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Dinosaur egg nests, mammals and other vertebrates from a new Maastrichtian site of the Haţeg Basin (Romania)

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Abstract – About ten dinosaur nests of large megaloolithid-type eggs have been discovered in the new Maastrichtian locality of Toteşti-baraj (Haţeg Basin, Romania). This is the largest dinosaur egg nest site discovered in Romania. Teeth and other micro-remains of vertebrates such as hadrosaurs, ankylosaurs, theropods, lizards and amphibians are associated with the eggs in the sediments, reflecting the great biodiversity of the Haţeg Basin during the Maastrichtian. But the most remarkable collected micro-remains are teeth of mammals representing at present the richest multituberculate collection from the Upper Cretaceous of Europe. ***To cite this article: V. Codrea et al., C. R. Palevol 1 (2002) 173–180.*** © 2002 Académie des sciences / Éditions scientifiques et médicales Elsevier SAS

Maastrichtian / Haţeg Basin / Romania / eggs / dinosaurs / mammals

Résumé – Pontes de dinosaures, mammifères et autres vertébrés d'un nouveau site maastrichtien du bassin de Haţeg (Roumanie). Une dizaine de pontes de dinosaures, contenant des œufs de type mégaloolithidé, a été découverte dans le nouveau site maastrichtien de Toteşti-baraj (bassin de Haţeg, Roumanie). C'est le gisement à œufs de dinosaures le plus important de Roumanie. Des dents et d'autres microrestes de vertébrés, appartenant à des hadrosaures, ankylosaures, théropodes, lézards et amphibiens, étaient associés aux œufs dans les sédiments, reflétant l'importante biodiversité du bassin de Haţeg pendant le Maastrichtien. Mais les microrestes les plus remarquables sont des dents de mammifères, qui constituent actuellement la plus riche collection de multituberculés du Crétacé supérieur d'Europe. ***Pour citer cet article : V. Codrea et al., C. R. Palevol 1 (2002) 173–180.*** © 2002 Académie des sciences / Éditions scientifiques et médicales Elsevier SAS

Maastrichtien / bassin de Haţeg / Roumanie / œufs / dinosaures / mammifères

Version abrégée

1. Introduction

Si les faunes de vertébrés continentaux du Maastrichtien sont relativement bien documentées dans l'Ouest de l'Amérique du Nord, les données sur les faunes d'Europe occidentale sont fragmentaires, en particulier en ce qui concerne les mammifères. En revanche, des dents de mammifères ont été découvertes, en association avec des restes de dinosaures, dans plusieurs localités maastrichtiennes du bassin de Haţeg, en Roumanie occidentale [16]. Au prin-

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temps 2001, le site de Toteşti-baraj a été fouillé par une équipe belgo-roumaine. Une dizaine de pontes de dinosaures y fut mise au jour et le tamisage des 1500 kg de sédiments dans lesquels se trouvaient ces pontes a livré une faune de microvertébrés particulièrement diversifiée et abondante, avec une moyenne d'une dent complète de mammifère pour 100 kg de sédiments.

2. Données géographiques et géologiques

Le nouveau gisement affleure sur une distance de 200 m dans le lit de la rivière Râul Mare, à proximité du barrage du village de Totesti (Fig. 1). Le pendage des couches est parallèle aux berges de la rivière (N50E) et est presque vertical (75–80N), de telle sorte qu'une vue aérienne du gisement correspond à une section verticale (Fig. 2). La distribution des facies indique un paléoenvironnement de type fluviatile. Les nids sont tous localisés dans des horizons de paléosols à calcrète. Comme les nids ont été découverts à différents niveaux, il est probable que le site a été fréquenté comme lieu de ponte pendant une longue période. D'après la carte géologique locale, les sédiments appartiennent à la formation de Sânpetru, d'âge Maastrichtien, mais cette attribution doit être confirmée par des travaux ultérieurs.

