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MAASTRICHTIAN DINOSAURS IN SW TRANSYLVANIA (ROMANIA)

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Abstract: Although the first dinosaur discoveries from the Transylvanian Basin were made at Bărăbanț near Alba-Iulia as early as the end of the 19th century, the Latest Cretaceous Transylvanian dwarf dinosaurs gained their worldwide notoriety only after Baron F. Nopcsa reported his first discoveries in the Hațeg Basin. Nopcsa realized the dwarfing tendencies of these dinosaurs and related this tendency to their limited environment, which he called "the Hațeg Island". In order to defend the pattern he identified, he attempted to outline the spatial extension of this island, as supported by the distribution of illustrative non-marine sedimentary deposits. In this context, he discovered several new localities with dinosaur-bearing rocks. Among these, the most important ones are located in the Alba-Iulia area. These faunal assemblages seem to be coeval with those from the Hațeg Basin. The non-marine Maastrichtian deposits from Alba County accumulated after the Late Cretaceous "Laramian" tectogenesis, when a fluvial system evolved in the area of the present-day Carpathians. As a matter of fact, the sediments exposed in Alba County suggest similar environments to those from the Hațeg Basin. In the red mudstones and the channel sandstones of the Şard Formation, several vertebrate teeth and bones have been preserved. In this paleobiota, dinosaurs are well represented by the following taxa: titanosaurian sauropods, the basal hadrosaurid *Telmatosaurus transsylvanicus*, the euornithopod taxa *Zalmoxes shqiperorum* and *Z. robustus*, the nodosaurid ankylosaur *Struthiosaurus transylvanicus*, as well as various small theropods. Besides dinosaurs, there are crocodilians (*Allodaposuchus* and *Doratodon*), turtles, and lizards. Fishes, amphibians, birds, and multituberculate mammals are other vertebrates making up this assemblage. More often than not, the remains are fragmentary, scattered and weathered, except for those preserved within sediments of lacustrine origin.

Keywords: Romania, Alba County, Maastrichtian, dinosaurs.

1. Introduction

Maastrichtian dinosaur remains in Romania were first reported in detail from Sânpetru, in the Hațeg Basin by Baron F. Nopcsa. He studied these fossils and later, he expanded his research into others areas of Transylvania (Nopcsa, 1905). Subsequently, he found new dinosaur localities with similar Late Cretaceous vertebrate assemblages as those from the Hațeg Basin. As a matter of fact, he outlined two regions of interest for such vertebrates, both located in the Transylvanian Basin: a first one in Vurpăr and Sebeş (both located in Alba County, southwestern Transylvania) and a second at Someş Odorhei, near the town of Jibou (Sălaj County, in northwestern Transylvania).

Although Nopcsa is considered as the geologist who found the first dinosaur remains in Transylvania, the oldest discovery of a dinosaur bone did not happen in the Hațeg Basin, but instead in Alba County, near Alba Iulia at Bărăbanț (Codrea and Mărginean, 2007; Codrea et al., 2009). His forerunner was probably Károly Herepei, museum curator at that time in Aiud (Téglás, 1886), who considered that the fossil originated from a large-sized Paleogene herbivorous mammal, referred to as "*Anoplotherium*".

2. Geological setting

Located on the southwestern margin of the Transylvanian Basin (Fig. 1), the oldest post-"Laramic" non-marine formations are Late Cretaceous continental deposits, mainly red beds. Following a history of marine sedimentation, which ended with the flysch deposits of the Bozeş Formation (Santonian-Campanian), a comprehensive sequence of alternating continental and shallow-marine deposits

