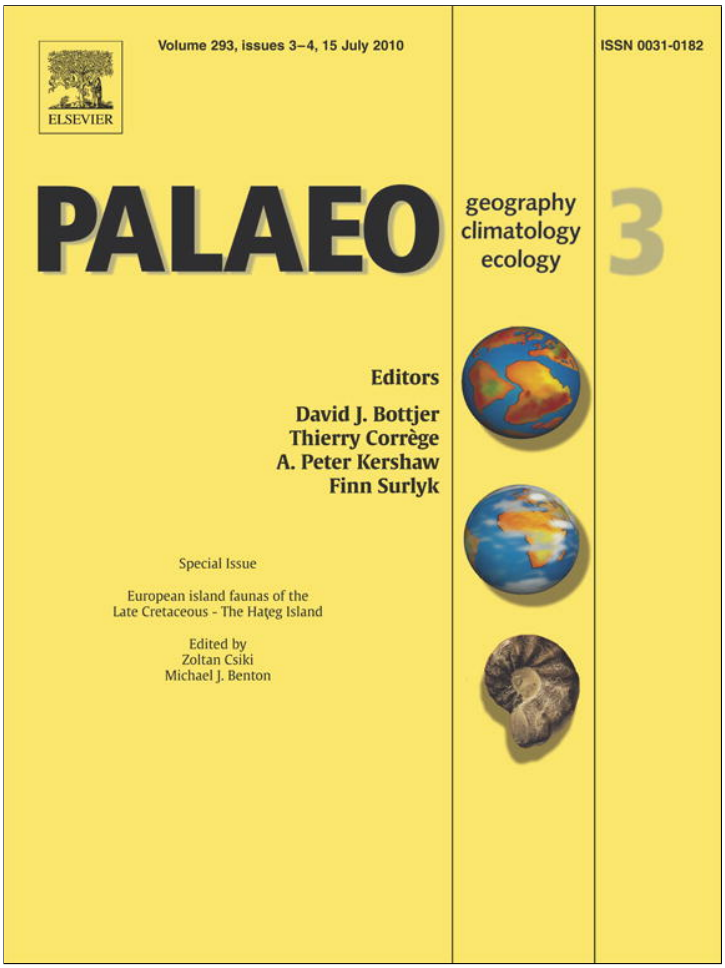

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More than just Nopcsa's Transylvanian dinosaurs: A look outside the Haţeg Basin

Vlad Codrea [a,*], Matei Vremir [b], Cătălin Jipa [b], Pascal Godefroit [c], Zoltán Csiki [d], Thierry Smith [c], Cristina Fărcaş [b]

[a] University Babeş-Bolyai Cluj-Napoca, Faculty of Biology and Geology, 1 Kogălniceanu Str., 400084, Cluj-Napoca, Romania
[b] University Babeş-Bolyai Cluj-Napoca, Faculty of Environment Science, Romania
[c] Institut Royal des Sciences Naturelles, Bruxelles, Belgium
[d] University of Bucharest, Faculty of Geology and Geophysics, Laboratory of Paleontology, Romania

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ABSTRACT

Since the end of the 19th century the notorious palaeontologist Baron Nopcsa reported several Late Cretaceous small-sized dinosaurs in the Haţeg Basin. He explained their sizes as the consequence of unusual evolution on an island he named the "Haţeg Island". He found similar dinosaurs outside Haţeg in other regions of Transylvania, near Alba Iulia, or nearby Jibou. Recent surveys carried out in these areas support Nopcsa's presumptions, even adding several new outcrops with dinosaur remains. In Sălaj and Cluj Counties, the dinosaur fossils are rather scarce, but still obvious in the Jibou Formation. In Alba County, the main outcrops are located between Vurpăr and Şard on the right bank of the Mureş River, but also between Petreşti and Oarda de Jos along the Sebeş Valley. The majority of the taxa from Haţeg are also documented in these areas. During the Palaeogene and early Miocene, several of these Mesozoic reptile bones were reworked to younger deposits. Another area with high potential for finding Maastrichtian vertebrates is the Rusca Montană Basin.

1. Introduction

In the last decade of the 19th century, the notorious palaeontologist Baron Nopcsa reported a peculiar assemblage of small-sized dinosaurs in the Late Cretaceous (Maastrichtian) of the Haţeg Basin (Pereda Suberbiola and Bardet, 1996), a sedimentary basin developed during the Late Cretaceous phase of deformation in the Southern Carpathians (Săndulescu, 1984; Willingshofer et al., 2001). Soon after, in his Ph.D. thesis Nopcsa (1905) extended his researches to all dinosaur-yielding formations in Transylvania, tracing these deposits into Jibou borough, in Sălaj County. This led him to propose the former existence of a Maastrichtian island that he named the "Haţeg Island" (Nopcsa, 1914). This island stretched far beyond the present limits of the Haţeg Basin, with the Maastrichtian land area probably extending over the Apuseni Mountains, as well as parts of the western Transylvanian Basin, the Southern Carpathians and perhaps to areas of the present-day Pannonian Basin as well. Even after a century of research, "Haţeg Island" cannot be clearly defined: at least a part of the continental deposits documenting it were removed by erosion or else these are poorly known, concealed under extensive Cenozoic sediments. Later, Nopcsa's island pattern was a subject of controversy, with some authors supporting it (Weishampel et al., 1991, 1993, 2003; Jianu and Weishampel, 1999; Benton et al., 2010-this issue), while others have challenged it (Jianu and Boekschoten, 1999; Le Loeuff, 2005; Pereda Suberbiola and Galton, 2009).

Although Nopcsa was the first to report Maastrichtian dinosaurs in Transylvania, he was not the first to find such fossils there. Before Nopcsa, other Transylvanian geologists or just amateur fossil hunters found dinosaur bones, but without realizing their true origin. The oldest find was in Bărăbanţ (former village, now a suburb of Alba Iulia), where a fragmentary tibia of a sauropod was found in the red beds once exposed "between the village and the flourmill" (Téglás, 1886); Téglás mistakenly reported this fossil as *Anoplotherium*. The discoverer's name, as well as the year of discovery, was unrecorded in the Aiud Natural Sciences catalogue, but Téglás' note proves that he made the find earlier than Nopcsa's first discoveries. Probably the discoverer was Károly Herepei, museum curator at that time in Aiud. However, Herepei makes no mention of this bone in the geological monograph he subsequently wrote on Alba County (Herepei and Gáspár, 1896). Later, Koch (1894, 1900) referred the same bone to *Anthracotherium*—this name is still on the specimen label at the Aiud Museum (Codrea and Mărginean, 2007). Nopcsa (1909) knew about this discovery and correctly referred the Bărăbanţ bone to dinosaurs, but his opinion was ignored by other Austro-Hungarian scientists.

Another early dinosaur find in the same region is one in the Râpa Roşie, near Sebeş borough, also discovered in the 19th century. The

* Corresponding author. Tel.: +40 744 700 438.
E-mail addresses: vcodrea@bioge.ubbcluj.ro, codrea_vlad@yahoo.fr (V. Codrea).

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bones, once curated at Sebeş Gymnasium (now lost), had been the subject of endless controversy between Koch and Nopcsa, the first presuming these to belong to the rhinoceros *Aceratherium* cf. *goldfussi* (Koch, 1900), while the second referring them to dinosaurs (details in Codrea, 2000; Codrea and Mărginean, 2007). Probably Nopcsa was correct as no large mammals have been found at Râpa Roşie after more than a century of collecting.

This contribution offers an overview of the main Romanian localities outside the Haţeg Basin that expose Upper Cretaceous continental formations with dinosaurs and other vertebrates. It examines the diversity of continental vertebrates in Transylvania, and the limits of the emerged lands at the end of the Mesozoic in this part of Europe. The stratigraphic framework for the northwestern and southwestern borders of the Transylvanian Basin was developed by Codrea and Dica (2005) (Fig. 1).

2. Maastrichtian localities outside Haţeg and their vertebrate faunas

2.1. Sălaj County

2.1.1. Someş Odorhei

Someş Odorhei (Fig. 2) is the only dinosaur locality reported in this county, being located near Jibou borough. This region is among the most representative for Palaeogene exposures on the northwestern side of the Transylvanian Basin, in the so-called "Meseş sedimentary area" (Rusu, 1987). In the Bârsa Valley, Nopcsa (1905) found a rib he assigned to the ornithopod *Mochlodon suessi*, a crocodilian tooth and some turtle bones (presently, only the rib fragment—useless for systematic assignment—remains in the Hungarian Geological Institute in Budapest, labeled as MAFI Ob.1954).

The fossils originated from fluvial deposits (red silty clays, coarse to medium quartz arenites and micro-conglomerates) of the basal third of the Jibou Formation (Maastrichtian–Lutetian) (Codrea and Godefroit, 2008), which overlies the folded basement of the Inner Dacides (Săndulescu, 1984).

For over a century, nobody succeeded in finding additional fossil vertebrates there. Only recently, Codrea and Godefroit (2008) described several vertebrae and a scapula fragment assigned to the euornithopod *Zalmoxes shqiperorum* (Weishampel et al., 2003) proving that the base of the Jibou Formation is of Maastrichtian age, being coeval with the Sânpetru and Densuş-Ciula formations of the Haţeg Basin. Although the preservation of these bones is poor, their palaeogeographical significance is noteworthy, indicating the extension of the "Haţeg Island" several hundreds of kilometers from Haţeg, to the northeast.

