SOME MAASTRICHTIAN VERTEBRATES FROM FLUVIAL CHANNEL FILL DEPOSITS AT PUI (HAȚEG BASIN)

SOLOMON Alexandru, CODREA Vlad

Abstract. Latest Cretaceous deposits are cropping out in various localities of the Hațeg basin (Romania). Among these localities Pui is of peculiar interest, being the southeastern most one where Maastrichtian fluvial deposits are exposed. These terrestrial deposits are represented mainly by red beds, which yielded since the end of the 19th century, rich vertebrate assemblages. From a channel fill block discovered *ex situ*, a diverse fossil vertebrate assemblage was recovered (turtles, crocodilians, pterosaurs, and various herbivore and carnivore dinosaurs). This study is focused on the fossil taxa collected from this block and their fossilization processes.

Keywords: latest Cretaceous, fluvial deposits, vertebrates, Hațeg basin, Romania.

Rezumat. Câteva vertebrate maastrichtiene din depozite de canal fluvial de la Pui (Bazinul Hațeg). Depozite cretacic terminale aflorează în varii localități din Bazinul Hațeg (România). Dintre acestea, Pui este localizată în extremitatea sud-estică a bazinului, unde apar la zi depozite fluviale maastrichtiene. Aceste depozite sunt dominate de *red beds*, din care au fost colectate, încă de la finele secolului XIX, bogate asociații de vertebrate fosile. Dintr-un bloc cu umplutură de canal descoperit *ex situ* a fost extrasă o asociație diversă de vertebrate fosile (țestoase, crocodili, pterosauri și variați dinozauri erbivori și carnivori). Asociația de fosile din acest bloc și procesele de fosilizare evidențiate sunt descrise în acest studiu.

Cuvinte cheie: Cretacic terminal, depozite fluviale, vertebrate, Bazinul Hațeg, România.

INTRODUCTION

In latest Cretaceous, an emerged land occurred in the actual Transylvania named the “Hațeg Island”. It was part of a larger Tethyan archipelago, in southern Europe (DERCOURT et al., 2000; CSONTOS & VÖRÖS, 2004). Geological evidence of this paleogeography can be noticed in Transylvania: besides the already notorious Hațeg basin, other data related on the Maastrichtian terrestrial deposits are found in the Transylvanian and Rusca Montană basins (NOPCSA, 1905; CODREA & DICA, 2005; CODREA & GODEFROIT, 2008; CODREA et al., 2010; 2012). It is estimated that the whole island had almost 80,000 km^2 (BENTON et al., 2010, and references therein). The island is known all over the world due its vertebrate fauna, which evolved in endemic (?insular) environment (NOPCSA, 1914; CODREA et al., 2014).

Within the ”Hațeg Island”, the Hațeg basin (Figs. 1A; 1B) is the most studied, due to the peculiar sedimentary Maastrichtian deposits (NOPCSA, 1905; GRIGORESCU et al., 1985; GRIGORESCU & ANASTASIU, 1990; GRIGORESCU, 1992; THERRIEN, 2005, 2006; VAN ITTERBEECK et al., 2005; THERRIEN et al, 2009; PANAIOTU & PANAIOTU, 2010) bearing rich fossil assemblages - mainly vertebrates - and among these ones, peculiar endemic dwarf dinosaurs, reported both by baron Francisc Nopcsa and Gyula Halaváts since the end of the 19th (NOPCSA, 1897; HALAVÁTS, 1897; GRIGORESCU, 2010). Apart their systematic, biodiversity and ecology, very important data refer to their taphonomy and fossilization processes (CSIKI et al., 2010a).

The majority of the Maastrichtian terrestrial deposits concerns *red beds*. The most illustrative ones are exposed in the southeastern side of the basin at Pui (Figs. 1B; 1C), a commune located 20 km from Hațeg town, on the road connecting Hațeg to Petroșani. The locality is crossed by the Bărbat River (Fig. 1C). The red beds can be best observed when the river water plane is low, in dry seasons.

GEOLOGICAL SETTING

In Hațeg basin two Maastrichtian terrestrial formations were coined (GRIGORESCU & ANASTASIU, 1990): Densuș-Ciula Formation, exposed in the northern sectors of the basin (ANASTASIU & CSOBUKA, 1989; GRIGORESCU et al., 1990; BOJAR et al., 2005), and Sânpetru Formation in the southern basin areas, as the Sibișel or the Râul Mare rivers (CODREA et al., 2002; SMITH et al., 2002; VAN ITTERBEECK et al., 2004, 2005; BOJAR et al., 2005; THERRIEN, 2005, 2006; THERRIEN et al., 2009). Both formations are of same fluvial origin (GRIGORESCU & ANASTASIU, 1990; GRIGORESCU, 1992; THERRIEN, 2005, 2006; VAN ITTERBEECK et al., 2004, 2005; THERRIEN et al., 2009; PANAIOTU & PANAIOTU, 2010). VAN ITTERBEECK et al. (2004, 2005) and THERRIEN (2005, 2006) considered that these sediments accumulated in well drained floodplain environments.

The deposits from Pui were related to Sânpetru Formation (NOPCSA, 1905; GRIGORESCU et al., 1985, 1999; GRIGORESCU, 1992; etc.). However, THERRIEN’s work (2005) points out the differences between the Sibișel type-section and the one exposed at Pui, underlining even the major dominance in colour of the rocks: while in Sânpetru the fluvial deposits are gray-yellow-greenish, in Pui the red mudstones are in prevalence. For this reason he called the deposits from Pui “Pui beds”, suggesting even a possible distinct formation, “Bărbat Formation”.

As in the others fluvial Maastrichtian deposits from the Hațeg basin, in Pui ones, one can outline sequences of fines marking overbank sediments *vs.* channel filling rocks - conglomerates, microconglomerates and mainly sandstones (VAN ITTERBEECK et al., 2004, 2005; THERRIEN, 2005, 2006; THERRIEN et al., 2009).

Another kind of deposits can be also noticed, interpreted as oxbow ponds. Such deposits are in sharp contrast with the red beds, dominated by dark colour mudstones with white mica flakes and pyrite noodles (CODREA & SOLOMON, 2012; VASILE & PANAITESCU, 2012; CODREA et al., 2013; SILYE et al., 2014). CODREA & SOLOMON (2012) reported three stratigraphic successive levels of this kind, calling them Pui Gater, Pui Depozit and Pui Islaz, but possibly some others could be also present into the Maastrichtian succession from the Bărbat River. The fossil assemblages of the oxbows are also different from the ones of the red beds, the fossilization being peculiar too (dark coloured bones and teeth).

Inside the red beds, the channel filling rocks were a specific fossilization environment. The channel deposits are common mainly in the basal part of the Bărbat River section. To the top they are not absent, but the vertebrate fossils are rather rare, compared to the basal ones. They are filled by coarse conglomerates and sandstones. The main clasts are represented by quartzite and other metamorphic rocks, but intra-formation reworked mudstones can be noticed too.

