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The fossil record of Palaeogene crocodilians in Romania: preliminary data

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Abstract. Crocodilian remains are rather rare in the Palaeogene formations from Romania. The fossil record from a series of late Eocene (Priabonian) and early Oligocene (Rupelian) localities spread in the Gilău and Meseş sedimentary areas (northwest Transylvanian basin) indicates the presence of the genus *Diplocynodon* and *Crocodylia* indet. as part of the European endemic crocodilian fauna, that apparently survived the great faunal turnover across the Eocene/Oligocene boundary. The most informative specimens are known from the former Cluj-Mănăştur quarry (Priabonian) and Suceag 1 (Rupelian). Some isolated teeth, too few and devoid of enough diagnostic value for clear systematic assignments, are known from Jibou, Treznea and Turnu Roşu (former Porceşti, southern border of the Transylvanian basin). However, further investigations are necessary to establish the closer taxonomic status of the available remains.

Key words: *Crocodylia*, *Diplocynodon*, Eocene, Oligocene, Romania.

Introduction

The late Eocene - early Oligocene time span means a period of huge importance for biota because it corresponds to a worldwide faunal turnover called the Grand Coupure (in English, Great Brake), that involved mammals and ectothermic vertebrates (Rage & Roček 2003). During the late Eocene, Europe still was an archipelago. Portions of this continent were immersed into extensive epicontinental seas, however the continental landmasses were interconnected at various times (Rage & Roček 2003). However, a trend of eustatic fall of about 50 m was estimated for the late Eocene - early Oligocene interval (Pekar et al. 2002). The Carpathian area has been reshaped in this period due to continuous northern moving of several continental blocks including the ALCAPA block (Austroalpine units in the Eastern Alps and Inner Western Carpathians), as well as the Tisia and the Dacia blocks (Schmid et al. 2008). Their collisions with the North European plate were oblique, causing an accretion wedge of Outer Carpathians (Golonka et al. 2003). The tectonic related volcanism, the uplifting mountain chains could have implications of the CO₂ level and on the atmospheric motion as well as on the water regime and implicitly, on the regional climate and biota. After the 'post-Laramic' overthrust nappe replacement in the Apuseni Mountains and South Carpathians three major sedimentary mega-sequences may be distinguished in the north-western area of the Transylvanian sedimentary basin: 1) uppermost Cretaceous – early Miocene (Egerian), 2) early Miocene (Eggenburgian) – middle Miocene (Ottangian) and 3) middle - late Miocene. We will focus only on the first sedimentary mega-sequence that recorded in Eocene and Oligocene an alternating series of marine and continental deposits in Gilău and Meseş sedimentary areas.

During the latest Eocene a large carbonate platform, rich in calcareous algae, ostracods and mollusc shells, has been developed in the Gilău sedimentary area known as Cluj Limestone Formation (Mészáros 2000). Sometimes this carbonate platform emerged and has been exposed to atmospheric erosion (Codrea et al., 1997). In the former Cluj-Mănăştur limestone quarry, nowadays abandoned, at least three layers of coarse-grained limestone may be distinguished (Fig. 2). Koch (1894) named these layers as 'upper coarse limestone', exploited in historical times as building stones for various public buildings. These limestones yielded sometimes isolated bones or larger skeletal parts of various vertebrate representatives, mainly sea cows (Koch, 1894).

Around the Eocene/Oligocene transition, in NW of Transylvania an uplift related to the pre-Pyrenean and Pyrenean tectonic movements (*sensu* Émile Haug, in Dudich & Mészáros, 1963, Mészáros & Dudich 1989, Mészáros & Moi-

sescu, 1991) lead to the deposition of continental strata consisting of fluvial red beds (Valea Nadășului and Moigrad formations). In Rupelian, an environmental turnover from fluvial to more flooded, fluvial-lacustrine, estuarine and marshy environments lead to the deposition of the overlying Dâncu Formation (Rusu 1972). The Dâncu Formation thickens from east to west; in the Cluj-Napoca city area it has a thickness of few centimetres (in the borehole on the location named Liliacul; VAC personal observation) to a few metres, whereas at Aghireș it reaches thicknesses of up to 14–17 metres (Moisescu 1975). Its lithology consists of alternating clay, marl and sand with several lumachelle and coal interbeddings. It has been suggested that the climatic deterioration during the Eocene/Oligocene transition (around 33.9 Ma) may have affected most of the ectothermic vertebrates, including snakes and crocodilians with considerable decline in their diversity (see e.g. Morlo et al. 2004, Martin 2010, Delfino et al. 2019).

