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Stratigraphic ranges of mosasaurs in Belgium and the Netherlands (Late Cretaceous) and cephalopod-based correlations with North America

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Abstract

Mosasaur taxa currently known from Campanian-Maastrichtian strata in the Liège-Limburg (SE Netherlands, NE Belgium) and Mons (southern Belgium) basins are listed and briefly discussed and their stratigraphic ranges indicated. Recently published and/or ongoing work on coleoid and ammonoid cephalopods in these areas allows tie points between NW Europe and the United States (Western Interior, Gulf Coast, Atlantic Seaboard) to be established. Future studies need to refine the resultant, rather crude, scheme. The ultimate aim is a more robust picture of mosasaur taxonomy, biostratigraphy and palaeobiogeography, and a detailed evaluation of migratory patterns across the Atlantic.

Keywords: Mosasauridae, Late Cretaceous, Campanian, Maastrichtian, biostratigraphy, palaeobiogeography, correlation, cephalopods

Introduction

To date, at least eight species of mosasaur have been recorded from strata of Campanian-Maastrichtian age in the extended type area of the Maastrichtian Stage (Liège-Limburg and Aachen area, Germany). A comparable number is known from the Mons Basin (southern Belgium) where, with the exception of *Globidens dakotensis* and possibly also of *Prognathodon giganteus*, all species stem from a narrow interval within the lower Maastrichtian (*obtusa* Zone).

The main aim of the present contribution is to put these mosasaur taxa in a biostratigraphic context, using cephalopod molluscs. In NW Europe, belemnitellid coleoids constitute the most reliable correlation tools, despite the fact that several species appear to be confined to particular areas (see e.g., Christensen, 1975, 1986, 1990, 1991, 1993, 1994, 1995, 1996, 1997a, b, 1998, 1999, 2000a, b; Christensen et al., 1975, 2000; Christensen & Schmid, 1987; Christensen & Schulz, 1976; Schulz, 1979, 1982; Schulz & Schmid, 1983). Unfortunately, none of the taxa recognised in Europe is known from the United States, where merely two (or three) species of *Belemnitella* are listed (Christensen in Kennedy et al., 1998). In the Western Interior, *Belemnitella bulbosa* ranges from the *Hoploscaphites birkelundae* to *Jeletzkytes nebrascensis* zones (Fox Hills Formation, South Dakota), and possibly also occurs in the *Baculites baculus* and *B. clinolobatus* zones (Pierre Shale Formation, South Dakota) (see Table 1). The other species, *Bt. americana*, is known from the Mount Laurel Formation and basal Navesink Formation of New Jersey, Delaware and Maryland (upper upper Campanian-lower Maastrichtian); in South Carolina, Christopher & Prowell (2002) showed it to range through the lower and middle Peedee Formation (upper lower Maastrichtian). Samples of *Bt. americana* from the upper Mount Laurel Formation of New Jersey are currently being revised by N. Keutgen (pers. comm., October 2004). So long as both taxonomy and stratigraphic ranges remain poorly understood, coleoids cannot be used for intercontinental correlations.

Although the resultant scheme is still a crude one, ammonites are more promising in this respect. Below, ammonite-based correlations between the Liège-Limburg and Mons basins on the one hand, and the Gulf Coast, Atlantic Seaboard and Western Interior on the other, are given (Table 2). Added are distribution data of ammonite taxa in Europe and beyond. It is hoped that future work will lead to a refinement of this scheme, and a tighter control on the stratigraphic ranges of mosasaur taxa on both sides of the Atlantic. Only in this way can comparisons between areas become more meaningful (compare Gallagher, 1993; Bardet & Pereda Suberbiola, 1996; Mulder, 1999, 2003a), nomenclatorial issues be resolved, and habitat preferences (compare Kiernan, 2002) be assessed in more detail. Such cephalopod-based correlations have great potential, as the recent suggestion of an intercontinental marine extinction event across the lower/upper Campanian boundary shows (Lindgren, 2004a, b; Lindgren & Siverson, 2002, 2004). This is not only reflected in mosasaur distribution, but also in a turnover of ammonite taxa, in particular pachydiscids and scaphitids.

*Table 1. Correlation, based on ranges of selected ammonoid cephalopods, between the Campanian-Maastrichtian of the Western Interior, Gulf Coast and Atlantic Seaboard (US) (after Cobban & Kennedy, 1991a, 1992b; Kennedy & Cobban, 1993b) and Europe (Kaplan et al., in press; pers. obs.), with standard white chalk section of NW Germany as reference. * added by Landman et al. (2004) as highest ammonite zone in the uppermost Maastrichtian of New Jersey, Alabama, Mississippi and Missouri.*

	US	**NW Europe (NW Germany)**
MAASTRICHTIAN	*Discoscaphites iris**	
	Jeletzkytes nebrascensis	
	Hoploscaphites nicolletii	
	Hoploscaphites birkelundae	*fastigata, cimbrica + tegulatus/junior*
	Baculites clinolobatus	
	Baculites grandis	
	Baculites baculus	*obtusa*
	Baculites eliasi	
CAMPANIAN	*Baculites jenseni*	*grimmensis/ granulosus (= hyatti)*
	Baculites reesidei	
	Baculites cuneatus	
	Baculites compressus	
	Didymoceras cheyennense	
	Exiteloceras jenneyi	
	Didymoceras stevensoni	
	Didymoceras nebrascense	
	Baculites scotti	
	Baculites reduncus	
	Baculites gregoryensis	
	Baculites perplexus	
	Baculites sp. (smooth)	*roemeri, vulgaris/ stolleyi*
	Baculites asperiformis	
	Baculites mclearni	
	Baculites obtusus	*basiplana/spiniger*
	Baculites sp. (weak flank ribs)	
	Baculites sp. (smooth)	
	Scaphites hippocrepis III	*pilula to conica/ gracilis*
	Scaphites hippocrepis II	*lingua/quadrata*
	Scaphites hippocrepis I	
	Scaphites leei III	*granulataquadrata*

Abbreviations

To denote the repositories of material referred to in the text, the following abbreviations are used: BMNH - The Natural History Museum, London; MNHN - Muséum National d'Histoire Naturelle, Paris; NHMM - Natuurhistorisch Museum Maastricht, Maastricht; IRScNB - Institut royal des Sciences naturelles de Belgique, Brussels.

1 – Type area of the Maastrichtian Stage (SE Netherlands, NE Belgium) (Fig. 1)

In recent years, two working quarries in the Eben Emael area (Bassenge, province of Liège, NE Belgium) have yielded a number of (semi-)articulated mosasaur skeletons, in particular from the upper Gulpen and lower/middle Maastricht formations. Both lower and higher in the section, mosasaur material usually comprises disarticulated and isolated remains only, especially tooth crowns and vertebrae.

Mosasaur taxa of Campanian age

To date, only a handful of specimens (tooth crowns and poorly preserved post-cranial elements) are known from strata of Campanian age.

A – Vaals Formation

A single tooth crown (NHMM VG 2184), collected autumn 1965 from outcrop 62G-10 along the Lüttigerstraße at Kelmis (La Calamine, NE Belgium) and subsequently identified as a plioplatecarpine (*Platecarpus* sp.) by Kuypers et al. (1998), is perhaps better referred to the tylosaurine genus *Hainosaurus*, thus adding another tylosaurine record for NW Europe (Bardet, 1990; Jagt et al., 2005). Macrofossil assemblages observed in the section exposed there suggest it to have been correlatable with either the Gemmenich Member or Vaalsbroek Member, of early (though not earliest) Campanian age.

The Vaals Formation in its type area ranges from the *granulataquadrata* to at least the *pilula* zones of the NW German scheme (Table 3), and possibly even higher (see below). The base of the *granulataquadrata* Zone in Germany corresponds to the *Scaphites leei* III Zone in the Western Interior, dated at 83.5 ± 0.5 Ma (McArthur et al., 1993). Ammonite taxa particularly suited for trans-Atlantic correlation include *Scaphites hippocrepis* II-III (sensu Cobban, 1969) and *Baculites vaalsensis*. In the Western Interior, the *S. hippocrepis* II Zone has been dated at 81 Ma (McArthur et al., 1994).

Table 2. Occurrences of selected ammonoid taxa in North America (Atlantic Seaboard, Gulf Coast and Western Interior Seaway) and the Maastrichtian type area, plus Mons Basin. Names are formations and/or members (compare Figs. 1, 2). Abbreviations: AL – Alabama; CA – California; CO – Colorado; DE – Delaware; MO – Missouri; MD – Maryland; MS – Mississippi; NC – North Carolina; ND – North Dakota; NJ – New Jersey; SD – South Dakota; TN – Tennessee; TX – Texas; WY – Wyoming.

