ORYCTOS, Vol. 1 : 55 - 64, Octobre 1998

# PRELIMINARY OBSERVATIONS ON THE STRATIGRAPHIC DISTRIBUTION OF LATE CRETACEOUS MARINE AND TERRESTRIAL REPTILES FROM THE MAASTRICHTIAN TYPE AREA (SE NETHERLANDS, NE BELGIUM)

**Eric W.A. MULDER[1], John W.M. JAGT[2], Marcel M.M. KUYPERS[3], Hans H.G. PEETERS[2] and Peggy ROMPEN[4]**

[1] Museum Natura Docet, Oldenzaalsestraat 39, NL-7591 GL Denekamp, the Netherlands
[2] Natuurhistorisch Museum Maastricht, Box 882, NL-6200 AW Maastricht, the Netherlands,
E-Mail: mail@nhmmaastricht.nl
[3] c/o Raevenstraat 27, NL-6014 BA Ittervoort, the Netherlands
[4] Rijksuniversiteit Limburg / Dienst Studentenzaken, Box 616, NL-6200 MD Maastricht, the Netherlands,
E-mail: peggyrompen@sz.unimaas.nl

**Abstract :** Despite the fact that many Late Cretaceous marine fossils from the Maastrichtian type area, and reptiles in particular, have become famous worldwide, the stratigraphic ranges of most of the species represented are still poorly known. In recent years, much progress has been made on the litho- and biostratigraphic subdivision of Campanian and Maastrichtian strata in the area. This makes it possible to collect stratigraphically well-documented material from the various working and disused quarries and natural outcrops in that area. In turn, these collections enable the ranges of the various taxa to be determined much more precisely. Naturally, collections made in the nineteenth century often suffer from lack of stratigraphic data. This is especially unfortunate since they comprise many type specimens. To make matters worse, specimens have often been completely freed from the matrix, making modern analyses of foraminiferal and/or bioclast contents impossible. The present paper summarises current knowledge of the stratigraphic distribution of marine as well as terrestrial reptiles known from the type area of the Maastrichtian Stage. This picture will undoubtedly be refined as field work continues; projects under way include an analysis of the distribution of possible prey items of mosasaur taxa and the description of juvenile turtles and mosasaurs.

*Key words: Reptiles, Late Cretaceous, Belgium, the Netherlands, stratigraphy.*

## Observations préliminaires sur la répartition stratigraphique des reptiles marins et terrestres de la région type du Maastrichtien (Pays-Bas du sud est, Belgique du nord est)

**Résumé :** Les fossiles marins du Crétacé supérieur de la région de Maastricht sont connus mondialement, en particulier les reptiles, mais la répartition stratigraphique de la plupart des espèces est encore mal connue. Des progrès récents dans la subdivision lithostratigraphique et biostratigraphique du Campanien et du Maastrichtien de la région permettent de collecter du matériel bien documenté stratigraphiquement dans les carrières et les affleurements naturels. Ces nouvelles récoltes permettent d'établir plus précisément l'extension stratigraphique des différent taxons. Les collections constituées au dix-neuvième siècle souffrent souvent d'un manque de données stratigraphiques. De plus, les spécimens ont souvent été complètement dégagés de leur gangue, ce qui empêche toute analyse de son contenu (foraminifères, bioclastes). Le présent article est une synthèse de la répartition stratigraphique des reptiles marins et terrestres de la région type de l'étage Maastrichtien. Cette image sera affinée au fur et à mesure de l'avancement des travaux de terrain. Les projets en cours comprennent une étude des proies des mosasaures et la description de tortues et mosasaures juvéniles. (traduit par la rédaction)

*Mots clés : Reptiles, Crétacé supérieur, Belgique, Pays-Bas, stratigraphie.*

## INTRODUCTION

In recent years, a renewed interest in the stratigraphy of Late Cretaceous strata and their fossil content in the type area of the Maastrichtian Stage (Fig. 1) has become apparent. Building on a detailed lithostratigraphic subdivision (Fig. 2) of Maastrichtian as well as Santonian-Campanian and early Palaeocene strata (W.M. Felder, 1975; W.M. Felder & Bosch, in press), much progress has been made in various disciplines. Zijlstra (1994) studied flint genesis and stratal rhythmicity and cyclicity in the type section of the Maastrichtian (ENCI Nederland BV quarry), while Vonhof and Smit (1996) calculated depositional rates for the upper Maastricht Formation and across the Cretaceous/Tertiary (K/T) boundary, the position of which was determined more precisely (Brinkhuis & Smit, 1996).

Detailed analyses of dinoflagellate assemblages enabled Schiøler *et al.* (1997) to propose the first sequence stratigraphic interpretation of the type Maastrichtian, whereas, amongst macrofaunas, a number of key taxa for interregional correlations have been recognized (Jagt, 1996). Whenever possible, reference is therefore made to the macrofaunal zonation proposed (Schönfeld *et al.*, 1996) for the standard section of the NW German Late Cretaceous white chalk facies (Fig. 3).

All this means that we are currently in a better position to determine the stratigraphic ranges of the various fossil groups more fully. For the present paper, the marine and terrestrial reptiles have been singled out.

| *Lithostratigraphy* | | *Chronostr.* |
|---|---|---|
| MAASTRICHT Formation | MEERSSEN Member | Late Maastrichtian |
| | NEKUM Member | |
| | EMAEL Member | |
| | SCHIEPERSBERG Member | |
| | GRONSVELD Member | |
| | VALKENBURG Member | |
| GULPEN Formation | LANAYE Member | |
| | LIXHE 1-3 Members | Early Maastrichtian |
| | VIJLEN Member | |
| | BEUTENAKEN Member | Late Campanian |
| | ZEVEN WEGEN Member | |
| VAALS Formation | BENZENRADE Member | Early Campanian |
| | TERSTRAETEN Member | |
| | BEUSDAL Member | |
| | VAALSBROEK Member | |
| | GEMMENICH Member | |
| | COTTESSEN Member | |
| | RAREN Member | |

Fig. 2. Lithostratigraphic subdivision of Late Cretaceous strata in the Maastrichtian type area (with the exception of the Aken Formation) after W.M. Felder (1975) and W.M. Felder and Bosch (in press) and chronostratigraphy.

