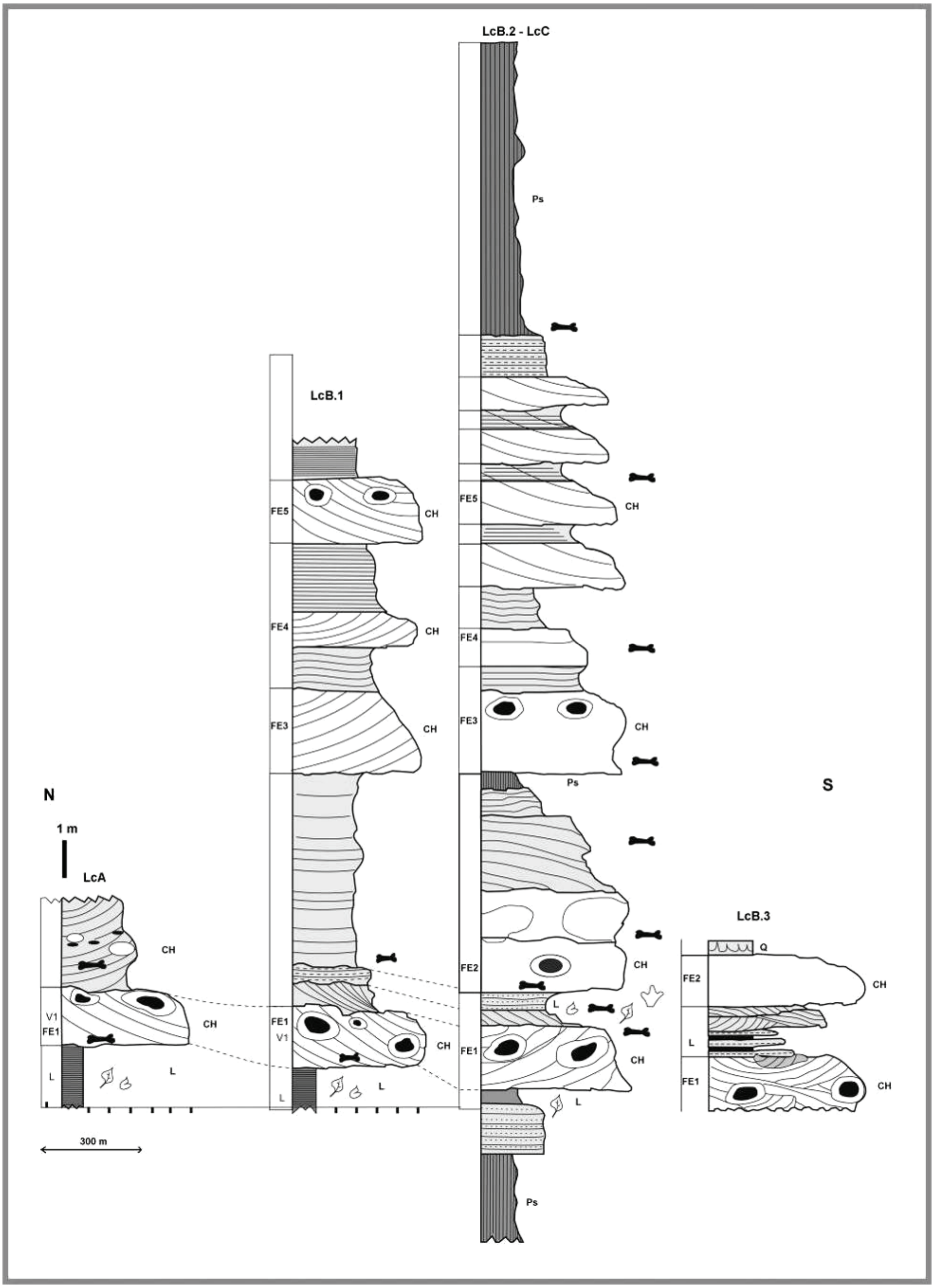

Fig. 6. Stratigraphic logs at Lancrăm (Lc/A, B) locality

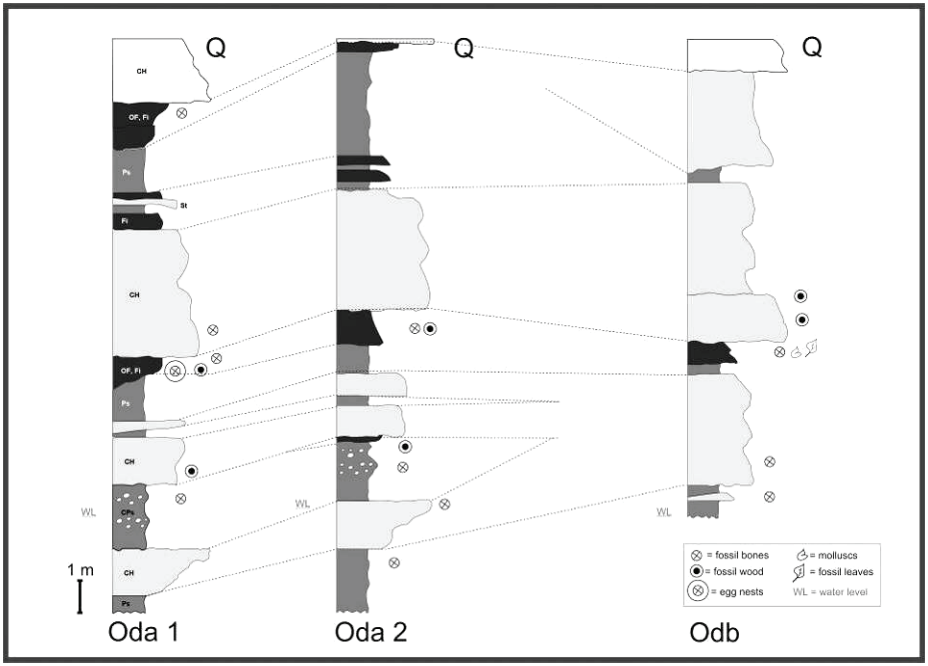

Fig. 7. Stratigraphic logs at Oarda de Jos (Od/A, B) locality

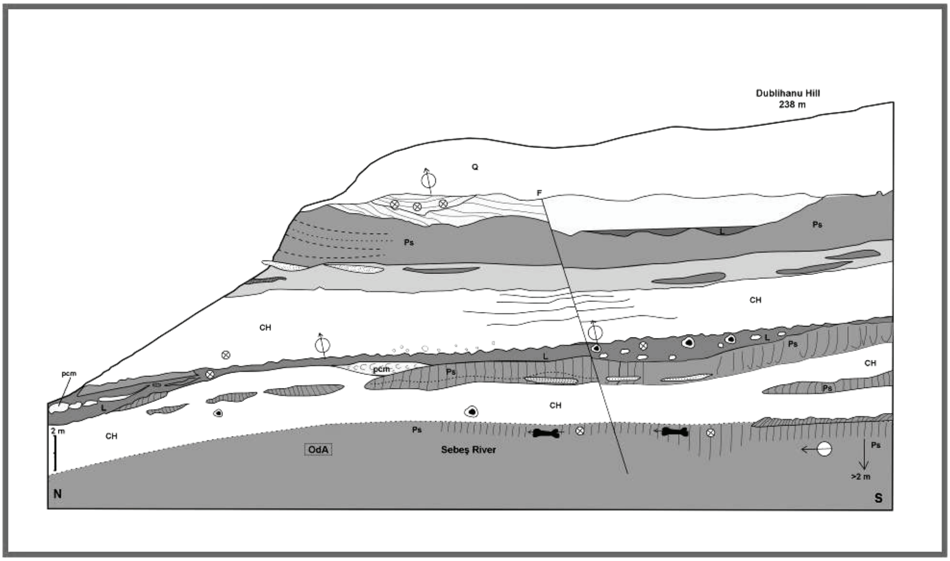

Fig. 8. Detailed stratigraphic profile of Oarda de Jos (Od/A) outcrop

Fig. 9. Cervical osteodermal scute of cf. *Allodaposuchus* from Râpa Roşie

Fig. 10. Left mandibular dentary fragment of cf. *Doratodon* from Râpa Roşie-lateral view