2.2. Cluj County

2.2.1. Iara

Iara is the only locality over a wide area where a dinosaur bone was found. It is located on the southwestern border of the Iara Basin, which represents just an embayment of the Transylvanian Basin bounded by

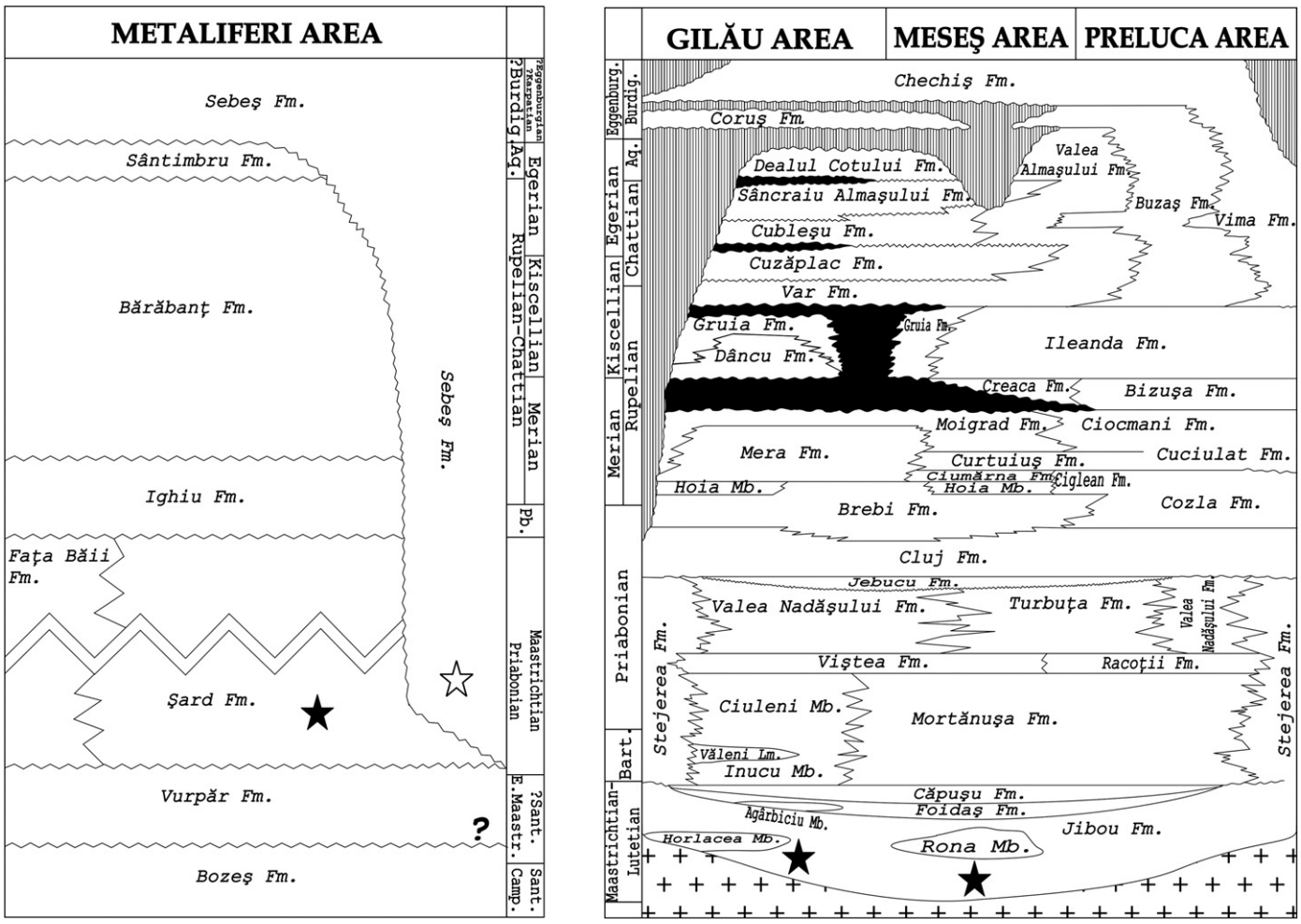

Fig. 1. Upper Cretaceous–Palaeogene lithostratigraphic units in Western Transylvania (modified after Codrea and Dica, 2005). Dark stars indicate teeth and bone occurrences in Upper Cretaceous formations; the white star indicates possibly reworked teeth and bones of the Sebeş Formation.

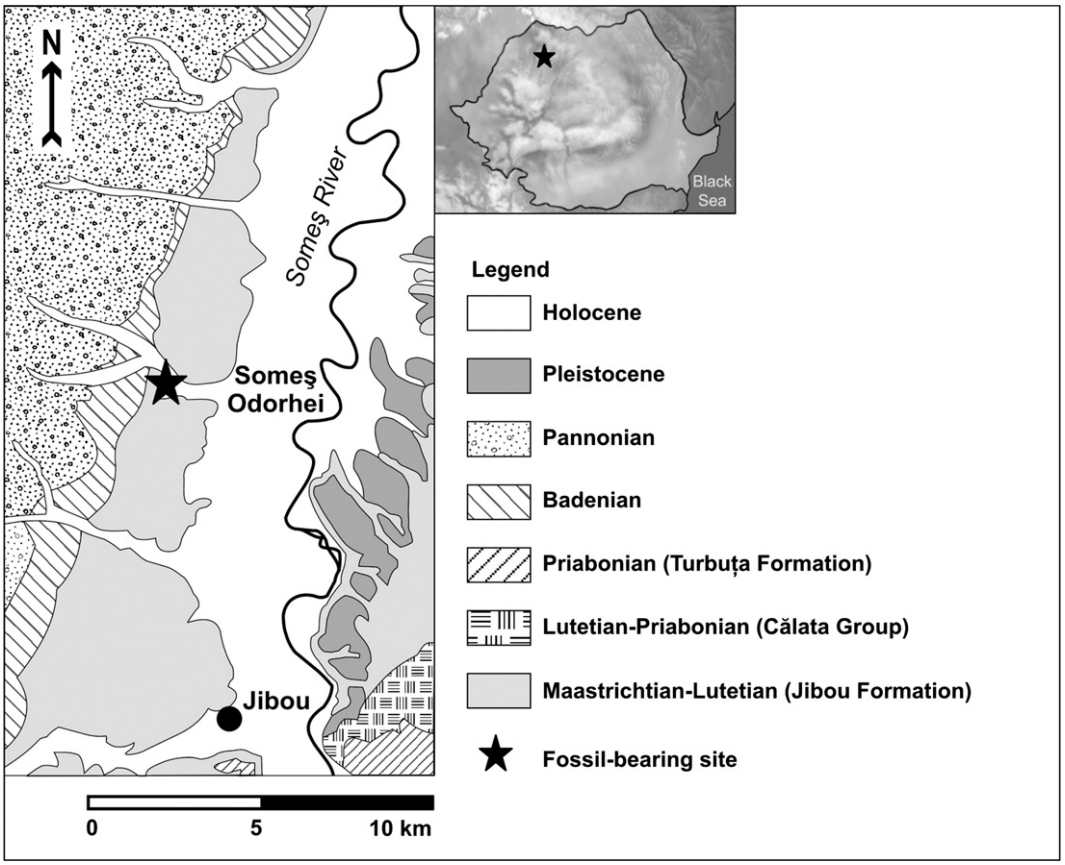

Fig. 2. Geological map and geographic location within Romania of the Someş Odorhei area (modified after Codrea and Godefroit, 2008).

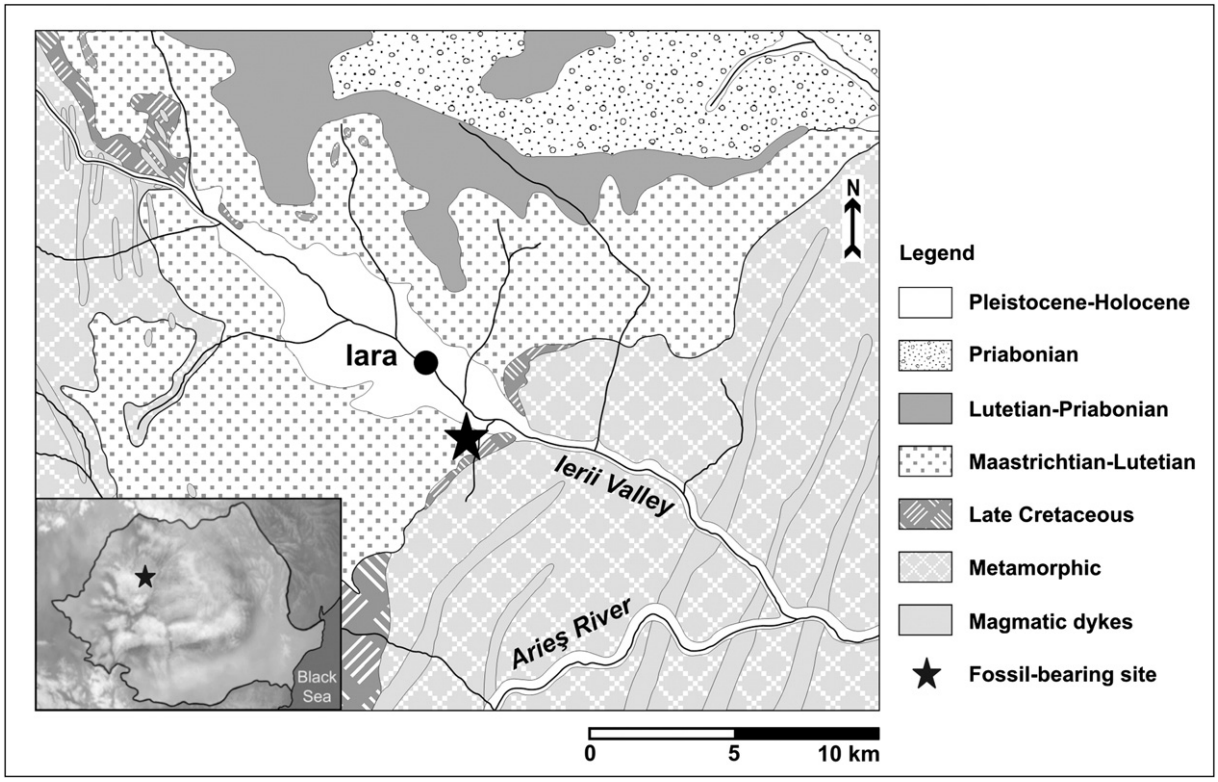

Fig. 3. Geological map and geographic location within Romania of the Iara area.

the Inner Dacidic and Transylvanide segments of the Carpathian orogenic belt (Săndulescu, 1984). According to Rusu (1987), the Palaeogene in this region belongs to the "Gilău sedimentary area".