3. Paléontologie

3.1. Nids d'œufs de dinosaures et autres fragments de coquilles

Plus de 40 œufs, organisés en 11 nids, ont été découverts à ce jour à Toteşti-baraj. Ces œufs appartiennent à l'oofamille des Megaloolithidae, et plus précisément à l'oogenre *Megaloolithus* (Figs. 3 et 4a, 4b). Ils ressemblent aux œufs précédemment découverts dans le bassin de Haţeg [17] et à l'ooespèce française *Megaloolithus siruguei* [8]. L'oofamille des Megaloolithidae, dont au moins quelques ooespèces peuvent être attribuées aux dinosaures titanosauridés [2], est particulièrement diversifiée dans le Crétacé supérieur d'Inde et d'Europe méridionale [9, 17, 19, 26]. Deux autres types d'œufs correspondant aux morphotypes théropode et geckonoïde ont été également identifiés.

3.2. Amphibiens

La présence de la famille des Albanerpetontidae (Allocaudata) est attestée par des extrémités distales d'humeri, un axis et plusieurs dentaires, dont les dents sont droites, pleurodontes, non pédicellées, biseautées, avec une couronne vaguement tricuspide. Quelques vertèbres présentent les caractéristiques de vertèbres sacrées d'anoures discoglosses (Fig. 4c).

3.3. Lépidosauriens

Deux formes de scincomorphes, aux dents pleurodontes, cylindriques, bicuspides et assymétriques, sont représentées par des fragments de mâchoires à Toteşti-baraj. Une des deux formes est nettement plus robuste que l'autre (Figs. 4d, 4e).

3.4. Dinosaures

Des dents typiques d'Hadrosauroidea (Fig. 4f) et une dent de Nodosauridae (Fig. 4g) ont été découvertes à Toteşti-baraj. Les dinosaures théropodes paraissent particulièrement diversifiés, représentés par au moins cinq morphotypes dentaires : Velociraptorinae (Fig. 4j), cf. Troodontidae (Fig. 4k), *Richardoestesia* (Fig. 4l), *Paronychodon* (Fig. 4m) et *Euronychodon* (Fig. 4n). Ces morphotypes se distinguent principalement par la forme et par l'ornementation des couronnes dentaires, ainsi que par la distribution et la forme des crénelures le long des carènes.

3.5. Mammifères

Au moins deux taxa de mammifères multituberculés Kogaionidae sont représentés à Toteşti-baraj. L'espèce la plus abondante ressemble à *Kogaionon ungureanui*, découverte à Sânpetru, à 4 km au sud-est de Toteşti-baraj [24], mais en diffère par sa taille nettement plus petite et par la rangée linguale de sa M^1 moins développée antérieurement (Fig. 4h). Le second taxon, attribué à un Kogaionidae indet., ressemble à *Hainina godfriauxi*, du Paléocène moyen de Belgique [28]. Il s'en distingue cependant par la présence de seulement deux grosses cuspides, au lieu de trois petites, sur la rangée linguale de sa M^2 (Fig. 4i).

4. Conclusions

Toteşti-baraj est le plus important gisement à nids d'œufs de dinosaures de Roumanie et le gisement à mammifères multitu-berculés le plus riche du Crétacé supérieur d'Europe. La présence d'au moins cinq taxa différents de petits théropodes, proches du sommet de la chaîne trophique, reflète bien l'importante biodiversité du bassin de Haţeg au cours du Maastrichtien.

1. Introduction

Maastrichtian continental vertebrate faunas are rather well documented in western North America, while they are poorly known in the rest of the world. Therefore, the knowledge on the influence of the K–T Event on continental vertebrates is mainly based on information collected in a limited geographical area. In Western Europe, Maastrichtian continental faunas are known in southern France, Spain and Portugal [12, 18, 19]. With the exception of Laño, the fossils collected in these localities are scarce and fragmentary and mammals appear to be particularly rare. On the other hand, mammal teeth were discovered in associ-

