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Latest Cretaceous mosasaurs and lamniform sharks from Labirinta cave, Vratsa district (northwest Bulgaria): a preliminary note

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Abstract. Preliminary descriptions are given of selected specimens from an assemblage of >65 isolated vertebrate remains, collected in 1985 at the Labirinta cave, situated between the villages of Drashan and Breste, east of Cherven Briag (Vratsa district, northwest Bulgaria), from strata of late Maastrichtian age (Kajlâka Formation). Recorded are a fragmentary lower jaw of a mosasaurine squamate, *Mosasaurus* cf. *hoffmanni* (Mantell, 1829), with two teeth preserved *in situ*, as well as two isolated teeth of lamniform sharks, assigned to *Squalicorax pristodontus* (Agassiz, 1843) and *Anomotodon* sp. Other vertebrate remains in this assemblage include rather poorly preserved fragments of ?skull and appendicular skeleton of mosasaurs, but it cannot be ruled out that other vertebrate groups (?elasmosaurid plesiosaurs) are represented as well. To establish this, the additional material needs to be studied in detail and compared with existing collections; it will be described in full at a later date. A partial phragmocone of a scaphitid ammonite, found associated, is here assigned to *Hoploscaphites constrictus* (J. Sowerby, 1817) and briefly described as well. This record dates the Labirinta cave sequence as Maastrichtian, as does the echinoid *Hemipneustes striatoradiatus* (Leske, 1778); tooth morphology of *Squalicorax pristodontus* and a find of the pachydiscid ammonite *Anapachydiscus* (*Menuites*) cf. *terminus* Ward & Kennedy, 1993 from correlative strata nearby narrow this down to late, or even latest, Maastrichtian. Finally, some remarks on mosasaur and plesiosaur distribution during the Campanian–Maastrichtian across Europe are added.

Key words: Mosasaurs, lamniform sharks, Maastrichtian, Bulgaria, scaphitid ammonites, echinoids, stratigraphy.

Апстракт. Дају се претходни описи примерака одабраних из асоцијације од преко 65 издвојених остатака кичмењака, сакупљених 1985. године у пећини Лабиринта између села Драшан и Бресте источно од Червеног Бриага (Врачански крај, северозападна Бугарска) из слојева горњомастрихтске старости (формација Кајлака). Регистрован је део доње вилице краљуштастог мозазаура, *Mosasaurus* cf. *hoffmanni* (Mantell, 1829), са два очувана зуба ин ситу, као и два посебна зуба ламниформних ајкула, који се приписују *Squalicorax pristodontus* (Agassiz, 1843) и *Anomotodon* sp. Међу осталим остацима кичмењака у овој асоцијацији налазе се доста слабо очувани фрагменти ?лобање и припадајућег скелета мозазаура, али се не искључује присуство и других група кичмењака (?еласмозауридски плезиозаури). Да би се то утврдило, потребно је детаљно проучити допунски материјал и упоредити га са постојећим колекцијама. Потпунији опис ће бити накнадно урађен. Делимични фрагмакон скафитидног амонита, нађен у асоцијацији, приписује се *Hoploscaphites constrictus* (J. Sowerby, 1817) и укратко се описује. Према овом налазу, као и на основу јежа *Hemipneustes striatoradiatus* (Leske, 1778); секвенца пећине Лабиринта одређује се као мастрихтска; морфологија зуба *Squalicorax pristodontus* и налазак пахидисцидног амонита *Anapachydiscus*

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(*Menuites*) cf. *terminus* Ward & Kennedy, 1993 из оближњег изданка формације Кајлака омогућава прецизнију одредбу старости као касни мастрихт, или чак најкаснији мастрихт. Ближа одредба на горњи мастрихт заснива се на морфологији зуба. На крају, дају се и нека запажања у вези распрострањености мозазаура и плезиозаура за време кампан–мастрихта широм Европе.

Кључне речи: Мозозаур, ламниформне ајкуле, мастрихт, Бугарска, скафитидни амонити, јежеви, стратиграфија.

Introduction

In the summer of 1981, a team of speleologists discovered a new, unexplored cave in Upper Cretaceous limestones between the villages of Drashan and Breste, Vratsa district (northwest Bulgaria; Fig. 1). This expedition was organised by the speleoclub 'Stalacton', based in the nearby town of Cherven Briag. After a vertical descent of eight metres, the speleologists encountered a labyrinth of several galleries with a total length of about 1 km. The new cave was named Labirinta, Bulgarian for 'The labyrinth'. On the way back to the entrance, 28 m below the surface, the group came across several fossil bones protruding from the cave wall at two sites (A, B in Fig. 2). During a subsequent expedition to the same area, the speleologist Zdravko Iliev invited two palaeontologists, Drs Stoycho Breskovski and Vassil Popov, who noted that this fossil occurrence was significant and rather unique. Together with Dr Nikolay Spassov they were responsible for a preliminary identification of the bones excavated. They attributed them to the extinct squamate family Mosasauridae and, more specifically, to the genus *Mosasaurus*. In the summer of 1985, a palaeontological excavation was carried out, during which all fossil material accessible was collected, albeit rather chaotically without documenting the exact position of specimens taken from the rock. The material from the two sites was subsequently mixed and transferred to the collections of the National Museum of Natural History Sofia (NMNHS). This excavation has so far been described in a popular paper (Genov, 1985) only. Part of the material was later sent to the Paleontological Institute of the Russian Academy of Sciences (Moscow) for detailed examination, while the remainder stayed at Sofia. After that, studies came to a halt. A single tooth from this lot was put on exhibit in the Paleontology Hall of the National Museum of Natural History, but the material was never formally published. The current whereabouts of the specimens sent to Moscow is unknown.

Fig. 1. Locality map of the study area in Vratsa district, northwest Bulgaria; the asterisk denotes the location of the Labirinta cave between the villages of Drashan and Breste.