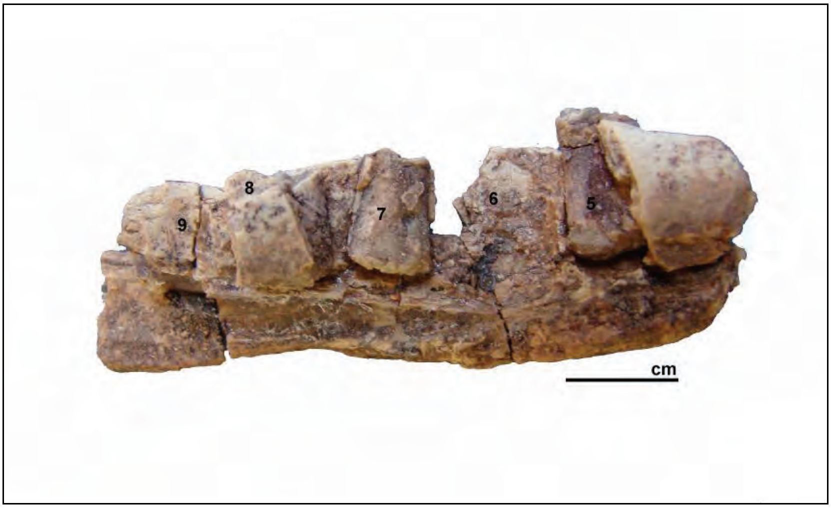

Fig. 11. Left mandibular dentary fragment of cf. *Doratodon* from Râpa Roşie-medial view

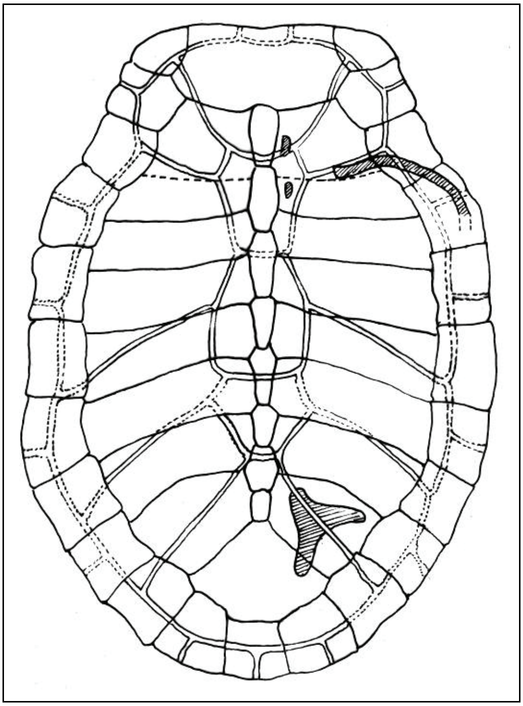

Fig. 12. Composite carapacial reconstruction of the pleurodiran *Muehlbachia nopcsai*