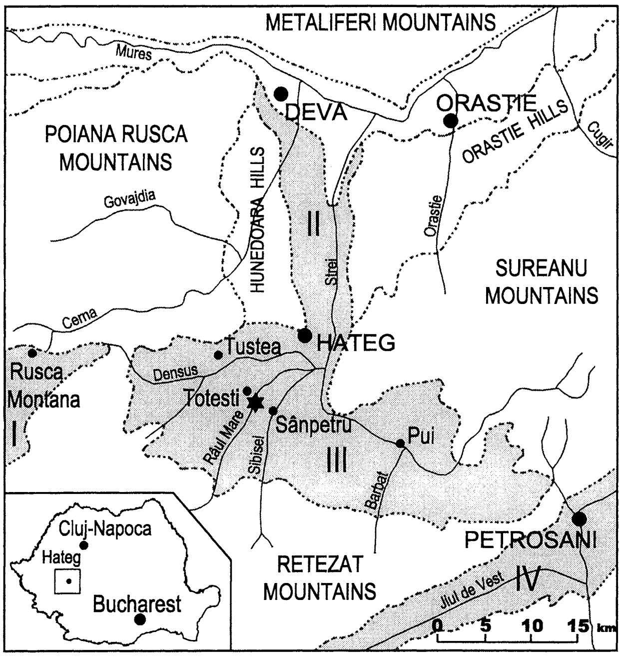

Figure 1. Map of the Haţeg Basin, inset map showing the location of the town Haţeg in Romania. The grey areas indicate the sedimentary basins: **I**, Rusca Montană Basin; **II**, Strei Basin; **III**, Haţeg Basin; **IV**, Petroşani Basin. The star marks the location of the newly discovered mammal and dinosaur-nesting site.

Figure 1. Carte du bassin de Haţeg ; en médaillon, localisation de la ville de Haţeg en Roumanie. Les zones en grisé indiquent les bassins sédimentaires : **I**, bassin de Rusca Montană ; **II**, bassin de Strei ; **III**, bassin de Haţeg ; **IV**, bassin de Petroşani. L'étoile signale l'emplacement du gisement de mammifères et de pontes de dinosaures, nouvellement découvert.

ation with dinosaur remains in several Maastrichtian localities from the Haţeg Basin, in western Romania [15, 16].

During the spring 2000, a four-person field party of the University Babeş-Bolyai and of the Royal Belgian Institute of Natural Sciences prospected the Transylvanian and Haţeg Basins to locate new potential vertebrate sites. At the end of the spring 2001, the first Belgo-Romanian excavation campaign started in the new locality of Toteşti-baraj, described herein. About ten dinosaur egg nests were discovered there. Screen-washing of 1500 kg of sediments collected around the nests provided a particularly diversified fauna of microvertebrates, leading to the discovery of one complete mammal tooth for 100 kg of sediments in average.

2. Geographical and geological setting

The newly discovered site is located in the central part of the Haţeg Basin, in the northwestern part of the South Carpathians. Like the neighbouring Strei, Petroşani and Rusca Montană Basins (Fig. 1), it is a post-orogenic basin, formed at the end of the Cretaceous after the main pulse of the Laramian orogeny.

The outcrops of the new site are located within the streambed of the Râul Mare River, near the barrage of the Toteşti village (Fig. 1). Therefore the site has been named Toteşti-baraj. Due to its location within the streambed, the site is accessible only during the summer, when the water level is low. Moreover, the extent of the outcrops is limited to 200 m due to the emplacement of dams and public works to improve the bank protection. These public works endanger the continued existence of the site.

The layers have a trend parallel to the riverbanks (N50E) and a nearly vertical slope (75–80N), so that an aerial view of the outcrops corresponds to a vertical section (Fig. 2). The facies distribution indicates a fluvial palaeoenvironment with sandy channel infills and mainly black silty and clayey overbank deposits. Within these overbank deposits, palaeosols develop, causing the red colouring of the sediments and the formation of the calcretes. The egg nests are all located within calcretic palaeosol horizons. The only exception is nest E, but this seems to be an observational hiatus, because the outcrop is very limited at that point. The locality was probably frequented as a nesting site during a large time span, as dinosaur nests have been found at different stratigraphic levels.

According to the geological map of the area, the outcropping sediments belong to the Maastrichtian Sânpetru Formation [14, 16]. However, the general appearance in the field of the studied sediments is rather different from the sediments of the type locality of the Sânpetru Formation. Due to the presence of faults, the limited extent of the outcrop and the observed differences with the Sânpetru Formation, the exact age and the assignment of the studied sediments to the Sânpetru Formation need to be specified by further studies.