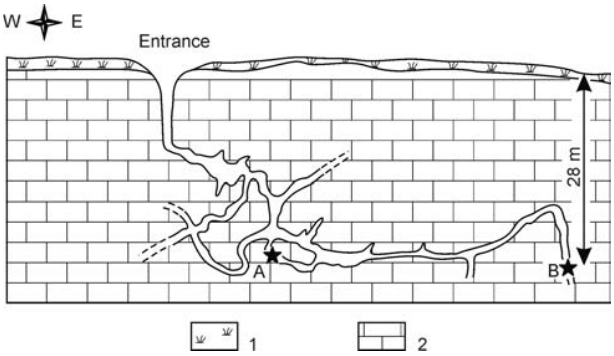

Fig. 2. Schematic vertical section of the Labirinta cave, showing the provenance (A and B) of macrofossil collections described herein; 1, soil; 2, limestones of the Kajlâka Formation.

In total, this lot comprises sixty registered, mostly fragmentary, specimens. Amongst them are two teeth (one of which is described below) associated with part of a jaw bone [NMNHS 11897/1 (*ex* Mos 60) and 11897/2 (*ex* Mos 20)], a radius, single phalanges, ribs, and vertebrae. For the present note, we have selected the following elements for brief discussion: a fragment of a lower jaw (NMNHS 11897/1) of a mosasaurine mosasaur with a tooth preserved *in situ*, and two isolated teeth of lamniform sharks [NMNHS 31362 (*ex* Mos 55) and NMNHS 31363 (*ex* Mos 7)]. Some of the other material is rather poorly preserved, being embedded in an indurated matrix not conducive to mechanical preparation. It may be that the present lot also includes isolated bones of other vertebrate groups, e.g. elasmosaurid plesiosaurs. Our aim is to provide, at a later date, detailed descriptions of this material (held at NMNHS), within the framework of a revision of all mosasaur material from the Upper Cretaceous of Bulgaria known to date, inclusive of the originals of TZANKOV (1939) and NIKOLOV & WESTPHAL (1976).

Of interest is a single scaphitid phragmocone (NMNHS 29929), collected when recovering the vertebrate remains from the Labirinta cave; its stratigraphic value is briefly commented on. Added also are more general notes on mosasaur and plesiosaur distribution in the Campanian–Maastrichtian across Europe, with references to a few recent papers.

Geological and stratigraphical setting

The Labirinta cave is situated within limestones assigned to the Kajlâka Formation (JOLKIČEV, 1986), a unit widely distributed in the Fore-Balkan and Moesian Platform of northern Bulgaria and usually the highest Cretaceous unit in outcrops in this area. Geomorphologically, the entrance to the Labirinta cave is situated in a sinkhole; such karst phenomena are very common in this area and are developed along vertical fractures in the Kajlâka Formation. This formation comprises whitish or beige, medium- to thick-bedded (albeit indistinctly), recrystallised limestones, and varies in total thickness between 10–25 and 200–280 m. In places, the limestones contain organogenic layers composed of shells and detritus mostly of bryozoans, bivalves and echinoids and rarely of gastropods, brachiopods and cephalopods. In the study area, within this limestone unit, there is an interval of 50–60 metres of whitish (with a beige hue), indistinctly bedded, fine- to medium-grained 'quarry type' limestones, the so-called Vratsa Stone, famous in Bulgaria and some other European countries for wall tiling (see JOLKIČEV, 2006, fig. 2). We assume that the mosasaurid material described by NIKOLOV & WESTPHAL (1976), and briefly commented upon below, originated from this interval.

The rock which yielded the mosasaur and shark material from the Labirinta cave described herein is a light grey, strongly recrystallised, slightly sandy limestone, containing Mn-oxihydroxide dendrites. This interval of the Kajlâka Formation probably correlates with the highest limestone unit in a section near the village of Varbeshnitsa, northwest of Mezdra. This highest unit overlies the 'quarry type' limestones (see description of section in JOLKIČEV, 1982, p. 18, fig. 7; topmost limestone unit 10).

The age assignment of the Kajlâka Formation in the study area has been based mostly on the superposition of this unit on strata of early Maastrichtian age, and on ammonite and echinoid evidence. A single echinoid species, commonly recorded from this formation, *Hemipneustes striatoradiatus* (LESKE, 1778), corroborates a Maastrichtian date [it occurring most commonly in the upper Maastrichtian]. The isolated scaphitid phragmocone (Fig. 3) found associated with the vertebrate remains from Labirinta cave is here assigned to *Hoploscaphites constrictus* (J. SOWERBY, 1817), also confirms a Maastrichtian date. The tooth morphology of the lamniform shark described here as *Squalicorax pristodontus* (AGASSIZ, 1843) allows this to be specified as late Maastrichtian, and the pachydiscid ammonite, *Anapachydiscus (Menuites)* cf. *terminus* WARD & KENNEDY, 1993, recorded from the 'quarry type' limestones of the Kajlâka Formation at the nearby village of Varbeshnitsa (see JOLKIČEV, 2006, fig. 5E) narrows the dating more precisely to the latest part of the late Maastrichtian. *Anapachydiscus (Menuites) terminus* is also known from the uppermost Maastrichtian of the Bay of Biscay sections (France, Spain), the southeast Netherlands, northern and eastern Denmark, central Poland, Azerbaijan, Crimea and South Africa (see WARD & KENNEDY, 1993) and the Bjala area of eastern Bulgaria (IVANOV, 1995).

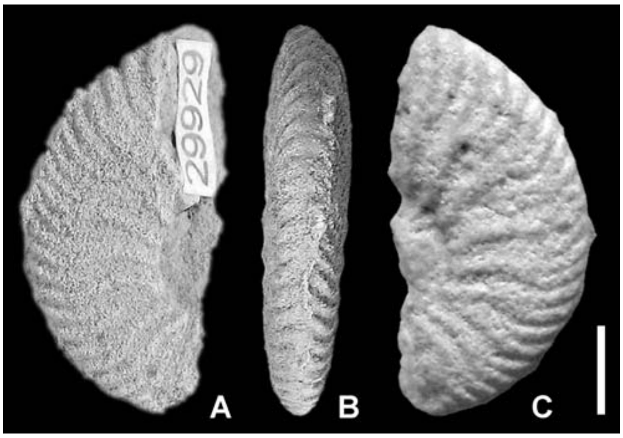

Fig. 3 A–C. *Hoploscaphites constrictus* (J. SOWERBY, 1817), NMNHS 29929, partial phragmocone, in lateral (left and right) and ventral views. Scale bar equals 5 mm.