Fig. 2. Lithostratigraphie et chronostratigraphie des dépôts du Crétacé supérieur dans la région type du Maastrichtien à l'exception de la Formation d'Aken, (d'après W.M. Felder (1975) et W.M. Felder et Bosch (sous presse) pour la lithostratigraphie).

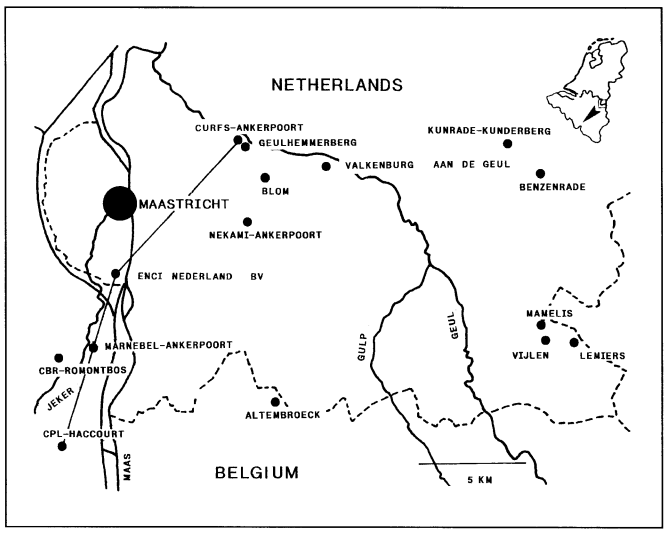


Fig. 1. Map of southern Limburg (the Netherlands) and contiguous areas, showing locations of quarries/outcrops and other localities referred to in the text. The line connecting the quarries CPL-Haccourt, Marnebel-Ankerpoort, ENCI Nederland BV and Curfs-Ankerpoort refers to the combined lithologs illustrated in Fig. 4A-C.

Fig. 1. Carte du sud du Limbourg (Pays-Bas) et des régions limitrophes montrant les carrières et autres localités mentionnées dans le texte. La ligne passant par les carrières de CPL-Haccourt, de Marnebel-Ankerpoort, d'ENCI Nederland BV et de Curfs-Ankerpoort se rapporte aux coupes lithostratigraphiques illustrées dans les Figures 4A-C.

| | |
|---|---|
| Late Maastrichtian | *'kazimiroviensis Zone'*<br>*baltica/danica Zone*<br>*danica/argentea Zone*<br>*argentea/junior Zone*<br>*tegulatus/junior Zone* |
| Early Maastrichtian | *fastigata Zone*<br>*cimbrica Zone*<br>*sumensis Zone*<br>*obtusa Zone*<br>*pseudobtusa Zone*<br>*lanceolata Zone* |
| Late Campanian | *grimmensis/granulosus Zone*<br>*langei Zone*<br>*polyplocum Zone*<br>*roemeri Zone*<br>*basiplana/spiniger Zone*<br>*conica/mucronata Zone* |
| Early Campanian | *gracilis/mucronata Zone*<br>*conica/gracilis Zone*<br>*papillosa Zone*<br>*pilula/senonensis Zone*<br>*pilula Zone*<br>*lingua/quadrata Zone*<br>*granulataquadrata Zone* |

Fig. 3. Macrofaunal zonation of the Campanian-Maastrichtian in the standard section of the white chalk facies in northern Germany (after Schönfeld *et al.*, 1996), as a reference to biozonations shown in Fig. 4A-C.

Fig. 3. Zones de macrofaune du Campanien-Maastrichtien de la coupe standard du faciès "white chalk" en Allemagne du Nord (d'après Schönfeld *et al.*, 1996), se rapportant aux biozones employées dans les Figures 4A-C.

Quite a number of type specimens of Late Cretaceous mosasaurs and turtles come from the Maastrichtian type area. However, many of these suffer from lack of stratigraphic detail. So long as the specimens have not been freed completely from the matrix, it is still possible to carry out bioclast and/or benthic foraminiferal analyses in order to determine their stratigraphic provenance. However, for a number of taxa this is no longer possible, and determination of their stratigraphic ranges must rely on newly collected material.

It should be noted that within the (extended) type area of the Maastrichtian Stage (Fig. 1) most, if not all, sections are characterized by periods of non-deposition (hiatuses and hardground development) of variable duration. Rapid lateral facies changes and considerable differences in stratal thickness have been considered to be the result of extensive synsedimentary tectonics. This explains why correlations, even over short distances, e.g. between Maastricht and the Kunrade area (Fig. 1) are difficult at times. To this day, the correlation between the "typical" coarse-grained biocalcarenites of the Maastricht Formation in the west (quarries CBR-Romontbos, Marnebel-Ankerpoort, ENCI Nederland BV, Nekami-Ankerpoort, Blom, Curfs-Ankerpoort) and the Kunrade limestone facies in the east (Kunrade-Kunderberg, Benzenrade) presents problems. This means that it is impossible to have a kind of "standard section" for the Late Cretaceous in the area. In view of this, three key sections are here selected, viz. the quarries CPL-Haccourt, ENCI Nederland BV, and Curfs-Ankerpoort (Fig. 1). Combined these three sections provide the most complete sequence, ranging from the early Campanian to the latest Maastrichtian, and even to the Early/Middle Danian (Paleocene). However, it should be noted that the Late Campanian Benzenrade Member (Vaals Formation) and Beutenaken Member (Gulpen Formation), as well as the largest portion of the Vijlen Member (Gulpen Formation) (Fig. 2) and entire "Kunrade Limstone facies" are not represented in this section. In discussing the stratigraphic distribution of marine and terrestrial reptiles this does not present too many problems, since these strata have been shown to yield few remains.