3. Palaeontology

3.1. Dinosaur egg nests and other eggshells

The site of Toteşti-baraj has yielded more than 40 eggs organised in 11 nests. The eggs, which are more or less fractured by burial, are subspherical in shape, with a maximum diameter ranging between 14–16 cm (Fig. 3). These eggs belong to the Megaloolithidae oofamily and more precisely to the *Megaloolithus* oogenus. This ootaxon exhibits a discretispherulitic microstructure with fan shape units that show arched growth lines, an outer surface composed of regular bulbous nodes (diameter = 0.6 mm in average), a tubocanaliculate pore system with frequent connec-

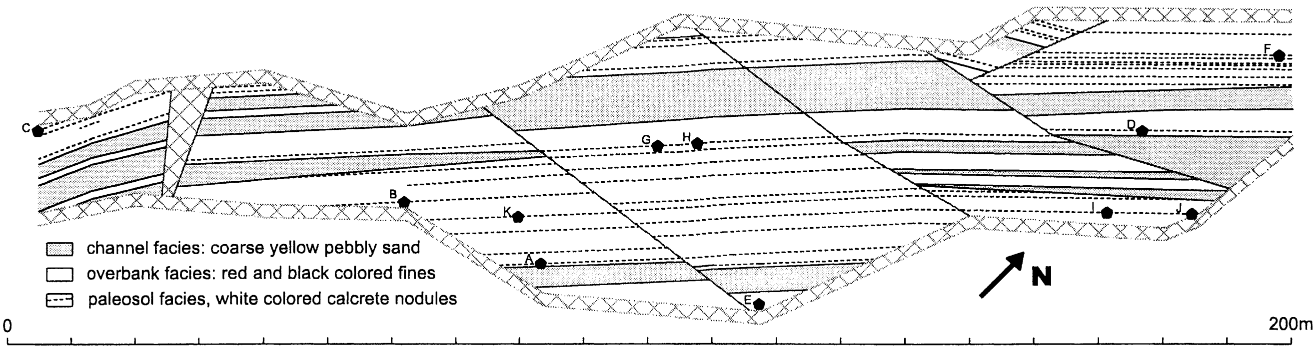

Figure 2. Aerial view of the new fossil site with the exact location of the dinosaur egg nests (indicated by black pentagons). The outcrop is situated within the bedding of the Râul Mare River that flows in a northeasterly direction. The hatched areas mark the border of the river and the end of the zone of outcrop.

Figure 2. Vue aérienne du nouveau gisement de fossiles, avec la localisation exacte des pontes de dinosaures (indiquées par des pentagones). L'affleurement est situé dans le lit de la rivière Râul Mare, qui coule vers le nord-est. Les zones hachurées indiquent les bords de la rivière et la fin de la zone d'affleurement.