Taxa		**US**	**Mons**	**Liège-Limburg**
Desmoceratidae	*Hauericeras rembda*	Prairie Bluff (AL)	-	Vijlen 6
Kossmaticeratidae	*Brahmaites brahma*	Arkansas (B. sp.)	-	Meerssen
Pachydiscidae	*Pachydiscus (P.) gollevillensis*	Prairie Bluff (MS)	-	pre-Emael
	Pachydiscus (P.) j. jacquoti	Prairie Bluff (MS) Corsicana (TX)	-	pre-Emael, Nekum
	Pachydiscus (P.) neubergicus	Navesink (NJ)	Ciply-Malogne	Vijlen 1-6
	Pachydiscus (P.) haldemsis	Pecan Gap (TX)	-	Zeven Wegen
Placenticeratidae	*Hoplitoplacenticeras (H.) marroti*	Anacacho (TX)	-	Vaals (top)
Sphenodiscidae	*Sphenodiscus lobatus/binckhorsti*	Fox Hills (SD, ND) Pierre Shale (SD, ND) Escondido (TX) Corsicana (TX) Ripley (MS) Providence (AL) Peedee (NC) Severn (MD) Red Bank/Tinton (NJ)	-	Nekum-Meerssen
Diplomoceratidae	*Glyptoxoceras aquisgranense*	Merchantville (NJ)	-	Vaals
	Glyptoxoceras rugatum	Severn (MD) Corsicana (TX)	-	Vijlen 6-Meerssen
Nostoceratidae	*Nostoceras spp.*	Kemp Clay (TX)?	-	Meerssen (base)
Scaphitidae	*Jeletzkytes dorfi*	Fox Hills (CO, WY) Pierre Shale (CO)	-	Vijlen 6
	Scaphites (S.) hippocrepis II-III	Merchantville (NJ, MD, DE) Gober (TX) Western Interior	-	Vaals
	Trachyscaphites s. spiniger	Mooreville (AL) Ozan (TX) Annona (TX)	Nouvelles	Vaals (top) Zeven Wegen
Baculitidae	*Baculites aquilaensis*	Lower Campanian, Western Interior	Obourg (base)	-
	Baculites baculus	Maastrichtian, Western Interior, Canada, US Gulf Coast	Ciply-Malogne	-
	Baculites sp. (smooth)	mid-Campanian, Western Interior	Obourg (base)	Zeven Wegen (top)
	Baculites vaalsensis	Merchantville (NJ)	-	Vaals
	Baculites vertebralis	Severn (MD)	-	Emael-Meerssen
	Eubaculites carinatus	Prairie Bluff (MS, AL) Owl Creek (MO, MS, TN) Corsicana (TX) Hornerstown (NJ)	-	Meerssen
	Trachybaculites columna	Fox Hills (CO, SD) Prairie Bluff (AL, MS) Corsicana (TX) Garzas (CA)	-	Vijlen 6

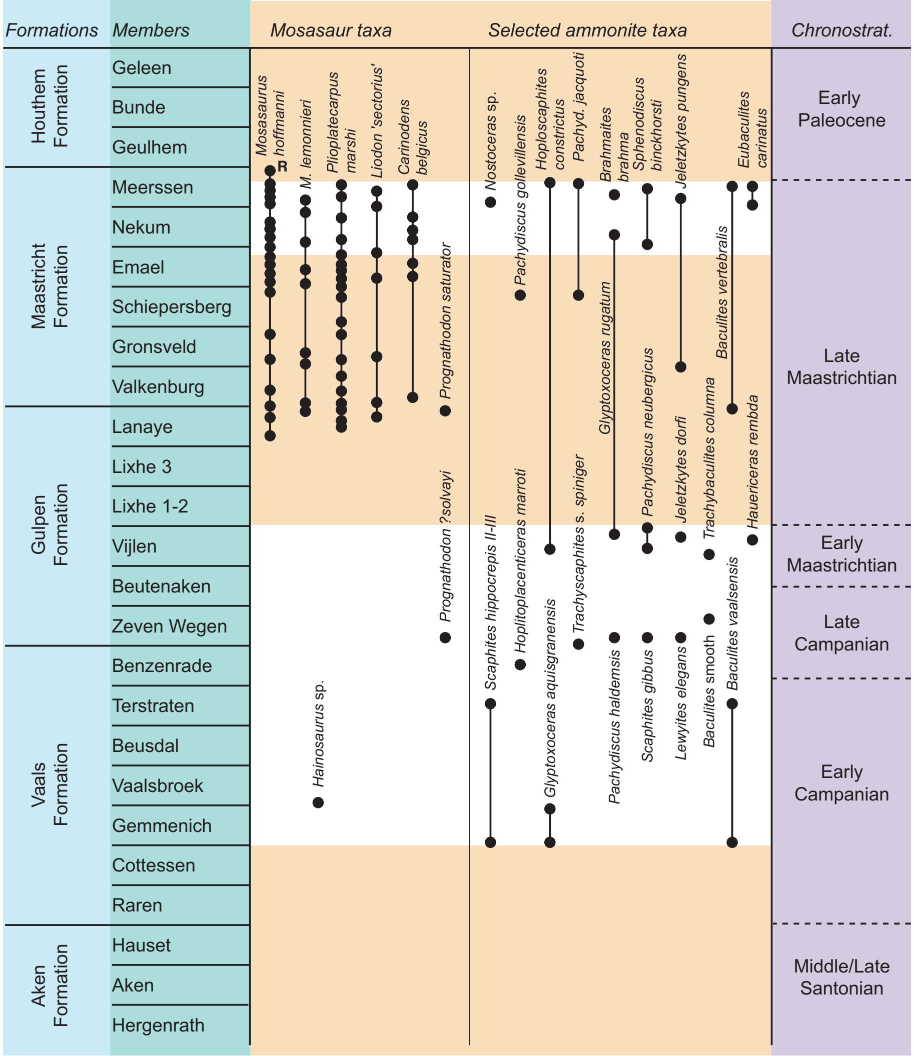


Fig. 1. Lithostratigraphy of Santonian-lower Paleocene strata in the Maastrichtian type area (after Felder & Bosch, 2001) and stratigraphic ranges of mosasaur taxa known to date, plus those of selected ammonoid cephalopods. White are portions of the sequence which correlate well with North America, using particular ammonite taxa.

Scaphites (S.) hippocrepis II is known from the Mooreville Formation in Alabama (Kennedy et al., 1997a), while *hippocrepis* III has been recorded from the Merchantville Formation of New Jersey, Maryland and Delaware (Kennedy & Cobban, 1993d; Kennedy et al., 1997c). In addition, it is widely distributed in the lower Campanian of the Western Interior (Montana, Wyoming, South Dakota, Utah, Colorado, New Mexico), and questionably occurs in the Blufftown Formation (Alabama) and Woodbury Formation (New Jersey). Passage forms between *hippocrepis* II and III occur in NE Belgium, Aquitaine and Provence (France; see Kennedy, 1986b), Hampshire and Sussex (England; see Gale, 1980), Münsterland (Wippich, 1995; Hauschke et al., 1999), the Lehrter Westmulde (Hannover area, Germany; see Niebuhr, 1996), southern Sweden (Kennedy & Christensen, 1997), southern Poland (Jagt et al., 2004) and Israel. Form III has been described from the Gober Chalk of Texas (Cobban & Kennedy, 1992b) and from Saskatchewan (Canada; see Cobban, 1993) as well. The species complex may range into the 'middle' Campanian of NE Texas (Cobban & Kennedy, 1992a) and the Barranca (northern Spain; Küchler, 2000).

Baculites vaalsensis occurs in the lower Campanian of NE Belgium, the Vaals-Vaalserberg area (the Netherlands), northern Aquitaine (France), Münsterland (Kaplan et al., in press) and the Merchantville Formation of New Jersey (Kennedy & Jagt, 1995; Kennedy et al., 1997c; Klinger & Kennedy, 2001).

Glyptoxoceras aquisgranense, well known from the Lower Campanian of NE Belgium, Ariège (France), the Aachen area (Germany) and the Münsterland Basin (Kennedy & Kaplan, 1995), has recently been described from the Merchantville Formation of New Jersey (Kennedy et al., 1997c).