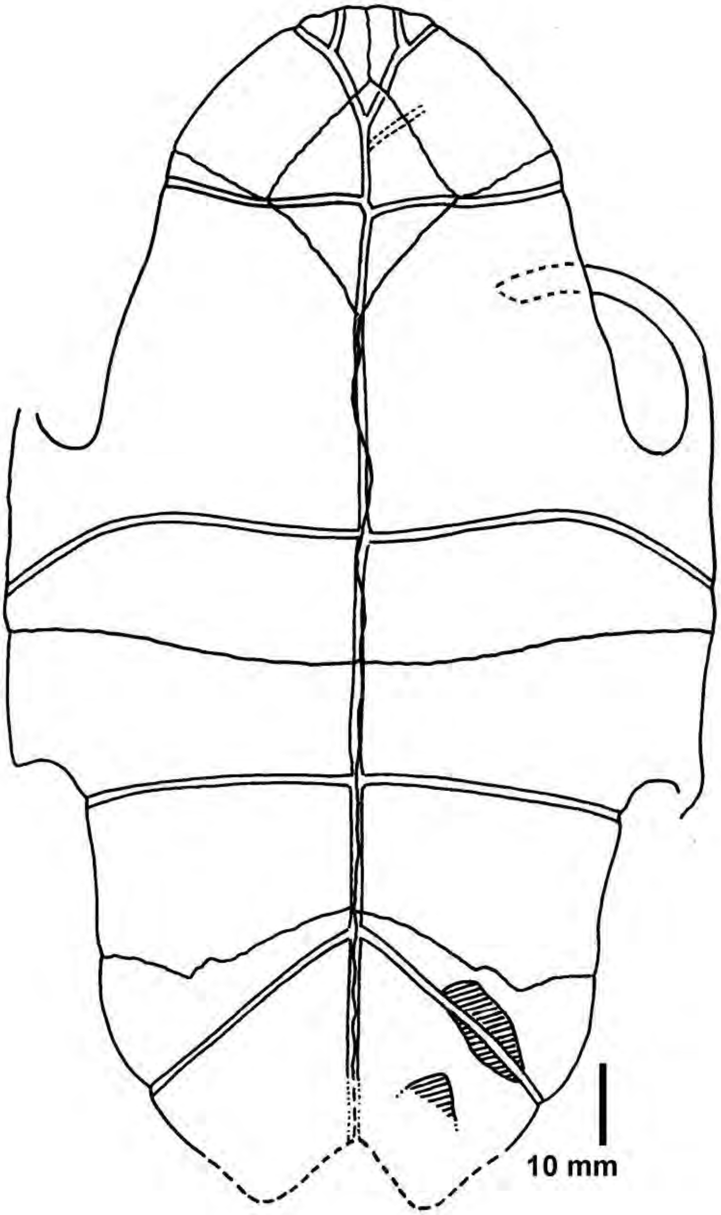

Fig. 13. Composite plastral reconstruction of the pleurodiran *Muehlbachia nopcsai*

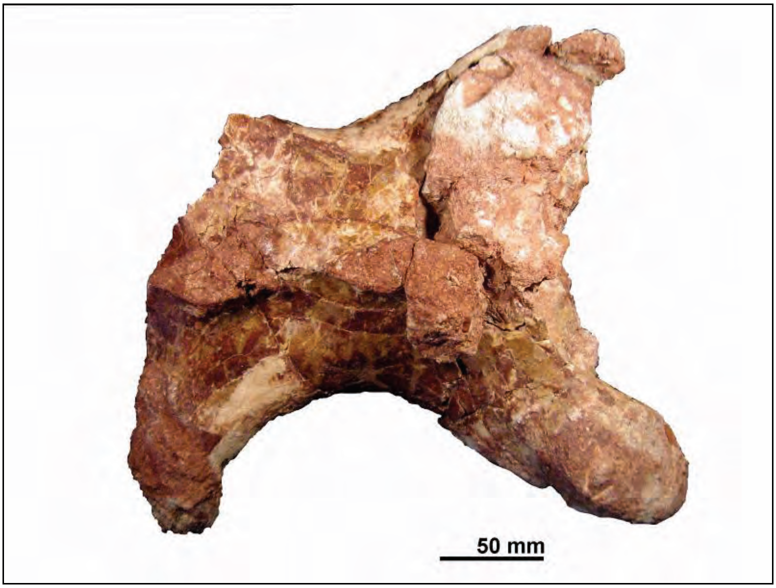

Fig. 14. 3rd cervical vertebra of a giant azhdarchid pterosaur from Râpa Roşie – dorsal view

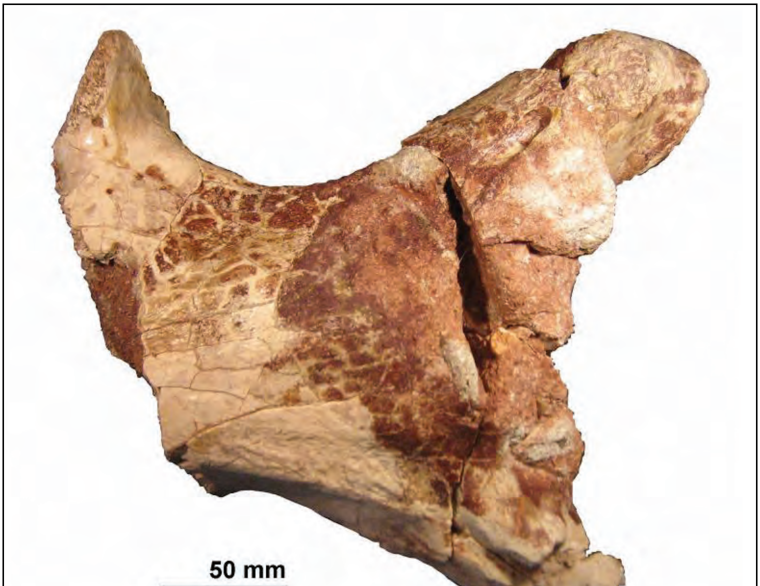

Fig. 15. 3rd cervical vertebra of a giant azhdarchid pterosaur from Râpa Roşie – ventral view