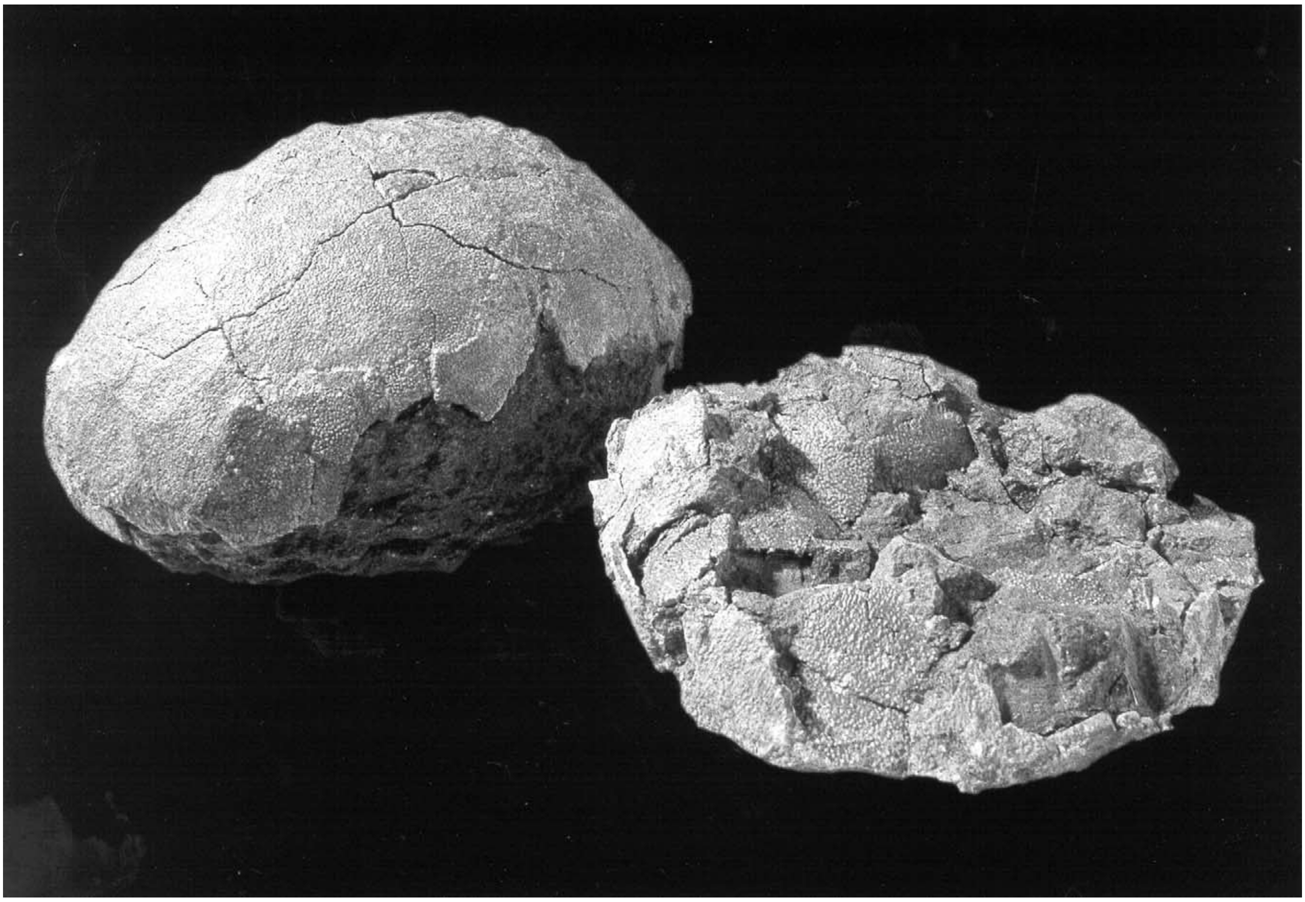

Figure 3. Eggs: *Megaloolithus* cf. *siruguei* from Toteşti-baraj (Haţeg Basin, Romania).

Figure 3. Œufs : *Megaloolithus* cf. *siruguei* de Toteşti-baraj (bassin de Haţeg, Roumanie).

tions between pore canals, and a shell thickness of 2.14–2.82 mm (Figs. 4a, 4b). This material closely resembles the eggshells previously described from Haţeg Basin [17] and the French oospecies *Megaloolithus siruguei*, in the pore canal pattern, by their thickness and their sometimes irregular unit pattern [8, 27]. The oofamily Megaloolithidae is well diversified in Late Cretaceous Indian and south European localities [9, 15, 17, 20, 23, 26]. The discovery of embryonic remains within megaloolithid eggs indicates that at least some Megaloolithidae oospecies may be referred to as titanosaurid dinosaurs [2].

Two 'thin' egg types have been collected after screen-washing of sediments around the megaloolithid eggs. The first morphotype ($n = 25$) shows a prismatic structure with a smooth surface and an eggshell thickness 0.9 mm in average. It might correspond to a theropod egglayer. The second ($n = 10$) shows a typical geckonoid microstructure. The shell units display an irregular pattern. The external surface is dispersituberculate, with pore openings often situated at the top of the nodes, like the geckonoid eggshells from the Upper Cretaceous of southern France [7].

3.2. Amphibians

The presence of the family Albanerpetontidae (Allocaudata) is attested by distal ends of humeri with a narrow shaft in line with a large spherical humeral ball and a small ulnar epicondyle [11]. Other typical bones include a 'mammal-like' axis and several fragments of dentaries with straight, pleurodont, non-pedicellate, chisel-like teeth and faintly tricuspid crowns [10].