Preliminary descriptions

To denote the repositories of material described, illustrated and/or referred to, the following abbreviations are used in the text: IRScNB, Institut Royal des Sciences Naturelles de Belgique, Brussels; MNHN, Muséum National d'Histoire Naturelle, Paris; NHMM, Natuurhistorisch Museum Maastricht, Maastricht; NMNHS, National Museum of Natural History, Sofia.

Mosasaurs

From what can be seen, the fragmentary lower jaw with two teeth preserved can be assigned to the mosasaurinae genus *Mosasaurus* CONYBEARE, 1822 (type species: *Mosasaurus hoffmanni* MANTELL, 1829).

***Mosasaurus* cf. *hoffmanni* MANTELL, 1829**
Fig. 4 A–D

Material. A partial lower jaw with two teeth associated (NMNHS 11897); here, we only describe the larger tooth (NMNHS 11897/1). The smaller one, situated more posteriorly, is longitudinally broken and not prepared yet.

Description. Being partially embedded in hard matrix and, in general, of rather poor preservation, the jaw bone cannot be described in detail. From what can be seen (e.g., foramina, overall size and height as compared to tooth size, as well as dental and root structure; Fig. 4A), this fragment is best interpreted as the anterior/mesial portion of a lower jaw (dentary) of an adult individual, pending further preparation. It contains two teeth *in situ*; the larger of these is a sturdy, bicarinate crown (incomplete, tip broken off; Figs. 4 A–D) measuring 43 mm in overall height (as preserved; original height estimated to have been 46 mm), and 19 mm in basal width, in mesodistal direction. It has an elliptical, typically U-shaped cross section (Fig. 4 D), with unequal labial and lingual surfaces; labial face gently convex with no facetting visible, not even proximally; lingual face deeply U-shaped and no facetting seen either. Enamel beading is not well developed; it is seen only in patches proximally. The crown is moderately posteriorly and lingually recurved. Both anterior and posterior carinae are well developed, but partially damaged; carinae minutely serrated over their entire length. The uppermost portion of the root is exposed considerably (Fig. 4A), being reversed conical in shape but lacking a clearly developed 'rim'; its length cannot be determined and the resorption pit is not seen. The extent to which the root is exposed is exceptional in comparison to material of *M. hoffmanni* from the Maastrichtian type area; it could be a pathological feature of the present individual.

Remarks. Tooth morphology (U-shaped cross section, minutely serrated carinae, obliquely positioned carinae, recurvature and enamel beading) allow this material to be compared favourably with *Mosasaurus hoffmanni*, the largest species in the genus *Mosasaurus*. The type material of *M. hoffmanni* is from the upper part of the Maastricht Formation (upper Nekum Member; holotype is MNHN AC 9648) in the type area of the Maastrichtian Stage (St Pietersberg, Maastricht and environs, the Netherlands; see LINGHAM-SOLIAR, 1995; BARDET & JAGT, 1996; KUYPERS *et al*., 1998) and is of late Maastrichtian age (*Belemnitella junior* Zone of authors). In southern Limburg (the Netherlands) and adjacent Belgian territory (provinces of Liège and Limburg), *M. hoffmanni* (or a closely related taxon) first appears, albeit extremely rarely, in the upper Vijlen Member (Gulpen Formation; interval 6), is comparatively rare in the remainder of this formation (Lixhe 1–3 and Lanaye members) and the lower portion of the overlying Maastricht Formation (Valkenburg, Gronsveld and Schiepersberg members), but common in the Emael