The single dinosaur bone fragment was found in 1929 by geology student Alexandru Ferenczi, on Bicălat Creek, near Iara (Pop, 1952), where severely faulted, mainly red silty clays are exposed. These sediments belong to the base of the Jibou Formation as well (Fig. 3). The bone, which still existed in the Babeş-Bolyai University collection until the last decade of the 20th century—then, apparently, it was lost—was a mid-shaft fragment of a femur 120 mm in transverse diameter. It was greenish in colour and probably belonged to a sauropod. Its reptilian origin had been presumed by the geologist Ion Popescu-Voiteşti who examined the bone at that time (1936).

The Iara find, although meager, could document the same Upper Cretaceous stratigraphic position for the base of the Jibou Formation as in Someş Odorhei.

2.3. Alba County

Among the areas outside Haţeg, Alba County is the main region where dinosaur remains occur (Fig. 4). Codrea and Dica (2005) named it the "Metaliferi area".

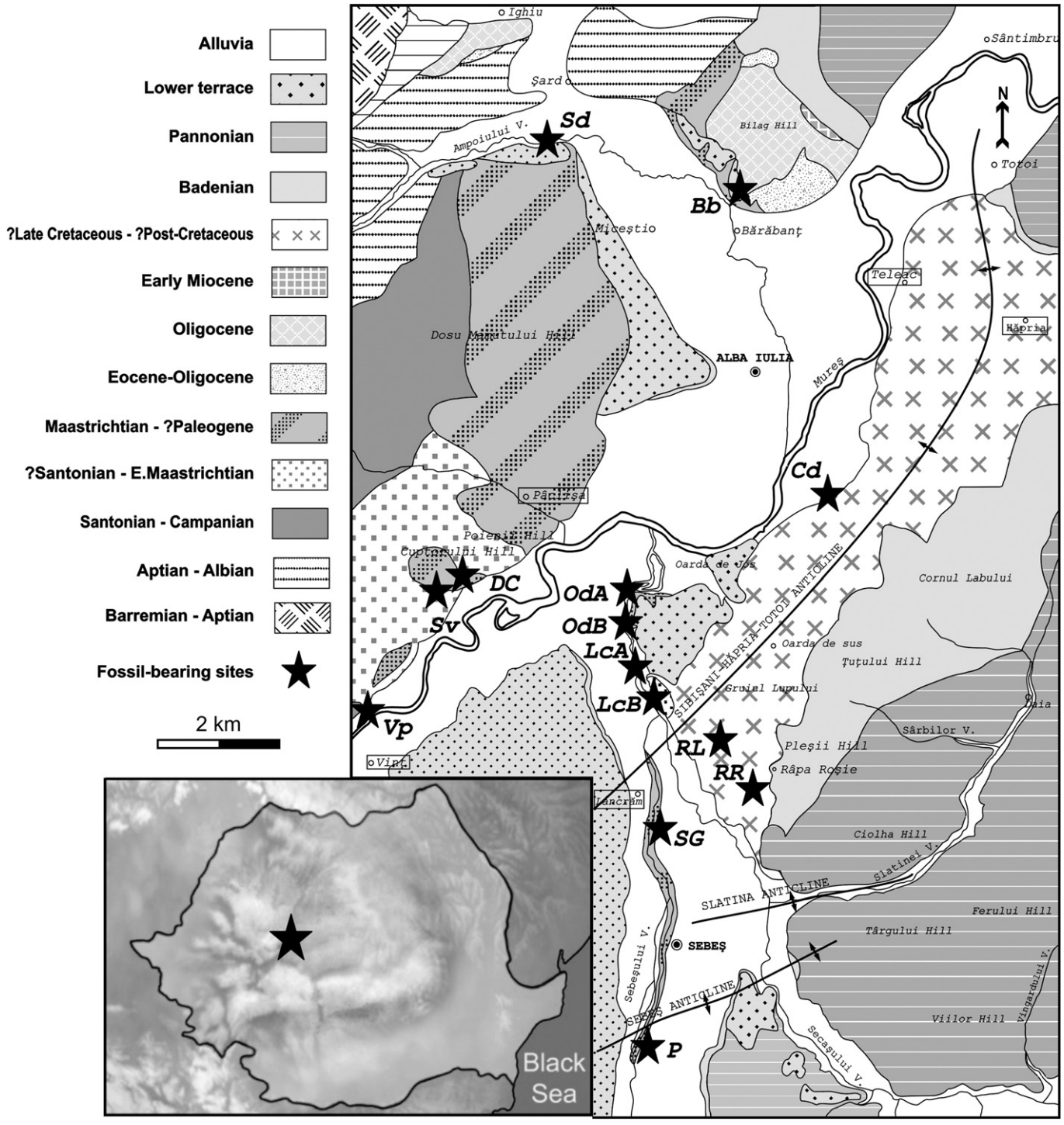

Fig. 4. Geologic map and geographic location within Romania of the Alba Iulia–Sebeş area (modified after Codrea and Dica, 2005; for abbreviations, see text).

2.3.1. Vurpăr

Vurpăr (Vp) is a village located on the right bank of the Mureş River, downstream from Alba Iulia town. Nopcsa (1905) was the first to report dinosaur bones in the red strata exposed near this village, but his collection was not large. In the last decade about one hundred additional bones and teeth were collected during several successive field excursions.

Sequences of fluvial origin (Codrea et al., 2001, 2002b, 2003; Therrien, 2005; Codrea and Dica, 2005) are exposed north of the village in "Râpele din susul Dumbrăvii", midway between Vurpăr and Câmpuţ (Fig. 5A). The continental succession occurs on a single restricted surface (several square metres) as a monocline dipping 20–35° to the NNE. Red and brown overbank mudstones and siltstones dominate, interbedded with a few lens-like (0.5 to 3 m thick) beds of yellowish sand, sandstone and microconglomerate channel fills (Fig. 5B). The majority of the channel fills expose internal architecture specific for braided flows, with numerous internal bars (SB, GB, LA elements) that temporarily supplied the sediments. The downstream migration of the sand and gravel bars led to dominant trough cross-bedding. The instability of the channels led to the formation of fining-upward type channel-fill sequences, a few metres in width. The channels are flanked by crevasse splays, sand/silt levees and floodplain silty clays (OF). Paleosols are common, with pedogenic processes indicated by root-marks or centimetre-sized carbonate nodular concentrations, very specific for the Bk horizon. Frequently root traces may be preserved within the nodules. This kind of paleosol containing caliche nodules is indicative of climatic seasonality (Therrien et al., 2002). Van Itterbeeck et al. (2004, 2005) estimated a dry subtropical climate for the Haţeg Maastrichtian; a similar palaeoclimate can be suggested for this area as well. All these deposits accumulated in a high-sinuosity fluvial system that carried a significant suspended solid load. Therrien (2005) reported southward trending flow directions (southwest through southeast) away from the nearby Southern Apuseni Mountains.

Most of the fossils were found in the basal sequence of the Şard Formation, nearly 30–50 m above the boundary with the Vurpăr Formation. The finds are mainly disarticulated teeth and bones (Fig. 5C), but some incomplete skeletons preserving bones still in connection are also known (occurring in red silty clays: young and adult *Zalmoxes* as well as *Struthiosaurus*; Figs. 6, 7). For the incomplete skeletons, one can suggest a high to medium rate of burial. However, the majority of the bones are white, with cracked surfaces filled with red clay, indicating prolonged weathering before burial. No marks of predators or scavengers occur on these bones. The dominance of young and subadult individuals could indicate periodic causes (e.g. droughts) of death, the carcasses and partially disturbed skeletons subsequently being buried relatively rapidly by very fine floodplain deposits. The isolated white bones remained exposed for longer time intervals under subaerial conditions, being later reworked by the streams, and then buried.

Vertebrate faunal list at Vurpăr includes so far: two turtle taxa (*Kallokibotion* and probably an unnamed ?Dortokiidae), a large crocodilian (*Allodaposuchus*), two euornithopod species (*Zalmoxes shqiperorum*, *Z. robustus*—very frequent), one hadrosaur (*Telmatosaurus transsylvanicus*—rare) and one ankylosaur (*Struthiosaurus transylvanicus*—common) (Fig. 8).

A well drained, open, bushy–patchy savanna-like environment can be reconstructed, with a few ephemeral water-pools (turtles) and riverbeds (crocodiles) crossing the landscape. The bush-dominated vegetation attracted the ankylosaurs (*Struthiosaurus*) and partly the ornithopods (*Zalmoxes*), but the lack of large trees and rich ground-plant communities kept away the sauropods and some ornithopods (e.g. *Telmatosaurus*). The seasonal, mostly dry climatic conditions (with short wet and longer dry periods), the landscape type and vegetation, could indicate a stressed environment with a series of limiting conditions, which controlled the structure of the local animal community.