The fossil record of crocodilians from the Palaeogene of Romania is rather scarce and mainly consists of isolated teeth (Pávay 1871, Koch 1884, Fărcaș 2011) and more rarely of skull remains, vertebrae and parts of the appendicular skeleton (Koch 1893, Fărcaș 2011). Nevertheless, in the latest years some progress has been made by documenting new fossil localities with crocodilian remains from a number of Palaeogene localities (see below). In the present paper we: 1) review the fossil localities yielding crocodilian remains from the Paleogene of Romania, 2) evaluate their taxonomic status based on diagnostic material and 3) the paleobiogeographic links of the identified taxa.

Abbreviations used: **MAP**, mean annual precipitation; **MAT**, mean annual temperature.

The fossil record

Upper Eocene (Priabonian) localities

Treznea 1. The fossil locality belongs to the Upper Eocene Turbuța Formation (Meseș sedimentary area, early Priabonian) and is situated in Șanțului Valley near the locality of Treznea (Sălaj County). The taphonomic context indicates a freshwater palaeoenvironment of marshy-lacustrine type with occurrence of charophytes and a series of palynomorphs representing gymnosperms (Cupressaceae and Taxodiaceae) and angiosperms (Fagaceae, Juglandaceae, Arecaceae and Nyssaceae) that corresponds to a paleoclimatic curve with the MAT of around 20 °C and the MAP of about 1200 mm (Petrescu & Balintoni 2004). The faunal association after Fărcaș (2011) yielded among others lepisosteid fish, freshwater

