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Teeth of a small durophagous crocodile from the Late Jurassic (Kimmeridgian) of North Germany

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Abstract

An outcrop of Late Jurassic (Kimmeridgian) age in Lower Saxony (NW Germany) has yielded small teeth probably of crocodilian origin. The dental morphology is still unknown among crocodiles and indicates a durophagous habit. The teeth are provisionally referred to as Metasuchia fam., gen. et sp. indet.

Zusammenfassung

In einem oberjurassischen (kimmeridgezeitlichen) Aufschluß in Niedersachsen (NW-Deutschland) sind kleine Zähne gefunden worden, die wahrscheinlich von einem Krokodil stammen. Die Zahnmorphologie ist allerdings bei rezenten und fossilen Krokodilen bislang noch nicht beobachtet worden und weist auf durophage Ernährung hin. Die Zähne werden unter Vorbehalt den Metasuchia fam., gen. et sp. indet. zugeordnet.

Keywords: Metasuchia, teeth, durophagous, Late Jurassic, Kimmeridgian, Germany.

INTRODUCTION

Microvertebrate remains can occur fairly frequently in the sample residues that micropalaeontologists sort for microinvertebrate fossils such as foraminifers or ostracods. Most of these remains are tiny fish teeth. Sometimes these teeth are even illustrated in the papers of micropalaeontologists, but are often labelled only as "fish tooth indet." - meaning the indeterminable tooth of some kind of fish (Arbeitskreis Deutscher Mikropaläontologen, 1962; Weiler, 1957; Zihrul, 1990).
Prompted by some problems in the stratigraphic correlation of North German Late Jurassic rocks, one of the present authors (D. Thies) started some time ago to study Late Jurassic microvertebrate remains from North Germany. The study aimed to evaluate the stratigraphic significance of the microvertebrate remains present in the North German Late Jurassic rocks. Most of the material collected for this investigation consists of actinopterygian teeth. The lesser part comprised elasmobranch microvertebrate remains. The material also included 62 crocidilian teeth. Of these, 59 belong to an atoposaurid crocodile which was described by Thies et al. (1997) as a piscivorous element of the fauna living along the coasts of the Late Jurassic North German basin. The remaining three teeth differ in morphology from those of the atoposaurid crocodile, and by their blunt shape indicate a hard-shelled diet. Durophagous crocodiles are unknown today and occurred only rarely in crocodilian evolution. One example was made known from the Early Cretaceous of Spain (Brinkmann, 1989; 1992). Durophagous crocodilian teeth have not been observed before in the Late Jurassic sediments of North Germany and will be described here for the first time.

STRATIGRAPHIC AND GEOLOGICAL SETTING

A schematic drawing of the section of Late Jurassic rocks in North Germany is shown in Fig. 1. The se-quence is subdivided into several lithostratigraphic units with the

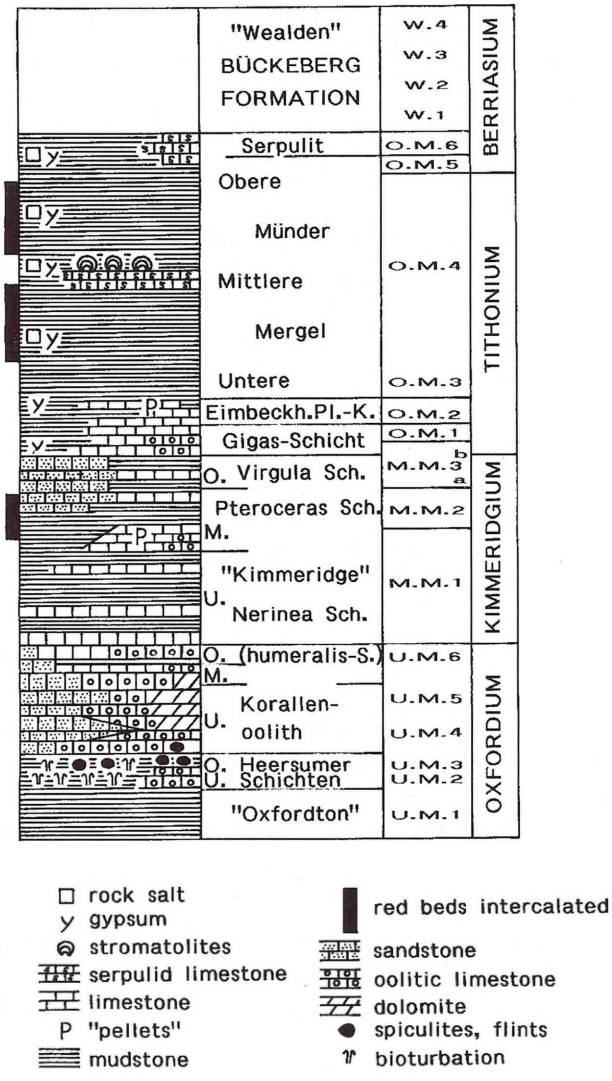


Fig. 1: - Scheme of the lithostratigraphic division of the Late Jurassic rocks in North Germany (after Gramann, 1983).