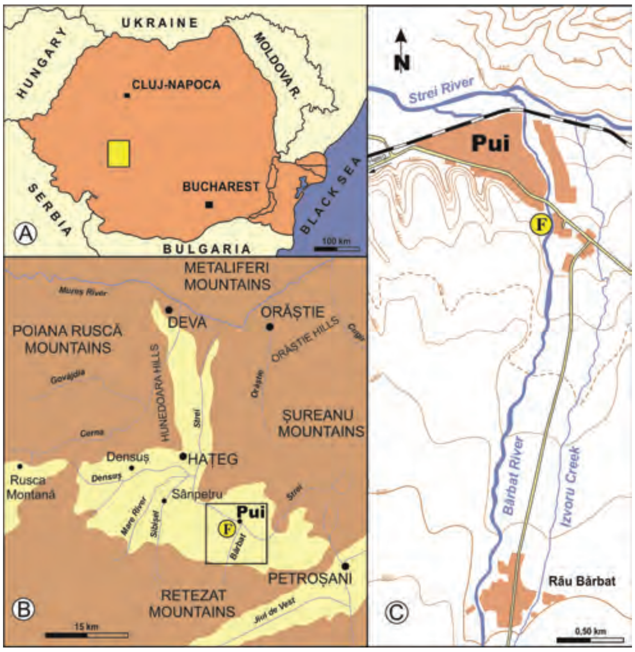

Figure 1. A. The yellow rectangle indicates the position of Hațeg basin on the map of Romania;
B. Location of Pui locality - marked by rectangle - in the Hațeg basin; ”F” indicates the place where the block originated from;
C. Map of Pui locality; ”F” indicates the place where the block was found *ex situ*.

MATERIAL AND METHODS

This work is focused on the vertebrate fossils recovered from a channel fill block collected at Pui, on the Bărbat River. The block was found *ex situ* in the river alluvia, at Pui Gater (Fig. 2A). According to the natives' statements, this block was extracted several years ago from its original bed, when a concrete bank was erected in order to protect the mill saw. It worth mentioning that several decades ago, probably in the first half of the 20th, two similar blocks bearing large bones (probably dinosaur bones) had been brought in the geological collection of Babeș-Bolyai University of Cluj-Napoca by an anonymous donor (inventory numbers: V508, V509).

The rock has a gray-faint greenish colour. The full rock block (Fig. 2C), estimated at 250-300 kg was extracted from the alluvia (Fig. 2A), than carried in the Laboratory of Vertebrate Paleontology of Cluj-Napoca university (Figs. 2B; 2C). The block was turned into small pieces using classical tools as chisels and hammers, but also electric bore hammer (Borehammer Z1C-Dl05-26; Fig. 2D) and microengraver (Dremel engreaver 290). The vertebrate fossils from the smaller pieces of rocks were extracted from their matrix by classical methods, using chisels, hammer and microengraver. Professional polymers such as paraloid and mowillite consolidated the bones, when necessary. The cleaned bones were measured with professional calipers, than photographed with Nikon Coolpix P520 (18.1 megapixels). The photos were processed in Adobe Photoshop CS2.

The material is hosted at the Laboratory of Vertebrate Paleontology at ”Babeș-Bolyai” University of Cluj-Napoca. The material was labelled as PB1-X, where PB is the abbreviation for ”Pui Block”, ”1” represents the fact that this is the first block of this type that was discovered, and ”X” represents the number of each fossil extracted from the block.

RESULTS

Inside the block matrix several bones - most broken - and teeth belonging to various reptiles were recovered. The majority of these remains belongs to crocodilians, especially to *Allodaposuchus precedens* Nopcsa 1928 (NOPCSA, 1928). Other remains by far less numerous, are documenting the crocodilian *Acynodon*. Various dinosaur remains are present in this block too. This study is focused on the description of the faunal material recovered from the block, and on some taphonomic processes, which took place before the final burial of the vertebrate remains.

Figure 2. A. The place where the block was found *ex situ*; B. Preparing the transport of the block to the Laboratory of Vertebrate Paleontology at Babeș-Bolyai University of Cluj-Napoca; C. The block in the laboratory; D. One of us (Al.S.) working on the block.

SYSTEMATIC PALAEONTOLOGY
Reptilia Laurenti 1768
Chelonii Brogniard (Latreille) 1800
Testudines Linnaeus 1758
Chelonia indet. (Plate I, Figs. 2a; 2b; 3)

Turtle carapace fragments were extracted from the block (e.g. PB1-38, PB-1-39). These remains are poorly preserved and a lot of cracks are crossing their surfaces. Due to the water stream transport and subsequent taphonomic processes, the ornamentation of external surfaces is almost lost.

In the "Hațeg Island" turtles were several times reported (NOPCSA, 1923; GAFFNEY & MEYLAN, 1992; DE LAPPARENT et al., 2009; VREMIR & CODREA, 2009; RABI & VREMIR, 2011; CODREA & SOLOMON, 2012; etc.), referring both to pleurodira and cryptodira. The poor state of preservation of the fragments does not allow assigning these remains to one or another of these groups.

Remains of turtles are widespread in the "Hațeg Island", being common elements in the Maastrichtian continental biota. The most common turtle in the "Hațeg Island" is *Kallokibotion bajazidi* Nopcsa 1923 (NOPCSA, 1923), but as we underlined above, Dortokidae representatives were also present.

Crocodylomorpha Walker 1970 (*sensu* Benton & Clark 1988)
Eusuchia Huxley 1875 (*sensu* Benton & Clark 1988)
Alligatoroidea Gray 1844 (*sensu* Norell et al. 1994)
Allodaposuchus Nopcsa 1928
Allodaposuchus precedens Nopcsa 1928 (Plate II, Figs. 1a; 1b; 1c; 2; 3)

This species is documented by numerous isolated teeth of various sizes, ranging from 11.34 to 25.30 mm in height and from 8.40 to 14.20 mm in wide. Following BUSCALIONI et al. (1986), these teeth tentatively can be separated into morphotypes. The first morphotype (morphotype B, in BUSCALIONI et al., 1986) is represented by a conical, slender, and pointed tooth crown, medially twisted, with well-developed mesial and distal keels, both continuous from the base to the top of the crown. The keels are devoid of serrations. The cross section of these teeth is sub-rounded. Some teeth preserve parts of their roots, the missing parts being removed by the water stream transport before their definitive burial in the sediment. On the medial side, fine vertical enamel ridges can be noticed. The largest tooth from the available sample (PB1-1) is longitudinally broken: in this manner the crown of the new replacing tooth, can be observed inside the older crown. This type of tooth was already noticed by DELFINO et al. (2008a) in the *A. precedens* skull collected from the Maastrichtian deposits at Oarda de Jos (Alba District), considering it to be placed on premaxilla. The second morphotype (morphotype C, in BUSCALIONI et al., 1986) is less frequent in the sample. The crown is robust, less elongated and slender compared to the previous morphotype, and the apex of the crown is less pointed. The cross section of the crown is sub-rounded. The mesial and distal keels are present, and fine enamel ridges can be also noticed on both sides, starker on the medial one. This morphotype is also reported on the *A. precedens* skull, assigned to maxillary teeth (DELFINO et al., 2008a).