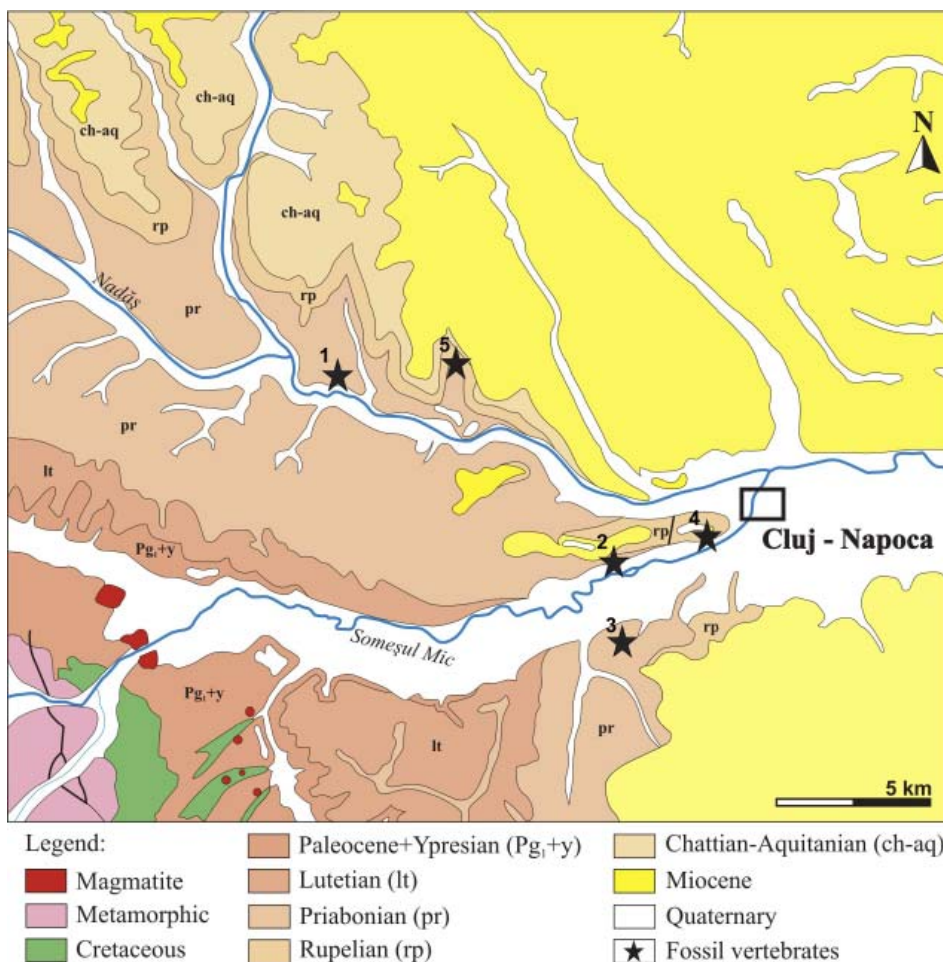


Figure 1. Geological map mentioning the Palaeogene localities with crocodilians from Cluj-Napoca area, Romania. 1, Rădaia; 2, Cluj-Napoca (Someș dam); 3, Cluj-Mănăștur; 4, Cluj-Napoca (Cetățuia); 5, Suceag.

turtles (Emydidae: ?*Mauremys*), alligatoroid crocodilians and marsupial mammals (*Peratherium lavergnense*).

The fossil material of alligatorid crocodilians consists of isolated teeth of various sizes. The teeth are variable in shape with at least two morphotypes: 1) lanceolate shaped teeth with labiolingual compression, provided with mesial and distal carinae and bearing faint apicobasal striations developed on both the lingual and labial sides (Fărcaș 2011: plate 21: 9-12); 2) low crowned teeth representing probably the posterior series with their crowns compressed labiolingually and pro-

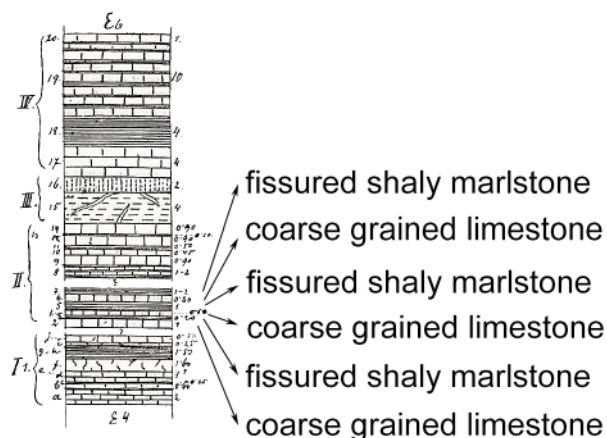


Figure 2. Synthetic lithostratigraphic Koch's (1894) log of the coarse limestone beds around Cluj, with details highlighted on the Cluj-Mănăştur former limestone quarry.

vided with mesial and distal carinae. The apicobasal striations are well-developed on both the lingual and labial sides (Fărcaş 2011: plate 21: 7, 8; plate 22: 10).

Rădaia. The fossil locality belongs to the Upper Eocene Valea Nadăşului Formation (early Priabonian) and is situated in the Nadăşului Valley within the village of Rădaia (Gilău sedimentary area, Cluj County). Rădaia is the type locality of famous mammals: the rhinocerotoid *Prohyracodon orientale* Koch, 1897 and of the brontothere *Brachydiastematherium transilvanicum* Böck & Matyasowski, 1876. Beside mammals the fossil locality has yielded also few carapace fragments of *Trionyx* sp. (Fărcaş 2011) and fragmentary remains of crocodilians (Koch 1894). After Koch (1894) two isolated teeth of crocodilians have been recovered from Rădaia. Their height is 6 mm and their width at the base is about 3-4 mm (Koch 1894).

Cluj-Napoca (Someş dam). The fossil locality belongs to the Cluj Limestone Formation (Turea Group, Gilău sedimentary area, Priabonian). After Koch (1894), two isolated teeth of crocodilians have been recovered from "Someş beds" by Pávay (1871) along with a series of fragmentary sea cows remains. In fact, all these remains have been firstly assigned by Pávay (1871) to crocodilians (i.e. *Toliapicus* sp.). The tooth height is about 18 - 20 mm and their width at the base is about 7 mm (Koch 1894).