The present paper thus summarises our knowledge of the distribution and diversity of reptilian fossils, and is based mainly on recently collected material and on those literature sources which we consider reliable. It is apparent from Fig. 4A-C that diversity increases considerably up-section, with many species first appearing in the Lanaye Member (Gulpen Formation) and upper Maastricht Formation. However, in part, this picture is biased by an increased collection effort in the upper part of the Late Cretaceous sequence in the area, and by the generally poorer accessibility of the lower portion of the sequence. But, as recent field work has shown, the paucity of reptilian remains in Campanian and early

Maastrichtian strata is real and cannot be explained by biased collection. Ranges shown in figure 4A-C are the "total ranges" recorded to date, the lines connecting the first and last occurrence of the various species, but it should be realised that these ranges are preliminary and that observed acmes of distribution are not shown.

Added to the brief discussions below of the geographic and stratigraphic distribution of the various reptilian taxa, are a few remarks on taxonomy and other features of interest, which will be discussed more fully in forthcoming papers.

## MARINE REPTILES

### *1 - Mosasaurs*

Lingham-Soliar's (1995) detailed redescription of the largest of the Maastricht mosasaurs, *Mosasaurus hoffmanni* Mantell, 1829, was published almost simultaneously with Rompen's (1995) detailed analysis of Faujas's (1799) account of the discovery of the type specimen and its subsequent turbulent history. Although a number of inconsistencies have now been resolved in this widely quoted narration (see e.q. Bell, 1997a), other problems remain, and these call for an additional study of archives abroad (Rompen, in prep.). Although there was never much doubt about the stratigraphic provenance of the type specimen of *M. hoffmanni*, an analysis of the bioclast content (Bardet & Jagt, 1996; P.J. Felder & Jagt, 1998) of a chalk matrix sample has recently shown the block in which it is preserved to have come, beyond doubt, from the upper third of the Nekum Member (Maastricht Formation; see Figs. 2, 4B).

Lingham-Soliar's revisions of mosasaur species from the Mons Basin (southern Belgium, Early Maastrichtian, *obtusa* Zone; see Fig. 3) and from the Maasticht area have greatly improved our knowledge of these reptiles (Lingham-Soliar, 1992, 1993, 1994, 1996; Lingham-Soliar & Nolf, 1990), being based on the type material. However, finds of near-complete mosasaur skeletons are exceptionally rare in the Maastricht area, isolated tooth crowns and vertebrae being the commonest elements found. In an attempt to provide a kind of identification key for local collectors, Jagt *et al.* (1995) and Kuypers *et al.* (1998) studied isolated, but generally stratigraphically well-documented, material. Associated remains, in particular of *M. hoffmanni* and *Plioplatecarpus marshi* Dollo, 1882, served as a basis for assigning isolated remains, especially tooth crowns and cervical/dorsal/caudal vertebrae, to the various species.

The oldest record of mosasaurs in the area is from the Early Campanian (Fig. 4A); a single tooth crown from northeastern Belgium has been assigned to the plioplatecarpine *Platecarpus* sp. by Kuypers *et al.* (1998). For the time being it is here considered to be of *lingua/quadrata* Zone age, but may ultimately prove to be slightly older (*granulataquadrata* Zone) or slightly younger (*pilula* Zone; see Fig. 3), depending on refined future correlations within the Vaals Formation.

From the overlying Late Campanian Zeven Wegen Member (Fig. 4A) only poorly preserved, isolated vertebrae and a single tooth crown from the Haccourt area (Fig. 1) are known to date. Kuypers *et al.* (1998) have noted that the latter was reminiscent of some teeth of the otherwise exclusively early Maastrichtian plioplatecarpine *Prognathodon solvayi* Dollo, 1889 (see revision by Lingham-Soliar and Nolf, 1990).

The Early Maastrichtian portion of the Vijlen Member (Fig. 2) has so far yielded a fragmentary jaw of a possible plioplatecarpine only. This is from Altembroeck (Fig. 1), and is of *sumensis* Zone age (Figs. 2, 3). To our knowledge, no further mosasaur remains are known from the type area of the Vijlen Member (Mamelis, Lemiers, Vijlen; Fig. 1).

The middle/upper portion of the Lanaye Member witnesses the first occurrence of a number of mosasaur taxa (Fig. 4B), e.g. *M. hoffmanni, Leiodon sectorius* (Cope, 1871) and *P. marshi.* On dinoflagellate/acritarch evidence, Schiøfler *et al.* (1997) have recently demonstrated a change from open marine to marginal marine conditions to have taken place at the transition from the Lixhe 3 to Lanaye members (Figs. 2, 4B). The incoming of the above-mentioned mosasaur taxa may thus be linked to more favourable living conditions (shallower, warmer water and increased food availability) for these reptiles. The taxa involved appear closely related to species described from the Maastrichtian of New Jersey (Atlantic Coastal Plain, USA); only a phylogenetic analysis of both New Jersey and Maastricht mosasaurs along the lines proposed by Bell (1997b) could be expected to formalise these relationships.