Acynodon Buscalioni, Ortega & Vasse 1997
Acynodon sp. (Plate II, Figs. 4a; 4b; 5a; 5b; 6a; 6b)

This crocodilian is documented by several isolated teeth. BUSCALIONI et al. (1997, 1999), and DELFINO et al. (2008b) coined two types of teeth for this genus. The anterior teeth are spatula-like, while the posterior ones are molariform. In our sample, four anterior (PB1-15, 16, 17, 19) and a single posterior one (PB1-18) are present. The size of the anterior teeth varies from 4.10 mm to 6.50 mm in height, and 3.47 mm to 6.95 in wide. The crown is bulbous and the apex is rounded. Fine enamel wrinkles are present on both the labial and lingual sides of the crown. As in our sample there are exclusively isolated teeth, we are devoid of enough arguments to separate the upper from the lower ones. The rear molariform tooth has wider than higher crown, with oval outline in crown view, apically worn. The crown is ornamented by numerous fine pustules, as in *A. adriaticus* Delfino, Martin & Buffetaut 2008.

Crocodylia indet.

Mandible - a surangular articulation fragment (PB1-24) and an indeterminate mandible fragment (PB1-25) were recovered.The preserved portion of the surangular articulation is elongated, the total preserved length being 81.96 mm. In outer view, the lateral surface is completely sculptured by pits and grooves (Plate II, Fig. 7a), while in inner view the bone is less ornamented (Plate II, Fig. 7b). The dorsal surface is almost smooth. The dorsal edge is caudally ascendant. Due to its size, it may belong to the eusuchian *A. precedens*. The other mandible fragment (PB1-24) presents the same sculptured surface in outer view, while in inner view the surface is almost smooth.

Vertebrae - two caudal vertebrae are available. One of them is much damaged (PB1-23), preserving only the centrum, in a very poor condition. Therefore, only the other vertebra worth a detailed description (PB1-22; Plate II, Figs. 8a; 8b; 8c; 8d). It is a caudal vertebra, probably coming from the proximal half of the tail. It is procoelous, with an elongated centrum. The total length of the centrum is 47.48 mm. The centrum is strongly transversally compressed. The neural arch is much higher than the centrum, a feature already observed in the caudal vertebra described by CODREA et al. (2012) from Rusca Montană Basin. The prezygapophyses and postzygapophyses are well developed. The neural spine is broken, as well as the left postzygapophysis, which is partially broken too. One of the transverse processes is almost complete, while the other one is partially broken. The transverse processes are dorsally trended. In lateral view a groove can be noticed under the transverse processes. The condyle is damaged, while the cotyle is better preserved. The neural canal is round-shaped, still filled by sediment. The prezygapophyses are larger than the postzygapophyses, all of them having the articular surface oval-elongated.

Tibia - one fragmentary young crocodilian tibia (PB1-26; Plate II, Fig. 9) was recovered from the block. Unfortunately, the proximal epiphysis is damaged, lacking the medial and lateral condyles. The distal epiphysis is damaged too. In dorsal view, the proximal extremity has a subtriangular outline, as in *Allodaposuchus palustris* Blanco, Puértolas-Pascual, Marmi, Vila & Sellés 2014. The shaft has an elliptic outline, being similar to *A. palustris* (BLANCO et al., 2014). The proximal and distal epiphysis of the bone is expanded, while the shaft is slender.

Osteoderms - a rich sample of osteoderms, complete or fragmentary, was extracted from the block (Plate II, Figs. 10; 11; 12; 13; 14). Two morphotypes were recognized: oval-shaped and subrectangular. The majority of the osteoderms exposes a keel on the surface, but there are some devoid of keel (ie. PB1-46; Plate II, Fig. 11). None of the osteoderms has such a high keel as in the Spanish eusuchian presented by BUSCALIONI et al. (1986). The whole dorsal surface of the osteoderms is ornamented by circular or sub-circular pits, while the ventral surface is smooth, with nutritional foramens.

Pterosauria Kaup 1834
Pterodactyloidea Plieninger 1901
Pterosauria indet. (Plate I, Figs. 4a; 4b; 5a; 5b)

Two pterosaur bone fragments were recovered from the block (PB1-27, PB1-28). Pterosaurs are rather rare in the Romanian Maastrichtian deposits (NOPCSA, 1899; BUFFETAUT et al., 2002; VREMIR et al., 2013; GRELLET-TINNER & CODREA, 2014). The cortex of the bone is thin, and due to this fact, in both bones the cortex was broken and the filling sediment can be observed (Plate I, Figs. 4a; 5a; 5b). These fragments could originate from the wings, based on their shapes and bone structure. Based on this scarce sample and the fragmentary state of the bones, we cannot assign these remains to any of the known pterosaurs from the “Hațeg Island”.

Dinosauria Owen 1842
Saurischia Seeley 1888
Theropoda Marsh 1881
Theropoda indet. (Plate I, Figs. 6a; 6b; 6c; 7a; 7b)

Two fragmentary theropod phalanges (PB1-33, PB1-34) were recovered from the block. The maximum length of PB1-33 is 26.11 mm, while in PB1-34 is 31.57 mm. The fragmentary state of the preservation is due to the fact that the theropod bones are very fragile and could be easily broken by water transport. The non-ungual phalanges have extensor pits, a typical feature for theropods. In both phalanges, the distal condyles are damaged; the extensor groove between the condyles is shallow. The distal condyles are better preserved in PB1-33, and its distal articular surface has a typical theropod outline (Plate I, Fig. 6b). The proximal articular surface is broken in both cases, but the general outline is typical for theropods. These phalanges could originate from a paravian theropod.

Two theropod species are documented by postcranial bones in the "Haţeg Island": *Elopteryx nopcsai* Andrews 1913, and *Balaur bondoc* Csiki, Vremir, Brusatte & Norell 2010 (CSIKI et al. 2010b; BRUSATTE et al., 2013). Various isolated teeth (e.g. GRIGORESCU et al., 1985; CSIKI & GRIGORESCU, 1998; CODREA et al., 2002; SMITH et al., 2002; CSIKI et al., 2008; VASILE, 2008; CODREA & SOLOMON, 2012) are indicative for a high diversity of theropods in this Maastrichtian biota. Besides crocodilians, the theropods were top predators in "Haţeg Island".

Sauropoda Marsh 1878
Titanosauriformes Salgado, Coria & Calvo 1997
Titanosauria Bonaparte & Coria 1993
Titanosauria indet. (Plate I, Figs. 10; 10b; 11a; 11b; 11c)

Sauropod remains recovered from the block are represented by an ungual phalanx (PB1-36) and a femur mid-shaft fragment (PB1-30). The ungual phalanx is gracile and asymmetrical in dorsal view. Its length is around 49 mm. It is crescent-shaped, with a convex dorsal surface and a relatively flat ventral side. The medial side is convex, while the lateral side is almost flat. A groove is visible on the medial side, near the proximal part of the phalanx. The articular proximal surface (Plate I, Fig. 11c) is concave, and a central ridge divides this surface in two distinct lateral parts. In proximal view, the ungual phalanx has a round-triangle shape. The lateral side is damaged in its distal part; the apex is pointed and ventrally trended. Other ungual sauropod phalanges from the Haţeg basin were reported by NOPCSA (1915) and CSIKI et al. (2010c). By comparison with an ungual phalanx (UBB NVM1-11) of *Paludititan nalatziensis* Csiki, Codrea, Jipa-Murzea & Godefroit 2010 (CSIKI et al., 2010c), which is a left ungual phalanx, the one from the block it is a right ungual phalanx, probably the third one.