Cluj-Mănăştur. The fossil locality belongs to the Upper Eocene Jebuc and Cluj Limestone formations (Turea Group, Gilău sedimentary area, Priabonian). After Koch (1894) the main layers from the Cluj-Mănăştur limestone quarry are as follows: 1) coarse grained limestone bank (one metre depth, used as building stones or carved stones) with abundant ostracods, moulds of gastropods (mainly *Anomia tenuistriata*) and rare vertebrate remains (e.g. "*Delphinus* sp."); 2) fissured shale marlstone (0.2 meters depth) with ostracods and *Anomia*; 3) coarse grained limestone (0.5 meters depth) with ostracods and extremely small gastropods used as building stones or carved stones; 4) fissured shale marlstone (one meter depth) with ostracods and *Anomia tenuistriata*; 5) coarse grained limestone (0.8 meters depth) with ostracods and extremely small gastropods and rare *Anomia*; it represents the uppermost limestone horizon from the Cluj-Mănăştur limestone quarry; 6) fissured shale marlstone (one meter depth) with numerous chalk-like white limestone concretions; it represent the uppermost sedimentary layer from the quarry.

After Koch (1894), a partial skull of a small crocodilian consisting of "a maxilla and several inner bones of the skull" has been recovered by quarry workers. It somewhat resembled *Crocodylus communis* (i.e. *C. nyloticus*) but it is not identical with that because the fossil specimen possessed higher number of teeth (21-22) vs. *Crocodylus* having a lower number of teeth (Koch 1894).

Lower Oligocene (Rupelian) localities

Cluj-Napoca (Cetățuia) and Suceag 1. Both localities belong to the Dâncu Formation consisting of alternating clay, marl and sand with several lumachelle and coal interbeddings that indicate environmental changes from fluvial to more flooded, fluvio-lacustrine and marshy environments (Rusu 1972, Venczel & Codrea 2018). The Dâncu Formation thickens from east to west, having in Cetățuia Hill at Cluj-Napoca, a thickness of several tens of centimetres to a few metres, whereas at Aghireș, it reaches thicknesses of up to 14–17 m (Moisescu 1975). The formation contains one of the most diverse Rupelian continental faunal assemblages in Transylvania, especially yielding molluscs and vertebrates (fishes, frogs, squamates, turtles, crocodilians, birds, and mammals) consistent with an age of MP 23–24 (Reichenbacher & Codrea 1999; Codrea & Fărcaș 2002; Fărcaș & Codrea 2008). Fărcaș (2011) assigned the material to *Diplocynodon* sp. consisting of a fragmentary hemimandible, cervical, thoracal and caudal vertebrae, fragmentary ribs, humerus, pelvis, femur, tibia, metatarsal bones, phalanges and osteoderms.

Systematic part

EUSUCHIA Huxley, 1875
CROCODYLIA Gmelin, 1789
ALLIGATOROIDEA Gray, 1844
Diplocynodon Pomel, 1847
Diplocynodon sp.

Material: Cluj-Mănăştur: UBB V 1453, partial skull; Suceag: UBB V 450 uncatalogued, fragmentary left hemimandible.

Description. The UBB V 1453 sample exposes a partial skull in ventral view (Fig. 3). The following cranial bones have been identified in the sample: the premaxillae (the lateral margin of the right premaxilla is damaged), the maxillae (the posterior part of the right maxilla is broken off, probably when the skull has been recognized and collected by quarry workers), anterior parts of the paired palatines, a partial left quadrate, part of the right pterygoid with impressions of choanae and the posterior part of the left ectopterygoid. The rostrum is elongated and relatively narrow. The suture between the premaxilla and the maxilla is perpendicular to the sagittal plane and, lateral to the premaxillary-maxillary suture, a well-defined notch is developed.

The premaxilla is provided with five tooth alveoli of which the second and the fourth alveoli are larger than the others three ones. A large occlusal pit for the reception of the first dentary tooth is developed medial to the space between the first and second premaxillary tooth alveoli. The incisive foramen, enclosed completely by the premaxillae is large and almost circular, extending anteroposteriorly between the levels of the second and fourth tooth alveoli. The posterolateral margin of the premaxilla is not perpendicular to the sagittal plane at the level of the premaxillary-maxillary notch suggesting that it is not developed from the occlusal pit of the third and fourth dentary teeth.