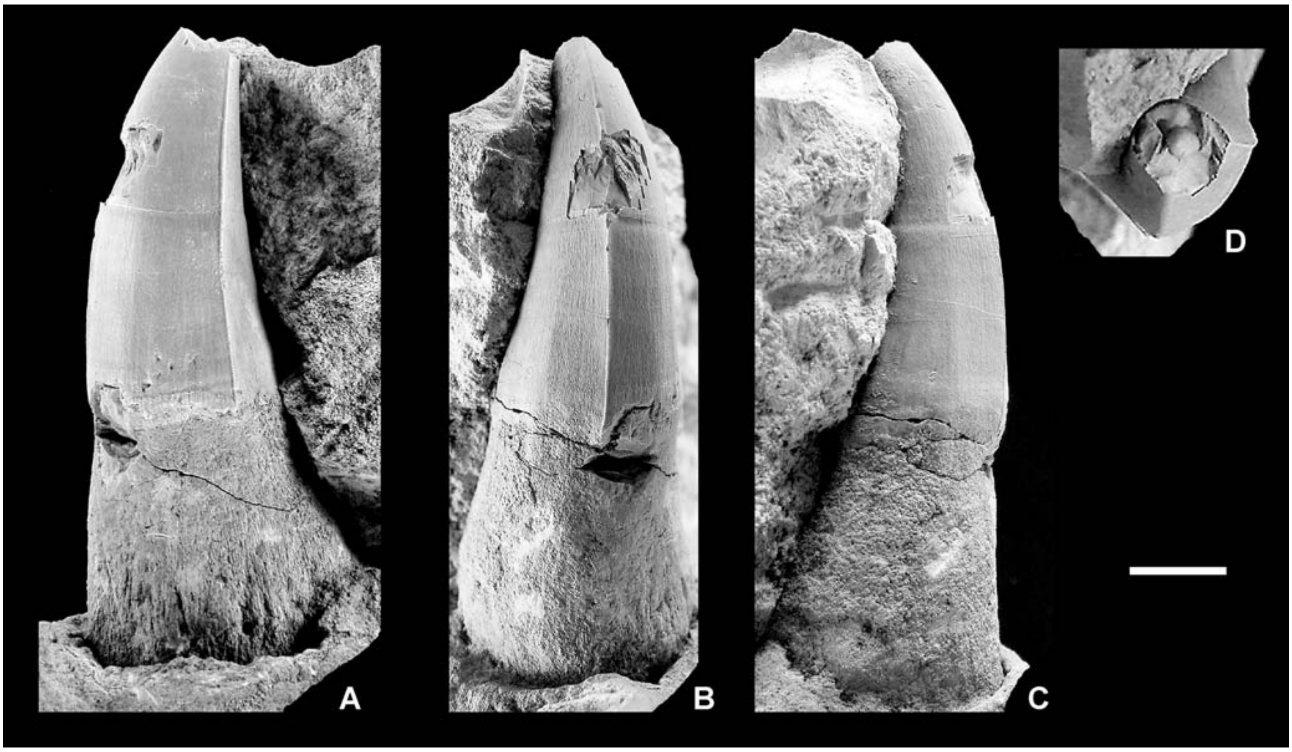

Fig. 4 **A–D**. *Mosasaurus* cf. *hoffmanni* MANTELL, 1829, anterior-mesial fragment of lower jaw (NMNHS 11897/1), with a single tooth preserved *in situ*; tooth shown in labio-mesial (**A**), mesial (**B**), lingual (**C**) and apical (**D**) views, respectively. Scale bar equals 10 mm.

and Nekum members of that formation, in particular. The species ranges to within a metre below the Cretaceous–Paleogene (K/Pg) boundary in the area, and shows a wide range of variation in tooth morphology (facetting, size, enamel structure) which may be ontogenetically controlled (compare MERTENS, 1942); there is currently no evidence of sexual dimorphism in mosasaur taxa. From the Eben Emael area (northwest Belgium) in particular, fairly numerous finds have been made of articulated material in the past decade, inclusive of at least five skulls (JAGT *et al*., 2002). This material is currently being studied, in an attempt to describe the species in detail and better determine its range of morphological and ontogenetic variation. Tooth morphology along the dental and (pre)maxillar rami in particular is assessed to allow isolated tooth crowns and teeth to be assigned with more confidence.

MULDER (1999) relegated the North American (New Jersey) species, *M. maximus* COPE, 1869 into the synonymy of *M. hoffmanni*, and subsequently MULDER *et al*. (2004) expressed doubts over the specific status of *M. lemonnieri* DOLLO, 1889 (holotype is IRScNB R 28 [*ex* 1470]) from the lower Maastrichtian ('Craie phosphatée de Ciply'; *Belemnella obtusa* Zone) at Mesvin, Mons Basin (southern Belgium), noting that it might well be nothing more than a juvenile *M. hoffmanni*. Interestingly, CALDWELL *et al*. (2004) noted that the type lot of *M. lemonnieri* from that unit included a specimen (IRScNB R3211) that would be better assigned to *Moanasaurus*, a genus otherwise known only from the Campanian (Haumurian) of New Zealand (WIFFEN, 1980).

The current stratigraphic and geographic range of *M. hoffmanni*, or of closely related taxa generally referred to in the literature as *M*. cf. *hoffmanni*, corresponds to the late Campanian to latest Maastrichtian in a belt across the Northern Hemisphere (LINDGREN & JAGT, 2005). From west to east this includes Missouri, Alabama, New Jersey (all USA), southern and northeast Belgium, southeast Netherlands, Denmark, northern Germany, central Poland, northwest Bulgaria and Turkey (BARDET & TUNOĞLU, 2002; KIERNAN, 2002; REICH & FRENZEL, 2002; MACHALSKI *et al*., 2003; GALLAGHER *et al*., 2005; TUNOĞLU & BARDET, 2006).

Sharks

The present lot from the Labirinta cave comprises two isolated neoselachian teeth, both assignable to lamniforms, with the larger one representing the anacoracid genus *Squalicorax* WHITLEY, 1949, and the other the ?alopiid genus *Anomotodon* ARAMBOURG, 1952.

Squalicorax pristodontus (AGASSIZ, 1843)
Fig. 5 A, B

Material. A single, incomplete lateral tooth (NMNHS 31362 [*ex* Mos 55]).

Description. This is an element of the lateral file, the crown being well preserved, broad and triangular, with a regularly convex cutting edge, bearing strong serrations. The distal cutting edge is oblique on the whole, with a slight concavity in its upper two-thirds; the labial face is very flat while the lingual one, much more reduced, is slightly convex. The root, not perfectly preserved, is also labio-lingually flattened and shows many small, irregularly spaced foramina on the labial face.

Remarks. Morphologically, this tooth can be identified as *S. pristodontus* beyond any doubt. Considering its general design, a late Maastrichtian age can be assigned to this specimen, by comparison with Maastrichtian material collected from the phosphate series of Benguerir (Morocco), currently under study (H. CAPPETTA, pers. obs.). Thus, this allows the general age assignment of the vertebrate association of Labirinta cave to be narrowed down to the late Maastrichtian.

Occurrence. This species is widely distributed and occurs in the Campanian of Belgium, France and Germany (LERICHE, 1929; ALBERS & WEILER, 1964; VULLO, 2005), but is particularly common in the Maastrichtian of the Netherlands and Belgium (LERICHE, 1929; HERMAN, 1977), Spain (CAPPETTA & CARMELO CORRAL, 1999), northern Bulgaria (TZANKOV & DATCHEV, 1966), Morocco (ARAMBOURG, 1952; NOUBHANI & CAPPETTA, 1997), Angola (ANTUNES & CAPPETTA, 2002), Syria (BARDET *et al*., 2000), New Jersey and Texas (CAPPETTA & CASE, 1975; WELTON & FARISH, 1993) and Brazil (REBOUÇAS & DA SILVA SANTOS, 1956).

Anomotodon sp.
Fig. 5 C–E

Material. A single, incomplete latero-anterior tooth (NMNHS 31363 [*ex* Mos 7]).

Description. This is an element of a latero-anterior file, the crown being fairly high, narrow, and with a sharp apex. The labial face is slightly convex transversely but shows a basal median excavation of triangular outline; the lingual face is transversely convex and completely smooth. On one side, a short oblique heel, slightly and irregularly serrated, can be seen. The root is damaged and only one side is preserved; its lingual face is rather high, and it seems that there was not a long lobe.