Other ammonite species from the Vaals Formation have correlative value mostly within Europe. *Placenticeras bidorsatum* (see Kennedy & Jagt, 1995) appears to be confined to the *lingua/quadata* Zone in Münsterland and the Braunschweig area (Kennedy & Kaplan, 1995; Kaplan et al., in press), and a similar range has been described for northern Aquitaine (Kennedy, 1986b). *Pachydiscus (P.) duelmensis* has a comparable range in Münsterland (Kennedy & Kaplan, 1995; Wippich, 1995) and northern Aquitaine (Kennedy, 1986b). *Pachydiscus (P.) launayi* also occurs in the latter area (Kennedy, 1986b) and possibly in the upper lower Campanian of Münsterland

(Wippich, 1995) as well, while *Eupachydiscus levyi* is also known from the mid-lower Campanian of Navarra (Küchler, 2000), the upper lower Campanian of Münsterland (Wippich, 1995; Hauschke et al., 1999), southern France (Alpes Maritimes), northern Spain, Poland, Kopet Dagh and Madagascar.

The upper part of the Vaals Formation near Cottessen (Jagt et al., 1995a), and the Benzenrade Member in the Benzenrade area (the Netherlands), have yielded different ammonite assemblages. The single taxon in this assemblage to have been recorded from both sides of the Atlantic is *Hoplitoplacenticeras (H.) marroti*, which is now known from Ariège (Kennedy et al., 1992b), Portugal, Israel, central Asia, Madagascar and south-central Texas (Anacacho Limestone; Kennedy & Cobban, 2001). In northern Spain (Küchler, 2000), *H. (H.) marroti* is typical of the basal upper Campanian, as it is in northern Aquitaine (Kennedy, 1986b).

Pachydiscus (P.) colligatus occurs in southern Sweden (uppermost lower Campanian to upper Campanian), Brabant (Belgium), northern Aquitaine, possibly Tercis and ?Madagascar (Kennedy, 1986b, 1987; Kennedy & Christensen, 1997; Kennedy & Jagt, 1998), while *Pachydiscus (P.) subrobustus* has been recorded from southern Sweden (Kennedy & Christensen, 1997), Münsterland, Tercis, Ariège (Kennedy & Bilotte, 1995), Austria, Pontus (Turkey), Ukraine and southern Poland (Kaplan et al., 1996; Machalski et al., 2004).

Patagiosites stobaei ranges from the upper lower Campanian to the ?lower *roemeri* Zone, being best known from the basal *stobaei/basiplana* Zone (Table 3), with records from northern Germany (Kaplan et al., 1996; Kennedy & Kaplan, 1997), southern Sweden, Donbass, southern Belgium, province of Liège and southern Limburg (the Netherlands).

B – Gulpen Formation (lower portion)

From the lower upper Campanian Zeven Wegen Member, there is a questionable record of *Prognathodon solvayi*, based on a single tooth crown from Heure-le-Romain (Liège, NE Belgium) (Kuypers et al., 1998). From the basal portion of this unit in

Table 3. Biozonation of the Campanian-Maastrichtian of Lägerdorf-Kronsmoor-Hemmoor (LKH), the Münsterland Basin and the Lehrter Westmulde (Hannover area, Germany; after Kaplan et al., in press; Niebuhr, 2003, 2004; Niebuhr et al., 1997); 1 – Dülmen Formation, lower portion; 2 – Dülmen Formation, upper portion; 3 – Holtwick Formation, Legden Member, lower part; 4 – Holtwick Formation, Legden/Asbeck members, in part; 5 – Holtwick Formation, Asbeck Member, middle part; 6 – Holtwick Formation, Asbeck Member, upper part; 7 – Holtwick Formation, Darfeld Member; 8 – Coesfeld Formation, lower part; 9 – Coesfeld Formation, middle part; 10 – Coesfeld Formation, upper part.

	LKH	**Münsterland**	**Lehrter Westmulde**
MAASTRICHTIAN	*(kazimiroviensis)*	-	-
	baltica/danica	-	-
	danica/argentea	-	-
	argentea/junior	-	-
	tegulatus/junior	-	-
	fastigata	-	-
	cimbrica	-	-
	sumensis	-	-
	obtusa	-	-
	pseudobtusa	-	-
	lanceolata	-	-
CAMPANIAN	*grimmensis/granulosus*	-	-
	langei	-	*bipunctatum/roemeri*
	polyplocum	*polyplocum*[10]	*minor/polyplocum*
	roemeri	*roemeri*[9]	*vulgaris/stolleyi*
	basiplana/spiniger	*vulgaris/basiplana*[9]	*vulgaris/basiplana*
	basiplana/stobaei	*basiplana/stobaei*	*stobaei/basiplana*
	conica/mucronata	*conica/mucronata*[8]	*conica/mucronata*
	gracilis/mucronata	*gracilis/mucronata*[7]	*gracilis/mucronata*
	conica/papillosa	*conica/papillosa*[6]	*conica/papillosa*
	papillosa	*papillosa*[5]	*papillosa*
	senonensis	*senonensis*[4]	*senonensis*
	pilula/senonensis	*pilula/senonensis*[3]	*pilula/senonensis*
	pilula	*pilula*[2]	*pilula*
	lingua/quadrata	*lingua/quadrata*[1]	*lingua/quadrata*
	granulataquadrata	*granulataquadrata*	-

the Haccourt area nearby, a number of poorly preserved mosasaur vertebrae are known, which must remain indeterminate. From strata ('Tuffeau jaune', not 'jaunâtre') at Folx-les-Caves (province of Brabant, Belgium) which, on calcareous nannoplankton evidence, Mulder & Mai (1999) considered to be of early late Campanian age, these authors recorded the tylosaurine *Hainosaurus* cf. *bernardi*. However, Robaszynski et al. (2002) noted that that age assignment must be based on reworked material, since the 'tuffeau jaune', or Jauche Member, contains the typically late Maastrichtian brachiopod *Thecidea papillata* in great numbers.

Coleoid cephalopods, which are much commoner than ammonites in this member, demonstrate this unit to be equivalent to the *conica/mucronata*, *stobaei/basiplana*, *vulgaris/basiplana* and *vulgaris/stolleyi* zones (see Keutgen & Jagt, 1999) (Table 3).

Ammonite taxa used for trans-Atlantic correlation include *Trachyscaphites s. spiniger* and *Baculites* sp. (smooth; sensu Cobban, 1962). Typical members of the former taxon are known from the Arcola Limestone Member (Mooreville Formation) in Alabama (Kennedy et al., 1997a), the Ozan Formation and Annona Chalk in Texas (Cobban & Kennedy, 1992a). European records include northern Germany (Niebuhr, 1996), southern Limburg, province of Liège, Mons Basin, Aquitaine, northern Spain, southern Sweden, central and southern Poland, Russia, Ukraine, Armenia and Turkmenistan (Błaszkiewicz, 1980; Kennedy, 1986b; Kennedy & Kaplan, 1997; Küchler, 2000; Jagt et al., 2004; Machalski et al., 2004). In northern Germany, it is common in the lower *basiplana/spiniger* Zone (Table 3), but extends up into the *roemeri* Zone (Kaplan et al., in press).

Of other species and subspecies of *Trachyscaphites* recorded from North America, just a single one, *T. pulcherrimus* is known from Europe as well, ranging into the *polyplocum* Zone, with records from central Poland, Aquitaine, northern Spain, Germany, Austria, Russia and Armenia (Kennedy & Summesberger, 1984; Kennedy, 1986b; Niebuhr, 1996; Kennedy & Kaplan, 1997; Niebuhr et al., 1997; Küchler, 2000). American records include the Wenonah Formation in New Jersey (Kennedy & Cobban, 1994a) and the Bergstrom Formation of central Texas (Kennedy & Cobban, 1999). *Trachyscaphites s. porchi* has been described from the Wolfe City Sand (NE Texas; Cobban & Kennedy, 1993), the Pecan Gap Chalk (central and NE Texas), Anacacho Limestone (south-central Texas; Kennedy & Cobban, 2001), Demopolis Formation (Texas), from the *Baculites mclearni* and *B. asperiformis* zones (Montana, Colorado) (Table 1), and possibly from the upper Mishash Formation in Israel (Cobban & Kennedy, 1994b). *Trachyscaphites redbirdensis* is known from the *Baculites perplexus* and *B. gregoryensis* zones in Wyoming, South Dakota, Colorado and Arkansas (Kennedy & Cobban, 1993b), while *T. densicostatus* seems to be confined to the Middle Campanian Ozan Formation of NE Texas (Cobban & Kennedy, 1992a). From Maastrichtian strata, *T. alabamensis* has been described from the Prairie Bluff Formation of Alabama and Mississippi (Cobban & Kennedy, 1995) and *T. yorkensis* from the Prairie Bluff of Alabama and the Corsicana Marl of Texas. In Europe, this lineage appears to have become extinct during the late Campanian, *T. pulcherrimus* being the last representative. Following that, species of *Jeletzkytes* (uppermost Campanian), *Acanthoscaphites* (lower Maastrichtian) and *Hoploscaphites* (lower-upper Maastrichtian) dominated scaphitid faunas there.