Some small vertebrae possess a hemispherical anterior condyle and two rounded posterior condyles (Fig. 4c), which remind of the sacral vertebra of discoglossid Anura [6].

3.3. Lepidosaurians

Scincomorphs are represented by eight fragments of jaws with pleurodont, cylindrical, bicuspid and asymmetrical teeth. The cusps are antero-posteriorly aligned. The bases of the teeth are slightly lingually expanded. These forms resemble the Scincomorpha described from Laño (Campanian, Spain) [25]. Two forms are present. The first one is more robust and the bone is ornamented labially with pits and ridges (Fig. 4e). The teeth are lingually curved and exceed the dental parapet on more than half of their height. One of the two cusps is distinctly taller than the other one. In the second form, the jaw is less robust, with few foramina on the labial face. Teeth are straight and exceed the dental parapet on a third of their height. The cusps are of about the same height (Fig. 4d).

3.4. Dinosaurs

3.4.1. Hadrosauroidea

Typical hadrosauroid teeth are represented in the Toteşti-baraj sample (Fig. 4f). Their crown is characteristically diamond-shaped. The enamelled side bears a single prominent ridge. The marginal denticles are particularly well developed: this character is usually observed in basal Hadrosauroidea, such as the Romanian form *Telmatosaurus transsylvanicus*.

3.4.2. Nodosauridae

One tooth may be confidently attributed to nodosaurid ankylosaurs, as it displays the following characters (Fig. 4g): the crown is leaf-shaped, laterally compressed and asymmetrical in labial view, with a well-developed basal cingulum [3]. The roughened cingulum is asymmetrically developed, being more swollen and somewhat higher on one side; this feature is more common in nodosaurids than in other thyreophorans [1]. Nevertheless, the crown is atypical for nodosaurids as it is very low and formed by only four cusps. However, this unusual morphology may simply reflect ontogenetic variation [22]. The crown is ornamented by prominent flutings, asymmetrically developed on either side of the crown; unlike most nodosaurids, flutings do not coincide with the notches between secondary cusps [3].

3.4.3. Theropod dinosaurs

At least five different kinds of isolated theropod teeth may be distinguished. Most of them may be attributed to the subfamily Velociraptorinae (Fig. 4j), because of the great disparity in size and distribution of the denticles on the mesial and distal carinae, which is usually regarded as an important apomorphy of this sub-family [4]. The mesial carina is serrated only along its distal portion; mesial denticles are minute, usually less than half the length and base width of distal denticles. The distal carina is serrated along its whole height. Distal denticles are perpendicular to the tooth axis, longer than wide and sometimes slightly hooked. The tooth crown is always very compressed laterally, pointed and sharply recurved.

Some fragmentary teeth may be tentatively attributed to troodontid-like theropods (Fig. 4k), as they display the following characters [4]: the crown is less recurved than in teeth ascribed to velociraptorines, both the mesial and distal denticles are well developed, the mesial denticles extend towards the base of the crown, distal denticles are wider than long, oblique to the tooth axis and often hook-like.

Three other dental morphotypes may be attributed to Theropoda incertae sedis. The *Richardoestesia* morphotype, known from several Late Cretaceous localities in western North America, is represented at Toteşti-baraj (Fig. 4l): the crown is very high, lanceolate and straight to slightly recurved. Serrations are limited to the distal carina and individual denticles are minute (up to five denticles per millimetre). The absence of curvature on part of the tooth, as observed in the Romanian sample, characterises the Maastrichtian *Richardoestesia* specimens; on the other hand, some curvature is always present in Campanian ones [4].