Remarks. In lateral teeth of *Anomotodon*, the lingual face of the crown often is devoid of folds. The same is seen in teeth of the genus *Paranomotodon* HERMAN *in* CAPPETTA & CASE, 1975, the crown of which completely lacks folds (SIVERSON, 1992; VULLO, 2005). So, on the basis of the material available, it is quite difficult to give a definite generic assignment. NMNHS 31363 can be compared to *A. toddi* CASE & CAPPETTA, 1997 (p. 142, pl. 5, figs. 1, 2) from the upper Maastrichtian Kemp Clay Formation of Texas, but also to *A. hermani* SIVERSON, 1992 (p. 544, pl. 5, figs. 1, 2) from the lower-upper Campanian of southern Belgium and south-

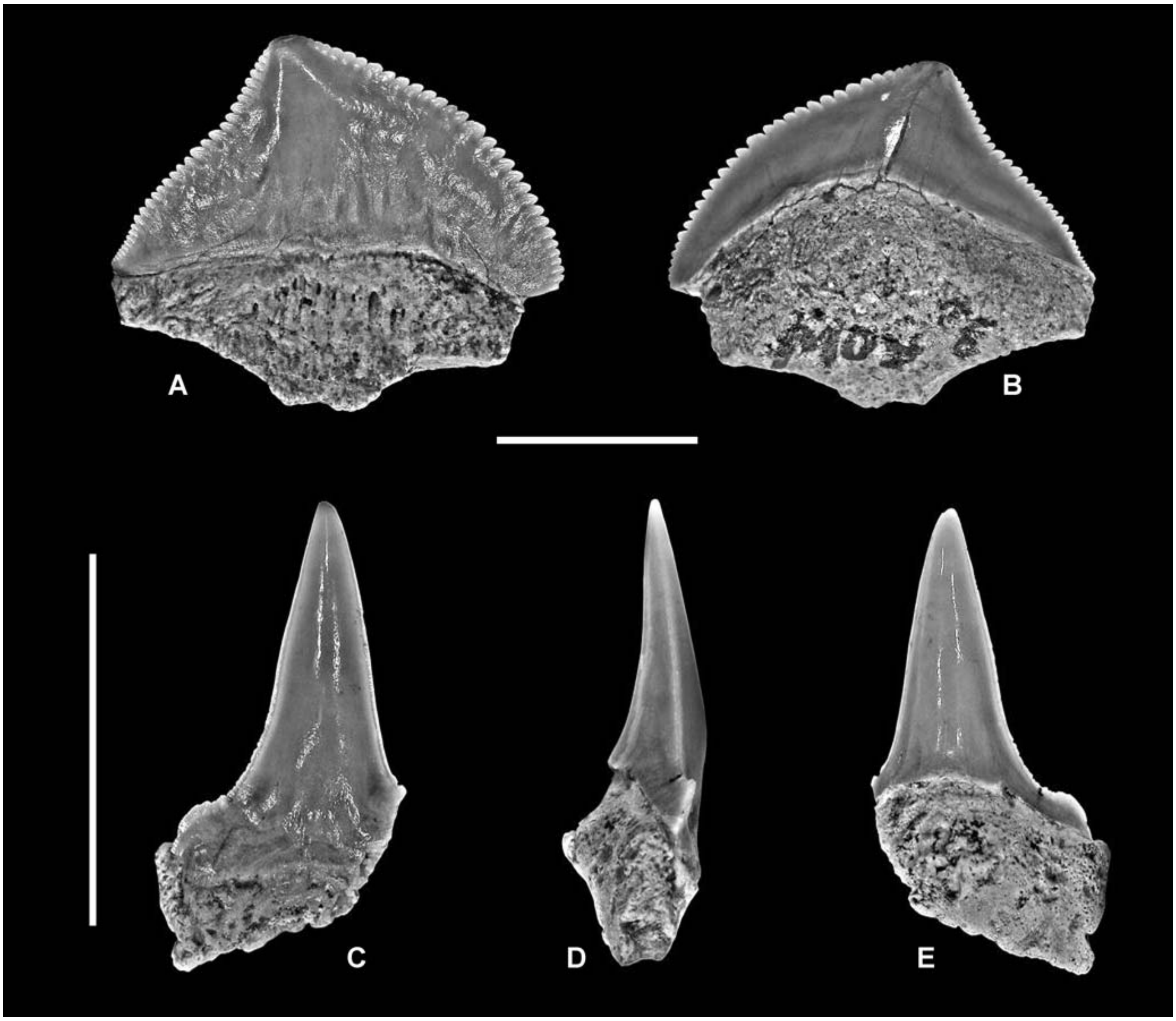

Fig. 5. Lamniform shark teeth. **A, B**. *Squalicorax pristodontus* (L. Agassiz, 1843), lateral tooth (NMNHS 31362), in labial and lingual view, respectively. **C–E.** *Anomotodon* sp., lateral anterior tooth (NMNHS 31363), in labial (**C**), lateral (profile) (**D**) and lingual (**E**) view. Scale bars equal 10 mm.

ern Sweden. Yet, as a definite specific identification is difficult on the basis of a single, imperfect tooth, it appears better to leave it in open nomenclature.

Discussion

Earlier records of mosasaurs from the Upper Cretaceous of northern Bulgaria include dissociated teeth and tooth crowns from near the village of Somovit at the River Danube, listed and illustrated by Tzankov (1939). That author referred these strata to the uppermost Maastrichtian, but his listing [in original nomenclature] of characteristic macrofossil taxa from there shows that a modern revision is called for, as there appears to be a curious mixture of typically Campanian and Maastrichtian elements (e.g., *Echinocorys gibbus*, *Bostrychoceras polyplocum*, *Belemnitella mucronata* and *Parapachydiscus colligatus* being Campanian, and *Hemipneustes striato-radiatus* and *Discoscaphites constrictus* being Maastrichtian). Mosasaur taxa recorded by Tzankov are *Leiodon anceps*, *Mosasaurus giganteus* (= *M. hoffmanni*) and *Globidens fraasi* (= *Carinodens belgicus*). Judging from his description of the matrix and based on the occurrence of the echinoid *Hemipneustes striatoradiatus* (which cannot be misidentified), we assume the material described by Tzankov (1939) to have come from strata assignable to the Kajlâka Formation as well, and thus to be of (late) Maastrichtian age.