The femur mid-shaft fragment is broken and a lot of cracks are visible on its surface, probably due to the water transport.

Until now, the sauropods from the "Haţeg Island" were assigned to two genera, *Magyarosaurus* von Heune 1932 (VON HUENE, 1932) and *Paludititan*, but recent unpublished discoveries could evidence a higher sauropod diversity in the Maastrichtian of Transylvania.

Ornithischia Seeley 1887
Hadrosauridae Cope 1869
Telmatosaurus Nopcsa 1903
Telmatosaurus transsylvanicus Nopcsa 1900 (Plate I, Fig. 9)

The presence of duck-bill dinosaurs (hadrosaurs) in this channel fill deposit is documented only by a tooth fragment (PB1-21). The tooth is highly damaged, but the preserved part of the crown is completely covered by enamel. A strong medial carina is present on the crown, but the secondary ridges are absent. Relatively large denticles are disposed along the preserved margin, but without the marginal ridges reaching them. The apex is broken. The general morphology of the tooth is concordant with the teeth of *Telmatosaurus transsylvanicus* Nopcsa 1900 (NOPCSA, 1900) described by WEISHAMPEL et al. (1993).

Ornithopoda Marsh 1881
Euornithopoda (*sensu* Weishampel 1990)
Iguanodontia Sereno 1986
Rhabdodontidae Weishampel, Jianu, Csiki & Norman 2003
*Zalmoxes*Weishampel, Jianu, Csiki & Norman 2003
Zalmoxes sp. (Plate I, Figs. 8a; 8b)

The euornithopod *Zalmoxes* Weishampel, Jianu, Csiki & Norman 2003 (WEISHAMPEL et al., 2003), is documented by a single isolated and highly damaged tooth. The crown is slightly taller than wide. The enamel is distributed on both sides of the crown, but it is much damaged. The root is higher than the crown and labially curved, as in the *Zalmoxes* specimen from Nălaţ-Vad described by GODEFROIT et al. (2009). Despite the fact that the tooth is heavily damaged, in buccal view (Plate I, Fig. 8a) slightly divergent vertical ridges can still be noticed on the crown. The remains of *Zalmoxes* are the most abundant in the Maastrichtian of the “Haţeg Island”. Two species were coined, *Z. shquiperorum* Weishampel, Jianu, Csiki & Norman 2003 (WEISHAMPEL et al., 2003), and *Z. robustus* Nopcsa 1902 (NOPCSA, 1902). As CODREA & SOLOMON (2012) pointed out, isolated teeth are not indicative for one or another of these species.

Reptilia indet. (Plate II, Figs. 12; 13)

Apart the reptiles described above, a lot of indeterminate fragments belonging to various reptiles were extracted from theblock. The majority bear roll marks (e.g. Plate II, Fig. 12), or are broken (e.g. Plate II, Fig. 13) due to taphonomic processes.

TAPHONOMY

The remains are isolated, broken and some of them rounded, indicating a pre-burial transport. Usually, the vertebrate fossils found at Pui in the red beds, are white coloured. The ones from this channel fill block are dark coloured, resembling the teeth and bones reported (CODREA & SOLOMON, 2012; CODREA et al., 2013) from the dark mudstone deposits. Dark-coloured bones and teeth are indicative for fossilization processes that took place in poor oxygen content environments, where the bones were soon buried into the sediment. No microvertebrate remains were found in the block because the channel fill consists of coarse clasts which do not represent a proper environment for the fossilization of micro remains.

Following CSIKI et al. (2010a), the sedimentary facies of the block is in concordance with ”massive, structureless conglomerates and coarse conglomeratic sandstones, cross-bedded coarse and medium grained sandstones”, a near-channel facies, coded ”CH”, and interpreted as a channel fill. Also following their hierarchical classification of the taphonomic modes, in the block are present two groups of fossils: complete isolated bones, coded”A1” (e.g. teeth and one of the vertebrae), and incomplete isolated bones, coded ”A2” (in dominance). The remains from the block bear marking features for these two taphonomic modes, such as: for A1 - low degrees of weathering, abrasion, breakage; for A2 - advanced weathering, breakage, rarely identifiable taxonomically. However, a difference between the fossil assemblages from this block and the above mentioned taphonomic modes consist in the mix of taxa in the block, while in the coined modes there is only a mono-taxon.

CONCLUSIONS

The block extracted near the location called ”Pui Gater” (CODREA & SOLOMON, 2012) contained at least eight reptiles taxa, documented either by teeth, or cranial and postcranial bones. The majority of the remains belongs to crocodilians, an unusual aspect at Pui where the presence of crocodilians is usually, poor. At least two crocodiles, *A. precedens* and *Acynodon* sp. are documented in the fossil assemblage from the block. The vertebrate remains include also turtles, pterosaurs and various dinosaurs. No small vertebrates were found inside the block. Therefore, this channel fill may be interpreted as a high-energy deposit (storm deposit). It is possible that a flood took place bringing together teeth and bones originating from several skeletons. Obviously, no anatomical connection could be observed. The teeth and bones were carried by the water stream on various distances, but we cannot think to a very long lasting transport, as far as some bones were extremely fragile (i.e. pterosaurs). This taphonomic context could have been possible due the fact that the climate in “Haţeg Island” was subtropical, characterized by alternation of dry and rainy seasons (VAN ITTERBEECK et al., 2004; THERRIEN, 2005).

CSIKI et al. (2010a) even suggested that the genesis of some fossil assemblages from the Haţeg basin could be related to flooding events, and that these events preferentially concentrated the bones.

ACKNOWLEDGEMENTS

This research was supported by the grant PN-II-PCE-2011-3-0381 of the National Research Council of Romania. For one of us (Al.S.) this paper is also the result of a doctoral research financial supported by the Sectoral Operational Programme for Human Resources Development 2007-2013, co-financed by the European Social Fund, under the project POSDRU/159/1.5/S/133391 - **“Doctoral and postdoctoral excellence programs for training highly qualified human resources for research in the fields of Life Sciences, Environment and Earth”**. We thank Cristina Fărcaș for drawings on computer, Mihai Dumbravă, Răzvan Andrei, Emanoil Săsăran, and the owner of the saw mill for the help in extracting the block in the field. We thank Ioan Balintoni for his generous help for bringing the block to Cluj-Napoca, Dumitru Andreica for his contribution in extracting the fossils from the block, as well as the work of anonymous reviewers for their useful comments that greatly helped to improve the manuscript.

REFERENCES

ANASTASIU N. & CSOBUKA D. 1989. Non-marine uppermost Cretaceous deposits in the Stei-Densuș region (Hațeg Basin): sketch for a facial model [sic]. *Revue Roumaine de Géologie, Géophysique et Géographie-Géologie*. **33**: 43-53.