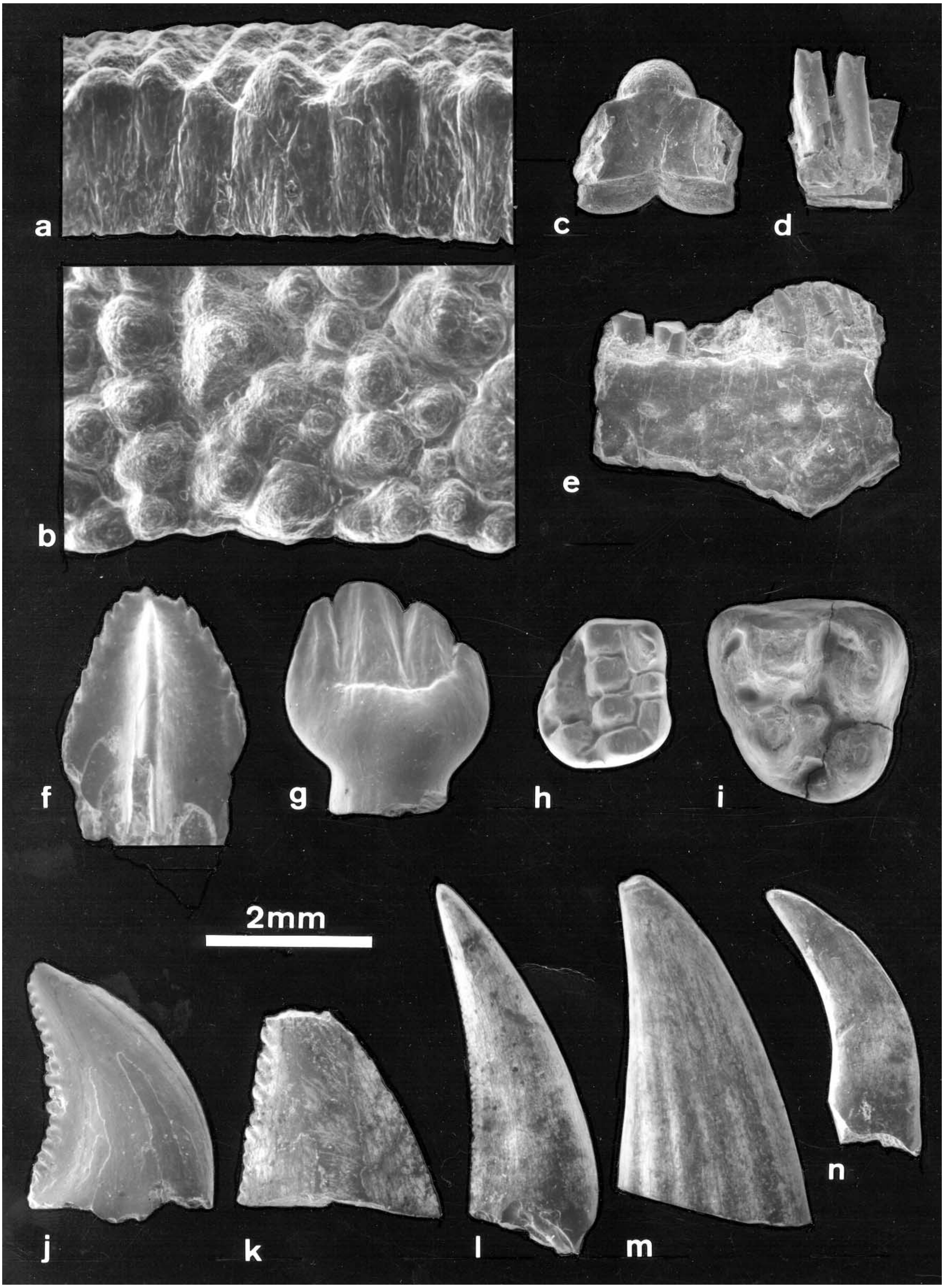
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Figure 4. a. Eggshell fragment of *Megaloolithus* cf. *siruguei* in radial view. **b.** Eggshell fragment of *Megaloolithus* cf. *siruguei*, outer surface. **c.** Sacral vertebra of a discoglossid frog. **d.** Scincomorph jaw fragment in lingual view, slender form. **e.** Scincomorph jaw fragment in labial view, robust form. **f.** Hadrosauroid tooth in lateral view. **g.** Nodosaurid ankylosaur tooth in labial view. **h.** Mammal tooth: *Kogaionon* n. sp., left M^1 in occlusal view. **i.** Mammal tooth: Kogaionidae indet., right M^2 in occlusal view. **j.** Velociraptorine theropod tooth in lateral view. **k.** Troodontid-like theropod tooth in lateral view. **l.** Theropoda incertae sedis 1: *Richardoestesia* morphotype, tooth in lateral view. **m.** Theropoda incertae sedis 2: *Paronychodon* morphotype, tooth in lateral view. **n.** Theropoda incertae sedis 3: *Euronychodon* morphotype, tooth in lateral view.

