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A NEW MICROVERTEBRATE SITE FROM THE UPPER CRETACEOUS (MAASTRICHTIAN) DEPOSITS OF THE HAȚEG BASIN

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Abstract
A new microvertebrate site from the Upper Cretaceous (Maastrichtian) deposits of the Hațeg Basin

The Upper Cretaceous (Maastrichtian) continental deposits of the Hațeg Basin are well known for the diverse vertebrate assemblage they have yielded. Most of the taxa have been identified through intense micropaleontological processing of the material collected from across the basin.

The floodplain deposits from several sites around the village of Vălioara are abundant in microvertebrate remains. This paper reports on the most important fossil remains recorded from a new site near Vălioara, first sampled in 2007, as well as the main sedimentary features presented by the deposits from this site.

The fossil remains mainly consist of isolated teeth belonging to different crocodilian, theropod and multituberculate taxa, hosted by a gray-greenish pebbly mudstone, deposited within a poorly drained floodplain environment.

Key words: microvertebrate, Upper Cretaceous, Maastrichtian deposits, Hațeg Basin

Rezumat
Un nou sit cu microvertebrate din depozitele continentale Cretacic Superior (Maastrichtian) din Bazinul Hațeg

Depozitele continentale Cretacic Superior (Maastrichtian) din Bazinul Hațeg sunt bine cunoscute pentru asociația diversă de vertebrate. Cei mai mulți taxoni au fost identificați în urma procesării micropaleontologice intense a materialului prelevat de pe întinsul bazinului.

Depozitele de câmpie inundabilă ce aflorează în câteva puncte din jurul satului Vălioara sunt bogate în resturi de microvertebrate. Această lucrare prezintă cele mai importante resturi de microvertebrate înregistrate dintr-un nou punct fosilifer din această zonă, probat pentru prima dată în 2007, precum şi principalele caracteristici sedimentare prezentate de depozitele din acest punct.

Resturile fosile constau în special în dinți izolați aparținând unor crocodilieni, theropode şi mamifere multituberculate, conținute de o argilă cenuşiu-verzuie cu elemente ruditice, depusă într-un mediu de câmpie inundabilă slab drenată.

Cuvinte cheie: microvertebrate, depozite Cretacic superior, Maastrichtian, Bazinul Hațeg

Introduction

The first Latest Cretaceous vertebrate remains from the Hațeg Basin have been reported by Franz Nopcsa at the end of the 19th and the beginning of the 20th century. He described a megafaunal assemblage of 10 taxa (crocodilians, chelonians and dinosaurs), of which 6 were confirmed by more recent revisions. Most of the taxa reported from the Hațeg Basin were discovered in the last three decades, after the research activity in the area was reinitiated by D. Grigorescu (GRIGORESCU 2005). During this period, a great part of the newly discovered taxa has been found by bulk micropaleontological processing of fossiliferous material from the Maastrichtian continental deposits of the Hațeg Basin.

The micropaleontological material is of great importance in the attempt to reconstruct the paleoenvironmental conditions or the ecological relationships within the local ecosystem. One of the most important micropaleontological fossil sites is located near the village of Vălioara (Fig. 1), on the left slope of the Fântânele Creek. The classical fossil site of Fântânele has yielded a rich and diverse vertebrate fauna (GRIGORESCU et al. 1999; CSIKI & GRIGORESCU 2000), comprising fossil remains from many vertebrate groups (fishes, anurans, albanerpetontids, lizards, chelonians, crocodilians, dinosaurs and mammals), as well as several types of eggshells and freshwater gastropod shells (PANĂ et al. 2002).

In the summer of 2007, some 60 kg of material has been collected from a site close to the classic microvertebrate fossil site of Fântânele, on the right slope of the same valley, from a bed with a similar lithofacies. This new site, described in the present contribution, proved to be slightly different from the classic site of Fântânele in lithology and taphonomy, and will be referred to hereon as Fântânele 2, whilst the first microvertebrate site from Fântânele will be referred to as Fântânele 1.