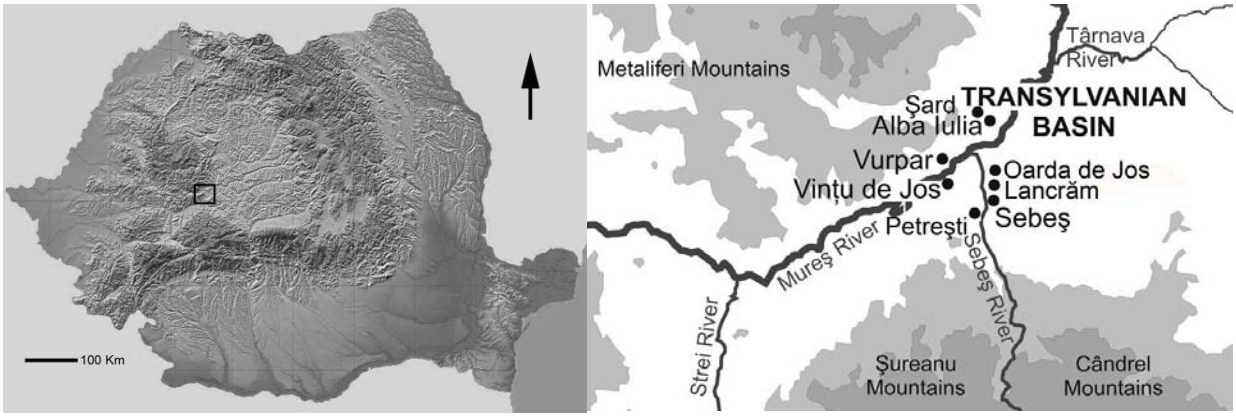

Fig. 1. Location of the Metaliferi sedimentary area in Romania.

accumulated between the Campanian and the Aquitanian (Egerian) within a distinct sedimentary area called the Metaliferi Area (Codrea & Dica, 2005; Fig. 2). The Vurpăr and Şard formations represented the earliest continental sequences, both deposited during the Maastrichtian. Antonescu (1973) and Antonescu et al. (1983) carried out palynological studies and documented a Maastrichtian age for the Şard Formation.

The Vurpăr Formation is a deltaic sequence with several short marine transgressions, dominated by yellow silty sandstones, conglomerates and silty sands (Dimian and Dimian, 1963; Tomescu et al., 1969).

The Şard Formation accumulated in fluvial environments, documented by floodplain overbank red silty mudstones and conglomeratic and sandy channel fills (Codrea et al., 2001, 2009; Therrien et al., 2002; Therrien, 2005). The sediments are indicative of a meandering fluvial system, with numerous inner bars and channel lags (sandstones and coarse conglomerates). The red silty mudstones show pedogenic levels with root traces and caliche. In several localities, such as at Oarda de Jos and Lancrăm, pond and lacustrine tendencies developed within the fluvial system, as documented by green-grey silty clays and limestone bed (Codrea et al., 2001, 2009). It is somewhat unclear whether the sedimentation continued into the Paleogene. The top of the Şard Formation is overlaid by the Priabonian marine deposits of the Ighiu Formation.

3. Dinosaurs from the Alba area

The local dinosaur assemblage includes: a single species of ankylosaur (*Struthiosaurus transylvanicus* NOPCSA, 1915), three ornithopod taxa (the euornithopods *Zalmoxes robustus* WEISHAMPEL, JIANU, CSIKI, NORMAN, 2003*, Z. shquiperorum* WEISHAMPEL, JIANU, CSIKI, NORMAN, 2003, and the basal hadrosaurid *Telmatosaurus transsylvanicus* NOPCSA, 1900), titanosaurian sauropods, and diverse small theropods. The bones are uncommon in the Maastrichtian continental deposits of the Transylvanian Basin, and occur most frequently as disarticulated, scattered, and broken remains (Grigorescu, 1987; Codrea et al., 2009); however, sometimes the fossils are well preserved, usually when found in deposits that accumulated within pond and lacustrine environments (e.g., Oarda, Lancrăm). There are several similarities between these preservational patterns and the taphonomic features reported from the Haţeg Basin (Csiki et al., 2009). Nevertheless, partial skeletons occasionally occur, even in the red mudstones, preserving the bones in anatomical connection (e.g., Vurpăr, Sebeş Glod). The faunal assemblage of the Transylvanian Basin is reminiscent of that described from the Haţeg Basin by Nopcsa at the beginning of the 20th century.

Ornithopods

Telmatosaurus transsylvanicus (NOPCSA, 1900)

First described as *Limnosaurus transsylvanicus* Nopcsa, 1900 from the Haţeg Basin, the taxon was renamed a few years later as *Telmatosaurus transsylvanicus* (Nopcsa, 1903), as the first name claimed was already preoccupied by a crocodyliform described by O. Marsh, in 1872. Today, it is one of the best known Maastrichtian dinosaurs from Romania (Weishampel et al., 1993; Dalla Vecchia, 2006), based on a large sample including a fragmentary skull and various postcranial bones. Among the latter, the vertebrae are by far the most poorly known.