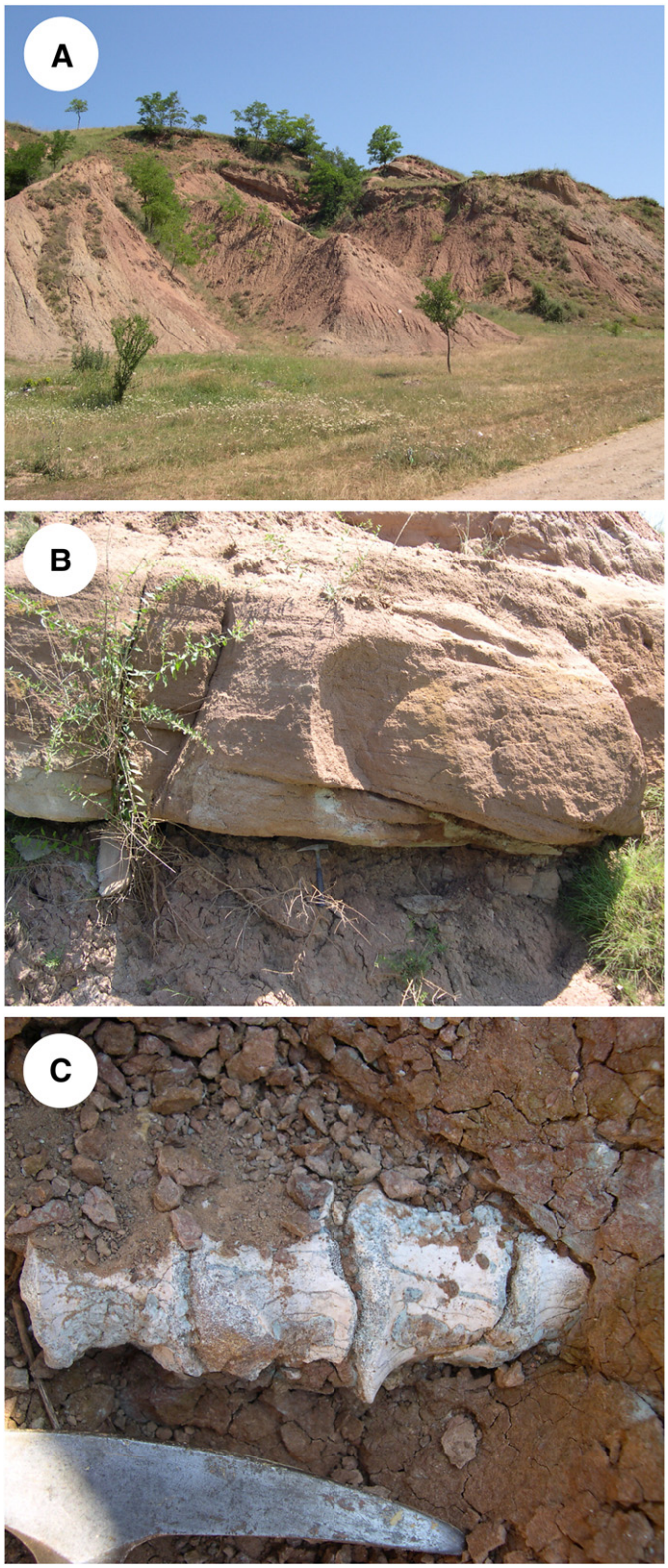

Fig. 5. Views of the red beds of the Şard Formation at Vurpăr. (A) Outcrops at "Râpele din Susul Dumbrăvii". Channel fills are interbedded in red silty clays. (B) Channel bar sandstone, downstream accretion (sedimentary architecture element DA). Hammer for scale. (C) Fragment of associated *Struthiosaurus* vertebrae *in situ*. Hammer for scale.

2.3.2. Stăuini

Stăuini (Sv = Cheii) Valley is a right tributary of the Mureş River, discharging upstream of Vurpăr.

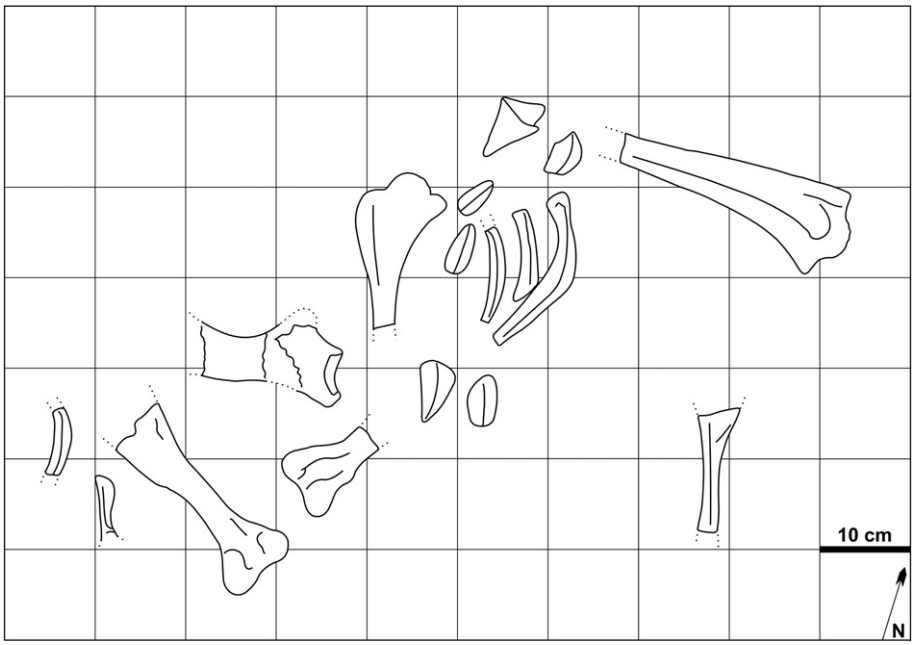

Fig. 6. Site map of a partial *Struthiosaurus* skeleton at Vurpăr.

Dominantly yellowish brown to grey and dark siliciclastic sequences (conglomerates, sandstones, siltstones, claystones, mudstones) are represented here, belonging to the Vurpăr Formation (Codrea and Dica, 2005). It represents the transition from the flysch deposits (turbidites) of the Bozeş Formation (Santonian—?Early Maastrichtian) to the Maastrichtian lacustrine–marshy deposits (dark brown–black mudstones and siltstones) containing invertebrate and leaf imprints, as *Sabal major* and *Pandanus*. It is an 80–100 m thick delta-sand unit (distal facies) with numerous isolated and/or superposed channels. The upper section shows a transition to red and bluish coloured paleosol-dominated medio-distal facies. Only scarce vertebrate fossils were found there (a rib fragment probably belonging to a sauropod, one crocodilian tooth, various undetermined bone fragments), besides coaly or silicified tree stumps/trunks.

2.3.3. Cuptorului Hill

Cuptorului Hill (DC) is located near Stăuini Valley, on its left bank. The red beds have the same direction and dip as at Vurpăr. Here, the Şard Formation begins with red or bluish-grey paleosols and sandstone sheet interbeds. Only scarce vertebrate fossils (one Ankylosauria indet. osteoderm and some other indeterminate disarticulated fragmentary bones) have been found until now.

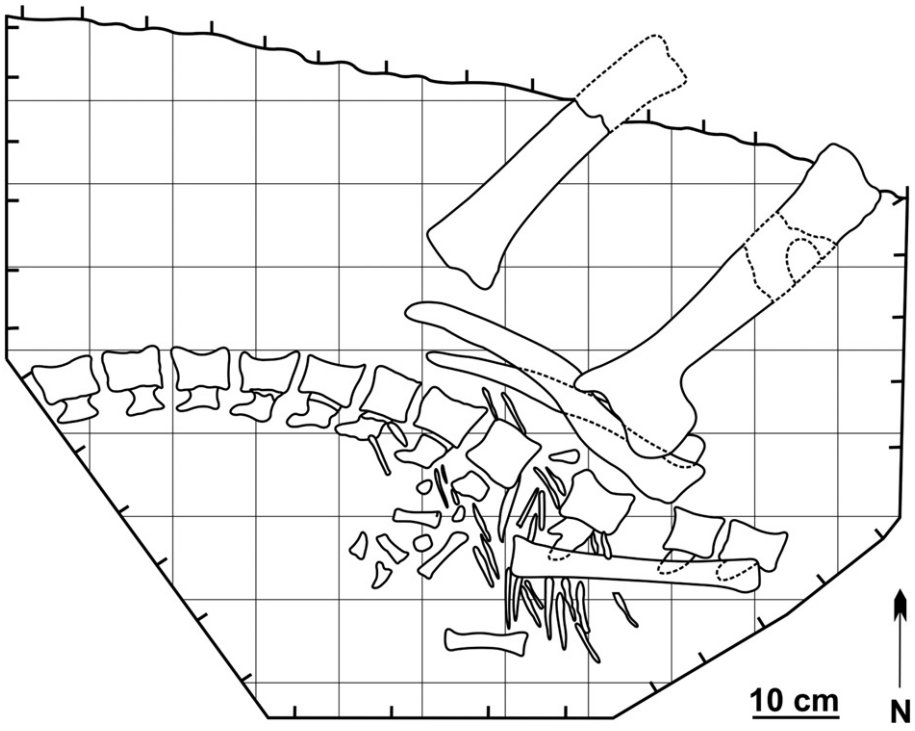

Fig. 7. Site map of a partial *Zalmoxes* skeleton at Vurpăr.