Geological setting

Covered by vegetated soil and bounded by beds of red mudstones, the fossiliferous layer from Fântânele 2 that yielded microvertebrate remains consists of a gray-greenish massive mudstone that contains subrounded ruditic clasts of metamorphic origin, up to 3 cm long. The fossiliferous mudstone from Fântânele 2 is located in a geometrically lower position on the right slope of the valley than the one from Fântânele 1 on the opposite side, but the exact stratigraphic relationship between the two beds is not well established; some torrents that cut the valley slopes suggest a more complicated tectonic setting of the deposits from that area, with the probable presence of faults cross-cutting the Maastrichtian deposits.

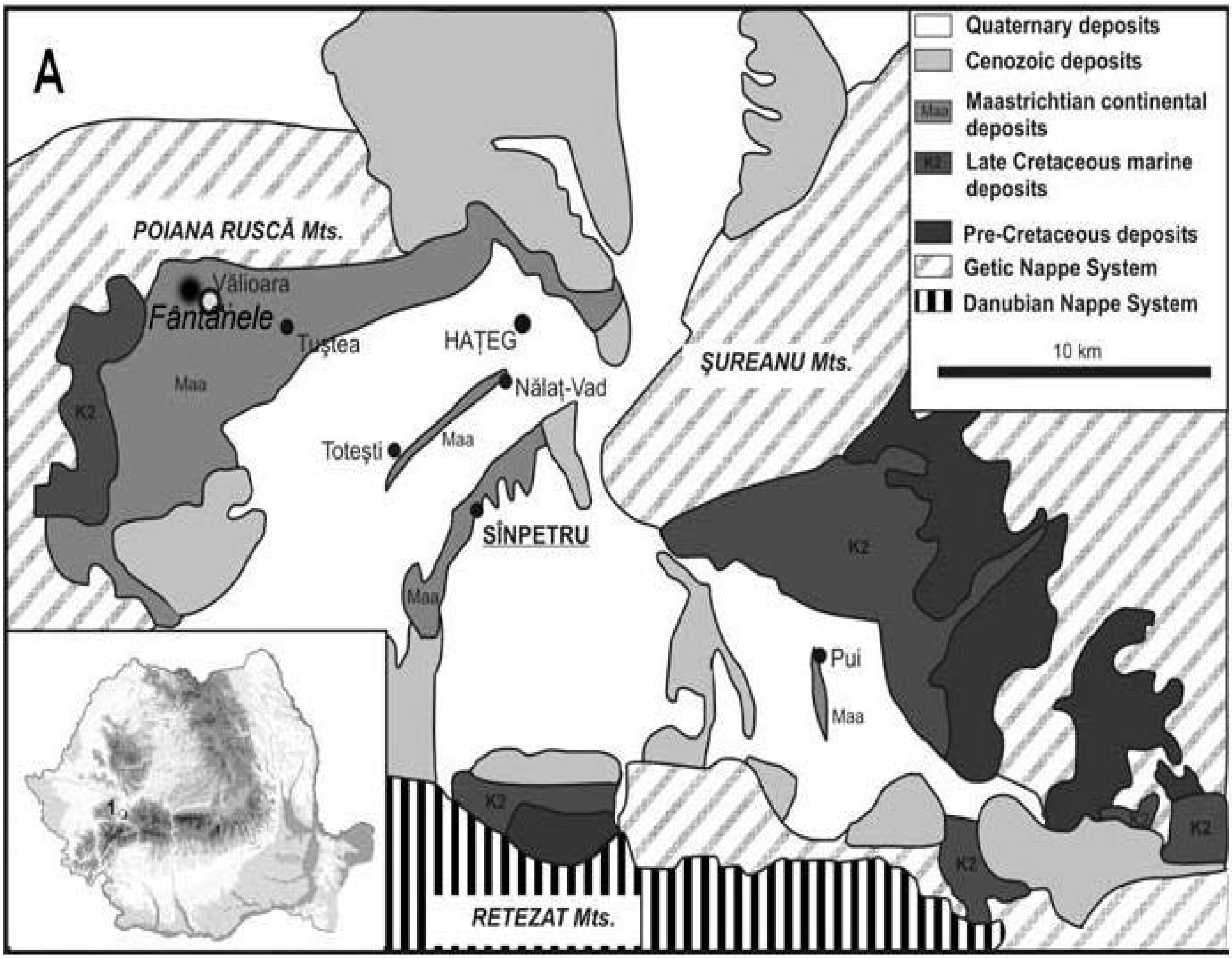

Fig. 1. Simplified geological map of the Haţeg Basin, showing the location of the Fântânele (1 & 2) microvertebrate sites, near the village of Vălioara; inset shows the position of the Haţeg Basin. (After CSIKI et al. 2008)