ANDREWS C.W. 1913. On some bird remains from the Upper Cretaceous of Transylvania. *Geological Magazine*. 1**0**: 193-196.

BENTON M. J., CSIKI Z., GRIGORESCU D., REDELSTORFF R., SANDER P. M., STEIN K., WEISHAMPEL D. P. 2010. Dinosaurs and the island rule: The dwarfed dinosaurs from Haţeg Island. *Palaeogeography, Palaeoclimatology, Palaeoecology*. **293**: 438-454.

BLANCO A, PUÉRTOLAS-PASCUAL E, MARMI J, VILA B, SÉLLÉS A.G. 2014. *Allodaposuchus palustris sp. nov.* from the Upper Cretaceous of Fumanya (South-Eastern Pyrenees, Iberian Peninsula): Systematics, Palaeoecology and Palaeobiogeography of the Enigmatic Allodaposuchian Crocodylians. *PLOS ONE*. **9(12):**e115837. doi:10.1371/journal.pone.0115837. (accessed: January 12, 2015).

BOJAR A.-V., GRIGORESCU D., CSIKI Z. 2005. Palaeoenvironmental interpretation of dinosaur- and mammal bearing continental Maastrichtian deposits, Haţeg basin, Romania. *Geological Quarterly*. **49**: 205-222.

BRUSATTE S. L., VREMIR M., CSIKI-SAVA Z., TURNER A. H., WATANABE A., ERICKSON G.M., NORELL M.A. 2013. The Osteology of *Balaur bondoc*, an Island-Dwelling Dromaeosaurid (Dinosauria: Theropoda) from the Late Cretaceous of Romania. *Bulletin of the American Museum of Natural History*. **374**: 1-100.

BUFFETAUT E., GRIGORESCU D., CSIKI Z. 2002. A new giant pterosaur with a robust skull from the latest Cretaceous of Romania. *Naturwissenschaften*. **89**: 180-184.

BUSCALIONI A. D., SANZ J. L., CASANOVAS M. L., SANTAFE J. V. 1986. An eusuchian crocodile from the Upper Cretaceous of Spain (Vilamitjana, province of Lérida). *Journal of Vertebrate Paleontology*. **6**: 209–214.

BUSCALIONI A. D., ORTEGA F., VASSE D. 1997. New crocodiles (Eusuchia, Alligatoroidea) from the Upper Cretaceous of Southern Europe. *Comptes Rendus de l'Académie des Sciences de Paris*. Institut de France Académie des Sciences. **335**: 525-530.

BUSCALIONI A. D., ORTEGA F., VASSE D. 1999. The Upper Cretaceous crocodilian assemblage from Lãno (Northcentral Spain): Implications in the knowledge of the Finicretaceous European faunas. *Estudios del Museo de Ciencias Naturales de Álava. Diputación Foral de Álava: Departamento de Cultura*. **14 (Núm. Espec. 1)**: 213-233.

CODREA V., SMITH T., DICA P., FOLIE A., GARCIA G., GODEFROIT P., VAN ITTERBEECK J. 2002. Dinosaur egg nests, mammals and other vertebrates from a new Maastrichtian site of the Haţeg Basin (Romania). *Comptes Rendus Palevol*. **1**: 173-180.

CODREA V. & DICA P. 2005. Upper Cretaceous-lowermost Miocene lithostratigraphic units exposed in Alba Iulia-Sebeş-Vinţu de Jos area (SW Transylvanian Basin). *Studia Universitatis Babeş-Bolyai*. Geologia. **50**: 19-6.

CODREA V. & GODEFROIT P. 2008. New Late Cretaceous dinosaur findings from northwestern Transylvania (Romania). *Comptes Rendus Palevol*. **7**: 289-295.

CODREA V., VREMIR M., JIPA C., GODEFROIT P., CSIKI Z., SMITH T., FĂRCAS C. 2010. More than just Nopcsa's Transylvanian dinosaurs: a look outside the Hațeg Basin. *Palaeogeography, Palaeoclimatology, Palaeoecology*. **293**: 391–405.

CODREA V. & SOLOMON A. 2012. Peculiar fossilization and taphonomy in Maastrichtian terrestrial deposits of Pui (Haţeg Basin, Romania). *Studii şi cercetări (Geologie-Geografie)*. **17**: 51-69.

CODREA V., GODEFROIT P., SMITH T. 2012. *First Discovery of Maastrichtian (Latest Cretaceous) Terrestrial Vertebrates in Rusca Montană Basin (Romania)*. In: Bernissart Dinosaurs and Early Cretaceous Terrestrial Ecosystems (Godefroit P. ed.). Indiana University Press: 571-581.

CODREA V., SOLOMON A., FĂRCAȘ C., BARBU O. 2013. On some local restricted local Maastrichtian environments of the "Hațeg Island" (Transylvania, Romania). *Bulletin of the Geological Society of Greece XLVII*. N**o. 1**: 82-91.

CODREA V., SOLOMON A., VENCZEL M., SMITH T. 2014. A new kogaionid multituberculate mammal from the Maastrichtian of the Transylvanian Basin, Romania. *Comptes Rendus Palevol*. **13**: 489-499.

CSONTOS L. & VÖRÖS A. 2004. Mesozoic plate tectonic reconstruction of the Carpathian region. *Palaeogeography, Palaeoclimatology, Palaeoecology*. **210**: 1-56.

CSIKI Z. & GRIGORESCU D. 1998. Small theropods of the Late Cretaceous of the Hațeg Basin (western Romania)-an unexpected diversity at the top of the food chain. *Oryctos*. **1**: 87-104.

CSIKI Z., IONESCU A., GRIGORESCU D. 2008. The Budurone microvertebrate site from the Maastrichtian of the Haţeg Basin - flora, fauna, taphonomy and paleoenvironment. *Acta Palaeontologica Romaniae*. **6**: 49-66.

CSIKI Z., GRIGORESCU D., CODREA V., THERRIEN F. 2010a. Taphonomic modes in the Maastrichtian continental deposits of the Haţeg Basin, Romania-Palaeoecological and palaeobiological inferences. *Palaeogeography, Palaeoclimatology, Palaeoecology*. **293**: 375-390.

CSIKI Z., VREMIR M., BRUSATTE S. L., NORELL, M. A. 2010b. An aberrant island-dwelling theropod dinosaur from the Late Cretaceous of Romania. *Proceedings of the National Academy of Sciences of the United States of America*. **107 (35)**: 15357-15361.

CSIKI Z., CODREA V., JIPA-MURZA C., GODEFROIT P. 2010c. A partial titanosaur (Sauropoda, Dinosauria) skeleton from the Maastrichtian of Nălaţ-Vad, Haţeg Basin, Romania. *Neues Jahrbuch für Geologie und Paläontologie - Abhandlungen*. **258(3)**: 297-324.

DE LAPPARENT F., CODREA V. A., SMITH T., GODEFROIT P. 2009. *New turtle remains (Kallokibotionidae, Dortokidae) from the Upper Cretaceous of Transylvania (Romania).* In: The 7th International Symposium of Paleontology (Bucur I., Săsăran E., Pop D. eds), Cluj-Napoca, Romania. Abstract Volume: 68-69.