The second species of correlative value is *Baculites* sp. (smooth, sensu Cobban, 1962), which occurs in the uppermost Zeven Wegen Member in the province of Liège, east of Haccourt. As noted by Kennedy (1993), in the northern Western Interior this species defines a zone between the *Baculites asperiformis* Zone below and the *B. perplexus* Zone above, in the 'middle Campanian' (see Table 1).

Nostoceras hyatti (= *N. pozaryskii*), which is typical of the upper upper Campanian in North America, is also known from various European localities (see Kennedy et al., 1992a; Küchler & Odin, 2001; Küchler et al., 2001). Unfortunately, no material is yet known from Liège-Limburg, although the Beutenaken Member is the age-correlative of strata yielding this ammonite elsewhere (Keutgen & Jagt, 1999). Kennedy & Cobban (1993c), Cobban & Kennedy (1994a), Küchler (2000) and Kennedy et al. (2000a) and Odin et al. (2001) recorded *N. hyatti* from the Ripley Formation of Tennessee, the Saratoga Chalk of Arkansas, the Nacatoch Sand in NE Texas, the basal Navesink Formation of New Jersey, the Pierre Shale (*Baculites jenseni* Zone) of southern Colorado, plus the upper Campanian of Angola, ?Israel, Tercis and Aquitaine (France), northern Spain and central Poland.

Recently, a fourth species, *Pachydiscus (P.) haldemsis*, has been documented from the Pecan Gap Chalk of central and northeast Texas (Cobban & Kennedy, 1994b). This is also known from Austria, Aquitaine, northern Spain, southern Sweden, northern Germany, northern Ireland, Norfolk, central and southern Poland, Ukraine and Turkmenistan (Kennedy & Summesberger, 1984; Kennedy, 1986b; Kennedy & Christensen, 1997; Kennedy & Kaplan, 1997; Küchler, 2000; Machalski et al., 2004).

Other ammonite taxa known from the Zeven Wegen Member are predominantly European in distribution, e.g., *Patagiosites stobaei* (see above), *Patagiosites* aff. *griffithi* (northern Ireland), *Hoplitoplacenticeras (H.)* cf. *coesfeldiense* (Wyoming, Austria, northern Germany, Aquitaine, Russia; Cobban, 1963; Kaplan et al., 1996, in press; Kennedy & Kaplan, 1997; Kennedy & Summesberger, 2001), *Scaphites (S.) gibbus* (northern Germany, southern Belgium, province of Liège, southern Limburg, Aquitaine, southern Poland, Donbass, Ukraine and Kazakhstan; Wippich, 1995; Kaplan et al., 1996; Kennedy & Kaplan, 1997; Jagt et al., 2004; Machalski et al., 2004), *Lewyites elegans* (northern Germany, southern Sweden, Aquitaine, southern Poland, Austria; Kennedy & Christensen, 1997; Kennedy & Kaplan, 1997; Jagt et al., 2004; Machalski et al., 2004; Summesberger & Kennedy, 2004), and *Neancyloceras? phaleratum* (northern Spain, ?Austria, ?Lehrter Westmulde, central Poland; Küchler, 2000). Close to the last-named species is *N.*? *bipunctatum* from the upper Campanian of Aquitaine, northern Germany, central Poland, Austria, and possibly northern Spain and the Ozan Formation of Arkansas (Kennedy & Cobban, 1993b; Kennedy & Kaplan, 1997; Niebuhr et al., 1997; Kennedy & Summesberger, 1999, 2001; Küchler, 2000).

The Beutenaken I and II members, of late Campanian (upper *polyplocum* and lower *langei* zones) to early Maastrichtian (upper *grimmensis/granulosus* to *pseudobtusa* zones) age (Table 4), have so far not yielded any ammonites, nor mosasaur remains. Biozonation and correlation with Norfolk (England) and the Mons Basin rely primarily on coleoids (Keutgen & Jagt, in prep.). Current interpretations of the Zeven Wegen and Beutenaken members assume large sedimentary gaps in the middle to upper upper Campanian, which, together with possible facies-related differences, may explain the absence in the Liège-Limburg Basin of such key index ammonite taxa as *Hoploscaphites vistulensis*, *H. pumilus*, *Pseudokossmaticeras galicianum* and *Jeletzkytes compressus*. The first-named is known from central Poland (*Nostoceras pozaryskii* Zone, upper upper Campanian) and the Mount Laurel Sand of Delaware (Błaszkiewicz, 1980; Kennedy & Cobban, 1994b), while *H. pumilus* has been recorded from Haute Garonne, Tercis (Landes) and Petites Pyrénées (France), the Saratoga Chalk of Arkansas, the Nacatoch Sand in Texas and the basal Navesink Formation of New Jersey (Kennedy et al., 1986, 2000b; Kennedy & Cobban, 1993c; Machalski & Odin, 2001). The third species, *P. galicianum*, is known from the Saratoga Chalk of Arkansas, as well as from the uppermost Campanian of central Poland and the lower Maastrichtian of Austria, Italy, Bulgaria, the Ukraine, Crimea, Armenia and the Bithynian Peninsula (Turkey) (Kennedy & Cobban, 1993c). Finally, *J. compressus* has been recorded from the upper Campanian of northern Ireland, northern Germany, central Poland and from the Mount Laurel Sand of Delaware (Kennedy & Cobban, 1994b); Kennedy & Kaplan (1997) listed it from the upper Haldem Schichten (*polyplocum* Zone), while Niebuhr (1996) and Niebuhr et al. (1997) collected specimens at Hannover-Ahlten (upper *bipunctatum/roemeri* Zone). Its congener, *J. nodosus*, is known from the Ripley Formation (Coon Creek Tongue) of Tennessee, the Nacatoch Sand in NE Texas, the basal Saratoga Chalk of southwest Arkansas, the basal Navesink Formation of New Jersey and the Pierre Shale (*Baculites compressus*, *B. cuneatus*, *B. reesidei* and *B. jenseni* zones) of the Western Interior, as well as from the upper Campanian of central Poland. From the basal Navesink Formation of New Jersey and the *B. compressus* Zone of the Pierre Shale in Colorado, respectively, Kennedy et al. (2000b) and Cobban et al. (1992) mentioned *J.* cf. *nodosus*.

An additional typically North American taxon, *Didymoceras stevensoni*, index of the *stevensoni* Zone in the Western Interior, has been recorded to co-occur with European species such as *Pseudokossmaticeras brandti* and *Pachydiscus (P.) subrobustus* by Kennedy & Bilotte (1995) in Ariège (sub-Pyrenees, southern France).

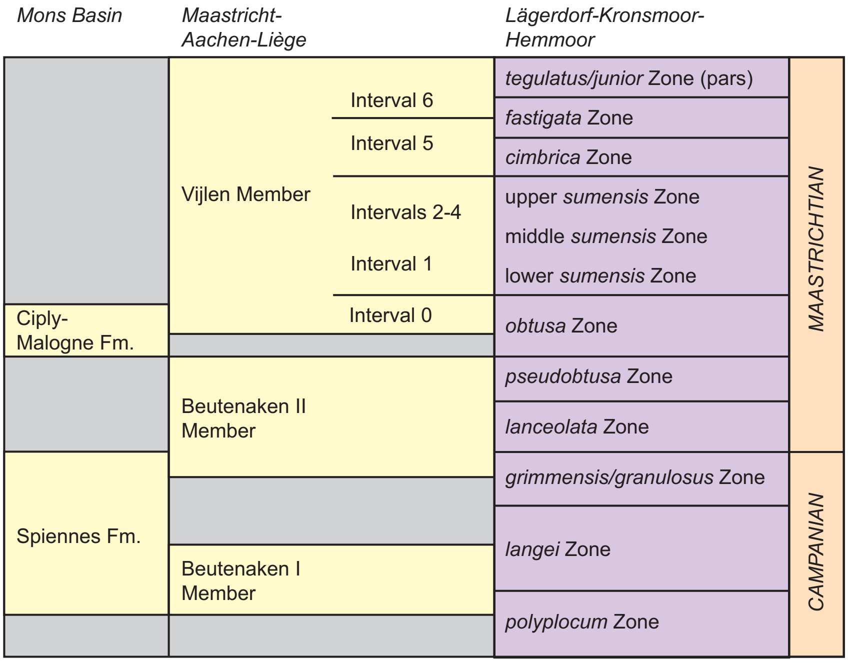
Mosasaur taxa of Maastrichtian age

C – Gulpen Formation (upper portion)

The Vijlen Member (Table 4), subdivided into seven intervals (numbered 0 to 6) and ranging from the *obtusa* Zone to the lower part of the *tegulatus/junior* Zone, has yielded merely a single tooth and two tooth crowns from the CPL SA-Haccourt and ENCI-Maastricht bv quarries. For the time being, these are best referred to the genus *Mosasaurus*, and seem close (?ancestral) to *M. hoffmanni* (compare also Machalski et al., 2003). From the *sumensis* Zone at Altembroeck (Voer, NE Belgium), there is a fragmentary dentary, which may prove conspecific with one of the species recorded from the Mons Basin (see below); so far, no detailed description of this jaw has appeared (compare Jagt et al., 1995b).