According to its geographic position, lithology and structural setting, the new microvertebrate fossil site of Fântânele 2 belongs to the middle member of the Densuş-Ciula Formation, already known to outcrop in the northwestern part of the Haţeg Basin (GRIGORESCU 1992; GRIGORESCU & CSIKI 2002; GRIGORESCU 2005).

The main lithological difference as compared to the Fântânele 1 section is the presence of ruditic clasts, common for the Fântânele 2 deposits, but only occasionally occurring in those of the Fântânele 1 site. The presence of larger clasts suggests somewhat higher basin energy for the depositional environment at Fântânele 2; otherwise it presents the same characteristic features of a reducing, poorly drained braided river floodplain environment as the Fântânele 1 deposits (GRIGORESCU & CSIKI 2002).

Material and methods

After a small portion of the slope has been stripped of soil, and the appropriate bed was identified, the sediment was loaded into bags and transported for further processing. A total of around 140-150 kg of sediment was sampled during the field campaigns of 2007 and 2008. The sediment was dried, and then soaked into buckets for about two days, until the clayey matrix broke down into mud. To help the matrix breakdown, some hydrogen peroxide was added, in low concentrations (below 5%).

The resulting mud was then preliminarily screen-washed using a 2 mm and 0.71 mm mesh sieve battery in the waters of the Galbena River, the procedure screen-washing being repeated in the laboratory afterwards. After being thoroughly dried, the remaining material was sorted under a Zeiss GSZ optical microscope. The pictures from Fig. 2 have been taken using a Nikon Coolpix 990 and a Canon PowerShot 640 digital camera mounted on a Zeiss Stemi SV 11 and on a Zeiss Stemi 2000-C optical microscope, respectively.

Results and discussions

The fossil material mostly consists of unidentifiable bone fragments, generally less than 2 mm in diameter. This degree of fragmentation can be a consequence of the higher basin energy; alternatively, it can suggest an advanced degree of (probably intraformational) reworking of the largest part of the fossil material. The best preserved elements, grace to their stronger bone structure, are the isolated teeth.

Although the first fossil remains recovered from the deposits of Fântânele 2 in 2007 were represented only by abrasion-resistant chelonian, crocodilian, theropod and multituberculate remains (this selectivity being probably due to the higher-energy depositional environment than the one from Fântânele 1), recent preliminary screening of the material collected in 2008 suggests an even higher microvertebrate diversity for the Fântânele 2 assemblage. Anuran and albanerpetontid skeletal remains have been identified, as well as an eggshell fragment, along with new crocodilian tooth morphotypes, previously not reported from the Haţeg Basin.

The anurans are represented by a fragment of the right ilium (FGGUB v.510: Fig. 2a), which preserves a small anterior part of the acetabular region and part of the iliac shaft and crest. The features of this fragment are similar to those reported in the holotype specimen of *Paralatonia transylvanica* (VENCZEL & CSIKI 2003).

The albanerpetontids are represented by a conical half-vertebra (FGGUB v.512: Fig. 2c) and a dentary fragment (FGGUB v.511: Fig. 2b). The amphicoelous albanerpetontid trunk or caudal vertebrae are known to be hourglass-shaped (FOLIE & CODREA 2005), while the dentary fragment is poorly preserved, conserving only the basal part of the slender needle-like pleurodont teeth (GRIGORESCU et al. 1999).

The crocodilian remains are most abundant: six dental morphotypes belonging to at least three taxa have been found.

A first dental morphotype consists of the basal portion of a conical tooth, with well-developed marginal carinae, bearing blunt robust denticles (FGGUB v.507: Fig. 2d.). The tooth is constricted at the base, and is similar in morphology to the ziphodont crocodyliform *Doratodon*, a taxon already reported from the Haţeg Basin (MARTIN et al. 2006), but also mentioned from the Late Cretaceous of Spain (COMPANY et al.. 2005) or Austria (BUNZEL 1871).