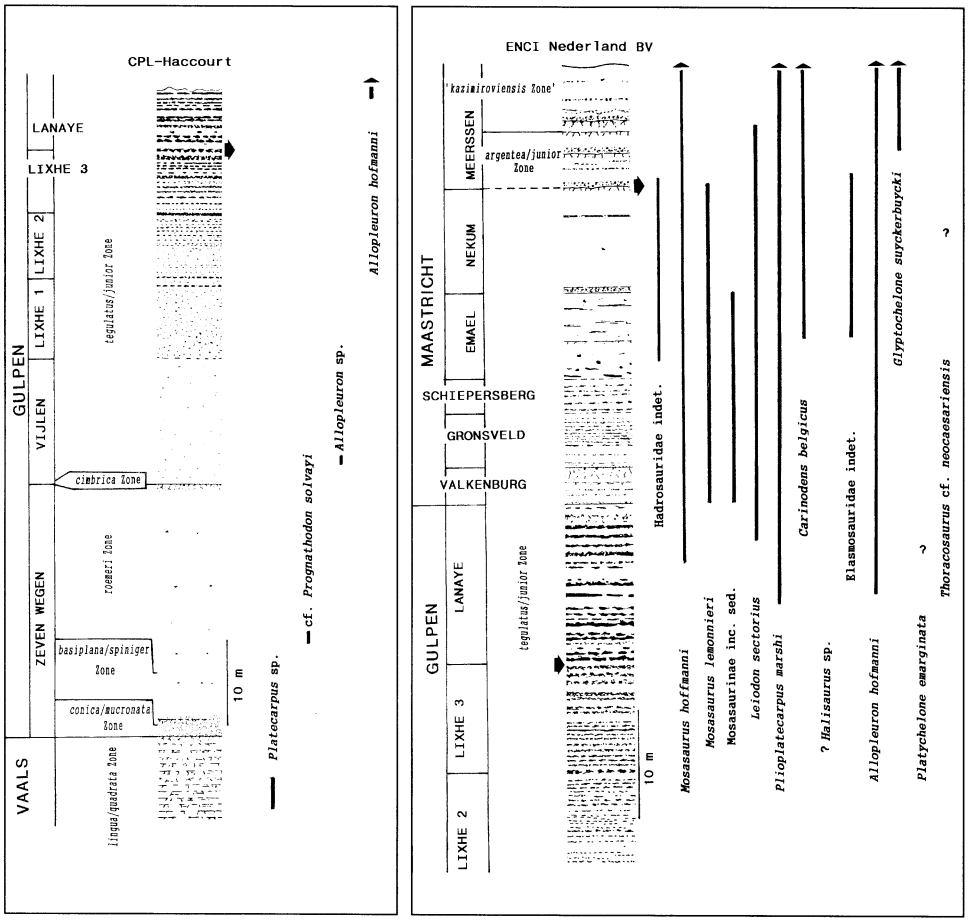


Fig. 4A-C. Lithostratigraphy and biozonation (see Fig. 3) of three key sections in the type area of the Maastrichtian Stage Combined these provide the most complete section of Late Cretaceous and Early Palaeogene strata in the area, with the exception of the middle Santonian (to Early Campa-nian?) Aken Formation, the Late Campanian Beutenaken Member and large portions of the Early Maastrichtian Vijlen Member (see Fig. 2). Arrows to the left and right of the lithologic logs indicate correlative levels in the three sections illustrated. Ranges shown of the various species of marine and terrestrial reptiles are based on material collected recently, which is stratigraphically well documented, as well as on reliable literature sources. As these three logs are meant to represent sections exposed in the various quarries/outcrops in the area, ranges combine data collected at these various localities.

The Houthem Formation (Geulhem Member) in Fig. 4C is of Early/Middle Danian (i.e. Early Palaeocene) age, the Cretaceous/Tertiary (K/T) boundary corresponding to a level high in the underlying Meerssen Member.

---

Fig. 4A-C. Lithostratigraphie et biozones (voir Fig. 3) des trois coupes typiques dans la région type du Maastrichtien. La synthèse de ces coupes constitue la plus complète des sections du Crétacé supérieur et du Paléogène inférieur dans la région, à l'exception de la Formation d'Aken (Santonien moyen à Campanien inférieur?), du membre de Beutenaken (Campanien supérieur) et d'une partie du membre de Vijlen (Maastrichtien inférieur) (voir Fig. 2). Les flèches à droite et à gauche permettent de corréler les trois coupes.

La répartition des taxons de reptiles marins et terrestres est basée sur du matériel collecté récemment et sur les données bibliographiques fiables. Les trois coupes représentant des sections dans diverses localités, la répartition stratigraphique des taxons est établie d'après les données provenant de ces différents gisements. La Formation d'Houthem (membre de Geulhem; Fig. 4C) est d'âge Danien inférieur à moyen (Paléocène inférieur), la limite Crétacé/Tertiaire (K/T) se situant dans la partie supérieure du membre de Meerssen.

Occurring slightly later are M. *lemonnieri* Dollo, 1889, of which, with the exception of a fragmentary lower jaw, only isolated teeth and tooth crowns have been recognized so far, and Mosasaurinae *incertae sedis*, which may represent an extreme form of M. *hoffmanni,* and is reminiscent of some tooth morphologies of *L. sectorius*.

The first occurrence of *Carinodens belgicus* (Woodward, 1891), of which *C. fraasi* (Dollo, 1913) appears to be a junior synonym (see Kuypers *et al.*, 1998, for a discussion) is definitely later than the other mosasaur taxa (Fig. 4B). In their sequence stratigraphic analysis, Schiøler *et al.* (1997: fig. 6) assumed a transgression to correspond to the interval between the Lava and Laumont horizons (= upper half Emael Member, Fig. 2 & 4B), the maximum flooding surface corresponding to the base of the Nekum Member. It appears that in this part of the sequence faunal elements of a southern Tethys / north African origin were able to migrate into the Maastrichtian type area.

The record of another mosasaur taxon, *Halisaurus* sp., from the type Maastrichtian (Lingham-Soliar, 1996) is based on a number of isolated vertebrae, completely freed from matrix. Whether or not these specimens do come from the type Maastrichtian remains to be substantiated; if they do, their stratigraphic provenance needs to be determined as well (see Fig. 4B). The occurrence of a representative of this genus would substantiate the link between mosasaur taxa from New Jersey and the Maastricht area.

Improvement in our knowledge of the ranges of mosasaur taxa in the Maastrichtian type area also allows preliminary comments on preferred mosasaur food items to be made. Kuypers *et al.* (1998) have considered previous records of mosasaur remains with associated macrofaunal elements such as coleoid cephalopods and echinoids (e.g. Dollo, 1913; Umbgrove, 1956) to be based rather on chance preservation. Naturally, near-complete skeletons with preserved stomach contents are the best source of information in this respect. However, since more or less complete skeletons are extremely rare in the type Maastrichtian, other pieces of evidence must be considered. An analysis of tooth morphology (Massare, 1987, 1997) combined with a documentation of potential prey items amongst macrofaunas at those levels where mosasaurs are common to abundant would seem to offer the best possibilities. In addition, an analysis of bone structure (see Sheldon, 1997) could furnish data on preferred habitat and water depth of the various species. In future studies of mosasaurs from the Maastrichtian type area, the above-mentioned aspects will be given special attention.