In the extended type area of the Maastrichtian Stage, coleoids again constitute the best correlation tools (Keutgen, 1996, 1997; Keutgen & Van der Tuuk, 1991). Ammonites are much rarer, but the taxa that have been recorded do include such that can be used for trans-Atlantic correlation (Table 2). Vijlen Member interval 6 (= Vijlen 6) has yielded (Jagt & Kennedy, 1994; Kennedy & Jagt, 1998; Jagt, 2002):

- *Jeletzkytes dorfi*, occurring in the *Hoploscaphites birkelundae* Zone (upper Pierre Shale and Fox Hills Formation of Colorado and Fox Hills in Wyoming; Landman & Waage, 1993; Landman & Cobban, 2003);
- *Trachybaculites columna*, known from the Prairie Bluff Chalk of Alabama and Mississippi, the Fox Hills Formation of South Dakota and ?Colorado, the Corsicana Formation of Texas as well as the Garzas Formation in California. All other Western Interior records are from the zones of *Hoploscaphites nicolletii* and *Jeletzkytes nebrascensis* in the Fox Hills Formation (Kennedy & Cobban, 1993a; Cobban & Kennedy, 1995; Klinger & Kennedy, 2001; Landman & Cobban, 2003);
- *Pachydiscus (P.) neubergicus*, recorded from the Western Interior and Atlantic Coastal Plain (Navesink Formation, New Jersey), as well as from northern Germany, southern Limburg and Liège, Denmark, southern Belgium, Landes (France), northeast and ?southeast Spain, Austria, the ?Czech Republic, central Poland, Bulgaria, Ukraine, European Russia, Balochistan, South India, Nigeria, Zululand, Madagascar, United Arab Emirates/Oman border region and ?Sakhalin (Kennedy & Summesberger, 1986; Kennedy & Henderson, 1992a; Kennedy et al., 1995, 2000b; Jagt, 2002; Jagt & Felder, 2003; Niebuhr, 2003; Wagreich et al., 2003); and



Mons Basin	Maastricht-Aachen-Liège		Lägerdorf-Kronsmoor-Hemmoor	
	Vijlen Member	Interval 6	*tegulatus/junior* Zone (pars)	MAASTRICHTIAN
			fastigata Zone	
		Interval 5	*cimbrica* Zone	
		Intervals 2-4	upper *sumensis* Zone	
			middle *sumensis* Zone	
		Interval 1	lower *sumensis* Zone	
Ciply-Malogne Fm.		Interval 0	*obtusa* Zone	
	Beutenaken II Member		*pseudobtusa* Zone	
			lanceolata Zone	
Spiennes Fm.			*grimmensis/granulosus* Zone	CAMPANIAN
	Beutenaken I Member		*langei* Zone	
			polyplocum Zone	

Table 4. Correlation between the Spiennes and Ciply-Malogne formations in the Mons Basin (southern Belgium), the Beutenaken and Vijlen members (Gulpen Formation) in the extended type area of the Maastrichtian Stage (SE Netherlands-NE Belgium; Aachen area, Germany), and the combined Lägerdorf-Kronsmoor-Hemmoor sections (northern Germany) (after Keutgen & Jagt, in prep.).

- *Hauericeras* cf. *rembda*, also documented from the Bay of Biscay sections, South India, Madagascar, Zululand, NE Mexico and the Prairie Bluff Chalk of Alabama (Kennedy & Henderson, 1992a; Ward & Kennedy, 1993; Cobban & Kennedy, 1995; Ifrim et al., 2004).

Other ammonites from the Vijlen Member, and intervals 1, 2 and 6 in particular, are either cosmopolitan or strictly European in distribution, and include:

- *Pachydiscus (P.)* aff. *armenicus* (Bay of Biscay sections, Tercis (Landes), Pyrénées Atlantiques and Armenia; Kennedy & Hancock, 1993; Ward & Kennedy, 1993; Courville & Odin, 2001);
- *Diplomoceras cylindraceum* (occurring worldwide; Klinger & Kennedy, 2003a, b);
- *Hoploscaphites constrictus* (ranging from the base to the very top of the Maastrichtian; see e.g., Machalski, 1996; Niebuhr, 2003);
- *Hoploscaphites tenuistriatus* (narrow range in northern and eastern Europe);
- *Acanthoscaphites (A.) tridens* (*lanceolata* and *sumensis* zones in northern Germany, Poland, Ukraine, NE Belgium and unspecified Maastrichtian of Kangerlussuaq (East Greenland); Kennedy & Summesberger, 1987; Jagt et al., 1999; Niebuhr, 2003; Kelly et al., 2004);
- *Acanthoscaphites (Euroscaphites) varians blaszkiewiczi* (confined to Vijlen 5 and 6 in the Maastrichtian type area, and ranging from the *cimbrica* Zone to low in the *junior* Zone in Denmark; Jagt et al., 1999); and
- *Baculites knorrianus* (northern Germany, Denmark, Poland, Czech Republic, Ukraine and NE Belgium (Birkelund, 1993; Kennedy & Summesberger, 1987; Kennedy & Christensen, 1997).

In recent years, inoceramid bivalves have been shown to constitute valuable tools in European trans-Atlantic correlations (Walaszczyk, 2004; Walaszczyk et al., 1996, 2001, 2002a, b). From all intervals of the Vijlen Member, but the *sumensis* and lower *tegulatus/junior* zones (= Vijlen 1 - 4, 6) in particular, inoceramids have been collected. These are currently being studied (Walaszczyk & Jagt, in prep.).

The Lixhe 1 - 3 members have so far only yielded coleoids (*Belemnitella junior* group), of early late Maastrichtian age. The overlying Lanaye Member is also very poor in ammonites, with the exception of phosphatised baculitids, apparently of European stock and thus not suitable for correlation with the North American biozones. However, as far as mosasaurs are concerned, this unit documents an important shift in faunal distribution (Fig. 1), closely linked to a change from an open oceanic to a marginal marine setting. This member has yielded at least five species (*Mosasaurus hoffmanni*, *M. lemonnieri*, *Plioplatecarpus marshi*, *Prognathodon saturator* and *Liodon* '*sectorius*'; see Dortangs et al., 2002; Jagt et al., 2002). The holotype of *P. saturator* (NHMM 1998141) is the sole specimen referable to this taxon, at least for the time being. It may turn out that some isolated tooth crowns referred to other species (NHMM and private collections) actually belong to this species.

The holotype of *P. marshi* is IRScNB R38 (Dollo, 1882) from the 'craie grisâtre à silex gris', near Zichen (NE Belgium), close to Eben Emael, which in all probability would correspond to the Emael Member. Recent fieldwork in the Eben Emael area has shown that the first appearance datum (FAD) of this species is within the Lanaye Member (Gulpen Formation), and that the Emael Member (Maastricht Formation) yields the best-preserved material, inclusive of partially articulate skull and post-cranial material, confirming earlier records (Lingham-Soliar, 1994). It should be noted that it is possible that

Plioplatecarpus depressus from the 'Maastrichtian greensands of New Jersey', the type of which is lost (Russell, 1967; Gallagher, 1993) is conspecific with *P. marshi*. Confirmation or rejection of this observation must await the discovery of additional material from New Jersey; of *P. marshi* the remains of at least ten individuals are now known, allowing proper documentation of range of skeletal variation.

D – Maastricht Formation

This unit, of late Maastrichtian age (zones of *Belemnitella junior* and *Belemnella* (*Neobelemnella*) *kazimiroviensis*), has produced the best-preserved mosasaur material, especially from the Eben Emael area (Bassenge, Liège, NE Belgium), and from the Emael and Nekum members in particular. At least five species of mosasaur are now known from the Maastricht Formation, although, as a consequence of limited material available, a few of these remain poorly known. In addition, relationships between taxa referred to in previous literature as *M. hoffmanni*, *M. lemonnieri* and *L. 'sectorius'* (sensu Lingham-Soliar, 1993) have yet to be determined. Recent finds of partial skulls preserving dentary, maxillary and pterygoid teeth are currently being assessed; these should provide definitive clues for identification of isolated tooth crowns.