Another ziphodont tooth morphology is represented by an equilateral triangle-shaped, strongly labiolingually compressed tooth crown, also showing a basal constriction (FGGUB v.513: Fig. 2g.-h.). This dental morphotype also has carinae bearing the same kind of denticles as the previous one. On both labial and lingual side a faint central ridge going from base to tip, bounded by two shallow grooves, can be observed. The lingual side is slightly concave, giving the tooth a spatulated appearance. This morphotype is very likely to represent a more posterior *cf*. *Doratodon* tooth (GRIGORESCU et al. 1999; MARTIN et al. 2006), in respect to the above-mentioned more anterior one.

A third morphotype is represented by sub-conical teeth, slightly recurved to the blunt tip, slightly constricted at the base (FGGUB v.514: Fig. 2e-f). The lingual side of the tooth is flattened and the unserrated carinae can only be seen in lingual view. This type of crocodilian teeth is similar to the one previously described as "troodontid-like" theropod tooth (FGGUB R.1218; CSIKI & GRIGORESCU 1998), but recently considered to represent a crocodilian morphotype (Z. Csiki, 2009, verbal communication). The two morphotypes differ by the position of the carinae, lying close to the sagittal plane in FGGUB R.1218, and their serrated character in the latter specimen. In the morphotype described here, the carinae are not serrated and they are migrated to the lingual side, in respect to the ones described by CSIKI & GRIGORESCU (1998). This variation in the position of the carinae is known to occur among the anterior dentary/premaxillary and posterior dentary/maxillary teeth of theropods (CURRIE et al. 1990) and ziphosuchians, such as *Doratodon*. The morphotype described here is tentatively attributed to *Doratodon*, but further study is needed to thoroughly assess its taxonomical affinities.

A crocodilian dental type never reported before from the Haţeg Basin consists of one button-like tooth crown, presenting a low, blunt, rounded profile (FGGUB v.515: Fig. 2i-j). In occlusal view, the outline is nearly oval, with a small constriction mid-length that suggest a slight kidney shape. The enamel shows a distinct ornamentation, with a longitudinal crest from which fine wrinkles radiate on the sides of the crown. The wrinkles disappear near the base, where the enamel becomes smooth. The antero-posterior diameter of the tooth is around 5 mm. The features and size of this dental morphotype are similar to those of *Bernissartia*, a tribodont crocodile known from the Lower Cretaceous ("Wealden") deposits of Belgium, England, Spain, and, possibly the United States (BUFFETAUT & FORD 1979). However, the same dental morphotype has been encountered (J. M. Martin, 2009, written communication, unpublished data; MARTIN 2007) among the *Acynodon* material from the Late Cretaceous of southern France. Based on the occurrence of *Acynodon*-like teeth in the Haţeg Basin (MARTIN et al. 2006), it seems more likely to consider this morphotype as *cf. Acynodon* posterior tooth. The presence of posterior blunt, short, rounded teeth has been associated to a durophagous diet (turtles, mollusks, etc.) (*e.g.* BUFFETAUT & FORD 1979), as such a dental morphology is much more suitable for crushing purposes than a long and slender tooth shape. This adaptation may represent a feeding specialization, where crocodiles fed mostly on hard-shelled animals, but it could also represent a feeding versatility, allowing them to complete their diet with such prey.