"Oxfordton" at the base and the "Münder Mer-gel" at the top. Problems of correlation with Late Jurassic rocks outside North Germany arise from the lack of index ammonites in most of the horizons. Also, the microinvertebrate faunas are endemic and are therefore of only limited significance for stratigraphy.

Microvertebrate remains are known to occur in numerous Late Jurassic horizons in North Germany (Weiler, 1957; Thies, 1993; Thies & Mudroch, 1996). However, most of the material on which our studies of micro-vertebrate remains are based were collected from Kim-meridgian rocks.

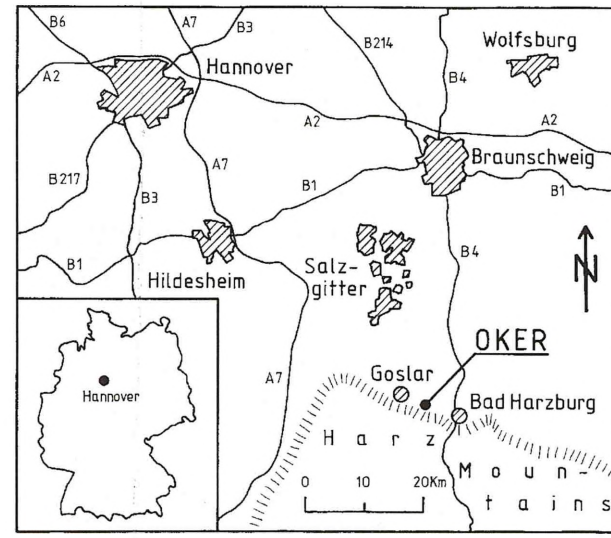


Fig. 2: - Location of the „Rohstoffbetriebe Oker" quarry in North Germany (from Thies, 1995).