The maxillary tooth row probably is composed of 16-17 alveoli; however, some uncertainty persists in this estimation because in both sides the posterior parts of the maxillae are damaged. The largest maxillary alveoli are represented by those of the nearly confluent fourth and fifth maxillary teeth and as a consequence the lateral margin of the maxilla depicts a lateral convexity between the first-sixth tooth alveoli, whereas those between the fifth-eighth are shallowly concave laterally; posterior to the eighth tooth position, the alveoli depict a nearly straight line. The occlusal pits are present posterior to the fifth maxillary tooth and positioned in line or slightly medial to the maxillary tooth row. A contact surface between the pos-

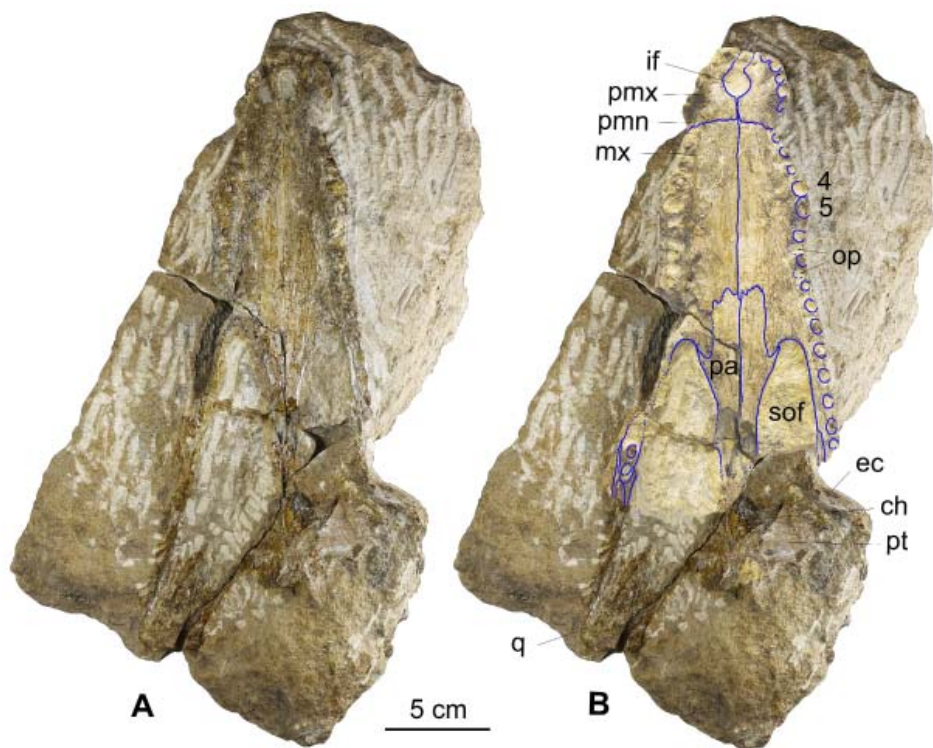


Figure 3. Partial skull of *Diplocynodon* sp. from the Cluj-Mănăştur former limestone quarry recovered in 1890. A. The original sample exposing the *Diplocynodon* sp. specimen in ventral view. B. Skeletal parts highlighted. Abbreviations: 4, 5 – fourth and fifth tooth maxillary tooth alveoli; ch – choana; ec – ectopterygoid; if – incisive foramen; mx – maxilla; op – occlusal pits; pa – palatine; pmn – premaxillary-maxillary notch; pmx – premaxilla; pt – pterygoid; q – quadrate; sof – suborbital foramen.

terior two or three maxillary alveoli and the anterior extension of the ectopterygoid is visible in both sides. However, this contact does not reach the medial margins of the tooth alveoli. No intact tooth crowns are available, but parts of the tooth crowns are conserved in few alveoli. The main feature of the crown remnants is that they have been provided with mesiodistal carinae and are devoid of any serration. The posterior alveoli are distinctly smaller and tend to have mediolateral compression.