In the Alba area, this basal hadrosaurid (Weishampel et al., 1993) is documented by a scapula, tibiae,

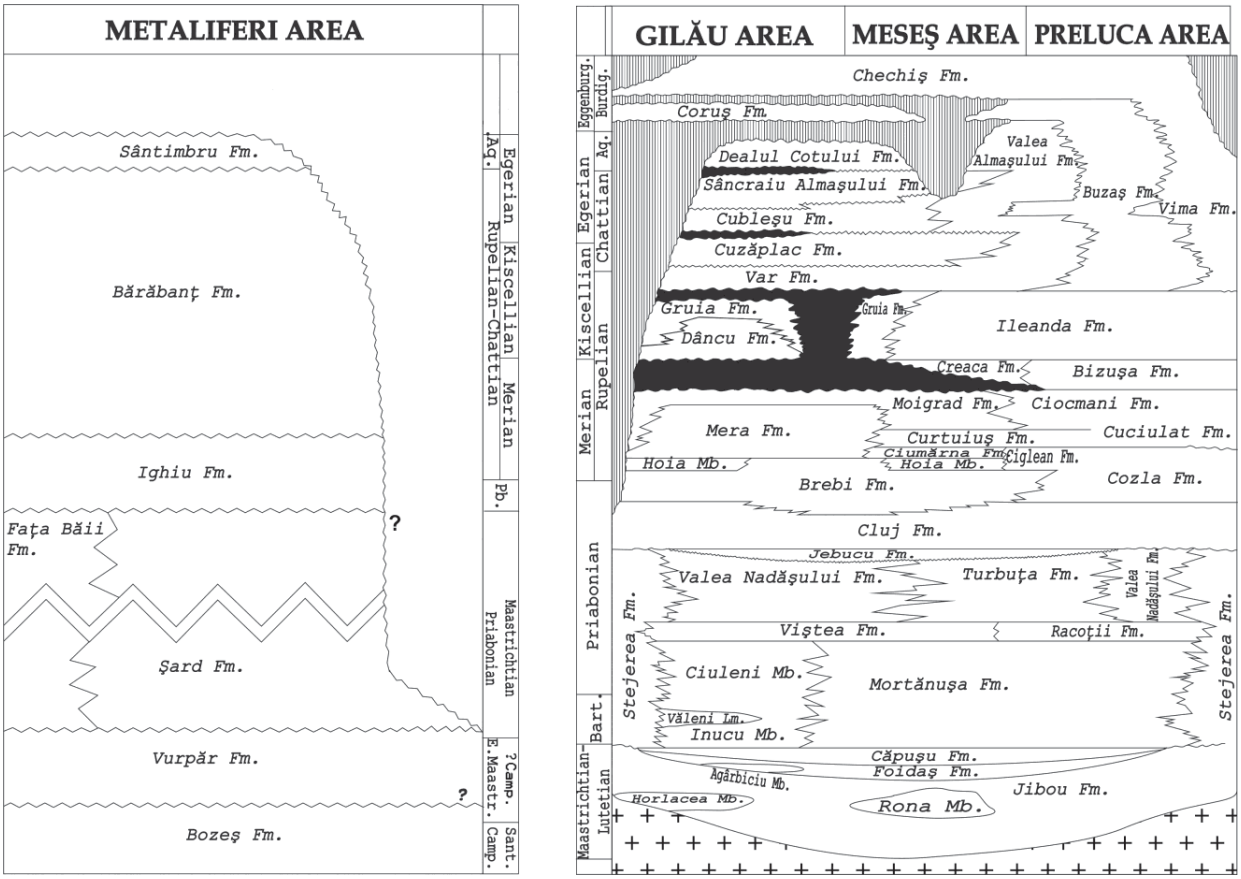

Fig. 2. Lithostratigraphic units in the Metaliferi area, compared with NW Transylvania (after Codrea & Dica, 2005 and Codrea et al., 2009, modified)

a radius, and femora. The scapula is well preserved. It is relatively long and narrow, with the blade slightly expanded on its distal part. Both tibiae are incomplete, preserving only the diaphyses devoid of articular surfaces. The medial face, observable in one of them, is relatively straight. The radius, quite well preserved, is long, thin, and relatively straight in cranial view. The femora have large articular condyles and a well-developed fourth trochanter on the medial face of the diaphysis.