DELFINO M., CODREA V., FOLIE A., DICA P., GODEFROIT P., SMITH T. 2008a. A complete skull of *Allodaposuchus precedens* NOPCSA, 1928 (Eusuchia) and a reassessement of the morphology of the taxon based on the Romanian remains. *Journal of Vertebrate Paleontology*. **28(1**): 111-122.

DELFINO M., MARTIN J., BUFFETAUT E. 2008b. A new species of *Acynodon* (Crocodylia) from the Upper Cretaceous (Santonian–Campanian) of Villaggio del Pescatore, Italy. *Palaeontology*. **51**: 1091-1106.

DERCOURT J., GAETANI M., VRIELYNCK B., BARRIER E., BIJU-DUVAL B., BRUNET M., CADET J. P., CRASQUIN S., SANDULESCU N. (Eds.) 2000. *Atlas peri-Tethys, palaeogeographical maps.* CCGM/CGMW. Paris. 269 pp.

GAFFNEY E. S. & MEYLAN P. A. 1992. The Transylvanian Turtle, Kallokibotion, A Primitive Cryptodire of Cretaceous Age. *American Museum Novitates*. American Museum of Natural History. **3040**: 1-37.

GODEFROIT P., CODREA V., WEISHAMPEL D. B. 2009. Osteology of *Zalmoxes shqiperorum* (Dinosauria, Ornithopoda), based on new specimens from the Upper Cretaceous of Nălaţ-Vad (Romania). *Geodiversitas*. **31(3)**: 525-553.

GRELLET-TINNER G. & CODREA V. A. 2014. *Thalassodromeus sebesensis*, an out of place and out of time Gondwanan tapejarid pterosaur. *Gondwana Research* : http://dx.doi.org/10.1016/j.gr.2014.06.002. (accessed: January 10, 2015).

GRIGORESCU D. 1992. *Nonmarine Cretaceous Formations of Romania*. In: Aspects of Nonmarine Cretaceous Geology (Matter N. J. & Pei-Ji Ch. eds.). Beijing. China Ocean Press: 142-164.

GRIGORESCU D.2010. The Latest Cretaceous fauna with dinosaurs and mammals from the Hațeg basin – A historical overview. *Palaeogeography, Palaeoclimatology, Palaeoecology*. **293**: 271–282.

GRIGORESCU D. & ANASTASIU N. 1990. *Densuş-Ciula and Sînpetru formations (Late Maastrichtian-?Early Paleocene)*. In: Field Guide of the IGCP Projects 245 (Non-marine Cretaceous Correlation) and 262 (Tethyan Cretaceous Correlation) International Symposium (Grigorescu D., Avram E., Pop G., Lupu M., Anastasiu N., Rădan S. eds.). Institute of Geology and Geophisics. Bucharest: 42-54.

GRIGORESCU D., HARTENBERGER J.-L., RĂDULESCU C., SAMSON P. M., SUDRE J. 1985. Découverte de mammiféres et Dinosaures dans le Crétacé supérieur de Pui (Roumanie). *Comptes Rendus de l'Académie des Sciences.* Paris II. **19**: 1365-1368.

GRIGORESCU D., ȘECLĂMAN M., NORMAN D. B., WEISHAMPEL D. B. 1990. Dinosaur eggs from Romania. *Nature*. **346**: 417.

GRIGORESCU D., VENCZEL M., CSIKI Z., LIMBEREA R. 1999. New latest Cretaceous microvertebrate fossil assemblages from the Haţeg Basin (Romania). *Geologie en Mijnbouw*. **78**: 301-314.

HALAVÁTS GY. 1897. Adatok a Hátszegi medence földtani viszonyainak ismeretéhez. *Magyar Királyi Földtani Intézet*, Évi Jelentések. 1896-ról: 90–95.

NOPCSA F. 1897. Vorläufiger Bericht über das Auftreten von oberer Kreide im Hátszeger Thale in Siebenbürgen. *Verhandlungen der Kaiserlich-Könighlichen Akademie des Wissenschaften*: 273–274.

NOPCSA F. 1899. Jegyzetek a Hátszeg vidékének geológiájához. *Földtani Közlöny*. Budapest. **29**: 332–335.

NOPCSA F. 1900. Dinosaurierreste aus Siebenbürgen. 1. Schädel von *Limnosaurus transsylvanicus* nov.gen. et spec. *Denkschriften der königlichen Akademie der Wissenschaften*. **69**: 555-591.

NOPCSA F. 1902. Dinosaurierreste aus Siebenbürgen II. (Schädelreste von *Mochlodon*). *Denkschriften der königlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Klasse*.**72**: 149-175.

NOPCSA F. 1905. Geology of Alba Iulia, Deva, Rusca Montană and the territory to the Romanian borders. *A Magyar Királyi Földtani Intézet Évkönyve*. Budapest. **14**: 82-254 [in Hungarian].

NOPCSA F. 1914. Über das Vorkommen der Dinosaurier in Siebenbürgen. *Verhandlungen der Zoologischen und Botanischen gessellschaft*. **54**: 12-14.

NOPCSA F. 1915. Die dinosaurier der Siebenbürgischen landesteile Ungarns. *Mitteilungen aus dem Jahrbuche der Königlich-Ungarischen Geologischen Reichsanstalt*. Wien. **23**: 1-24.

NOPCSA F. 1923. The geological importance of the primitive reptilian fauna in the uppermost Cretaceous of Hungary; with a description of a new tortoise (*Kallokibotion*). *Quarterly Journal of the Geological Society of London*. **89**: 100-116.

NOPCSA F. 1928. Paleontological notes on Reptilia. 7. Classification of the Crocodilia. *Geologica Hungarica*. Series Palaeontologica. **1**: 75-84.

PANAIOTU C. & PANAIOTU C. 2010. Palaeomagnetism of the Upper Cretaceous Sânpetru Formation (Haţeg Basin, South Carpathians). *Palaeogeography, Palaeoclimatology, Palaeoecology*. **293**: 343-352.

RABI M. & VREMIR M. 2011. *Evolution of dortokid turtles in the Late Cretaceous - Paleogene of Europe*. 9th Annual Meeting of the European Association of Vertebrate Palaeontologists. Heraklion. **Abstract Volume**: 48-49.

SMITH, T., CODREA V., SĂSĂRAN E., VAN ITTERBEECK J., BULTYNCK P., CSIKI Z., DICA P., FĂRCAŞ C., FOLIE A., GARCIA G., GODEFROIT P. 2002. A new exceptional vertebrate site from the Late Cretaceous of the Haţeg Basin (Romania). *Studia Universitatis Babeş-Bolyai Geologia*. Special Issue**. 1**: 321-330.

SILYE L., CODREA V., COLIN J. P. 2014. *Globotalicypridea mirabilis* sp. nov. - the first non-marine ostracod taxon from the Upper Cretaceous of the Haţeg Basin, Romania. *Annales de Paléontologie*. **100**: 273-280.

THERRIEN F. 2005. Paleoenvironments of the Late Cretaceous (Maastrichtian) dinosaurs of Romania: insights from fluvial deposits and paleosols of the Transylvanian and Haţeg basins. *Palaeogeography, Palaeoclimatology, Palaeoecology*. **218(1-2)**: 15-56.