The palatines shallowly widen anteriorly, whereas posteriorly these remain apparently parallel. The palatine-maxillary suture starts at the anteromedian corner of the suborbital fenestra and it reaches anteriorly the level of the eighth maxillary tooth position. The posterior part of the palatines is broken off exposing the complete choanal septum.

On the left cranial side, part of the pterygoid and ectopterygoid are exposed; the choanae are preserved only as imprints within the embedding sediments (seemingly the relatively thin pterygoid wings were broken off during the collecting procedures). The posterolateral parts of these bones are damaged. However, the pterygoid-ectopterygoid flexure is present.

The quadrate is exposed on the right ventral part of the sample. It preserves a relatively small sized quadrate condyle.

The UBB V 450 right hemimandible is fragmentary (Fig. 4: B-E), both the anteriormost (anterior margin with the first and second tooth positions) and posteriormost parts (posterior to the 14th tooth position) are broken off. The symphyseal region is relatively short reaching the level of the third tooth position. In lateral view, the dentary is shallowly concave between the fourth and 11th tooth positions. The largest alveoli are the third and fourth alveoli, which are confluent. The 11th and 12th alveoli are placed at some distance from each other and are comparable in size to those of third and fourth. In dorsal view, the dentary is gently curved with a lateral convexity at the level of third-fifth alveoli, whereas between the fifth-11th alveoli there is shallow labial concavity.

Comments. The main feature of the partial skull is the possession of a pair of large and almost equal sized maxillary tooth alveoli (the fourth and fifth), which are nearly confluent similarly to the other members of the genus *Diplocynodon*. This character differs from *Asiatosuchus*-like taxa, which are provided with a single enlarged fifth maxillary tooth (Delfino et al. 2019). Another important feature is the presence of a premaxillary-maxillary notch which seemingly is not formed ontogenetically by the eroded margins of a premaxillary-maxillary occlusal pit (in the latter case the lateral margins should have been more abruptly angled). The anterior process of the ectopterygoid is short and approaches to the posterior two or three tooth alveoli, however it does not reach directly these alveoli. The ectopterygoid-ptyerygoid flexure is present and therefore it is retained during the ontogeny (Martin et al. 2014).

Crocodylia indet.

Material: Rădaia: partial left jugal; Treznea 1, Cluj-Napoca (Someş dam): isolated teeth.

Description. The bone, originating from historical collecting in Antal Koch's epoch is fragmentary, elongated and flattened labiolingually (Fig. 4: A). It is wider anteriorly and the orbital margin in this region is gently convex and rounded dorsally. The