Traces of predation by squalid (? and other) sharks have been recognised on a few mosasaur bones; they are of the general tooth mark type (Bardet *et al.*, 1998; Welton & Farish, 1993) and appear to have occurred *post-mortem*.

Puzzling is the paucity of remains of juvenile specimens in the area; the only remains known to date comprise a few cervical and dorsal vertebrae and a small coracoid. Generally, records of juvenile mosasaurs are rare in the literature (see e.g. Bell & Sheldon, 1986).

*Mosasaurus hoffmanni, C. belgicus* and *P. marshi* apparently range to the K/T boundary (Fig. 4C), with records from the fossil hash deposit at the base of the Geulhem Member.

### *2 - Plesiosaurs*

In comparison with mosasaurs and turtles, remains of plesiosaurs are extremely rare in the type Maastrichtian. This could signify either that these remains represent partial corpses which were swept into the shallow Maastricht basin from deeper water settings, or that live animals accidentally entered the area. The material available to date comprises three anterior cervical vertebrae and a single pectoral or sacral vertebra, in addition to three isolated teeth, all definitely belonging to Elasmosauridae Cope, 1869. These specimens will be described and illustrated in a separate paper, now in preparation.

The oldest record of elasmosaurids in the area is based on an isolated tooth from Kunrade-Kunderberg, which, on the basis of recently proposed correlations, would be of basal Emael Member age. Slightly younger are a rather worn vertebra from the CBR-Romontbos quarry (Fig. 1) and the tooth from Maastricht (ENCI Nederland BV quarry) described by Mulder (1990). Other remains are less well documented, but their preservation suggests them to have come from the Upper Nekum and/or Lower Meerssen members (Fig. 4B, C). There is no evidence to suggest that elasmosaurids ranged up into the latest

Maastrichtian (Upper Meerssen Member, *'kazimiroviensis Zone'*; see figures 3, 4B, C). This part of the sequence is characterised by rapid subsidence, increased water depth and decreased water temperatures (Zijlstra, 1994; Jagt, 1996; Schiøler *et al.*, 1997).

### *3 - Crocodiles*

Although isolated crocodile teeth are occasionally recorded from the type Maastrichtian (i.e. Maastricht Formation), the only unambiguous record of these reptiles to date is based on a few isolated vertebrae. These specimens will be described and illustrated by Mulder (1998). Again, they are completely free from matrix, but the state of preservation, colour and geographic provenance suggest they were collected from the Nekum or lower Meerssen members (Fig 4B). Morphologically these specimens are close to the eusuchian *Thoracosaurus neocesariensis* (DeKay, 1842) from the Maastrichtian-Early Palaeocene of New Jersey (Gallagher, 1993).

From the Geulhem Member of Early/Middle Danian age (Fig. 4C), and in particular from the upper part of that unit, a number of isolated crocodile teeth have lately been collected. Whether or not these will ever prove to be identifiable at the generic and/or specific levels remains to be determined.

In 1888, Koken described a crocodilian skull, assigned to *Thoracosaurus macrorhynchus* (De Blainville, 1835), (see also Kuhn, 1936), which was considered to originate from chalk deposits of the Maastrichtian stratotype area. The specimen is kept in the Netherlands National Museum of Natural History (Naturalis, Leiden). This specimen has been entirely freed from the matrix, and is currently preserved lying on top of a block of biocalcarenitic sediment. However, there is no certainty as to its provenance from this type of rock, and its exact stratigraphic position within the chalk deposits of the Maastricht area thus remains dubious (Mulder, 1998).

### *4 - Turtles*

Ever since the day they figured prominently in the plates of Faujas's (1799) work on the Sint Pietersberg, south of Maastricht, the large turtles from the Maastrichtian have attracted the attention of many scientists. A total of three species have been described in the literature, the commonest taxon by far being the type of the genus *Allopleuron* Baur, 1888, *A. hofmanni* (Gray, 1831) (see Dollo, 1922; P.J. Felder, 1980). The phylogenetic position of this genus is still unresolved; it is placed either in the Cheloniidae Gray, 1825 (see Hiryama, 1995, 1997) or in the Desmatochelyidae Williston, 1894 (see Moody, 1993, 1997). This species first occurs in the Lanaye Member (Fig. 4B; see also P.J. Felder, 1980: Fig. 9) and ranges to the top of the Meerssen Member (Fig. 4C), where it is rare. The record of *Allopleuron* sp. from the Vijlen Member (Fig. 4A) is based on a few isolated remains, including part of a lower jaw. This material may ultimately prove to belong to *A. hofmanni* too, but in view of the stratigraphic gap between it and the first *A. hofmanni*, it is here left in open nomenclature. Recent finds of *A. hoffmanni* from the Maastricht Formation (in particular Emael and Nekum members) include several remains of carapaces (especially marginals) and lower jaws. Marginals of juvenile and subadult turtles have recently been collected, but are comparatively rare. The abundance of seagrass in the Lanaye, Emael and Nekum members is undoubtedly linked to the common occurrence of cheloniid turtles, and confirms Moody's (1997) view of a 'palaeo-feeding site' in the area.

*Glyptochelone suyckerbuyki* (Ubaghs, 1879) (see Ubaghs, 1879: p. 249, pls. 6, 7), a possible cheloniid as well, appears to be confined to the Meerssen Member (Maastricht Formation), and possibly even to its upper part (Hofker, 1955, 1957; Kruytzer, 1955; P.J. Felder, 1980). However, Hofker (1955: p. 92) noted that material, from Cadier en Keer (east of Maastricht), referred to the present species could have come from the lower Maastricht Formation. The type of this species comes from the uppermost Maastricht Formation as exposed in the environs of Valkenburg aan de Geul (Minis-van de Geijn, 1955). The only stratigraphically well-documented specimens are those described by Kruytzer (1955), from the upper Meerssen Member; in general this appears to be a much rarer species than *A. hofmanni*.

The third species recorded from the area is the type of the genus *Platychelone* Dollo, 1903, *P. emarginata* Dollo, 1909. This taxon is based on a single, large-sized carapace in the collections of the Institut royal des Sciences naturelles de Belgique at Brussels (see Dollo, 1922; Umbgrove, 1956: Figs. 81, 84), which was not illustrated by Dollo (1909: p. 105).