Nikolov & Westphal (1976) recorded from an active quarry c. 2 km east of Varbeshnitsa, northwest of

Mezdra, part of the vertebral column (580 mm in length, 14 vertebrae) of a mosasaur, as well as three teeth, possibly of a single individual. The level from which these remains came was described as a unit of white to yellowish, fine-grained limestone quarried for wall tiles, c. 40 m thick, with occasional, scattered flint nodules, yielding the coleoid cephalopod *Belemnitella mucronata* and the holasteroid echinoid *Hemipneustes striatoradiatus*. The quarry exposing the Kajlâka Formation near Varbeshnitsa is in unit 9 of 'quarry-type' limestones (see JOLKIČEV, 1982, p. 18, fig. 7, limestone unit 9), having yielded *Pachydiscus gollevillensis gollevillensis* (*sensu* JOLKIČEV, 1982 = *Anapachydiscus* cf. *terminus*; see JOLKIČEV, 2006). *Anapachydiscus (Menuites) terminus* is characteristic only of the latest part of the late Maastrichtian (see remarks about the species distribution above).

With regard to the macrofossil taxa mentioned in NIKOLOV & WESTPHAL (1976), we wish to observe the following. Amongst belemnite workers, there currently is consensus that *B. mucronata* is a predominantly late Campanian species (CHRISTENSEN, 1997a, b; compare STOYANOVA-VERGILOVA & JOLKIČEV, 1993), which is why the record by NIKOLOV & WESTPHAL (1976) may be taken to refer to another species of *Belemnitella*, probably of the *B. junior* group which in northwest Europe characterises the late Maastrichtian. The presence of *B. junior* in the lower Maastrichtian of southern Limburg (the Netherlands), as noted by KEUTGEN (1996) and CHRISTENSEN *et al.* (2004), could not be substantiated in recent belemnite studies in the area (KEUTGEN *et al.*, in prep.). The holasteroid echinoid *Hemipneustes striatoradiatus* is widely distributed in the Kajlâka Formation (JOLKIČEV, 1989, 2006). This species is a typically Tethyan element, known to range through the whole of the Maastrichtian, but particularly characteristic of the latter part of the stage in the Netherlands, northeast Belgium, French Pyrenees, Navarra and Alicante (Spain), Bulgaria, Georgia, Kazakhstan, northern Caucasus and Tadzhikistan (SMITH & JEFFERY, 2000). In the Maastrichtian type area, *H. striatoradiatus* first appears in the lower Lanaye Member (Gulpen Formation), of late Maastrichtian age (*Belemnitella junior* Zone of authors; equivalents of *tegulatus/junior* Zone *sensu* SCHULZ & SCHMID, 1983) and ranges to the top of the Meerssen Member (Maastricht Formation, IVf-7; *Belemnella (Neobelemnella) kazimiroviensis* Zone) (JAGT, 2000).

Elsewhere in Bulgaria, the age of Kajlâka Formation is late Maastrichtian as based on records of the ammonite *Sphenodiscus binckhorsti* J. BÖHM, 1898 (see TZANKOV, 1982; KENNEDY, 1987; JAGT, 2002, 2005; MACHALSKI, 2005a), as well as on the basis of regular superposition in several outcrops with underlying lower Maastrichtian sediments.

For dating the present material from the Labirinta cave, an associated scaphitid phragmocone (NMNHS 29929) collected during recovery of the vertebrate material, is of importance. This consists of half a whorl (Fig. 3), of c. 22 mm in length (as preserved) and represents a highly compressed, flat-sided phragmocone, with fairly broadly rounded ventrolateral shoulders and a narrow, flattened venter (Fig. 3B). The diameter of the umbilicus is c. 6.5 mm. Ornament consists of up to nine flexuous primary ribs, arising at the umbilical seam (Fig. 3A, C); these are feebly concave and prorsiradiate on the inner flank, convex at mid-flank and concave on the outer flank and ventrolateral shoulder and convex over the venter. Primary ribs divide at mid-flank, and single (or double) intercalatories are inserted on the outer flank, giving a total of c. 22 ribs at this growth stage. No ventrolateral tubercles are seen at the largest diameter, but this may in part be preservation induced. No sutures can be seen.

Comparison with similar-sized material from the Maastrichtian type area (Maastricht Formation, Meerssen Member, subunits IVf-5 and -6; NHMM JJ 8297 and JJ 13341a–c), the upper Maastrichtian of Petites-Pyrénées, France (KENNEDY *et al.*, 1986, pl. 4) and the uppermost Maastrichtian of Turkmenia (JAGT *et al.*, in prep.) shows NMNHS 29929 to be comparatively coarsely ribbed and with a large umbilicus, but this is well within the range of variation documented for corresponding growth stages of *Hoploscaphites constrictus* (J. SOWERBY, 1817). This species is typically Maastrichtian, with records from southern Sweden, Denmark, northern Germany, the Netherlands, southern and northeast Belgium, Cotentin (Manche), Landes and Petites-Pyrénées (all France), Lleida (Spain), Switzerland, Austria, the Czech Republic, Poland, Bulgaria, the Ukraine, Carpathians, Donbass, Transcaspia, Kazakhstan and Kopet Dag, Turkmenia (KENNEDY, 1987; JAGT, 2002; NIEBUHR, 2003; MACHALSKI, 2005a, b). At least at two localities, Stevns Klint (Denmark) and the Maastrichtian type area (the Netherlands), it extends into the lower Paleocene (MACHALSKI & HEINBERG, 2005). On the basis of a detailed study of shell ornament, both of micro- and macroconchs, MACHALSKI (2005a, b) was able to demonstrate the occurrence of several temporal subspecies during the late Maastrichtian. Unfortunately, with but a single, incomplete phragmocone available, it cannot be determined to which of these taxa NMNHS 29929 might be assigned. A more detailed age assignment than Maastrichtian is thus impossible on the basis of this scaphitid record.