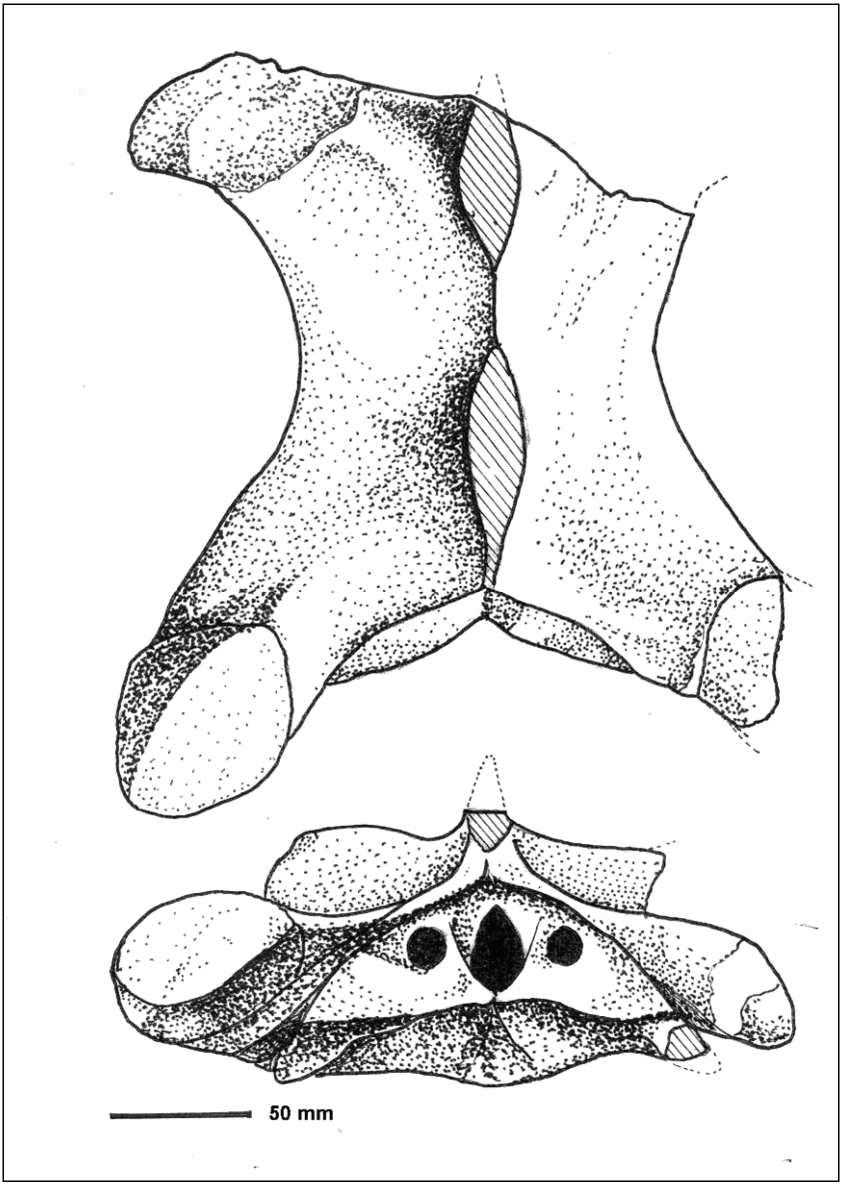

Fig. 16. 3rd cervical vertebra of a giant azhdarchid pterosaur from Râpa Roşie – dorsal and cranial views