Neither did he provide a diagnosis of this form, so that, strictly speaking, this could be considered to be a *nomen nudum* (see also Bardet & Pereda Suberbiola, 1996: p. 94). We do not know of any subsequent records of this species, nor of recent finds from the type area of the Maastrichtian. Provided that it is a genuine taxon, and that it did come from the environs of Zussen (NE Belgium) (see P.J. Felder, 1980: p. 101), it might have come either from the upper Gulpen Formation (Lanaye Member) (Fig. 4B) or lowermost Maastricht Formation.

## TERRESTRIAL REPTILES

### *5 - Dinosaurs*

Mulder *et al.* (1997) have recently recorded a fragmentary left metatarsal III of an indeterminate hadrosaurid from the lower Emael Member of the quarry Marnebel-Ankerpoort. They also commented on previous records of dinosaur remains from the type Maastrichtian, and noted that these were either poorly documented stratigraphically or confined to the base of the Meerssen Member (Fig. 4B). Although the material is limited, it appears that the distribution of dinosaur remains in the type Maastrichtian is intimately linked to the interpretation of relative sea level changes as proposed by Schiøler *et al.* (1997). An isolated hadrosaurid tooth, collected recently from the base of the Nekum Member at the quarry Blom (Fig. 1), will be described in a separate paper.

The taxonomic status of the only theropod to have been described from the type Maastrichtian, *'Megalosaurus' bredai* Seeley, 1883, is still unresolved. Russell (1972) considered it to be ornithomimid, while more recently Le Loeuff (1992) suggested it to be ceratosauroidean (? abelisaurid). As far as we know, there are no recent records of theropod remains from the area.

## ACKNOWLEDGEMENTS

We extend our best thanks to the following people for the supply of items of literature or the assistance to find it : Drs N. Bardet, A.V. Dhondt, E. Gaffney, R. Hiramaya, T. Lingham-Soliar, R.T.J. Moody, G.W. Storrs and Mr. J. van Veen; for the loan or donation of material : M.J.M. Deckers, R.W. Dortangs, D. Eysermans, P. van Knippenberg, H. Kohnen and J.P.H. Reynders; and for allowing access to their quarries: the managements of CPL-Haccourt, CBR-Lixhe, CBR-Romontbos, Ankerpoort-Marnebel and ENCI Nederland BV.

**REFERENCES**

BARDET, N. & JAGT, J.W.M. 1996. *Mosasaurus hoffmanni,* le "Grand Animal fossile des Carrières de Maestricht": deux siècles d'histoire. *Bulletin du Muséum national d'Histoire naturelle de Paris,* (4) **18** (C4) : 569-593.

———————————KUYPERS, M.M.M.& DORTANGS, R.W., 1998. Shark tooth marks on a vertebra of the mosasaur *Plioplatecarpus marshi* from the late Maastrichtian of Belgium. *Publicaties van het Natuurhistorisch Genootschap in Limburg,* **41** (1) : 52-55

————————& PEREDA SUBERBIOLA, X. 1996. Las faunas de reptiles marinos del Cretácico final de Europa (margen norte del Tetis mediterráneo). *Revista Española de Paleontología,* **11** (1) : 91-99.

BAUR, G. 1888. Unusual Dermal Ossifications. *Science*, **2** (268) : 144.

BELL, G.J. Jr. 1997a. Part IV. Mosasauridae. Introduction; pp. 281-292. *In* CALLAWAY, J.M. & NICHOLLS, E.L. (eds) *Ancient Marine Reptiles*. Academic Press, New York/London.

————————1997b. A phylogenetic revision of North American and Adriatic Mosasauroidea; pp. 293-332. *In* CALLAWAY, J.M. & NICHOLLS, E.L. (eds) *Ancient Marine Reptiles*. Academic Press, New York/London.

————————& SHELDON, M.A. 1986. Description of a very young mosasaur from Greene County, Alabama. *Journal of the Alabama Academy of Sciences,* **57** (2) : 76-82.

BLAINVILLE, H.M. DE 1835. *Ostéographie*, vol. 8, Atlas, pl. 6.

BRINKHUIS, H. & SMIT, J. 1996. The Geulhemmerberg Cretaceous/Tertiary boundary section (Maastrichtian type area, SE Netherlands). *Geologie en Mijnbouw*, **75** (2-3): ii + 101-293.

COPE, E.D. 1869. On the reptilian orders Pythonomorpha and Streptosauria. *Proceedings of the Boston Society of Natural History,* **12** : 250-266.

———————— 1871. Supplement to the "Synopsis of the extinct Batrachia and Reptilia of North America." *Proceedings of the American Philosophical Society,* **12** : 41-52.

DEKAY, J.E. 1842. *Zoology of New York, or the New York fauna.* Part 3, Reptiles and Amphibia, vii + 98 pp., Albany.

DOLLO, L. 1882. Note sur l'ostéologie des Mosasauridae. *Bulletin du Musée royal d'Histoire naturelle de Belgique*, **1** : 55-74, 3 pls.

———————— 1889. Première note sur les mosasauriens de Mesvin. *Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie,* Mémoires, **3** : 271-304, pls 9, 10.

———————— 1903. Sur l'évolution des chéloniens marins (Considérations bionomiques et phylogéniques). *Bulletin de l'Académie royale de Belgique*, Classe des Sciences, **8** : 801-850.

———————— 1909. The fossil vertebrates of Belgium. *Annals of the New York Academy of Sciences*, **19** (4): 99-119, pls. 4, 7-10

———— 1913. Globidens Fraasi [sic], Mosasaurien mylodonte nouveau du Maestrichtien (Crétacé supérieur) du Limbourg, l'Ethologie de la Nutrition chez les Mosasauriens. *Archives de Biologie*, **28** : 609-626, pls. 24, 25.

———— 1922. Les vertébrés vivants et fossiles du Musée royal d'Histoire naturelle de Bruxelles. *In* Congrès Géologique International, *Livret Guide pour la XIII^e Session Belgique 1922, Excursion D1*: 1-53.