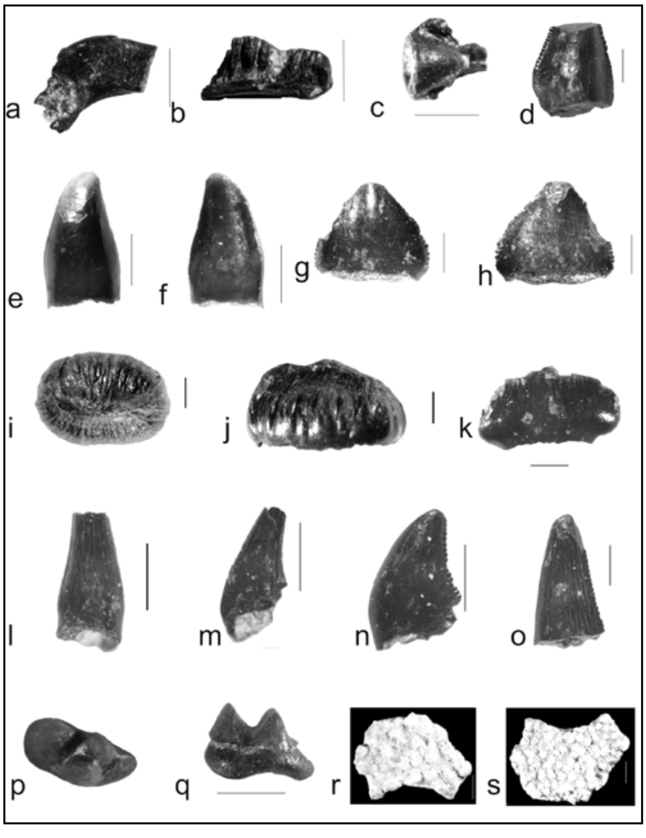

Fig. 2. Microvertebrate remains from the Fântânele 2 fossil site, Haţeg Basin, Romania. a. *Paralatonia* right ilium, right lateral view (FGGUB v.510); b. Albanerpetontid left dentary, lingual view (FGGUB v.511); c. Albanerpetontid half-vertebra (FGGUB v.512); d. *cf. Doratodon* anterior ziphodont tooth (FGGUB v.507); e.-f. *Doratodon?* tooth (FGGUB v.514) in labial and, respectively, labial view; g.-h. *cf. Doratodon* ziphodont posterior tooth (FGGUB v.513) in labial and, respectively, lingual view; i.-j. *cf. Acynodon* posterior crushing tooth (FGGUB v.515) in occlusal and, respectively, labial view; k.-l. Indeterminate crocodilyform: posterior (FGGUB v.506) and, respectively, anterior (FGGUB v.509) tooth morphotype, both in labial view; m. *cf. Euronychodon* (FGGUB R.2080); n. Velociraptorine dromeosaurid (FGGUB R.2081); o. *cf. Richardoestesia* (FGGUB R.2079); p.-q. Indeterminate kogaionid, PM1 (FGGUB M.1654) in occlusal and, respectively, lateral view; r.-s. Megaloolithid eggshell fragment, outer and, respectively, inner morphology. Scale bar: 1 mm

Two dental morphotypes may come from the same taxon. The first morphotype (FGGUB v.509: Fig. 2k) shows a high conical crown, with a well-marked basal constriction, with small lateral carinae, or none at all. The tooth crown is more convex labially, leading to a slight labiolingual curvature of the tooth. The second morphotype (FGGUB v.506, Fig. 2 l) is represented by a wide and short leaf-shaped tooth crown, also constricted at the base, labiolingually compressed and labially more convex, having a spatulated aspect. A skull fragment previously recovered from the Tuştea nesting site, in Maastrichtian continental deposits of the same formation as those of Fântânele 2 presents a peculiar abrupt change in dental morphology between the anterior and posterior teeth (MARTIN et al. 2006). The former of the two morphotypes described above is similar to the anterior maxillary teeth from this skull fragment, while the latter morphotype appears on the posterior maxillary portion.

The theropods are also well represented at Fântânele 2, and only by isolated teeth; 3 different morphotypes, belonging to different taxa, can be separated. The theropods from the Hațeg Basin are represented mainly by small cursorial forms, around one meter tall, comprising maybe as much as nine taxa (GRIGORESCU 2005).

A taxon reminiscent of *Euronychodon* (ANTUNES & SIGOGNEAU-RUSSEL 1991) is represented by the basal part of a small, elongated, strongly recurved tooth that exhibits unserrated mesial and distal carinae (FGGUB R.2080: Fig. 2m); it is similar to specimens already mentioned from the Hațeg Basin (CODREA et al. 2002; GRIGORESCU & CSIKI 1998). The tooth crown is strongly convex on the labial side and flat on the lingual side. Two longitudinal grooves appear on the lingual side, near the carinae, being separated by a median ridge. The mesial groove is deeper and narrower, while the distal groove is shallow and wide.