Figure 4. a. Fragment de coquille d'œuf de *Megaloolithus* cf. *siruguei*, en vue radiale. **b.** Fragment de coquille d'œuf de *Megaloolithus* cf. *siruguei*, surface externe. **c.** Vertèbre sacrée d'une grenouille discoglosse. **d.** Fragment de mâchoire de scincomorphe en vue linguale, forme mince. **e.** Fragment de mâchoire de scincomorphe en vue labiale, forme robuste. **f.** Dent d'Hadrosauroidea en vue latérale. **g.** Dent de ankylosaure Nodosauridae en vue labiale. **h.** Dent de mammifères : *Kogaionon* n. sp., M^1 gauche en vue occlusale. **i.** Dent de mammifères : Kogaionidae indet., M^2 droite en vue occlusale. **j.** Dent de théropode Velociraptorinae en vue latérale. **k.** Dent de théropode Troodontidae en vue latérale. **l.** Theropoda incertae sedis 1 : morphotype *Richardoestesia*, dent en vue latérale. **m.** Theropoda incertae sedis 2 : morphotype *Paronychodon*, dent en vue latérale. **n.** Theropoda incertae sedis 3 : morphotype *Euronychodon*, dent en vue latérale.

A number of teeth may be identified as theropods on the basis of overall shape, but lack serrations entirely. Some of them closely resemble the *Paronychodon* morphotype, discovered in many Late Cretaceous localities from North America in being flat on one side and covered with coarse longitudinal ridges (Fig. 4m). In North America, true *Paronychodon* morphotype tends to be more common in the Maastrichtian than in the Campanian [4].

Typical *Euronychodon* morphotype, previously reported in the Barremian of Spain, in the Campanian of southeastern France and in the Maastrichtian of Portugal and of the Haţeg Basin [5], is also represented at Toteşti-baraj (Fig. 4n): these teeth also lack serrations on both their mesial and distal carinae, but, contrary to the *Paronychodon* morphotype, they are not very asymmetrical and their enamel is not ornamented.

3.5. Mammals

The presence of at least two taxa of the family Kogaionidae (Multituberculata) is attested by fourteen complete teeth and several tooth fragments of mammals. This family is until now restricted to the Maastrichtian of Romania [21, 24] and the Palaeocene of Belgium, France, Spain and Romania [13, 21]. The most abundant species of Toteşti-baraj, represented by at least nine teeth, is small-sized and is attributed to the genus *Kogaionon* Rădulescu & Samson, 1996 [23] by its typically short and wide M^1 with a cusp formula 3:4:3 [24]. Its size is less than half of that of *K. ungureanui* Rădulescu & Samson, 1996 from Sânpetru (Maastrichtian, Sibişel valley, see Fig. 1). The species from Toteşti-baraj is also characterised by an M^1 with the lingual row less developed anteriorly than in *K. ungureanui*, giving a less square shape to the tooth. At least four upper and two lower dental positions are represented and several teeth come in all likelihood from the same individual. It is considered as a new species of *Kogaionon* (Fig. 4h).

The second species is middle-sized and is referred to as Kogaionidae indet (Fig. 4i). The M^2 is slightly larger than that of *Hainina godfriauxi* Vianey-Liaud, 1979 described from Hainin (Middle Palaeocene, Belgium) but has a close general morphology [28]. However, it differs from all *Hainina* species described to date [21, 28] in having only two large cusps on the lingual row, instead of three small cusps.

4. Conclusions

Although excavations have just begun in this newly discovered locality, Toteşti-baraj proves to be the largest dinosaur egg nest site of Romania and the potentially richest Late Cretaceous mammal site ever discovered in Europe. The presence of at least five different taxa of small theropods close to the top of the food chain reflects the great biodiversity of the Haţeg Basin during the Maastrichtian. Micropalaeontological analysis and study of vertebrates are in progress in order to determine more precisely the age, the faunal content and the palaeoenvironment of the Toteşti-baraj locality.

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