FAUJAS SAINT FOND, B. 1799. *Histoire naturelle de la Montagne de Saint-Pierre de Maëstricht,* H.J. Jansen, Paris : 1-263, 53 pls.

FELDER, P.J. 1980. Resten van fossiele zeeschildpadden gevonden in het Krijt van Limburg. *Natuurhistorisch Maandblad,* **69** (4): 78-85; 69(5): 100-104; 69(6/7): 117-124.

————& JAGT, J.W.M., 1998. De stratigrafie van het type exemplaar van *Mosasaurus hoffmanni* Mantell, 1829, "Het Grote Dier van Maastricht", bepaald. *Publicaties van het Natuurhistorisch Genootschap in Limburg*, **41** (1) : 48-51.

FELDER, W.M., 1975. Lithostratigrafie van het Boven-Krijt en het Dano-Montien in Zuid-Limburg en het aangrenzende gebied; pp. 63-75. *In* ZAGWIJN, W.H. & VAN STAALDUINEN, C.J. (eds). *Toelichting bij geologische overzichtskaarten van Nederland.* Rijks Geologische Dienst, Haarlem.

————& BOSCH, P.W. in press. Afzettingen uit het Boven-Krijt en Danien in Zuid-Limburg en omgeving. *In Geologie van Nederland.* Rijks Geologische Dienst, Haarlem.

GALLAGHER, W.B. 1993. The Cretaceous/Tertiary Mass Extinction. Event in the Northern Atlantic Coastal Plain. *The Mosasaur,* **5** : 75-154.

GRAY, J.E. 1825. A synopsis of the genera of reptiles and amphibia, with a description of some new species. *Annals of Philosophy*, **10** : 193-217.

————1831. Synopsis Reptilium; or short descriptions of the species of Reptiles. *Synopsis Reptilium, Part 1: Tortoises, Crocodiles and Enaliosaurians,* viii + 85 pp., London.

HIRAYAMA, R. 1995. Phylogenetic systematics of chelonioid sea turtles; pp. 270-284. *In* BARNES, L.G; INUZUKA, N. & HASEGAWA, Y. (eds) Evolution and migration of fossil marine vertebrates in the Pacific Realm. *The Island Arc,* **3** (40) (1994).

————1997. Distribution and diversity of Cretaceous chelonioids; pp. 225-241. *In* CALLAWAY, J.M. & NICOLLS, E.L. (eds) *Ancient Marine Reptiles.* Academic Press, New York/London.

HOFKER, J. 1955. Detering [sic] van fossielen door middel van foraminiferen, II. *Natuurhistorisch Maandblad,* **44** (9-10) : 91, 92.

———— 1957. Datering van fossielen door middel van foraminiferen, III. *Natuurhistorisch Maandblad*, **46** (3-4) : 30.

JAGT, J.W.M. 1996. Late Maastrichtian and Early Palaeocene index macrofossils in the Maastrichtian type area (SE Netherlands, NE Belgium); pp. 153-162. *In* BRINKHUIS, H. & SMIT, J. (eds) The Geulhemmerberg Cretaceous/Tertiary boundary section (Maastrichtian type area, SE Netherlands). *Geologie en Mijnbouw*, **75** (2-3).

———— KUYPERS, M.M.M. & PEETERS, H.H.G. 1995. Mosasauriers in het Natuurhistorisch Museum Maastricht opnieuw onder de loep genomen. *Natuurhistorisch Maandblad,* **84** (2) : 47-59.

KOKEN, E. 1888. *Thoracosaurus macrorhynchus* Bl. aus der Tuffkreide von Maastricht. *Zeitschrift der deutschen geologischen Gesellschaft,* **40** (4) : 754-773, pl. 32.

KRUYTZER, E.M. 1955. *Glyptochelone suyckerbuyki* (Ubaghs). *Natuurhistorisch Maandblad,* **44** (9-10) : 93-95.

KUHN, O. 1936. Pars 75 : Crocodilia; pp.1-100. *In* QUENSTEDT, W. (ed) *Fossilium Catalogus*, I : Animalia. W. Junk, 's-Gravenhage.

KUYPERS, M.M.M., JAGT, J.W.M., PEETERS, H.H.G., DE GRAAF, D.T., DORTANGS, R.W., DECKERS, M.J.M., EYSERMANS, D., JANSSEN, M.J., & ARPOT, L. 1998. Laat-kretaceische mosasauriërs uit Luik-Limburg : nieuwe vondsten leiden tot nieuwe inzichten. *Publicaties van het Natuurhistorisch Genoot-schap in Limburg*, **41** (1) : 5 -47.

LE LOEUFF, J. 1992. Les vertébrés continentaux du Crétacé supérieur d'Europe: Paléoécologie, biostratigraphie et paléobiogéographie. *Mémoires des Sciences de la Terre de l'Université Paris VI*, **92-3** : 1-273, 30 pls. (unpublished PhD thesis).

LINGHAM-SOLIAR, T. 1992. The Tylosaurine Mosasaurs (Reptilia, Mosasauridae) from the Upper Cretaceous of Europe and Africa. *Bulletin de l'Institut royal des Sciences naturelles de Belgique,* Sciences de la Terre, **62** : 171-194, pls. 1-8.

————1993. The mosasaur *Leiodon* bares its teeth. *Modern Geology*, **18** : 443-458.

————1994. The Mosasaur *Plioplatecarpus* (Reptilia, Mosasauridae) from the Upper Cretaceous of Europe. *Bulletin de l'Institut royal des Sciences naturelles de Belgique*, Sciences de la Terre, **64** : 177-211, pls. 1-8.

————1995. Anatomy and functional morphology of the largest marine reptile known, *Mosasaurus hoffmanni* (Mosasauridae, Reptilia) from the Upper Cretaceous, Upper Maastrichtian of the Netherlands. *Philosophical Transactions of the Royal Society London,* **B347** : 155-180.

————1996. The first description of *Halisaurus* (Reptilia Mosasauridae) from Europe, from the Upper Cretaceous of Belgium. *Bulletin de l'Institut royal des Sciences naturelles de Belgique*, Sciences de la Terre, **66** : 129-136, pl. 1.