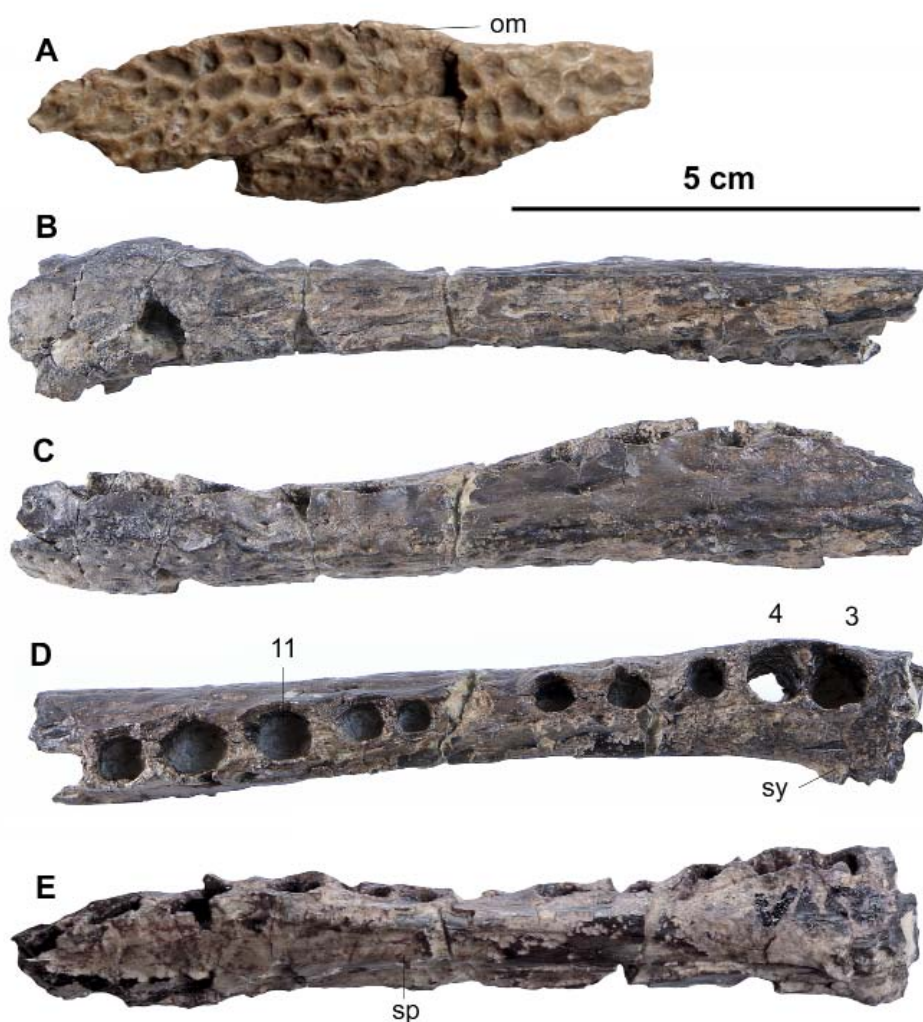


Figure 4. Some various isolated cranial remains of Palaeogene crocodylians from Romania. A. Fragmentary left jugal from the late Eocene (Priabonian) of Rădaia. B – E. Fragmentary left hemimandible from the early Oligocene (Rupelian) from Suceag 1. Abbreviations: 3, 4, 11 – third, fourth, eleventh dentary tooth alveoli; om – orbital margin; sp – splenial; sy – symphysis.

medial side of the anteriormost part displays an imprint that may come in contact with the maxilla; the posterior part is distinctly narrower, it probably contacted the quadratojugal. The postorbital process is not preserved.

Several isolated teeth are of various size (Koch, 1894; Codrea & Fărcaș 2002, Fărcaș 2011) and may represent the premaxillary, maxillary and dentary

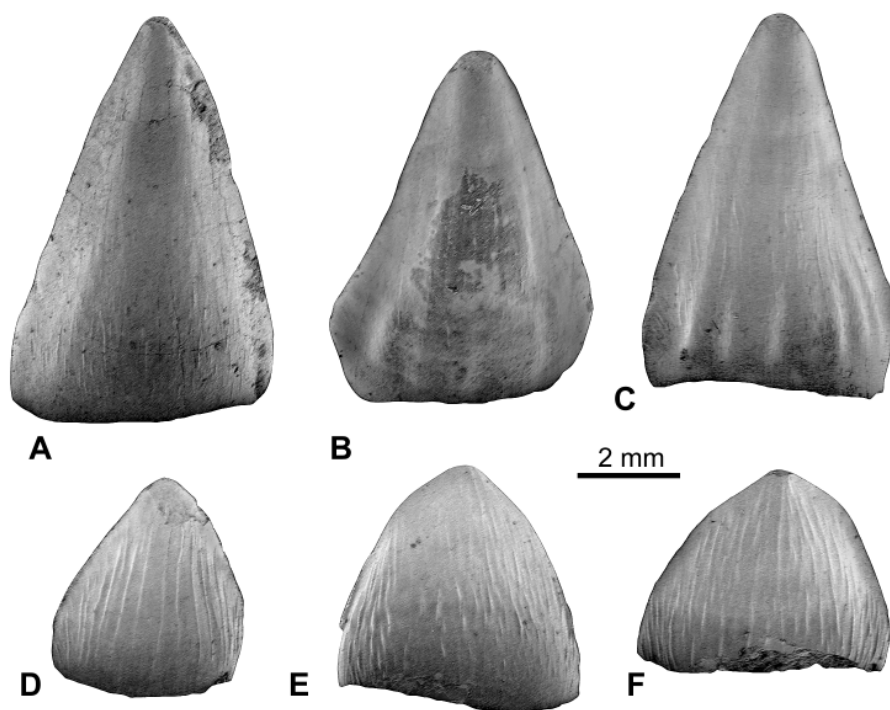


Figure 5. Isolated crocodylian teeth from Treznea. A-C. Isolated caniniform crocodylian teeth. D-E. Isolated conical crocodylian teeth.