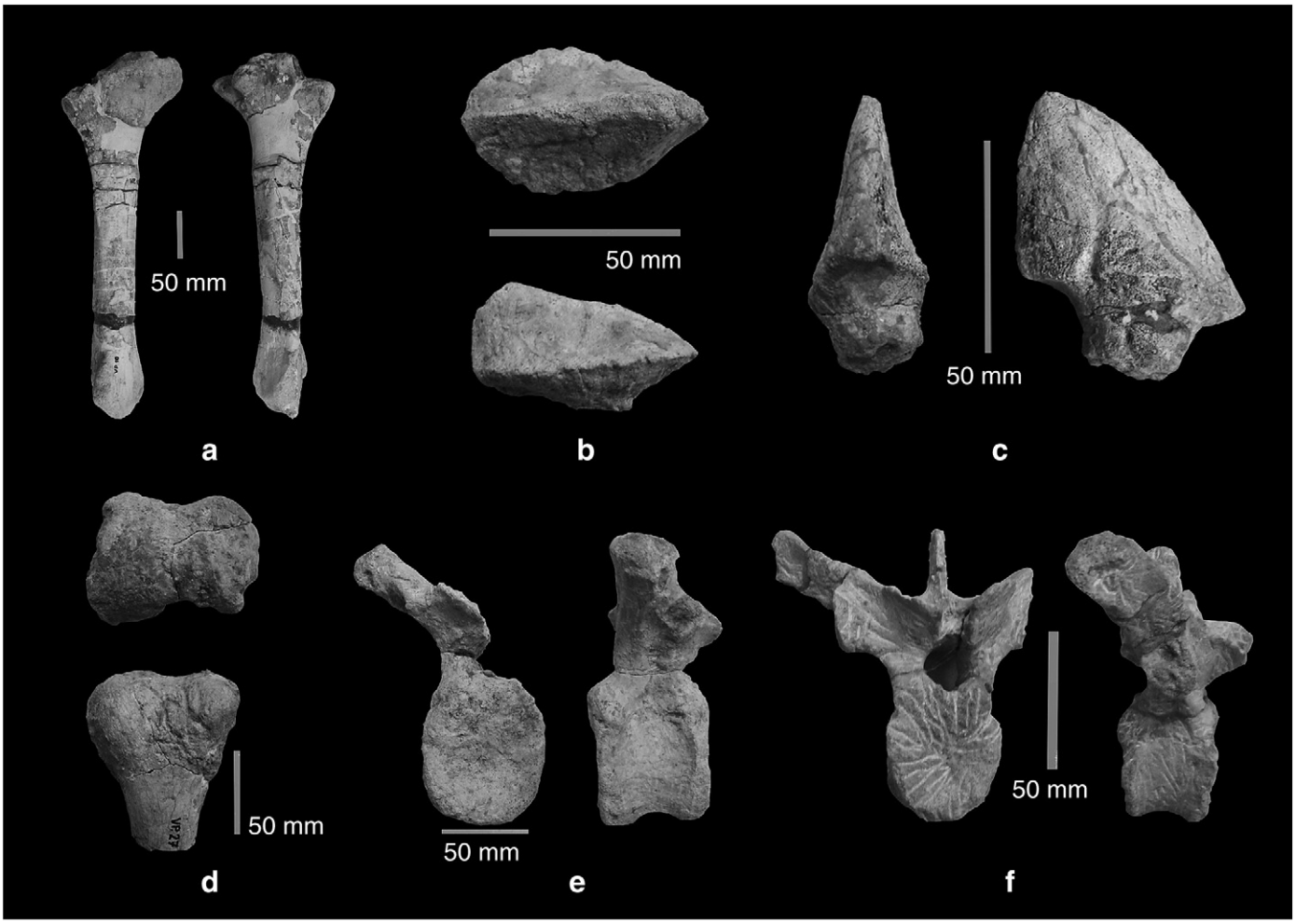

Fig. 8. Maastrichtian dinosaurs at Vurpăr. *Zalmoxes*: (a) right tibia (UBB VP 10) in medial and lateral views. *Struthiosaurus*: (b) osteoderm (UBB VP 63), (c) osteoderm (UBB VP 4), (d) left femur, distal end (UBB VP 27), in distal and caudal views; (e, f) dorsal vertebrae (UBB VP 63, VP Z-1) in cranial and right lateral views.

2.3.4. Şard

Şard (Sd), in the Ampoiului Valley, is similarly a right-side tributary to the Mureş River. The sequence, first exposed at the bridge crossing the valley, along the road linking Alba Iulia to Ighiu (Fig. 9A), can be followed upstream in two additional outcrops. It is represented mainly by coarse siliciclastic rocks (conglomerates, micro-conglomerates, sandstones, but also minor red silty clays) originating from repetitive superposed channels of the Şard Formation (Fig. 9B).

Large alluvial fans, medium- to high-energy braided rivers, a very dynamic environment with pronounced erosional and depositional processes can be presumed. In a few cases, undercut sections of riverbanks and floodplains are preserved, indicating a very sinuous water course characterized by coarse loads, fast erosion/deposition and frequent changes in flow direction (superposed/overlapping channels), a generally unstable environment.

Only scarce vertebrate fossils (a femur of a small-sized sauropod, ? ornithopod limb bone shaft, as well as several other unidentifiable reptilian bones) have been found in these deposits; some of these show signs of reworking. These few fossils are para-autochthonous or even allochthonous.

2.3.5. Bărăbanţ

Bărăbanţ (Bb) once a distinct village located north of Alba Iulia, is now included in this town. The single find of interest concerns the sauropod tibia mentioned in the Introduction (Fig. 10). We have no data regarding the lithology of the deposits from where it originates, but the matrix still adhering to this bone is a red sandstone-microconglomerate, both common channel-fill rocks in the Şard Formation.

2.3.6. Ciugud

Ciugud (Cd), a village on the left bank of the Mureş River, east of Alba Iulia, has yielded a single dinosaur limb bone fragment, curated at the Aiud Natural Science Museum, labeled as AiM 1025 (Codrea and Mărginean, 2007). Initially, the bone was considered of Eocene age, and was later referred to as a "mammoth ankle bone". There is no information on this discovery, but probably it represents another old find, perhaps from the end of the 19th century.

2.3.7. Oarda de Jos

Oarda de Jos includes two distinct outcrops located 3 km south of Alba Iulia, both on the right bank of the Sebeş River, about 1 km upstream of the junction with Mureş River, labeled as Oarda A (OdA) and Oarda B (OdB).

Koch (1894) examined the continental formations exposed between Oarda de Jos and Sebeş, but he referred them to the Oligocene. Nopcsa (1905, 1909) had a different opinion, considering them to be Danian. Grigorescu (1987) and Givulescu et al. (1995) recently referred these deposits to the Cenozoic. Codrea et al. (2001, 2003) based on several dinosaur and crocodilian bones, reassessed the age of these outcrops considering them to be Maastrichtian.

Both OdA (Figs. 11A, 12) and OdB (Fig. 12) expose deposits of a peculiar sedimentological character, with laterally extensive channels (Fig. 11A, B) that preserve in the lateral accretion deposits or even in

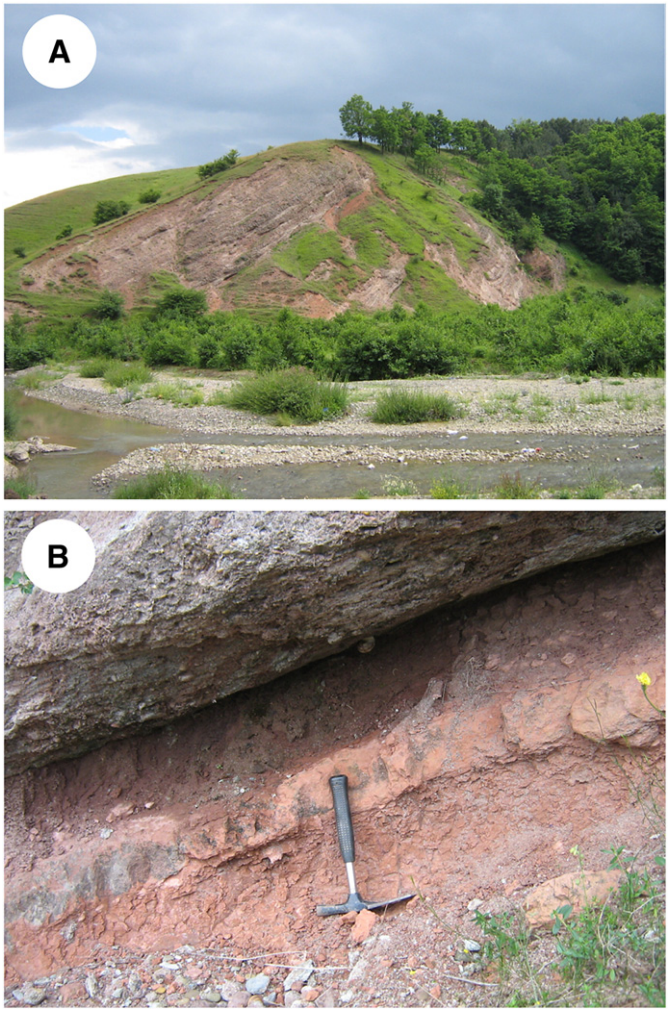

Fig. 9. Views of the red beds of the Şard Formation at Şard, on the Ampoiului Valley. (A) View of the main outcrop, near the Şard bridge, exposing the monoclinal dip of the strata. (B) Detail of the contact between red mudstone and coarse channel fill. Hammer for scale.

the river beds large coaly or silicified tree trunks and other plant remains, such as *Mastixia amygdalaeformis* endocarps (Givulescu et al., 1995). The floodplain also preserves several abandoned meanders, where grey-greenish clays accumulated. In OdB, clear lacustrine environments can be observed, with a distinctive sedimentary character, contrasting with the red mudstone deposits. The lacustrine rocks include grey-blackish silty clays accumulated during the incipient and extensional stages of the lake, and nodular flattened calcretes (Fig. 11C), which mark the end of its evolution, a lake crisis stage (Codrea et al., 2001).

The large fossil vertebrates collected in Oarda include the dinosaurs *Telmatosaurus transsylvanicus*, *Zalmoxes* sp., titanosaurs, theropods (Dromaeosauridae indet.), as well as turtles (*Kallokibotion*, ?Dortokidae indet.) and the eusuchian *Allodaposuchus precedens* (2003; Delfino et al., 2008). The bones show contrasting preservation features compared to the previous localities, being dark black in colour. Some display bite marks (Fig. 13A), probably produced by crocodilians. Doubtless, the Oarda area was full of crocodilians, as their remains are very numerous.