Zalmoxes WEISHAMPEL, JIANU, CSIKI, NORMAN, 2003

The genus *Zalmoxes* (Weishampel et al., 2003) was historically referred to as "*Mochlodon*", then as "*Rhabdodon*" (Nopcsa, 1902a, b). Two species of *Zalmoxes*, Z. *robustus* and *Z. shqiperorum*, are reported from Romania according to Weishampel et al. (2003).

In Alba, a large sample of specimens referable to *Zalmoxes* is known from Vurpăr. Remains of these dinosaurs are less common in the other localities, limited to a few isolated teeth or broken bones: fibulae, humerus, tibiae, and dorsal and caudal vertebrae. The teeth are very characteristic, with their labial surfaces ornamented by numerous, vertically-oriented ridges (Fig. 3: j, k). The fibula is very gracile. The dorsal and caudal vertebrae are preserve mostly their centra; some of the dorsal vertebrae also preserve the diapophyses (Fig. 3: i).

Sauropods

Representative outcrops yielding remains of titanosaur sauropods are Sebeş, Oarda de Jos, and Lancrăm. The specimens include isolated bones, such as femora, humeri, tibiae, fibulae, a single metapodial, and caudal vertebrae. The by far best preserved bone is a tibia that displays a straight shaft with a well developed cnemial crest in its proximal part.

The femur is straight in cranial view and displays a slightly sigmoidal curvature of its posterior part when seen in lateral view. The femoral head is prominent and rounded. The fourth trochanter is reduced to a slight rounded prominence on the posterior edge of the femoral shaft and is located in the medial-proximal part of the bone.