Isolated teeth of neoselachian sharks are common in epicontinental Upper Cretaceous strata in Bulgaria. TZANKOV & DATCHEV (1966, pl. 7, figs. 6–16) recorded, for the first time in Bulgaria, the species *Anacorax* (= *Squalicorax*) *pristodontus* (AGASSIZ, 1843) (erroneously spelled *priostodontus*) from Maastrichtian strata near the towns of Pleven and Shumen, and near the village of Somovit on the River Danube, but they did not provide a description of the occurrence of the strata, hence, it is difficult to judge from which exact level of the Maastrichtian their material came. It is presumed that their material also originates from the Kajlâka Formation. The good preservation of the specimen described here allows a comparison with Maastrichtian material from Morocco and, thus, enables a more precise age to be assigned to this specimen.

In summary, the Labirinta cave material is definitely of late (?latest) Maastrichtian date as based on dental morphology of *Squalicorax pristodontus* and on correlation with nearby outcrops, which have been dated on echinoid and ammonoid evidence.

Remarks on mosasaur and plesiosaur distribution across Europe

Mosasaurid occurrences are known from numerous outcrops of Campanian and Maastrichtian strata across Europe. Distinct stratigraphic levels, representing mostly shallow-water, (sub)littoral settings, in three areas in particular have yielded diverse assemblages, and at two of these, more or less completely preserved cranial and post-cranial material has been shown to be relatively common. These are:

1. The lower Maastrichtian 'Craie phosphatée de Mons' (*Belemnella obtusa* Zone) in the Mons Basin, southern Belgium (Lingham-Soliar & Nolf, 1990; Lingham-Soliar, 1992, 1993, 1994, 1999, 2000; Caldwell *et al.*, 2004; Mulder *et al.*, 2004; Jagt, 2005), which has produced '*Mosasaurus lemonnieri*' (= *M. hoffmanni* juv.?; *Moanasaurus* sp.), *Plioplatecarpus houzeaui*, *Halisaurus ortliebi*, *Prognathodon solvayi* and *Hainosaurus bernardi*. Two additional species, *Prognathodon giganteus* and *Globidens dakotensis*, are of Campanian age (Jagt, 2005);

2. The extended type area of the Maastrichtian Stage (Lingham-Soliar, 1993, 1994, 1995, 1996, 1999; Dortangs *et al.*, 2002; Jagt *et al.*, 2002; Mulder, 2003a, b; Schulp *et al.*, 2004; Jagt, 2005; Schulp, 2006; see also Mulder & Mai, 1999). Here, Maastrichtian strata (Vijlen Member, Gulpen Formation to Meerssen Member, Maastricht Formation) have yielded *Mosasaurus hoffmanni*, *'M. lemonnieri'* (= *M. hoffmanni* juv.?), *Plioplatecarpus marshi*, *Liodon 'sectorius'*, *Carinodens belgicus* and *Prognathodon saturator*. Campanian species include *Prognathodon 'solvayi'* and *Hainosaurus* sp. (Jagt, 2005);

3. Skåne (southern Sweden, Kristianstad Basin), from where almost no articulated material is known, but which shows a remarkably high diversity in the lower and upper Campanian in particular, having yielded material assigned to *Platecarpus* sp., *Clidastes propython*, *Platecarpus* cf. *somenensis*, *Halisaurus sternbergi*, *Dollosaurus* sp., *Hainosaurus* sp., *Tylosaurus ivoensis*, *Prognathodon* sp. and *Plioplatecarpus* sp. From the lower Maastrichtian, two species are known, namely *Plioplatecarpus primaevus* and *Mosasaurus* aff. *lemonnieri* (Lindgren, 2005a, b; Lindgren & Siverson, 2002, 2004, 2005).

Taken together, these three areas can be assumed to represent all mosasaur taxa distributed across Europe during the Campanian–Maastrichtian, with the possible exception of one or two rare taxa. From other localities in Europe, far less common, and usually highly fragmentary material (with few exceptions), is known. These probably all represent deeper-water settings, far from coastal areas, and include:

4. The Münsterland (northwest Germany; Caldwell & Diedrich, 2005), from where a late Campanian species of *Clidastes* has been recorded;

5. England (Milner, 2002), from where material assigned to *Clidastes* sp. (Santonian–Campanian; Surrey, Sussex), indeterminate mosasaurines (Campanian–Maastrichtian; Norfolk), *Prognathodon* (upper Campanian; Norfolk), indeterminate plioplatecarpines (Santonian–Campanian; Sussex, Hampshire), ?*Tylosaurus* (upper Santonian–lower Campanian; Hampshire, Kent and Yorkshire) and *Leiodon anceps* (= ?*Hainosaurus*, Coniacian–upper Campanian; Sussex, Essex and Norfolk) has been recorded;

6. Southwest Russia and Crimea (Ukraine) (Yarkov, 1993; Storrs *et al.*, 2000; Schulp *et al.*, in press), with a cranial and post-cranial skeleton of *Dollosaurus lutugini* from the upper Campanian of central Russia and isolated tooth crowns of *Carinodens belgicus* from the upper Maastrichtian of Trudołyubovka, Crimea and Volgogradskaya oblast', Russia;

7. Northern Spain (Bardet *et al.*, 1993, 1997b, 1999; Bardet & Pereda Suberbiola, 1996), with isolated teeth and tooth crowns of *Prognathodon solvayi*, *Platecarpus* cf. *ictericus*, *Leiodon anceps*, *Leiodon* sp., *Mosasaurus* sp. and indeterminate mosasaurines;

8. Central Poland (Machalski *et al.*, 2003; Jagt *et al.*, 2005), with records of *Mosasaurus* cf. *hoffmanni* from the upper Campanian and uppermost Maastrichtian, *M.* cf. *lemonnieri* from the upper Maastrichtian, '*M. (Leiodon)* cfr. *anceps*' [*sensu* Arambourg, 1952] from the same level, *Hainosaurus* sp. 1 and *Prognathodon* sp. from the upper Campanian, and *Hainosaurus* sp. 2 from the upper Maastrichtian, all from sections in the Wisla River valley;

9. France (Bardet, 1990; Bardet *et al.*, 1991, 1997a), with records of *Hainosaurus bernardi* and ?*Hainosaurus* sp. from the Santonian–Campanian (Somme, Aude), *Prognathodon giganteus* from the lower Campanian (Champagne) and *Platecarpus* sp. from the lower Campanian of Corbières;

10. Denmark where lower and upper Maastrichtian strata in Jylland and Sjælland have yielded very rare remains, mostly tooth crowns, of *Mosasaurus* cf. *hoffmanni* and *Plioplatecarpus* sp. (Lindgren & Jagt, 2005).