The dromeosaurid (possibly velociraptorine) theropods are represented by a laterally compressed and strongly recurved tooth (FGGUB R.2081: Fig. 2n). Both the mesial and distal edges are convex and strongly recurved so that the tip projects behind the base of the crown. The distal carina, very well developed, is serrated from tip to base, while the anterior one has very small denticles, at most on the apical half. The denticles on the distal carina decrease in size from base to tip, and are generally straight and perpendicular to the tooth axis (GRIGORESCU & CSIKI 1998).

Another incomplete theropod tooth shows morphological features similar to those of *Richardoestesia* (SANKEY et al., 2002). The tooth crown is subconical, slightly compressed labiolingually, and it lacks variations in convexity or curvature (FGGUB R.2079: Fig. 2o). The tooth shows a serrated carina, bearing from tip to the base of the preserved fragment denticles that do not show size variation. This type of teeth has also been previously described from the Hațeg Basin (GRIGORESCU & CSIKI, 1998; CODREA et al., 2002).

One multituberculate upper premolar has been found so far (FGGUB M1654: Fig. 2p-q). The PM1 has three well-developed cusps on the occlusal surface forming an isosceles triangle. This type of teeth has been previously attributed to members of the Kogaionidae multituberculate family (RĂDULESCU & SAMSON, 1996). This occurrence is very important, since the Transylvanian area is the only place in Europe where Late Cretaceous multituberculate mammals were found so far (KIELAN-JAWOROWSKA et al. 2004; CSIKI et al. 2005)

Except for the microscopic fossil remains, a single fragment, identified macroscopically, represents a turtle plate. The only well-known turtle from the Maastrichtian continental deposits of the Hațeg Basin is *Kallokibotion bajazidi,* a basal cryptodiran, described by NOPCSA (1923) and confirmed later on by GAFFNEY & MEYLAN (1992). Based on the high abundance of *Kallokibotion* plate fragments all across the basin and similar external ornamentation pattern, the small fragment from Fântânele 2 has been attributed to this taxon.

The invertebrates are also represented in the Fântânele 2 material, although only by paper-thin freshwater gastropod shell fragments.

The microvertebrate fossil sites of the Hațeg Basin have generally yielded three, sometimes even four, types of eggshell fragments: a megaloolithid morphotype, considered to belong to the hadrosaurian *Telmatosaurus*, a geckonoid morphotype, and two other thin eggshell types possibly representing theropod and bird eggs (GRIGORESCU & CSIKI 2008; CSIKI et al. 2008). A characteristic of the Fântânele 2 microvertebrate site is the rarity of the eggshell, represented by the megaloolithid eggshell morphotype exclusively. The megaloolithid morphotype consists of a relatively thick eggshell (1-2 mm) with the outer surface covered by large tubercles (GRIGORESCU et al. 1994; VIANEY-LIAUD et al. 1994). A single megaloolithid eggshell fragment has been recovered from Fântânele 2 (Fig. 2r-s), showing signs of transport abrasion. The absence of other, thinner type of eggshells may be a consequence of the more agitated depositional environment inferred for this site, the higher basin energy leading to the fragmentation and destruction of such remains.

Conclusions

A new microvertebrate fossil site is reported from the Maastrichtian Densuş-Ciula Formation of the Hațeg Basin, located northwest of Vălioara, on the right slope of Fântânele creek. The fossil material mainly consists of isolated theropod, crocodilian and multituberculate teeth, with only a few amphibian skeletal remains.

The new fossil site of Fântânele 2 differs from other nearby microvertebrate sites (Fântânele 1, Budurone) by the coarser nature of the hosting sediment, the relative abundance of the vertebrate groups represented and the occurrence of only one type of fossil eggshell, the thicker and most resistant to transport of the four types previously reported from the Haţeg Basin.

The sedimentary features suggest a poorly-drained braided river floodplain environment, with possible episodic income of sediments in high-energy events that led to the fragmentation of most skeletal remains, gastropod shells or eggshells, leaving only the most resistant material, such as the isolated teeth.

The new microvertebrate fossil site of Fântânele 2 represents a new multituberculate site for the Haţeg Basin, as well as the first occurrence of a *cf. Acynodon* tribodont posterior tooth in the Haţeg Basin. It also yields new material referable to a possibly new crocodyliform taxon, previously known from a skull fragment from Tuştea.

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