LOCALITY, METHODS, AND MATERIAL

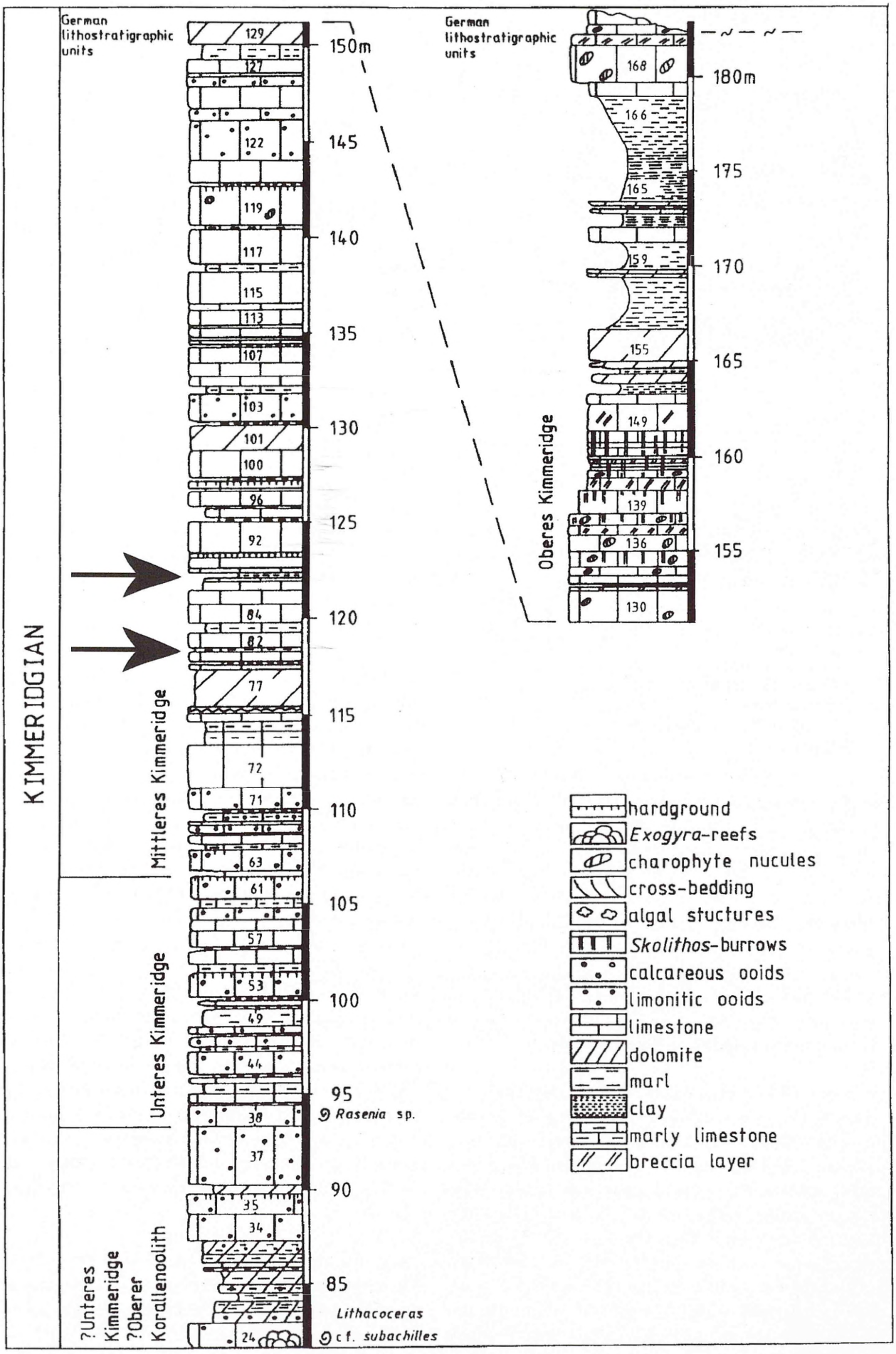
Locality

The material was collected in the "Rohstoffbetriebe Oker" quarry, where there is the best exposure of Kimmeridgian rocks in North Germany. The quarry is situated on the southern slope of the Langenberg, 5 km east of the town of Oker (Goslar) at the northern edge of the Harz mountains in North Germany (grid reference: To-pogr. Karte 1:25.000, Bl. 4029 "Vienenburg", Hoch 5753075, Rechts 3603175; Fig. 2). The section exposed in the quarry consists of interbedding of limestones and marls, and stratigraphically covers the Late Oxfordian and parts of the Kimmeridgian. A schematic drawing of the Kimmeridgian part of the section is shown in Fig. 3. Details of the geology, stratigraphy, lithology, and facies characters of the succession in the Oker quarry were summarized by Fischer (1991).

Methods

The crocodile teeth were recovered from residues resulting from bulk sampling taken exclusively from the Kimmeridgian part of the sequence. Samples with an average weight of approximately 20 kg were taken preferably from softer marl beds. The carbonate matrix was removed with 5-10% acetic acid. The samples were

Fig. 3 (opposite page): - Schematic drawing of the Kimmeridgian rock section exposed in the „Rohstoffbetriebe Oker" quarry, North Germany (modified after Fischer, 1991).


German lithostratigraphic units
KIMMERIDGIAN
?Unteres Kimmeridge ?Oberer Korallenoolith
Unteres Kimmeridge
Mittleres Kimmeridge
Oberes Kimmeridge
150m
145
140
135
130
125
120
115
110
105
100
95
90
85
180m
175
170
165
160
155
Rasenia sp.
Lithacoceras
cf. subachilles
hardground
Exogyra-reefs
charophyte nucules
cross-bedding
algal stuctures
Skolithos-burrows
calcareous ooids
limonitic ooids
limestone
dolomite
marl
clay
marly limestone
breccia layer