Although *Mosasaurus hoffmanni* (holotype: MNHN AC 9648; see Lingham-Soliar, 1995) first occurs in the Lanaye Member (Gulpen Formation), and possibly even lower in the section (see above), the best material has been collected from the Emael and Nekum members near Eben Emael, Maastricht (Sint Pietersberg) and Bemelen, from which at least ten fragmentary, yet articulated, individuals have been collected in the past three decades.

To *Mosasaurus lemonnieri* have been assigned isolated tooth crowns and a single partial dentary (Kuypers et al., 1998). It is still not clear whether these remains are truly conspecific with material from the lower Maastrichtian (*obtusa* Zone; see below) of the Mons Basin or not. In addition, in view of their rarity in comparison to tooth crowns of *M. hoffmanni*, it may be that these remains represent stray animals and/or floating carcasses. Even more tantalising is the recent suggestion by Mulder et al. (2004) that *M. lemonnieri* may in fact be nothing more than the juvenile of *M. hoffmanni* (see below).

Of *Liodon 'sectorius'*, collections available comprise isolated tooth crowns and fragmentary dentaries of at least two individuals (Jagt et al., 2002). The type material (Russell, 1967) is probably from the Navesink Formation of New Jersey, but Gallagher (1993) noted that other material may stem from the Hornerstown Formation, of late Maastrichtian to early Paleocene age. Since not much remains of the type material, this taxon cannot be properly evaluated. Furthermore, there seem to be differences in dental morphology between the two dentaries referred to this taxon.

A previous record (Lingham-Soliar, 1996) of halisaurine mosasaurs from the Maastrichtian type area has now been shown to be based exclusively on *Plioplatecarpus marshi* (Mulder, 2003b), a common species in the area (see previous).

Carinodens fraasi (holotype: IRScNB R43), based on a jaw of unknown stratigraphic provenance (Dollo, 1913), has been formally synonymised with *Carinodens belgicus* by Schulp et al. (2004), a species first described from the Mons Basin (see following), and ranges throughout the Maastricht Formation (Fig. 1). Not much is known of this species, with the exception of isolated tooth crowns and two dentaries, one of them heavily broken and abraded.

Mosasaur populations appear to have been well established at the time of deposition of the lower/middle Maastricht Formation, suggesting relatively little (if any) exchange with populations elsewhere, and with a decline towards the K/T boundary. The highest unit of the Maastricht Formation, the Meerssen Member, yields comparatively little mosasaur material, isolated pterygoid teeth of *P. marshi* being amongst the highest finds known to date. This may be related to the extremely shallow nature of the Meerssen depositional setting, with numerous hardgrounds and omission surfaces (?subaerial exposure). Albeit, this proves that mosasaurs did extend up to within less than a metre from the K/T boundary, at least in the study area, contrary to claims made by Sullivan (1987, table 1) that mosasaurs became extinct in the earliest Maastrichtian (around 74.5 Ma). For additional records of mosasaurs from very close to the K/T boundary, both in Alabama (Gulf Coast) and in Denmark, reference is made to Kiernan (2002) and Lindgren & Jagt (2005), respectively.

As far as ammonite distribution within the Maastricht Formation is concerned, it should be noted that assemblages from the 'tuffaceous chalk facies' in the Maastricht-Geulhem area on the one hand and those from the 'Kunrade limestone facies' in the Kunrade-Benzenrade area (southern Limburg, the Netherlands) on the other, have certain elements in common, but are otherwise quite different (Kennedy, 1987; Jagt, 2002). Species useful in trans-Atlantic correlations include:

- *Eubaculites carinatus*, known from the Prairie Bluff Formation in Mississippi and Alabama, the Owl Creek Formation of Missouri, Mississippi and Tennessee, the Corsicana Formation of NE Texas, and remanié in the Hornerstown Sand of New Jersey, plus Bay of Biscay sections, southwest France, northwest Spain, Austria, Mozambique, Zululand, South India, Western Australia, Argentina, Chile and California (Kennedy et al., 1986; Henderson et al., 1992; Klinger & Kennedy, 1993; Ward & Kennedy, 1993; Cobban & Kennedy, 1995; Kennedy & Cobban, 1996, 2000);
- *Baculites vertebralis*, which is common in the Emael, Nekum and Meerssen members, and occurs widely in Manche, Petites Pyrénées (France), Denmark, northern Germany, Poland, southern Russia and ?Tunisia. It has recently been recorded

from the Severn Formation of Maryland (Kennedy et al., 1997b);
- *Glyptoxoceras rugatum*, recorded from the Severn Formation of Maryland and the Corsicana Formation of Texas (Kennedy et al., 1997b, 2001), South India, Brazil, ?Chile, Western Australia, northern Spain and Pyrénées-Atlantiques, France (Kennedy & Hancock, 1993). In the study area, the first representatives of this species are known from Vijlen Member, interval 6;
- *Sphenodiscus binckhorsti*, which is closely related to, if not conspecific with *S. lobatus*. The latter has been documented from the Severn Formation of Maryland, the Escondido Formation of Trans-Pecos Texas and northern Mexico, the Corsicana Formation of northeast Texas, the upper Ripley Formation of Mississippi, the Prairie Bluff Formation of Alabama and Mississippi, the Providence Sand in Georgia, the upper Peedee Formation in North Carolina, the Red Bank and Tinton sands in New Jersey, as well as the *Hoploscaphites nicolletii* and *Jeletzkytes nebrascensis* zones (perhaps underlying *H. birkelundae* Zone as well) in the Western Interior, plus Israel and Nigeria (Cobban & Kennedy, 1995; Kennedy et al., 1997b);
- *Pachydiscus (P.) gollevillensis*, well known from Manche (France), Lleida (Spain), Bay of Biscay sections, Poland, northern Germany, Austria, Armenia, northern Caucasus, Bulgaria, the Bithynian Peninsula (Turkey) and Madagascar (Kennedy, 1986a; Ward & Kennedy, 1993). There is a recent record from the Prairie Bluff Chalk of Mississippi (Cobban & Kennedy, 1995);
- *Pachydiscus (P.) j. jacquoti*, recorded from Manche, Pyrénées Atlantiques (France), Bay of Biscay sections, Armenia, Madagascar, central Poland (Machalski, in prep.), ?British Columbia and ?South India, and also known from the Prairie Bluff Chalk of Mississippi and the Corsicana Formation of Texas (Kennedy, 1986a; Kennedy & Hancock, 1993; Ward & Kennedy, 1993; Cobban & Kennedy, 1995; Kennedy et al., 2001);
- *Nostoceras* sp. (spp.); the single specimen of a nostoceratid known from the Maastrichtian type area is from the basal Meerssen Member at Berg en Terblijt (former Blom quarry; see Van der Tuuk & Zijlstra, 1979) – it shows affinities with *N. colubriformis* from the Saratoga Chalk (upper upper Campanian) of Arkansas (Kennedy & Cobban, 1993c) and the Nacatoch Sand in Texas, as well as with *'Turrilites' saundersorum* from the basal Paleocene of Texas, presumed to be derived from the underlying Kemp Clay of mid-Maastrichtian age (Kennedy, 1987);
- The scaphitid genus *Jeletzkytes* – Maastrichtian strata in North America have yielded *J. criptonodosus* from the *Baculites baculus* Zone (Canadian Western Interior), the *B. grandis* Zone of Colorado, Wyoming, Montana and South Dakota, as well as the middle Navesink Formation of New Jersey (Kennedy et al., 2000b), the Prairie Bluff Chalk in Alabama (Cobban & Kennedy, 1995) and the Ripley Formation of Mississippi. Occurring, above the *Baculites clinolobatus* Zone, in the Fox Hills Formation in North and South Dakota and Nebraska, as well as in the Severn Formation of Maryland is *J. nebrascensis* (Kennedy et al. 1997b). It appears that *Hoploscaphites pungens* from the Gronsveld, Emael, Nekum and basal Meerssen members in the Maastrichtian type area represents the NW European counterpart of this lineage. Ornament of phragmocones and body chambers of macroconchs of this species indicate close affinities, and suggests that it is best referred to *Jeletzkytes* (Jagt, Kennedy & Yazykova, in prep.);
- *Brahmaites brahma*; of note is the record of *Brahmaites* sp. from the *Nostoceras alternatum* Zone (Maastrichtian) of SW Arkansas by Cobban & Kennedy (1991b), associated with *Baculites claviformis* which ranges from the uppermost Campanian (Coon Creek Tongue, base of Ripley Formation, with *Nostoceras hyatti*) into the Owl Creek Formation, co-occurring with *Eubaculites carinatus*. In Europe, *B. brahma* has been recorded from the Bay of Biscay sections and Dordogne (France), plus material from the Meerssen Member of the Maastrichtian type area (Jagt, Kennedy & Yazykova, in prep.). Elsewhere, it occurs in the upper Maastrichtian of South India and Tunisia (Kennedy & Henderson, 1992a; Goolaerts et al., 2004), and similar forms are known from Madagascar.