Interesting is also Rügen (northeast Germany) from where historical material of early Maastrichtian age, the current whereabouts of which is unknown, was illustrated by Reich & Frenzel (2002, pl. 2, fig. 4). This isolated tooth from the von Hagenow Collection appears conspecific to material recorded from the upper Maastrichtian of central Poland by JAGT *et al.* (2005), as *Hainosaurus* sp. 2. Representatives of the tylosaurine genus *Hainosaurus* may thus have been more widely distributed in the European Campanian–Maastrichtian than previously assumed. In general, mosasaur remains from deeper-water settings represented by the 'white chalk facies' of northeast Germany and Denmark are comparatively rare; a few isolated tooth crowns of *Mosasaurus* cf. *hoffmanni* are known from Rügen (REICH *et al.*, 2005). With the exception of some vertebrae in matrix, none of the vertebrate fossils recorded by LADWIG (1997) from Lägerdorf (northern Germany) can be assigned to mosasaurs; the majority of teeth illustrated are of enchodont teleosts and allies.

In comparison to mosasaurs, plesiosaurs in the Campanian–Maastrichtian are much rarer, and mostly refer to isolated cranial and post-cranial elements, rarely to associated skeletal elements of a single animal. Plesiosaurs appear to have frequented upwelling areas, rich in food; occurrences in shallow-water environments such as the upper Campanian of the Mons Basin (BARDET & GODEFROIT, 1995) and the upper Maastrichtian of the Maastricht area (MULDER *et al.*, 2000) are best explained as stemming from floating carcasses, or from animals that only on certain occasions visited the area to feed. Anomalous in this respect is the comparative richness of plesiosaur remains from the Campanian of southern Sweden (PERSSON, 1959, 1962, 1963, 1967); this may be related to preferred feeding and/or breeding grounds in the shallow-water settings of the Kristianstad Basin and other areas there. The find of a partial elasmosaurid skeleton in the uppermost Campanian (*grimmensis*/*granulosus* Zone) of Lägerdorf, northern Germany (MAISCH & SPAETH, 2004) is of special interest, in being one of the very few examples of associated plesiosaur remains known to us.

Conclusions

During the latest Cretaceous (Campanian–Maastrichtian), marine lizard (mosasaurid) species inhabited the epicontinental seas along the northerly margins of the Tethyan ocean. Mosasaurid records from Bulgaria are very rare and refer mostly to fragmentary material, all collected from strata assigned to the Kajlâka Formation. The new material described herein adds to our understanding of mosasaur distribution across Europe during the Campanian–Maastrichtian. For a proper documentation of all of the Bulgarian material, detailed comparisons with identified material contained in museum collections, both in Bulgaria and elsewhere in Europe, are needed. Future fieldwork in northern Bulgaria is also called for, in an attempt to recover more, and stratigraphically well-documented, skeletal remains there.

Rare and randomly distributed cephalopods and other characteristic macrofossils in the epicontinental Upper Cretaceous cause problems in Bulgaria, because there are no zonal subdivisions for the whole of the Upper Cretaceous based on ammonites or belemnites, or any other macrofossil group for that matter. For the Maastrichtian, in particular, only schemes based on microfossils are available. This study shows that shark teeth may be used for dating some strata where other characteristic fossils in the Upper Cretaceous of Bulgaria are missing.

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Резиме

Најмлађи кредни мозазаури и ламниформне ајкуле из пећине Лабиринта, Врачанска област (северозападна Бугарска) – претходна белешка

Из слојева који припадају формацији Кајлака, откривених у пећини Лабиринта у Врачанском крају, северозападна Бугарска, прикупљена је 1985. године збирка остатака кичмењака (укупно 65 регистрованих примерака у колекцијама Народног природњачког музеја у Софији). Од свих ових налаза даје се опис и слике једног дела доње вилице морског гуштера (мозозаура) са два зуба *in situ* и два изолована зуба ајкула (*Squalicorax pristodontus* и *Anomotodon* sp.). На основу величине, јако удубљеног попречног пресека у облику латиничног слова "U", карине и глеђног низа, овај мозозаурски материјал је условно одређен као *Mosasaurus* cf. *hoffmanni*, врсте познате из доњег и горњег мастрихта Мисурија, Алабаме, Њу Џерсија, Данске, северне Немачке, средње Пољске, Холандије, Белгије и Турске. Асоцијација макрофосилних таксона садржи и део фрагмакона скафитида, који припада *Hoploscaphites constrictus* по којем је одређена мастрихтска старост збирке. Морфологија зуба *S. pristodontus* указује на касно мастрихтску старост. Присуство ехинида *Hemipneustes striatoradiatus* такође указује на мастрихтску старост. Налаз пахидисцидног амонита *Anapachydiscus* (*Menuites*) cf. *terminus* из оближњег изданка формације Кајлака омогућава ужу одредбу старости – касни мастрихт. Ускоро ће бити извршена ревизија целокупног регистрованог материјала мозозаура из Бугарске, заједно са наласцима из пећине Лабиринта (који можда садрже и друге групе кичменјака као што су еластосауридски плесиосаури). Осим тога, потребна су нова теренска испитивања у северозападној Бугарској ради прикупљања више, стратиграфски поузданијег материјала. Изгледа да постоји добра корелација Бугарске са другим плитководним, епиконтиненталним срединама у Европи које су се крајем креде налазиле на ободу Тетиског океана. Ретки и случајни наласци цефалопода и других карактеристичних макро фосила у горњој креди стварају проблеме у Бугарској, јер не постоји зонална подела целе горње креде на основу амонита или белемнита, или неке друге макро фосилне групе. За мастрихт, углавном, постоје поделе засноване на микрофосилима. Наша проучавања су показала да се зуби ајкуле могу употребити за одредбу старости тамо где други карактеристични фосили у горњој креди Бугарске изостају.