teeth. The shape of tooth crowns representing probably the anterior series are caniniform (Fig. 5A-C). These are provided with mesiodistal carinae, but without serrations. A few gentle ridges are discernible near the base of the crown in one of the specimens (Fig. 5C). Part of the teeth are conical and may represent posterior tooth series on the maxillae or mandible (Fig. 5D-E). These are provided with mesiodistal carinae and are devoid of serrations. A series of irregular carinae extend apicobasally on both the lingual and labial side of the tooth crown.

Comments. The morphology of the jugal specimen resembles that of the genus *Diplocynodon*, however, the medial side does not preserve the postorbital process and the detail with the ectopterygoid contact is also unknown. The morphology and the size of the available teeth display the generalized crocodilian pattern. These structures may represent also the genus *Diplocynodon*, however, this assumption cannot be fully demonstrated based on the above remains.

Concluding remarks

The oldest Cenozoic crocodilians in Romania originate from Jibou-Rona (Jibou Formation, Meseş sedimentary area), localities considered as late Paleocene (Thanetian) – ? early Eocene (?Sparnacian) (Gheerbrant et al., 1999; Codrea & Săsăran, 2002; Codrea et al., 2003; Petrescu et Codrea, 2003, 2004; Gaudant et al., 2004). Codrea & Fărcaş (2002) mentioned "cf. *Doratodon* sp., and Crocodyliidae s.l. indet.", but the majority of authors refers only to indeterminate crocodilians. Until their discovery the progress about related systematic is extremely scarce, due to the poor sample of teeth and post-cranial bones. However, we can notice their small size not exceeding 1-1,5 meter in length. In these localities we notice fluvial-lacustrine environments where these fossil vertebrates had been preserved (Codrea & Săsăran, 2002, Petrescu & Codrea, 2003).

The available specimens document the presence of crocodilians in the late Eocene and early Oligocene localities from the Gilău and Meseş sedimentary areas. The fossil remains are relatively rare and up to present only the genus *Diplocynodon* has been identified, as part of the European endemic alligatoroid crocodilian fauna. The fossil record indicates that the above genus may have survived the major faunal turnover at the Eocene/Oligocene boundary ("Grand Coupure" = Great Break). Further research is necessary to establish the closer taxonomic status of these remains.

Apart from these fossils from the north-western Transylvanian basin, we have to mention also some isolated teeth originating from the southernmost border of the same basin. They are known from old collections from 19th century, stored in the collections of the Brukenthal Museum in Sibiu, Natural Sciences branch. They neither preserve too many diagnostic characters, nor clear stratigraphy. One may presume, however, that they are originating from Valea Nişului Formation (Priabonian), from Turnu Roşu (former Porceşti) Palaeogene locality (Mészáros, 1996). But, since in this area older deposits are also exposed (i.e. Cuisian and Lutetian), there is an uncertainty about their sharp stratigraphic level of origin. We may suspect that these crocodilian teeth were considered by ancient local palaeontologists (see Anonymous, 1850) to belong to Triassic reptiles (*Nothosaurus*), although such deposits are completely missing in Sibiu region. Therefore, we mention them herein just to complete the view on the paleogeography of the Palaeogene from the Transylvanian basin, but also to underline the potential of the deposits exposed on the southern border of the basin for such fossils.

Last but not least, we may expect crocodile Palaeogene remains also from the south-western corner of the Transylvanian basin, in the sedimentary area

called Metaliferi (Codrea and Dica, 2005). The most detailed study of these deposits (Băluță, 1973, 1987), does not make any mention about crocodiles, neither in the Eocene, nor in the Oligocene rocks of the Ighiu Formation (Codrea and Dica, 2005). But, a closer look to these deposits could yield such fossils in future.

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