At OdA, a lens-like clay accumulation yielded an extremely rich microvertebrate assemblage. Fish remains are restricted to several *Lepisosteus* sp. scales, while most fossils are of the allocaudatan amphibian *Albanerpeton* sp. Lacertilians are also present, but are less abundant. A large number of crocodilian teeth have been collected and over a dozen teeth document the presence of kogaionid multituberculates. These were found by screen-washing of about 800 kg of sediments, making Oarda the Cretaceous locality with the highest mammal recovery rate in Romania.

In the same deposit, an accumulation of eggshell fragments forms a peculiar coquina limestone (Fig. 13B), very similar to that reported by Smith et al. (2002) in the Haţeg Basin, at Nălaţ-Vad (Sânpetru Formation). Monique Vianey-Liaud (Montpellier, written communication 2008) recognized at least four eggshell types including ?*Pseudogeckoolithus* and Megaloolithidae, pointing to similarities with the eggshells discovered in the Haţeg Basin (Grigorescu et al., 1990, 1994; Codrea et al., 2002a; Smith et al., 2002; Csiki et al., 2008).

Invertebrates, including gastropods and crab chelipeds, also occur and the charophytes (study in progress) are abundant in these samples.

2.3.8. Lancrăm

Lancrăm includes three sites: two outcrops located along the Sebeş River, labeled as LcA and LcB (Fig. 14), and another one in the Râpa Lancrămului (RL) on the right bank of the Secaş River. The distance from OdB to LcA is almost 500 m, and to LcB, around 800 m.

The first two sites represent mainly coarse channel fills rich in silicified wood (Fig. 15) belonging dominantly to the cheirolepidiacean *Telephragmoxylon transsylvanicus* (Iamandei et al., 2005).

The fossil vertebrates recovered from LcA and LcB include titanosaurs, *Zalmoxes* sp., *Struthiosaurus transylvanicus* and Hadrosauridae indet. (Fig. 16). The bones show different colours: some are black as in OdA and OdB, but others are light grey. LcB is the only site which yielded dinosaur footprints in Romania (Vremir and Codrea, 2002), assigned to the ichnotaxon *Ornithopedoidei*, probably made by *Zalmoxes*.

RL exposes a facies dominated by several generations of superposed channel fills, with reworked coarse lithoclasts, interbedded with silty clays of fluvial origin. Several dinosaur bones, presumed to be reworked from older deposits, have been found there. The deposits from RL had been referred by Codrea and Dica (2005) to a distinct lithostratigraphic unit, the Sebeş Formation. Its geological age is still unclear (Grigorescu, 1987, 1992; Codrea et al., 2008).

Fig. 10. A sauropod tibia found at Bărăbanţ in the 19th century, reported by Téglás in 1886 (Aiud Natural Science Museum, AiM 1026).

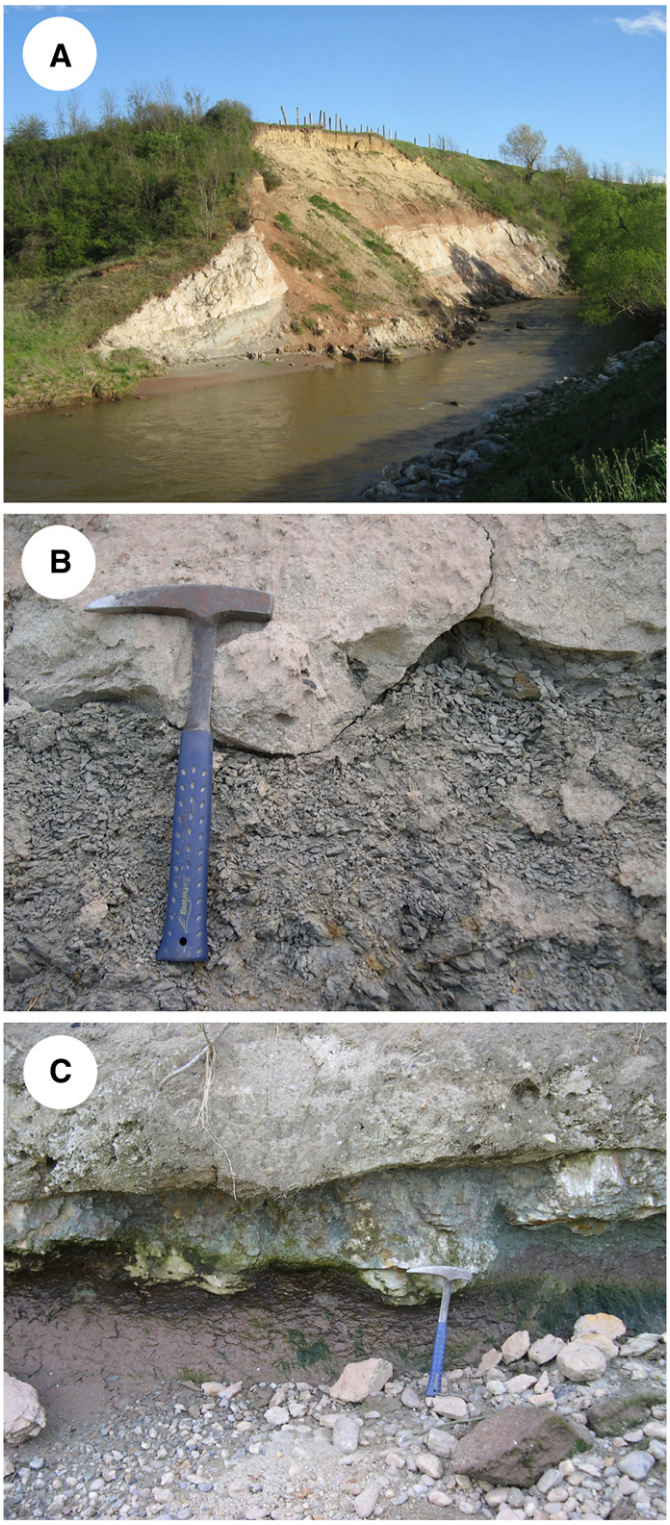

Fig. 11. Oarda de Jos A (OdA) outcrop. (A) View of the outcrop. (B) Detail of a channel base. (C) Caliche layer in OdB. Hammer for scale.

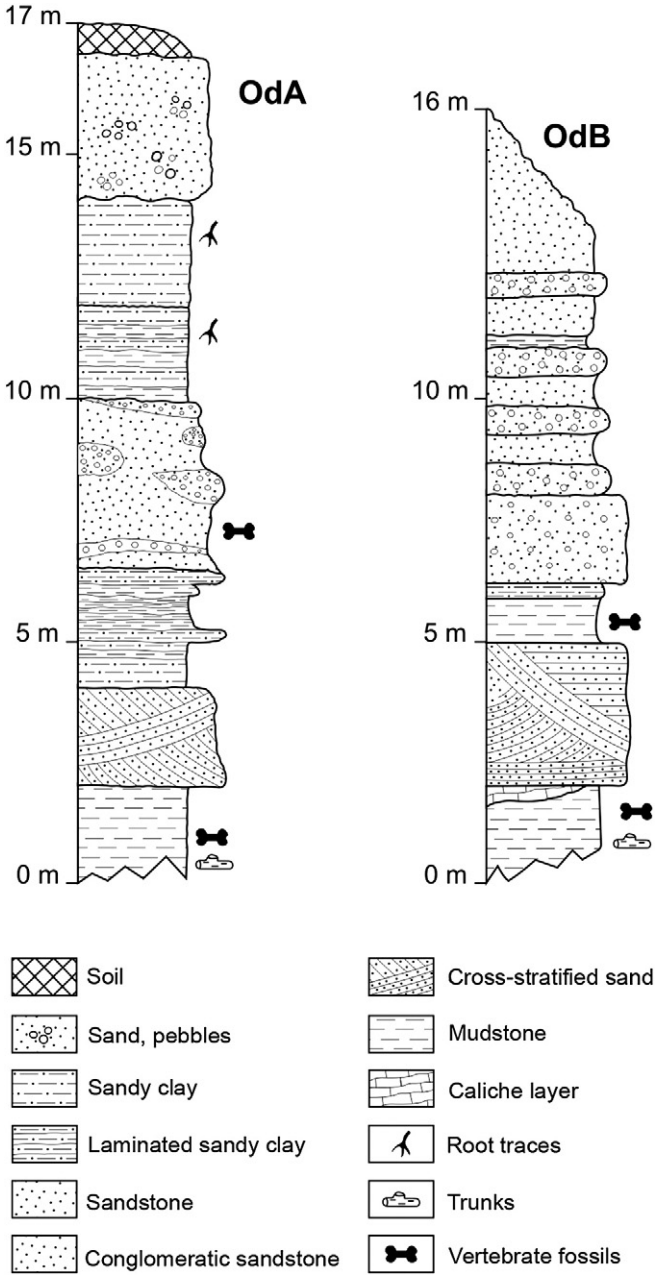

Fig. 12. Lithologic logs of the Oarda de Jos outcrops (OdA and OdB).

2.3.9. Sebeş

Sebeş refers to exposures of red beds located downstream from the borough, but also to those from the well-known protected geological site Râpa Roşie.

From the first category, the most representative outcrop is located between Sebeş and Lancrăm, labeled as Sebeş Glod (SbG). The rocks there are dominated by red silty clays, interbedded with high-energy channel deposits, which include reworked lithoclasts of allochthonous origin along with large blocks of intra-formational red clays (Fig. 17).

The fossil bones found in these rocks (Fig. 18) are white, resembling very much those from Vurpăr. Hitherto, no anatomical connection has been reported, the bones being fragmentary and spread within the red clay. These represent dinosaurs (titanosaurs, *Zalmoxes*), but also other reptiles including crocodilians and turtles (*Kallokibotion*).