Other ammonite taxa from the Maastricht Formation either show a mainly European distribution or are known from across the globe, with the exception of North America. These include:
- *'Menuites' fresvillensis* (Manche, Pyrénées Atlantiques, Petites Pyrénées (France), Denmark, Yugoslavia, Armenia, South India, Madagascar, Western Australia, Chile, ?Brazil, South Africa (Kwa Zulu); Kennedy, 1986a; Kennedy et al., 1986; Klinger et al., 2001);
- *'Menuites' terminus* (Bay of Biscay sections, central Poland, Bulgaria, Denmark and Crimea; Ward & Kennedy, 1993; Machalski & Jagt, 1998; Yazykova, Jagt & Naidin, in prep.);
- *Diplomoceras cylindraceum* (see previous);
- *Baculites anceps* (Manche, Russia, ?Spain, Bay of Biscay sections; Kennedy, 1986a; Ward & Kennedy, 1993);
- *Acanthoscaphites (?Euroscaphites) verneuilianus* (Manche; Kennedy, 1986a);
- *Hoploscaphites constrictus* (Manche, Petites Pyrénées, southern Belgium, northern Germany, Denmark, northern Spain, Bay of Biscay sections, southern Sweden, Poland, Austria, Bulgaria, Carpathians, Donbass, Crimea, Transcaspia and Kopet Dagh (Kennedy, 1986a; Ward & Kennedy, 1993; Machalski, 1996));
- *Phylloptychoceras* sp., of which two specimens have been collected from the Meerssen Member at Maastricht and Geulhem (Jagt, Cremers, Goolaerts & Verhesen, in prep.); *P. sipho* has been recorded from the Upper Maastrichtian of

the Bay of Biscay sections, ?California and South India, and perhaps also from Denmark (Kennedy & Henderson, 1992b; Birkelund, 1993; Ward & Kennedy, 1993);

- *Pachydiscus (P.) noetlingi*, which to date has been recorded from the Kunrade Limestone facies and the lower Nekum Member in the Maastrichtian type area and the Upper Maastrichtian Korara Shale of Balochistan, Pakistan (Jagt & Kennedy, 2003);
- *Hoploscaphites* gr. *waagei/angmartussutensis*, known from a single specimen of the upper Meerssen Member at Geulhem (Kennedy & Jagt, 1998); this species is best known from Greenland (Birkelund, 1965; see also Kennedy et al., 1999; Kelly et al., 2004).

2 – Ciply area, Mons Basin (southern Belgium) (Fig. 2)

For a general overview of strata exposed in the Ciply area, reference is made to Robaszynski & Martin (1988), Robaszynski & Christensen (1989), Robaszynski et al. (1988) and Dupuis & Vandycke (1990). Only two units, currently referred to as the Obourg Chalk Formation and the Ciply-Malogne Phosphatic Chalk Formation (Robaszynski et al., 2002) appear to have produced mosasaur material.

The 'Craie (brune) phosphatée de Ciply', of Early Maastrichtian age (*obtusa* Zone), as based on coleoid faunas (Christensen, 1999), has yielded numerous articulated mosasaurs, since this unit was intensively quarried mostly in subterranean galleries (La Malogne), for the production of agricultural fertilisers during the second half of nineteenth century. Close co-operation between the engineers A. Lemonnier and L. Bernard and L. Dollo (Muséum d'Histoire naturelle de Belgique, Brussels) in the period between 1880 and 1895 resulted in the recovery of fifty-two relatively complete skeletons from these works. As Lingham-Soliar & Nolf (1990) noted, the bulk of these collections is referable to *Mosasaurus lemonnieri*. Interesting is their observation that there are virtually no shark teeth associated with these mosasaur finds; large-scale scavenging can thus be ruled out, which may also explain the comparatively large number of (semi-)articulated skeletons.

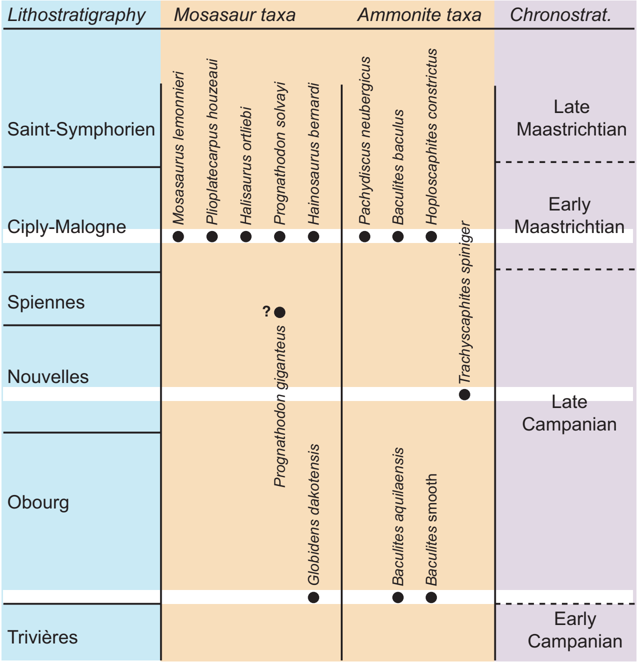


Fig. 2. Lithostratigraphy of Campanian-Maastrichtian strata in the Mons Basin (southern Belgium; modified from Dupuis & Vandycke, 1990; Robaszynski et al., 2002) and stratigraphic ranges of mosasaur taxa described from the area. Added are records of selected ammonoid taxa (after Kennedy, 1993; pers. obs.), and white are portions of the sequence which correlate well with North America using particular ammonite taxa.

From an unspecified level within the Obourg Chalk Formation near Mons comes an isolated tooth crown (IRScNB R41), assigned to *Globidens alabamaensis* by Dollo (1924; see also Lingham-Soliar, 1999, pl. 5, fig. 7a-c), which Russell (1975) thought would better be placed in *G. dakotensis*. *Globidens alabamaensis* is well known from the Selma Chalk of Alabama and Mississippi, while *G. dakotensis* occurs in the Wolfe City or Lower Marl members (Taylor Formation) in Texas, the ?Marlbrook Marl in Arkansas and the lower Pierre Shale of South Dakota. Kiernan (2002, fig. 2) showed *G. alabamaensis* to occur in the upper Mooreville Chalk and Arcola Limestone.

The base of the Obourg Chalk Formation has remanié components, such as *Baculites aquilaensis*, which in the Western Interior occurs in the upper lower Campanian (Table 2), associated with *Scaphites hippocrepis* III. The overlying Nouvelles Chalk Formation has yielded *Trachyscaphites* cf. *spiniger*, while *Scaphites gibbus* ranges through the Trivières and Obourg formations (Fig. 2), confirming records from northern Germany. This unit correlates well with the Zeven Wegen Member in the Haccourt area, as based on coleoid cephalopod (Christensen, 1999) and brachiopod evidence (Simon, 2000; Simon & Owen, 2001).

As far as the 'Craie phosphatée' is concerned, the following can be stated. In the literature, seven mosasaur species have been described from this unit, as follows:

- *Hainosaurus bernardi* (holotype: IRScNB R23; see Dollo, 1885a, b, 1889c, 1904), type species of the genus, collected from a former complex of abandoned and partly filled-in quarries near Mesvin (Ciply) (see Lingham-Soliar, 1992);
- *Bottosaurus belgicus* (holotype: BMNH R.1802; see Woodward, 1891), originally considered to be crocodilian in nature, but later recognised as mosasaur (Dollo, 1924). The exact provenance of the type specimen is unclear; Woodward (1891, p. 114) noted that, 'Among the vertebrate remains discovered by M. Houzeau de Lehaie in the 'Craie brune phosphatée' of Ciply, (....)'. In the caption to pl. 3, fig. 18, he stated, 'Lower Danian (Craie brune), Ciply'. Here, there seems to be confusion between the 'Craie phosphatée' (= Ciply-Malogne Phosphatic Chalk Formation in current terminology;

Robaszynski et al., 2002) of early Maastrichtian age (*obtusa* Zone), and the Ciply Formation of middle and late Danian age (Laga et al., 2002). If the type was collected from the uppermost portion of the 'Craie phosphatée', i.e. directly below the 'Poudingue de Malogne' hardground, matters are even more complicated (see below). For the time being, it is assumed that the type of *B. belgicus* stems from the 'Craie phosphatée' proper and is thus of early Maastrichtian age, and older than occurrences in the Liège-Limburg Basin, until new stratigraphically well localised material from the Mons Basin becomes available;