————& NOLF, D., 1990. The mosasaur *Prognathodon* (Reptilia, Mosasauridae) from the Upper Cretaceous of Belgium. *Bulletin de l'Institut royal des Sciences naturelles de Belgique*, Sciences de la Terre, **59** (1989) : 137-190, pls. 1-7.

MANTELL, G.A., 1829. A tabular arrangement of the organic remains of the county of Sussex. *Transactions of the Geological Society*, (2) **3** : 201-216.

MASSARE, J.A. 1987. Tooth morphology and prey preference of Mesozoic marine reptiles. *Journal of Vertebrate Paleontology,* **7** (2) : 121-137.

————1997. Part VI. Faunas, Behavior, and Evolution Introduction; pp. 401-421. *In* CALLAWAY, J.M. & NICHOLLS, E.L. (eds) *Ancient Marine Reptiles.* Academic Press, New York/London.

MINIS-VAN DE GEIJN, W. 1955. De strijd om het bezit van de schildpad van de Suyck. *Natuurhistorisch Maandblad,* **44** (9-10) : 95-98.

MOODY, R.T.J. 1993. Cretaceous-Tertiary marine turtles of North

West Europe. *Revue de Paléobiologie*, Volume spécial, **7** : 151-160.

————————1997. The paleogeography of marine and coastal turtles of the North Atlantic and Trans-Saharan regions; pp. 259-278. *In* CALLAWAY, J.M. & NICHOLLS, E.L. (eds) *Ancient Marine reptiles.* Academic press, New York /London.

MULDER, E.W.A. 1990. Ein Elasmosaurierzahn aus der oberen Kreide des St. Pietersberges bei Maastricht, Süd-Limburg, Niederlande. *Paläontologische Zeitschrift*, **64** (1/2) : 145-151.

————————1998. Thoracosaurine vertebrae (Crocodylia; Crocodylidae) from the Maastrichtian type area. *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen,* **100** (1-2) (1997) : 161-170.

————————KUYPERS, M.M.M., JAGT, J.W.M. & PEETERS, H.H.G. 1997. A new late Maastrichtian hadrosaurid dinosaur record from northeast Belgium. *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte* : 339-347.

ROMPEN, P. 1995. *Mosasaurus hoffmanni :* De lotgevallen van een type-exemplaar. Faculteit der Cultuurwetenschappen, Rijksuniversiteit Limburg, Maastricht : 1-105 (unpublished master's thesis).

RUSSELL, D.A. 1972. Ostrich dinosaurs from the Late Cretaceous of western Canada. *Canadian Journal of Earth Sciences*, **6** : 595-612.

SCHIØLER, P., BRINKHUIS, H., RONCAGLIA, L. & WILSON, G.J. 1997. Dinoflagellate biostratigraphy and sequence stratigra phy of the Type Maastrichtian (Upper Cretaceous), ENCI Quarry, The Netherlands. *Marine Micropaleontology*, **31** : 65-95, pls 1-4.

SCHÖNFELD, J., SCHULZ, M.-G., MCARTHUR, J.M., BURNETT, J. , GALE, A., HAMBACH, U., HANSEN, H.J., KENNEDY, W.J., RASMUSSEN, K.L., THIRLWALL, M.F. & WRAY, D.S., 1996. New results on biostratigraphy, palaeomagnetism, geochemistry and correlation from the standard section for the Upper Cretaceous white chalk of northern Germany (Lägerdorf-Kronsmoor-Hemmoor). *In* SPAETH, C. (ed) New developments in Cretaceous research topics, Proceedings of the Fourth International Cretaceous Symposium, Hamburg 1992. *Mitteilungen aus dem geologisch-paläontologischen Institut der Universiät Hamburg*, 77: 545-575.

SEELEY, H.G. 1883. On the dinosaurs from the Maastricht beds. *Quarterly Journal of the geological Society, London,* **39** (2) : 246-253.

SHELDON, A. 1997. Ecological implications of mosasaur bone microstructure; pp. 333-354. *In* CALLAWAY, J.M. & NICHOLLS, E.L. (eds) *Ancient Marine Reptiles.* Academic Press, New York/London.

UBAGHS, C. 1879. *Description géologique et paléontologique du sol du Limbourg avec Catalogue général des fossiles du terrain crétacé, Coupe de la superposition des couches, et Description de quelques grands vertébrés de la craie supérieure de Maastricht,* 275 + ii pp., 7 pls. J.J. Romen et fils, Roermond.

UMBGROVE, J.H.F. 1956. *Ons land zeventig millioen jaar geleden. Levensschetsen uit de Krijtperiode*, xiii + 150 pp. Martinus Nijhoff, 's Gravenhage.

VONHOF, H. & SMIT, J. 1996. Strontium-isotope stratigraphy of the type Maastrichtian and the Cretaceous Tertiary boundary in the Maastricht area (SE Netherlands); pp. 275-282. *In* BRINKHUIS, H. & SMIT, J. (eds) The Geulhemmerberg Cretaceous/Tertiary boundary section (Maastrichtian type area, SE Netherlands). *Geologie en Mijnbouw*, **75** (2-3).

WELTON, B.J. & FARISH, R.F. 1993. *The Collector's Guide to Fossil Sharks and Rays From the Cretaceous of Texas*, xviii + 204 pp. Before Time, Lewisville TX.

WILLISTON, S.W. 1894. A new turtle from the Benton Cretaceous. *Kansas University Quarterly*, **3** : 5-18.

WOODWARD, A.S. 1891. Note on a Tooth of an Extinct Alligator *(Bottosaurus belgicus*, sp. nov.) from the Lower Danian of Ciply, Belgium. *Geological Magazine*, n.s. (3) **8** : 114, 115.

ZIJLSTRA, J.J.P. 1994. Sedimentology of the Late Cretaceous and Early Tertiary (tuffaceous) chalk of northwest Europe. *Geologica Ultraiectina*, **119** : 1-192.

*Note reçue le 15-09-1997*
*acceptée après révision le 15-01-1998*