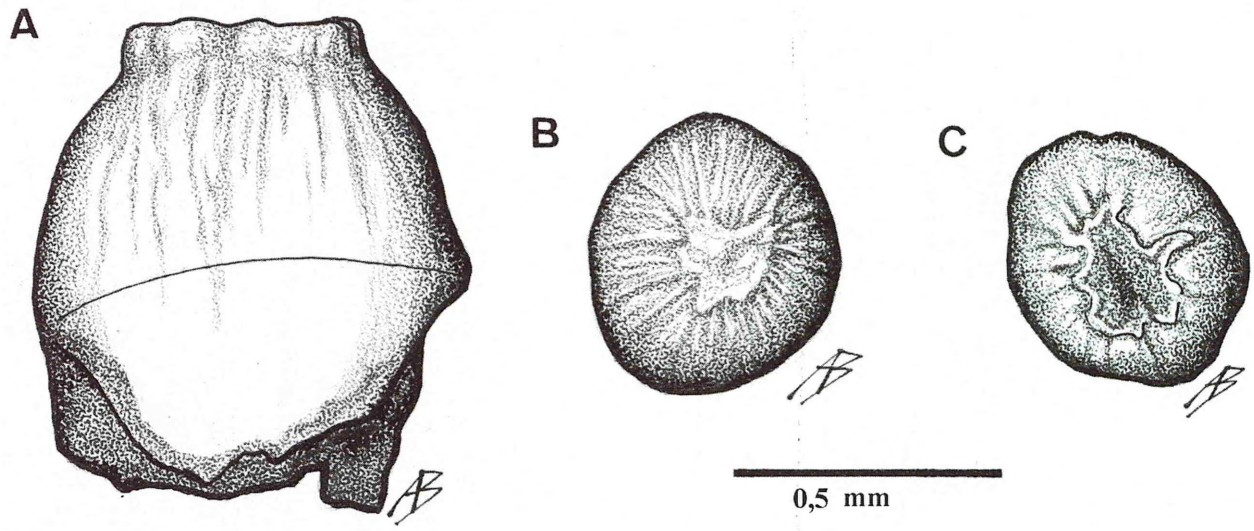


Fig. 4: - Teeth of Metasuchia fam., gen. et sp. indet. A - specimen GPH 2001-III-1 in lateral view, B - specimen GPH 2001-III-2 in apical view, C - specimen GPH 2001-III-3 in apical view.

sieved using a mesh width of 0.3 mm. The residues were sorted for microvertebrate remains. Most of the remains sorted out were actinopterygian and elasmo-branch oral teeth and placoid scales and have already been reported on (e.g. Mudroch & Thies, 1996; Thies 1995; Thies & Candoni, 1998).

Material

The residues of the samples from the horizons nos. 81 and 88 (indicated by arrows in Fig. 3) contained three tiny teeth of a durophagous crocodile, and it is these which form the basis of the present study. The specimens are housed in the collection of the Institut für Geologie und Paläontologie der Universität Hannover (GPH) under catalogue numbers 2001-III-1 to 2001-III-3.

SYSTEMATIC PALAEONTOLOGY

Description of the specimens

Specimen GPH 2001-III-1 (Figs. 4A, 5A): This specimen is the largest of the three teeth, with an approximate diameter of 0.9 mm. Its overall shape is globular. The tooth base has been broken and is irregularly shaped. From the alveolar side, traces of the pulpa are visible. Viewed laterally, the apex of the tooth has an elevated, even shelf. From the apical side, the outlines of the apical shelf are irregular; the margins are not circular, but show wave-like outlines. The sur-face of the shelf itself is slightly concave. All around the upper half of the tooth, there are radial striations which continue onto the lateral surface of the apical shelf. There is a smaller striation in between each second or third larger one. The striations are not very pronounced. Their apical endings taper into the shelf, forming a slight angle.

Specimen GPH 2001-III-2 (Figs. 4B, 5B): This specimen is markedly smaller than GPH 2001-III-1, less than 0.5 mm in diameter. Only its upper half has been preserved. Like the larger specimen, it has an overall globular shape and a peculiar small shelf on the apex. This minute "plateau" is irregularly shaped in apical view. There are many striae all over the tooth fragment. The striation was most probably restricted to the upper half of the tooth. Since the base of the tooth is absent, this is a tentative interpretation deduced from known crocodile teeth.

Specimen GPH 2001-III-3 (Fig. 4C): This specimen is the smallest of the three teeth, clearly less than 0.5 mm in diameter. It has a slightly elongated shape in apical view. It has some, but not many, striations. The striae themselves are markedly large in comparison to the overall size. The apex seems to be in a worn condition: an irregularly shaped concavity forms a morphological "crater", with a discernible rim around it. The striations continue up to the edge of the collar-like rim.

Discussion

The different forms of morphology of the three teeth described here seem to be either the apically enlarged form with the plateau-like shelf (GPH 2001-III-1, GPH

2001-III-2) or the corroded and worn type (as seen in GPH 2001-III-3) with a rounded and slightly flat-tipped crown. Nonetheless, all remaining characteristics except the strange additional shelf on the tooth crown of GPH 2001-III-1 and GPH 2001-III-2 allow the three teeth to be categorised as belonging to juvenile crocodiles with a durophagous habit. Characteristics indicating a durophagous lifestyle are:

- globular, spherical overall morphology
- marked vertical striations on the crown
- slightly thickened enamel layer (as seen at the edges of broken base parts).