The red beds from Râpa Roşie (RR) are exposed on the right bank of the Secaş River, being the type-section for the Sebeş Formation. The lithology is similar to that seen in RL, with a general fining-upward tendency (Fig. 19). The bones collected from RR belong to the same Cretaceous reptile assemblage: *Kallokibotion bajazidi*, titanosaurs, *Telmatosaurus*, Ankylosauria indet. (Grigorescu, 1987; Codrea and Vremir, 1997; Jianu et al., 1997; Codrea et al., 2008). Most bones show

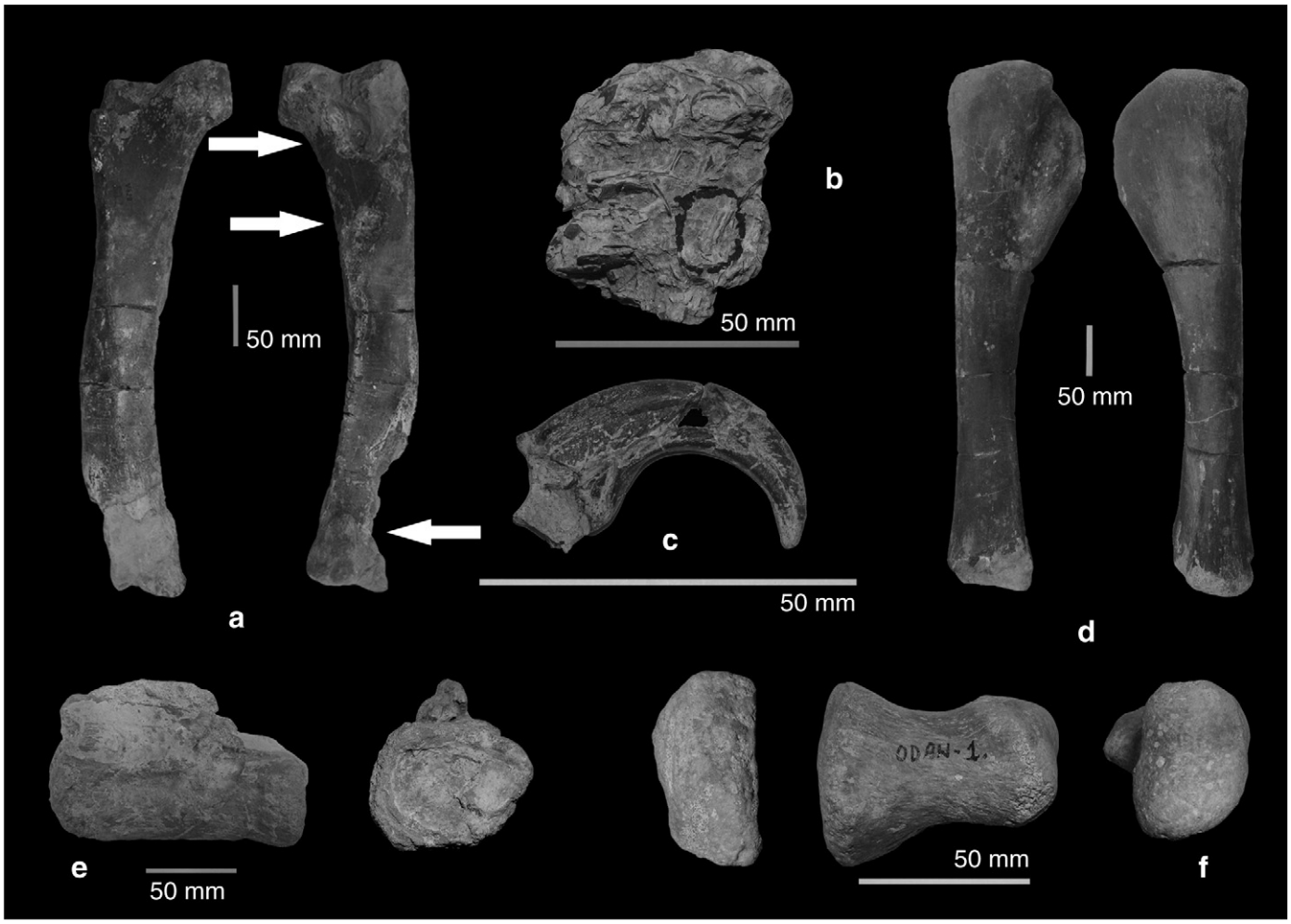

Fig. 13. Upper Maastrichtian vertebrates in Oarda. *Telmatosaurus*: (a) incomplete right femur (UBB ODA 2) with bite marks (arrows), in cranial and caudal views. (b) Coquina with eggshells and small bones. Dromeosauridae: (c) ungual phalanx (UB ODAN 17) in lateral view. Titanosauria: (d) right tibia (UBB ODA 7) in lateral and medial views; (e) distal caudal vertebra (UBB ODAN 32), lateral and distal views; (f) right metatarsal I (UBB ODAN 1) in proximal, lateral and distal views.

signs of reworking, suggesting they are allochthonous, but closer study is required.

2.3.10. Petreştii de Jos

Petreştii de Jos (P) is a section situated just on the Sebeş River riverbed, upstream from Sebeş town. Overlying the extremely condensed Vurpăr Formation, is a sequence of yellowish-grey gravels and sands as well as red silty clays, forming a variegated sequence (Fig. 20). The vertebrate fossils are extremely scarce; hitherto only a skull fragment, probably belonging to an indeterminate dinosaur, has been collected. The precise geological age of this locality remains unclear, pending additional discoveries.

3. Conclusions

For a long time, the Upper Cretaceous red beds outcropping outside the Haţeg Basin in Transylvania remained unstudied partly due to their lithological monotony and also the scarcity of fossils. These rocks occur in the Sălaj, Cluj and Alba regions (Fig. 21). In the last of these regions, the sedimentary succession is complex and difficult to interpret, because of the juxtaposition/superposition of several continental formations of similar facies, but different geological ages. The red beds may exceed 2500 m in thickness. The sediments were carried by fluvial systems with high discharge, and with deposition controlled by seasonality. The source areas probably had wide extent, over the whole area of the present-day Apuseni Mountains or even farther.

The Upper Cretaceous vertebrate fossils found outside Haţeg are sometimes uncommon, but their presence in these red beds is obvious and widespread. They include fishes, amphibians, lacertilians, turtles, crocodiles, dinosaurs and mammals, representing the majority of the taxa already known from the Haţeg Basin. The dinosaurs show the same peculiar small sizes, once underlined by Nopcsa (1914) when he defined the "Haţeg Island". However, occurrence of new taxa is to be expected in each of these areas, mainly among the small-sized vertebrate taxa.

The basal parts of the Jibou and Şard formations are coeval with the Sânpetru and Densuş-Ciula formations from the Haţeg Basin. It is also conceivable that they are coeval with at least a part of the uppermost Cretaceous deposits of the Rusca Montană Basin, a potentially promising area for prospecting for fossil vertebrates (Dincă et al., 1972; Antonescu et al., 1983). The Rusca Montană Basin includes examples of several, even more diverse, Upper Cretaceous environments, with coal accumulations and interbedded products of volcanic activity.

These Maastrichtian assemblages demonstrate the extent of "Haţeg Island" towards the northeast. But in spite of over of a century of research, this island still cannot be completely defined based only on palaeontological and sedimentological data, due to the lack of information in other areas. In these circumstances, every piece of new

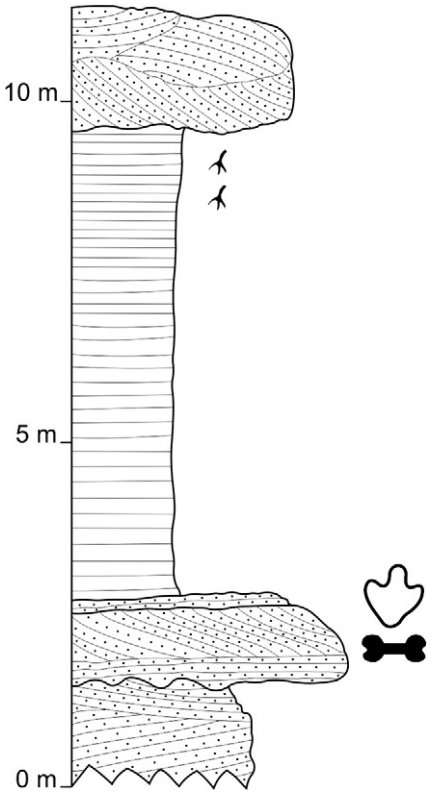

Fig. 14. Lithologic log at Lancrăm B, showing the position of the dinosaur footprint-bearing bed (after Vremir and Codrea, 2002).

data on the Upper Cretaceous continental deposits located outside Haţeg would add further arguments and evidence towards a better understanding of the palaeobiology and palaeogeography of the Latest Cretaceous in this part of the continent, as Rage (2002) pointed out.

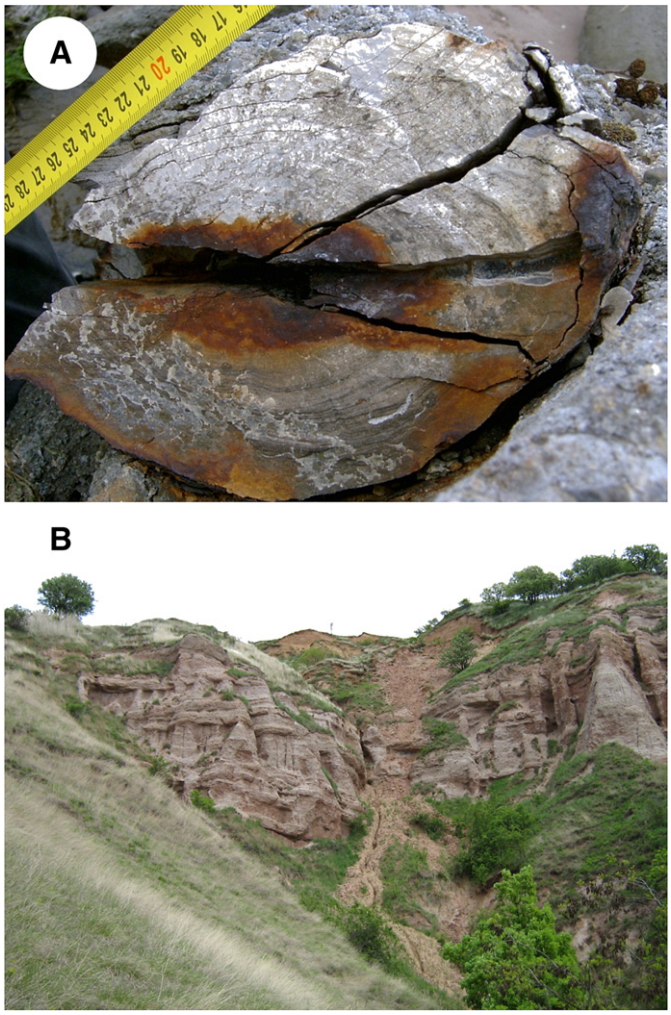

Fig. 15. Lancrăm. (A) Tree trunk inside channel fills at Lancrăm B. (B) View of the Răpa Lancrămului outcrop.