THERRIEN F. 2006. Sedimentary facies, depositional environments, and fluvial system changes in the dinosaur bearing Sânpetru Formation (Late Cretaceous, Maastrichtian), Romania. *Sedimentary Geology*. **192**: 183–205.

THERRIEN F., ZELENITSKY D. K., WEISHAMPEL D. B. 2009. Palaeoenvironmental reconstruction of the Late Cretaceous Sânpetru Formation (Hațeg Basin, Romania) using paleosols and implications for the "disappearance" of dinosaurs. *Palaeogeography, Palaeoclimatology, Palaeoecology*. **272(1-2)**: 7-52.

VASILE Ş. 2008. A new microvertebrate site from the Upper Cretaceous (Maastrichtian) deposits of the Haţeg Basin. *Sargetia. Acta Musei Devensis. Series Scientia Naturae*. **21**: 4-14.

VASILE Ş. & PANAITESCU D. 2012. *Primele resturi de vertebrate din "mlaştina" Cretacicului terminal de la Pui (Bazinul Haţeg, România)*. Lucrările celui de-al XI-lea Simpozion Naţional Studenţesc "Geoecologia": 59-62.

VAN ITTERBEECK J., SĂSĂRAN E., CODREA V., SĂSĂRAN L., BULTYNCK P. 2004. Sedimentology of the Upper Cretaceous mammal- and dinosaur-bearing sites along the Râul Mare and Bărbat rivers, Haţeg Basin, Romania. *Cretaceous Research*. **25**: 517-530.

VAN ITTERBEECK J., MARKEVICH V. S., CODREA V. 2005. Palynostratigraphy of the Maastrichtian dinosaur and mammal sites of the Râul Mare and Bărbat Valleys (Haţeg Basin, Romania). *Geologica Carpathica*. **56**: 137-147.

VON HUENE F. 1932. Die fossile Reptile-Ordnung Saurischia ihre Entwicklung und Geschichte. *Monographien zur Geologie und Palaeontologie.* **1**: 1-361.

VREMIR M. & CODREA V. 2009. *Late Cretaceous turtle diversity in Transylvanian and Hațeg basins (Romania)*. The 7th Romanian Symposium of Palaeontology (Bucur I., Săsăran E, Pop D. eds.), Cluj-Napoca, Romania. Presa Universitară Clujeană. Cluj-Napoca. Abstract Volume: 122-124.

VREMIR M., KELLNER A. W. A., NAISH D., DYKE G. J. 2013. A new Azhdarchid Pterosaur from the late Cretaceous of the Transylvanian Basin, Romania: implications for Azhdarchid diversity and distribution. *PLOS ONE*. **8(1)**: e54268. http://dx.doi.org/10.1371/journal. pone.0054268. (accessed: January 08, 2015).

WEISHAMPEL D. B., NORMAN B. D., GRIGORESCU D. 1993. *Telmatosaurus transsylvanicus* from the Late Cretaceous of Romania: the most basal hadrosaurid dinosaur. *Paleontology*. **36**: 361-385.

WEISHAMPEL D. B., JIANU C.-M., CSIKI Z., NORMAN D. B. 2003. Osteology and phylogeny of *Zalmoxes* (n. g.), an unusual Euornithopod dinosaur from the latest Cretaceous of Romania. *Journal of Systematic Palaeontology*. **1(2)**: 65-123.

Solomon Alexandru, CodreaVlad
"Babeș-Bolyai" University Cluj-Napoca, Faculty of Biology and Geology,
Department of Geology, 1, M. Kogălniceanu Str., RO-400084, Cluj-Napoca, Romania.
E-mail: alex_solomon88@yahoo.com; codrea_vlad@yahoo.fr

Received: January 28, 2015
Accepted: July 13, 2015:

Plate I: Maastrichtian terrestrial reptiles from Pui

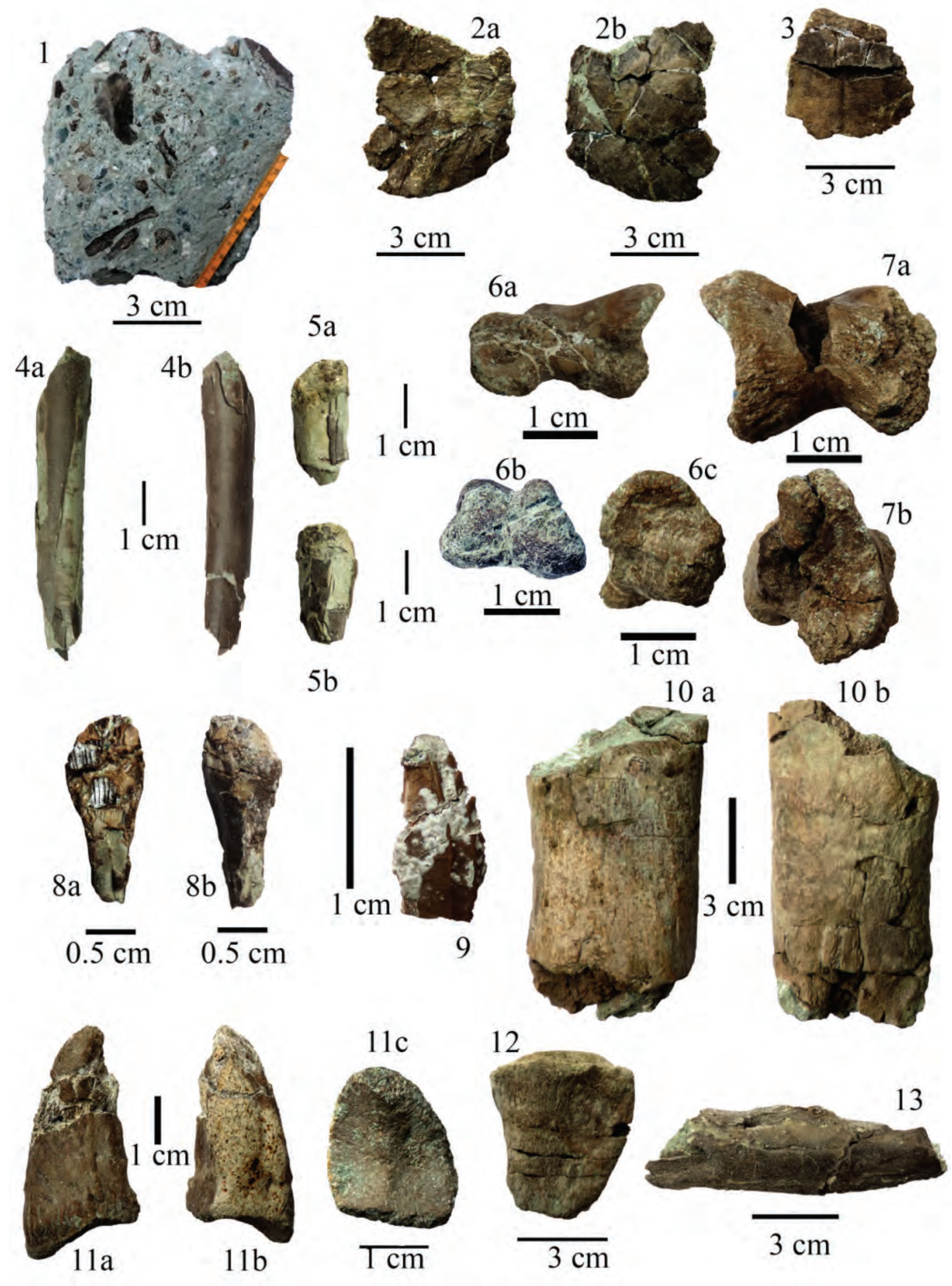

Figure 1. A block fragment illustrating the high concentration of fossils;
Figure 2. a - Chelonia indet., carapace fragment, internal view (PB1-38); b - carapace fragment, external view (PB1-38);
Figure 3. Chelonia indet., carapace fragment external view (PB1-39);
Figures 4a, b. Pterosauria indet., bone fragment (PB1-27);
Figures 5a, 5b. Pterosauria indet., bone fragment (PB1-28);
Figure 6. Theropoda indet., fragmentary phalanx (PB1-33): a. lateral view, b. distal view, c. proximal view;
Figure 7. Theropoda indet., fragmentary phalanx (PB1-34): a. lateral view, b. proximal view;
Figure 8. *Zalmoxes* sp., isolated tooth (PB1-20): a. buccal view, b. lingual view;
Figure 9. *Telmatosaurus transsylvanicus*, isolated tooth fragment, buccal view (PB1-21);
Figure 10. Titanosauria indet., mid-shaft fragment (PB1-30): a. caudal view, b. cranial view;
Figure 11. Titanosauria indet., ungual phalanx (PB1-36): a. lateral view, b. medial view, c. proximal view;
Figure 12. Reptilia indet., bone fragment (PB1-40);
Figure 13. Reptilia indet., bone fragment (PB1-41).

Plate II: Maastrichtian crocodiles from Pui

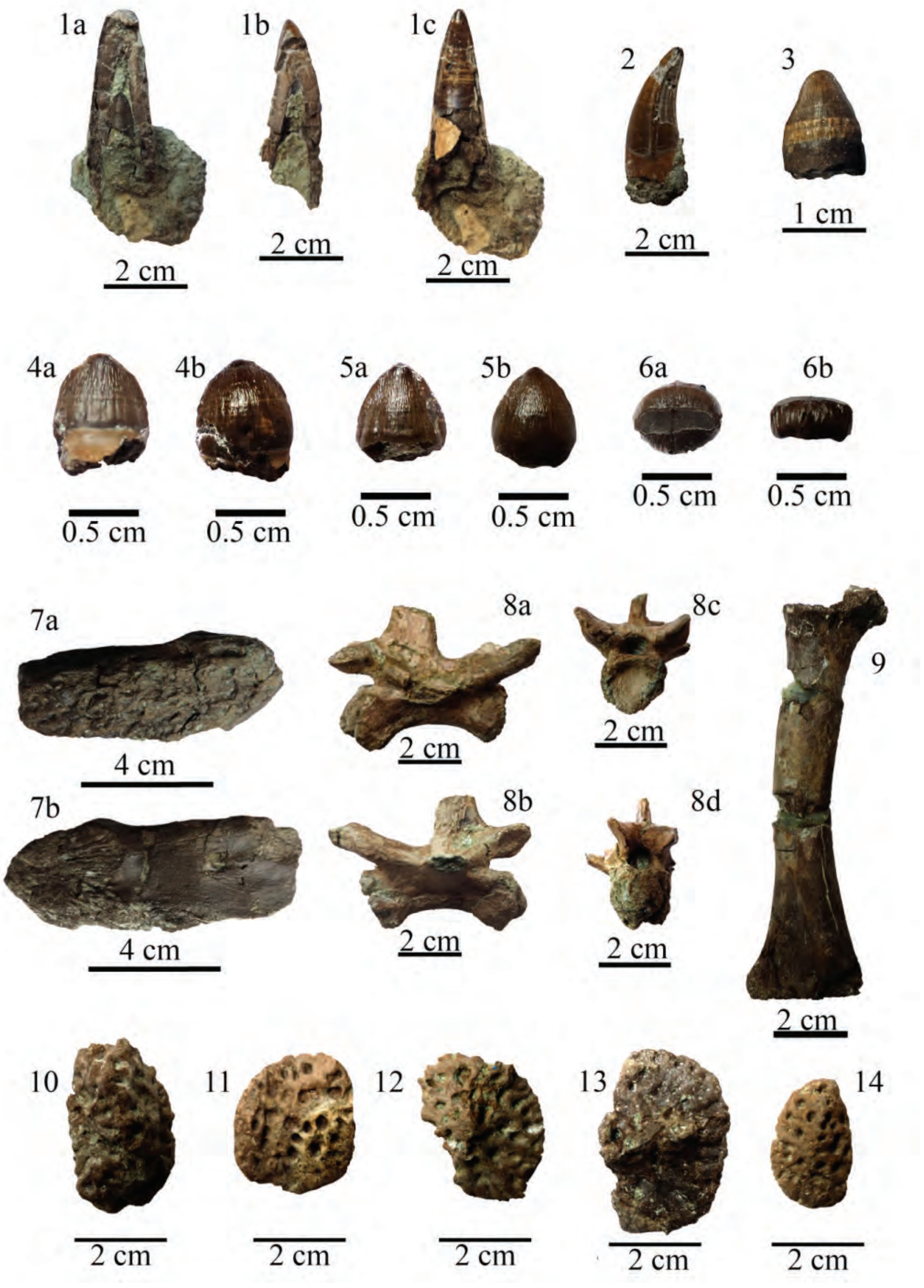

Figure 1. *Allodaposuchus precedens*, isolated tooth (Pb1-1): a, b. the broken tooth with the replacing tooth inside; c. lingual view;
Figure 2. *A. precedens*, isolated tooth, mesial view (Pb1-2);
Figure 3. *A. precedens*, isolated tooth, labial view (Pb1-7);
Figure 4. *Acynodon* sp., isolated tooth (Pb1-15): a. lingual view, b. labial view;
Figure 5. *Acynodon* sp, isolated tooth (Pb1-16): a. lingual view, b. labial view;
Figure 6. *Acynodon* sp, isolated tooth (Pb1-18): a. dorsal view, b. lateral view;
Figure 7. Crocodylia indet., surangular articular fragment (PB1-28): a. outer view, b. inner view;
Figure 8. Crocodylia indet., caudal vertebra (PP1-22): a, b. lateral views , c. anterior view, d. posterior view;
Figure 9. Crocodylia indet., tibia in caudal view (PB1-26);
Figure 10. Crocodylia indet., osteoderm in dorsal view (PB1-45);
Figure 11. Crocodylia indet., osteoderm in dorsal view (PB1-46);
Figure 12. Crocodylia indet., osteoderm in dorsal view (PB1-47);
Figure 13. Crocodyli aindet., osteoderm in dorsal view (PB1-49);
Figure 14. Crocodylia indet., osteoderm in dorsal view (PB1-52).