In terms of size, the three teeth fit well into the size range of actinopterygian teeth which occur frequently in the horizons from which the described specimens come. In their morphology, however, the teeth differ considerably from all that has been observed in actinopterygian teeth so far. This is particularly so with regard to the common occurence of a differentiated apex together with a vertical striation in the same specimen. In durophagous fishes the tooth crown is either smooth, spherical and lacking a differentiated cap and striations, as in *Lepidotes* (order Semionotiformes) for instance, or the crown is rather flat and has an irregular and elongated outline in apical view, as in the pycnodonts (Mudroch & Thies, 1996). This leaves only the reptiles as the probable group of origin of the three teeth.

Many mesosuchian crocodiles of Upper Jurassic and Lower Cretaceous origin exhibit such specialized or stabilized dentition (Steel, 1973). This holds equally true for marine mesosuchian crocodiles (e.g. *Machimosaurus*) as for freshwater types (*Unasuchus*, *Bernissartia* - possibly an early eusuchian crocodile in the sense given by Norell & Clark, 1990). With regard to the ontogenetic series, the robust spherical teeth are positioned foremost within the posterior region of the snout, both in the upper and the lower jaw.

Depending on the ontogenetic stage of the individual, there may be higher or lower numbers of crushing teeth relative to the anterior cone-shaped ones, mostly only a few in the early juvenile stages and more during growing age. A gradation is apparent between the cones and the spheres so that, within one specimen, five or six morphotypes of teeth can be observed. Due to the fact that crocodile dentine does not usually form any part of the external morphology - the wrinkles and striations are merely part of the enamel layer (Sander, 1999) - any corrosive effect or even a possible digestion of the teeth within the stomach of a predator can be excluded.
The faint development of the striations is due to the extreme youth of the individuals. According to their early ontogenetic age, they only have a few of these crushing

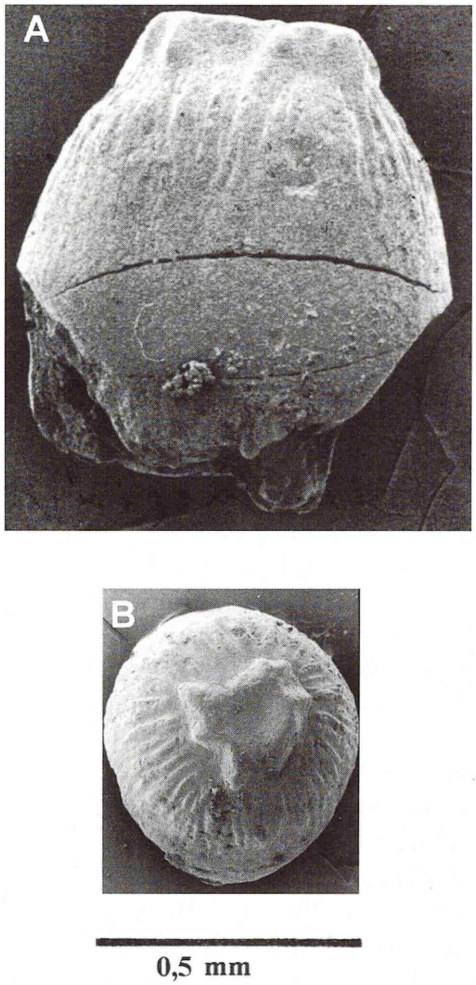


Fig. 5: - Teeth of Metasuchia fam., gen. et sp. indet. SEM photographs of the specimens 2001-III-1 (A, lateral view) and 2001-III-2 (B, apical view).

teeth on the posterior part of their short jaws. The presence of striations, no matter what age the in-dividual was, clearly demonstrates the important stabi-lization effect which the miniature rims have on the tooth as a whole when used for crushing. It should be noted, however, that in juvenile individuals "crushing" hardly means more than seizing and keeping hold of small prey such as little arthropods. Only subadult and adult durophagous crocodiles had a jaw apparatus strong enough to actually crush a hard-shelled diet like molluscs, larger arthropods or even turtles with their teeth.

In the absence of comparable material and published data, we tentatively identify the three teeth as belonging to a juvenile or even dwarf representative of the Mesosuchia with unknown familial, generic and specific affinities.