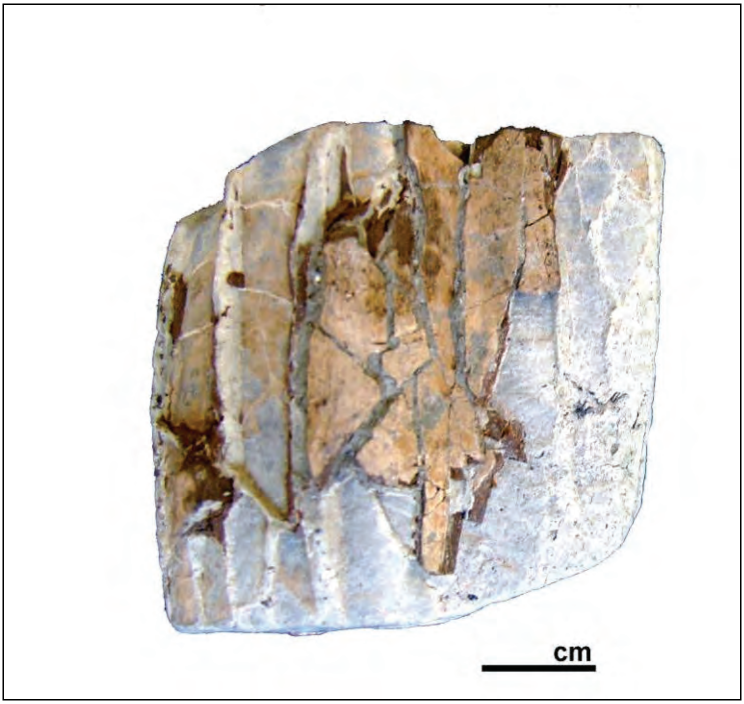

Fig. 17. 2nd wing phalange? shaft fragment of a giant azhdarchid pterosaur from Petreşti – lateral view

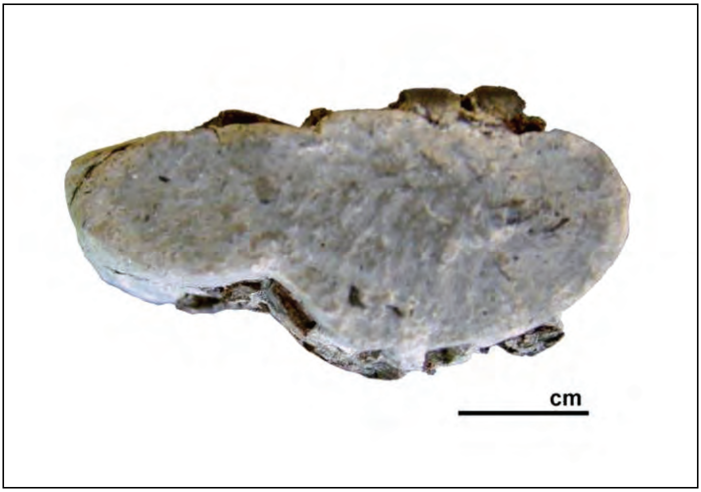

Fig. 18. 2nd wing phalange? shaft fragment of a giant azhdarchid pterosaur from Petreşti – cross section

Fig. 19. 5th cervical vertebra of a medium-large sized azhdarchid pterosaur from Sebeş-Glod – ventral view

Fig. 20. Right proximal femora of *Telmatosaurus* from Râpa Roşie - anterior view

Fig. 21. Posterior dorsal vertebra of a large-size titanosauridfrom Râpa Roşie – lateral view

Fig. 22. Posterior dorsal vertebra of a large titanosaurid from Râpa Roşie – caudal view