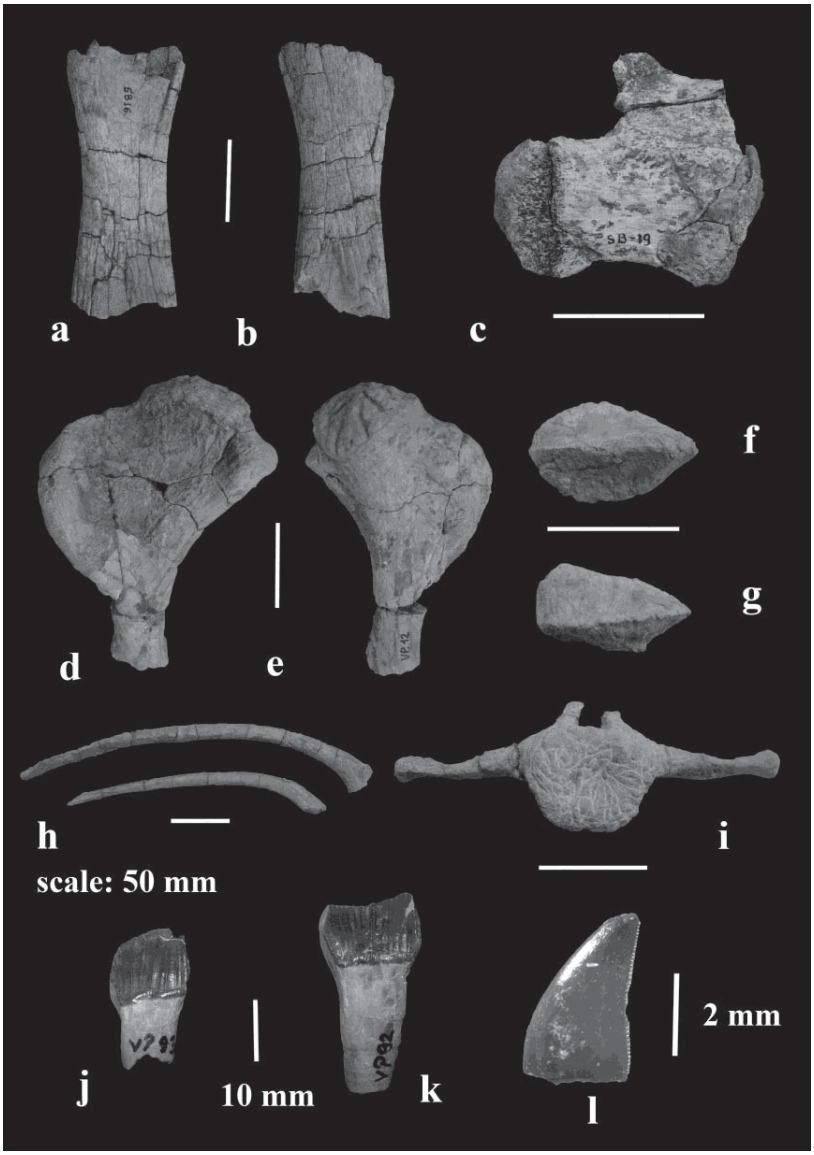

Fig. 3. Dinosaurs from the Metaliferi area: Titanosauria: (a, b) humerus (Sebeş), (c) caudal vertebra (Sebeş); *Struthiosaurus transylvanicus*: (d, e) left humerus (Vurpăr), (f, g) osteoderms; *Zalmoxes*: (h) ribs (Vurpăr), (i) dorsal vertebra (Vurpăr), (j, k) isolated teeth (Vurpăr), lingual views; Theropoda *incertae sedis*: (l) teeth (Oarda de Jos), lateral view.

The humerus (Fig. 3: a, b) and fibulae are damaged and belong to different juvenile individuals. Only the shaft is preserved for both elements. The single complete metapodial was found in a lens-shaped mudstone, accumulated together with other sauropod bones.

The caudal vertebrae are all from the distal tail section. They show elongate centra, with broken neural arches; in some cases, the pedicels of neural arch bordering the neural canal are also preserved (Fig. 3: c). In ventral view, the articulation facets for the hemapophyses are missing. The vertebral articulations are of the "ball and socket" type, typical for derived titanosaurs. Such a caudal vertebra was reported recently from Râpa Roşie, near Sebeş (Codrea et al., 2008).

Ankylosaurs

Struthiosaurus transylvanicus NOPCSA, 1915

S. transylvanicus is among the most poorly known dinosaurs from Romania, due to the scarcity of its fossils, a fact already observed by Nopcsa. The fossils from the Haţeg Basin belong to an adult individuals and include a few skull bones, vertebrae, a scapulo-coracoid, and elements of the dermal armor (Weishampel et al., 1991).

The Metaliferi area yielded a rich sample of fossils originating from this basal nodosaurid. The richest fossiliferous locality is Vurpăr, where *Struthiosaurus* remains are common. The nodosaurid ankylosaur sample from this locality includes dorsal vertebrae, distal femoral extremities, fragmentary ribs, a left humerus (Fig. 3: d, e), and numerous osteoderms. The dorsal vertebrae consist of a short centrum and a very tall neural arch. One of these preserves both prezygapophyses and the diapophyses form an angle greater than 75º with the horizontal axis of the centrum. Various rib fragments of different sizes were collected, most of them scattered or broken. The osteoderms occurred as isolated bones showing various morphologies and sizes (Fig. 3: f, g).

Theropoda indet.
The presence of theropods are documented by isolated teeth, assigned to the dromaeosaurid subfamily Velociraptorinae (Fig. 3: l) or to Theropoda *incertae sedis*.

Eggshells
Eggshell fragments are common at Oarda de Jos, but their maximum size does not exceed 1 cm². The fragments are referable to four different morphotypes (Monique Vianey-Liaud, Montpellier, *written communication* 2008), including ?*Pseudogeckoolithus* and Megaloolithidae, pointing to similarities with the eggshells discovered in the Haţeg Basin (Grigorescu et al., 1990, 1994; Codrea et al., 2002, 2009; Smith et al., 2002; Csiki et al., 2008).

4. Conclusions

The Late Cretaceous vertebrate assemblage from the Metaliferi area includes various dinosaurs, reminiscent of the ones from the Haţeg Basin. The dinosaurs lived alongside other reptiles such as lizards, turtles (the cryptodire *Kallokibotion* and a dortokid pleurodire; Codrea and Vremir, 1997; Vremir and Codrea, 2009; de Lapparent et al., 2009), crocodiles (*Allodaposuchus precedens* and *Doratodon*; Delfino et al., 2008) and azhdarchid pterosaurs (Vremir et al., 2009). Birds and mammals (kogaionid multituberculates) also lived in the same biota. Also, from Alba area was reported the first dinosaur footprint (Vremir and Codrea, 2002).

This repertory of fossil vertebrates emphasizes the potential of the Alba area for enhancing our knowledge of the Maastrichtian biota in Romania, as well as for the development of a refined stratigraphy of this region. Besides the Haţeg Basin, the Metaliferi area currently represents the second important region which documents the composition of the Maastrichtian terrestrial assemblages in Romania.

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