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LITERATURE

Arbeitskreis Deutscher Mikropaläontologen (1962) *Leitfossilien der Mikropaläontologie. Tafeln und Tabellen*. Gebrüder Borntraeger, Berlin.

Brinkmann, W. (1989) Vorläufige Mitteilung über die Krokodilier-Faunen aus dem Ober-Jura (Kimmeridgium) der Kohlegrube Guimarota, bei Leiria (Portugal) und der Unter-Kreide (Barremium) von Uña (Provinz Cuenca, Spanien). *Documenta naturae*, **56**, 1-28, München.

Brinkmann, W. (1992): Die Krokodilier-Fauna aus der Unter-Kreide (Ober-Barremium) von Uña (Provinz Cuenca, Spanien). *Berliner Geowiss. Abh.*, Reihe E, **5**, 1-123, Berlin.

Fischer, R. (1991) Die Oberjura-Schichtfolge vom Langenberg bei Oker. *Arbeitskreis Paläontologie Hannover*, **19**, 21-36, Hannover.

Gramann, F. (1983) Zur Biostratigraphie und Biofazies des Nordwestdeutschen Malm. In: **Fischer, R., Gramann, F.** and **Jordan, R.** (eds.): *Der Jura im südöstlichen Niedersachsen und in der Hils-Mulde. Exkursionführer Jahrestagung der Subkom-mission für Jura-Stratigraphie*, 20-31, Hannover.

Mudroch, A. and **Thies, D.** (1996) Knochenfischzähne (Osteichthyes, Actinopterygii) aus dem Oberjura (Kimmeridgium) des Langenbergs bei Oker (Norddeutschland). *Geologica et Palaeontologica*, **30**, 239-269, Marburg.

Norell, M. and **Clark, J.M.** (1990) A Reanalysis of *Bernissartia fagesii*, with Comments on its Phylogenetic Position and ist Bearing on the Origin and Diagnosis of the Eusuchia. - *Bull. Inst. Roy. Sci. Natur. Belgique, Sciences de la Terre*, **60**: 1125 - 1128, Bruxelles.

Steel, R. (1973) Crocodylia. In: **Kuhn, O.** (ed.), *Encyclopedia of Paleoherpetology,* Part 16, 1-116, G. Fischer Verlag, Stuttgart.

Sander, P. M. (1999) The Microstructure of Reptilian Tooth Enamel: Terminology, Function, and Phylogeny. *Müchner Geowiss. Abh.,* Reihe A, **38**, 1-102, München.

Thies, D. (1993) Upper Jurassic microvertebrate remains (Chondrichthyes: Elasmobranchii) from North Germany. In: **Turner, S.** (ed.), *IGCP 328 Palaeozoic Microvertebrates - SDS: The Gross Symposium, Göttingen 31 July - 7 Aug.* [Abstract].

Thies, D. (1995) Placoid scales (Chondrichthyes, Elasmobranchii) from the Late Jurassic (Kimmeridgian) of North Germany. *J. Vert. Paleont.*, **15**, 463-481, Lawrence.

Thies, D. and **Candoni, L.** (1998) *Corysodon* Saint-Seine 1949 - a valid genus of Mesozoic neoselachian sharks. *Geologica et Palaeontologica*, **32**, 221-233, Marburg.

Thies, D. and **Mudroch, A.** (1996) Actinopterygian teeth from the Late Jurassic (Kimmeridgian) of N Germany. In: **Arratia, G.** and **Viohl, G.** (eds.), *Mesozoic Fishes - Systematics and Paleoecology. Proceedings of the international meeting, Eichstätt 1993*, 105-114, F. Pfeil, München.

Thies, D., Windolf, R. and **Mudroch, A.** (1997) First record of Atoposauridae (Crocodylia: Metamesosuchia) in the Upper Jurassic (Kimmeridgian) of Northwest Germany. *N. Jb. Geol. Paläont. Abh.*, **205**, 393-411, Stuttgart.

Weiler, W. (1957) III. Die Fischreste. In: **Martin, G. P. R.** and **Weiler, W.** (eds.), Das Aldorfer Otolithen-"Pflaster" und seine Fauna (Mittlerer Münder Mergel, Malm), *Senckenbergiana lethaea*, **38**, 211-249, Frankfurt a. M.

Zihrul, B. (1990) Mikrobiostratigraphie, Palökologie und Mikropaläontologie in Gesteinen des Unteren und Mittleren Malm am Langenberg bei Goslar/ Oker. *Clausthaler Geowiss. Diss.*, **38**, 1-220, Clausthal-Zellerfeld.