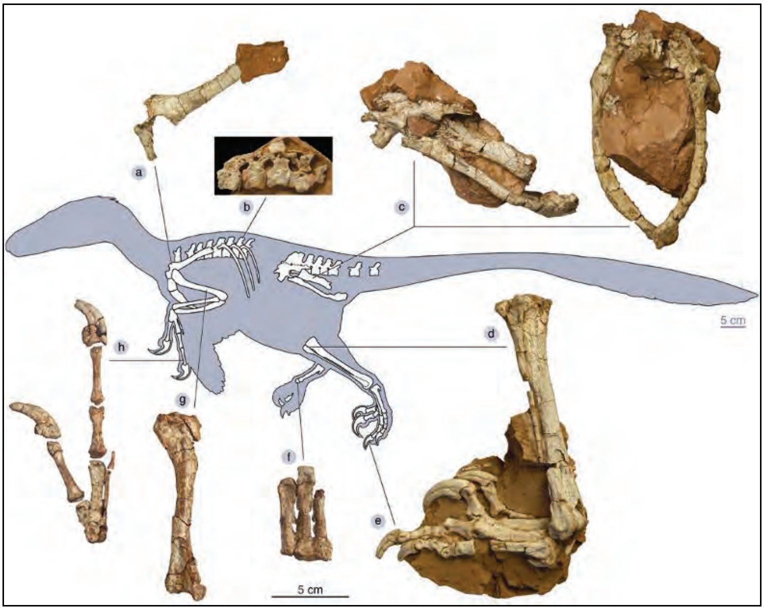

Fig. 23. The holotype of the velociraptorine theropod *Balaur bondoc* from Sebeş-Glod – the distribution of skeletal elements

Fig. 24. The forelimbs of *Balaur bondoc* in life positions

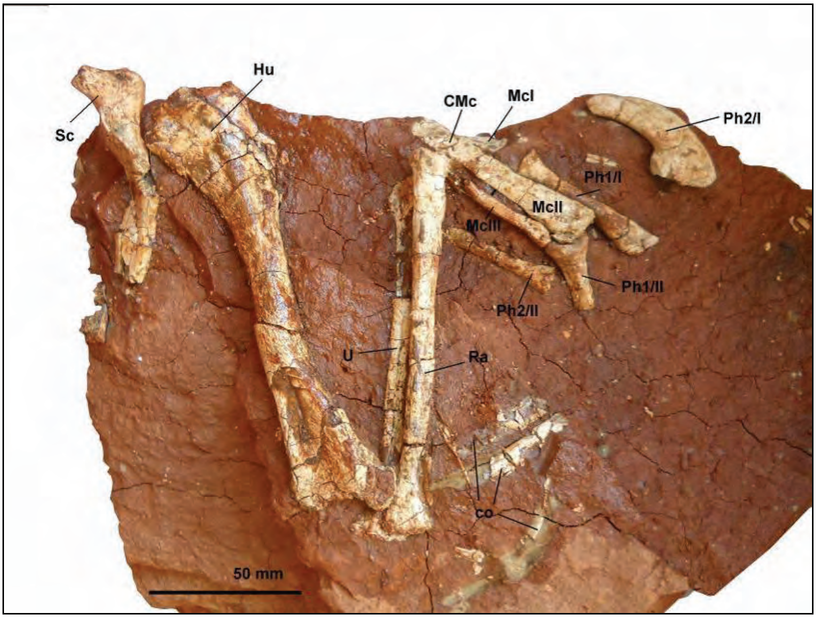

Fig. 25. The right forelimb of *Balaur bondoc* in its natural posture

Fig. 26. Avian eggs in ponded coquina limestone from Oarda de Jos

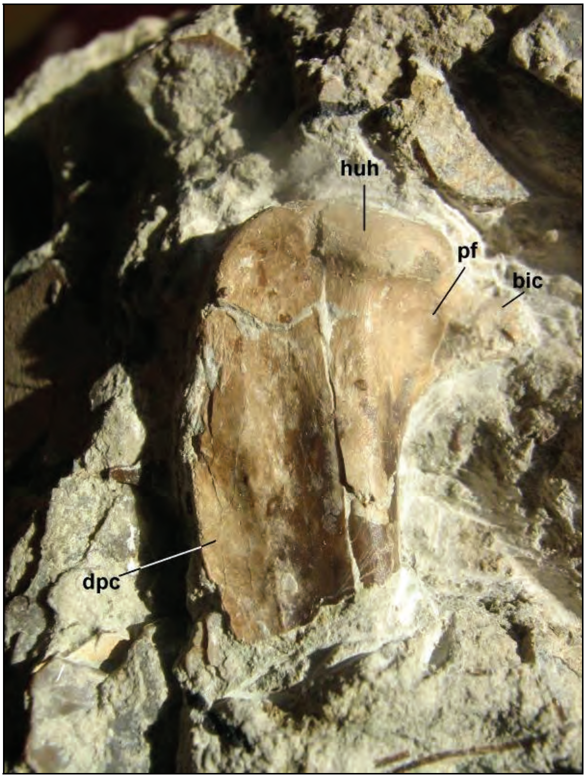

Fig. 27. Proximal humerus of an enantiornithin bird from Oarda de Jos

Fig. 28. Scapula of an enantiorithin bird from Oarda de Jos