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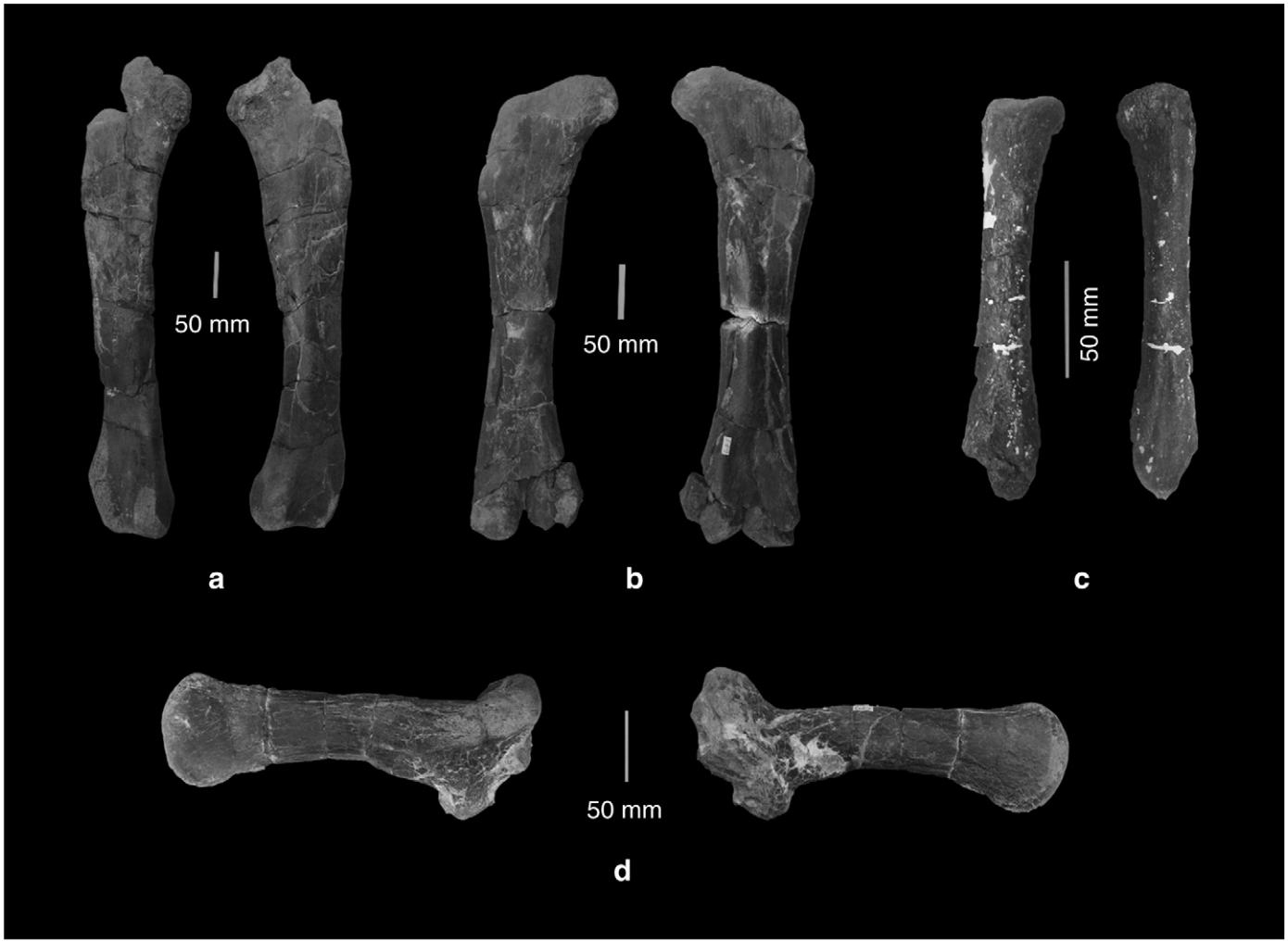

Fig. 16. Maastrichtian dinosaurs at Lancrăm. Titanosauria: (a, b) left femora (UBB LcB 18, LcB 5) in caudal and cranial views. Hadrosauridae indet. (c) ?left radius (UBB LcB 8) in cranial and lateral views. Indeterminate taxon: (d) left scapula in medial and lateral views.

Fig. 17. View of the Sebeş Glod outcrop along the Sebeş River. The large red intra-formational red mudstone blocks reworked inside the channel fill, are clear in the exposed river bank.

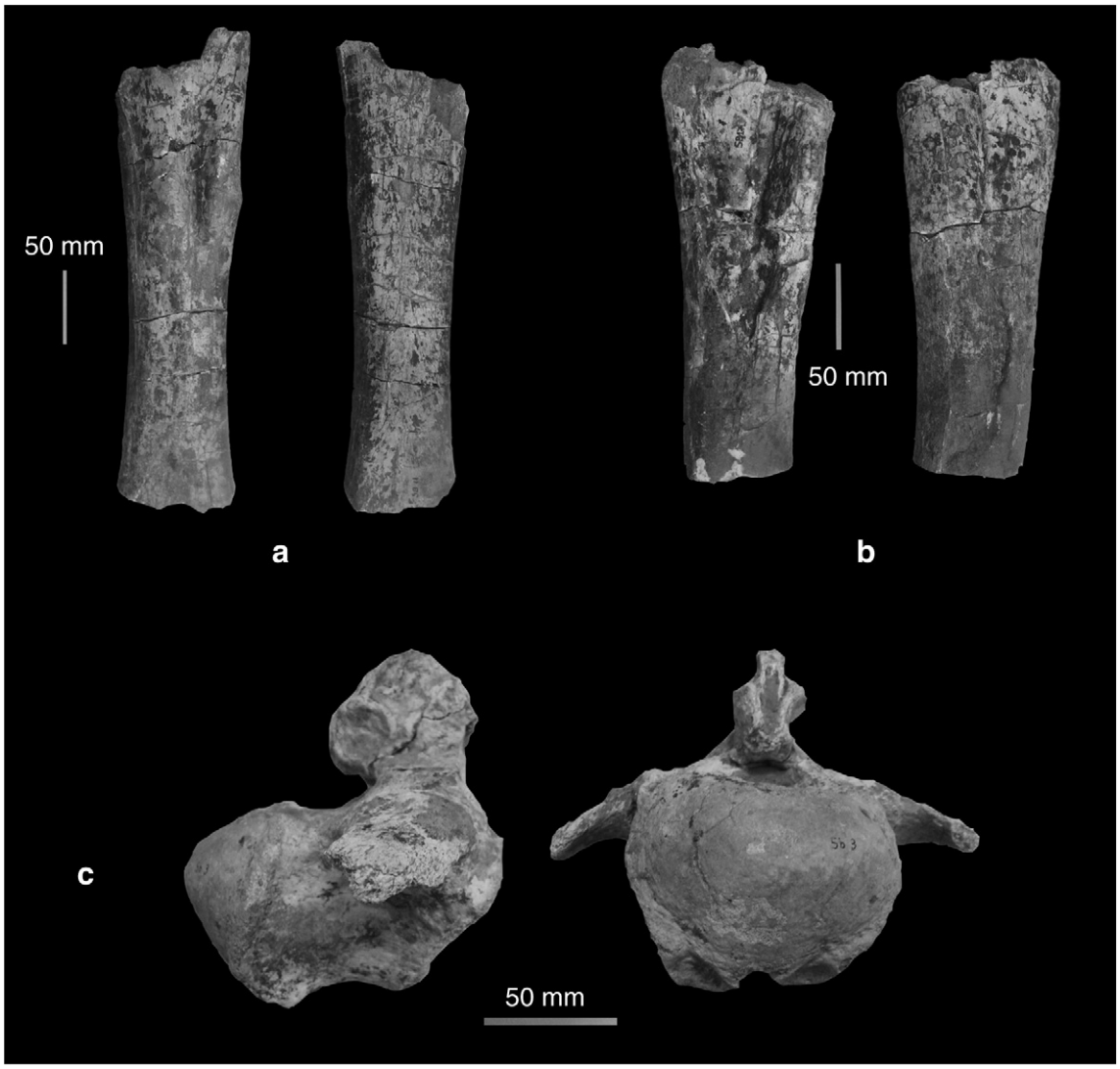

Fig. 18. Dinosaurs from Sebeş Glod. Titanosauria: a, b—fragmentary left femora (UBB SB 11, SB 17) in caudal and cranial views; c—proximal caudal vertebra (UBB SB 3) in right lateral and caudal views.

Fig. 19. The red beds at Râpa Roşie, near Sebeş borough, exposing the superposed, fining-upward channels.

Fig. 20. Variegated red beds at Petreşti, along the Sebeş River.

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Fig. 21. Maastrichtian vertebrates in Romania: 1. Sălaj County; 2. Cluj County; 3. Alba County; and 4. Haţeg Basin (Hunedoara County).

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