- *Plioplatecarpus houzeaui* (holotype: IRScNB R35 (ex 3111); see Dollo, 1889c; Lingham-Soliar, 1994), which is closely related to *P. marshi* from the upper Gulpen Formation and Maastricht Formation (see above). Newly collected material from the Eben Emael area suggests that distinctions between these taxa may not be as clear cut as indicated by Lingham-Soliar (1994);
- *Prognathodon solvayi* (holotype: IRScNB R33 (ex 4672); see Dollo, 1889a - c), from Mesvin (Solvay quarry; acquired 1889). Other material in the IRScNB collections is both from the same quarry and from the Houzeau quarry (Spiennes, acquired 1894);
- *Prognathodon giganteus* (holotype: IRScNB R106 (ex 3103), from the Solvay quarry, Spiennes; see Dollo, 1904; Lingham-Soliar & Nolf, 1990). Dollo (1904, p. 213) merely indicated that his new species (no diagnosis was given) came from Spiennes. Thus, it is not clear whether it was collected from the 'Craie phosphatée' or from the underlying 'Craie de Spiennes' (Spiennes Chalk Formation in current terms), of late Campanian age. It seems this possibility has not yet been considered (Fig. 2); if so, it may link the type to a recent record of *P. giganteus* from the upper Campanian of Champagne (France) by Bardet et al. (1997);
- *Halisaurus ortliebi* (holotype: IRScNB R34; see Dollo, 1889c; Lingham-Soliar, 1996), from near Mesvin; and
- *Mosasaurus lemonnieri* (holotype: IRScNB R28 (ex 1470); see Dollo, 1889c, 1892; Lingham-Soliar, 2000), from Mesvin. Mulder et al. (2004) have recently suggested that this 'species' might in fact be nothing more than the juveniles of *M. hoffmanni*. In addition, Caldwell et al. (2004) observed that one of the specimens referred to *M. lemonnieri* (IRScNB 3211) showed close similarities to members of the New Zealand genus *Moanasaurus*. These data clearly demonstrate that the status of *M. lemonnieri* and its relationship to other mosasaurines is far from clear and in need of further studies.

As far as ammonite faunas from this unit are concerned, it is interesting to note their 'mixed' character (Kennedy, 1993). Mostly preserved as phosphatic internal moulds, in old collections material is merely labelled 'Poudingue de la Malogne' (= top of 'Craie phosphatée') and comprises both late Campanian species such as *Nostoceras* cf. *hyatti* and *Solenoceras* sp., and early Maastrichtian ones (*Hauericeras* cf. *sulcatum*). The genus *Solenoceras* is an important element since it is restricted to the 'middle' and upper Campanian of the Western Interior, occurring in the zones of *Baculites gregoryensis* and *B. scotti* (North and South Dakota), *Didymoceras stevensoni* (Colorado, Wyoming, Montana), *Didymoceras nebrascense* (Montana, South Dakota, Colorado), *Exiteloceras jenneyi* (Montana, South Dakota, Colorado), *B. compressus* (Colorado), as well as *Baculites cuneatus* and *B. reesidei* (Colorado, Wyoming, Montana). *Solenoceras* has also been recorded from Arkansas, Texas, Tennessee, Delaware, Mississippi, Georgia, California, ?Spain, Italy, northern Germany (Jagt & Neumann, in prep.), Angola, ?Nigeria, ?Israel, ?Egypt and Japan (Cobban & Kennedy, 1991a, 1994a; Cobban et al., 1992; Kennedy & Cobban, 1993c, 1994b, 1997; Kennedy et al., 2000a, c). However, Ifrim et al. (2004) have recently described species of *Solenoceras* from the Maastrichtian of Mexico.

The 'Craie phosphatée' proper yielded *Pachydiscus* cf. *neubergicus*, *Diplomoceras cylindraceum*, *Baculites knorrianus*, *B. baculus* and *Hoploscaphites constrictus*. Of these, *B. baculus* is of particular importance in allowing direct correlation with the *Baculites baculus* Zone of the Western Interior (Kennedy, 1993) (see Tables 1, 2).

On the basis of brachiopod assemblages, Simon (1998) was able to provide the most detailed picture of the stratigraphy of the 'Craie phosphatée' yet. The bulk of the unit is correlatable with the *acutirostris-spinosa* Zone (see Table 5), while sediment fill of basal cavities within the 'Poudingue de Malogne' hardground has yielded taxa typical of the younger *subtilis-pulchellus* Zone, and those that occur at a higher level within that same hardground are markers of the late Maastrichtian *stevensis-chitoniformis* Zone. Material contained in old collections thus needs to be interpreted with great caution.

Table 5. Micromorphic brachiopod zonation of the Upper Campanian-Maastrichtian of NW Europe (after Surlyk, 1984; Johansen & Surlyk, 1990). On brachiopod evidence, Simon (1998) favoured the following age assignments; 1 - 'Craie phosphatée de Ciply' proper; 2 – sediment fill from basal cavities of overlying 'Poudingue de Malogne' hardground; 3 – sediment fill of cavities higher up-section within that hardground.

Upper Maastrichtian	***stevensis-chitoniformis* Zone**[3]
	humboldtii-stevensis Zone
	semiglobularis-humboldtii Zone
	tenuicostata-semiglobularis Zone
	pulchellus-tenuicostata Zone
	pulchellus-pulchellus Zone
Lower Maastrichtian	***subtilis-pulchellus*** Zone[2]
	spinosa-subtilis Zone
	***acutirostris-spinosa* Zone**[1]
	jasmundi-acutirostris Zone
Upper Campanian (*pars*)	*longicollis-jasmundi* Zone
	tenuicostata-longicollis Zone

Conclusions

Newly collected mosasaur material from the Maastrichtian type area has the advantage that it is stratigraphically well documented, and thus can be used to refine ranges of taxa and consider taxonomic issues in much more depth. Unfortunately, new mosasaur discoveries from the Ciply-Mesvin area cannot be expected, since quarrying activities have come to a halt. The crude cephalopod-based correlation between the Liège-Limburg and Mons basins on the one hand, and North America on the other, compiled primarily from literature data, needs to be refined as well. Perhaps the renewed interest in belemnitellids from the Atlantic Seaboard may yield additional data to tie these in with the highly detailed zonation applied to NW European sections. There appears to be consensus over environmental perturbations, whatever triggered them, across the lower/upper Campanian boundary, both in North America and Europe, seen in turnover in both mosasaur and ammonoid faunas. Campanian-Maastrichtian ammonites from the Western Interior, often held to be highly endemic, have been yielding elements that occur on both sides of the Atlantic at some levels within these stages.

It is not surprising to see that fully nektonic animals, such as mosasaurs, could cross the Late Cretaceous Atlantic Ocean with ease, and that many taxa are in fact conspecific. Detailed biozonations and age assignments are needed for type and additional referred material to allow migratory patterns to be reconstructed more faithfully. The present paper can be no more than a first step in that direction.

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References

Bardet, N., 1990. Première mention du genre *Hainosaurus* (Squamata, Mosasauridae) en France. Compte Rendu de l'Académie des Sciences (Paris) (2)311: 751-756.

Bardet, N., Barbin, V., Laurain, M. & Janin, M.-C., 1997. Première découverte du mosasaure *Prognathodon giganteus* (Squamata) dans le Campanien (Crétacé supérieur) du Champagne, France. Revue de Paléobiologie 16: 225-230.

Bardet, N. & Pereda Suberbiola, X., 1996. Las faunas de reptiles marinos del Cretácico final de Europa (margen norte del Tetis mediterráneo). Revista española de Paleontología 11: 91-99.

Birkelund, T., 1965. Ammonites from the Upper Cretaceous of West Greenland. Meddelelser om Grønland 179: 1-192.

Birkelund, T., 1993. Ammonites from the Maastrichtian White Chalk of Denmark. Bulletin of the Geological Society of Denmark 40: 33-81.

Błaszkiewicz, A., 1980. Campanian and Maastrichtian ammonites of the Middle Vistula River Valley, Poland: a stratigraphic-paleontological study. Prace Instytutu Geologicznego 92: 1-63.

Caldwell, M.W., Bell, G.L. Jr. & Holmes, R., 2004. Kiwis and trappists: a New Zealand mosasaur in Belgium and France. *In:* Schulp, A.S. & Jagt, J.W.M. (eds): First Mosasaur Meeting, Maastricht, 8-12 May 2004, Abstract book and Field guide. Maastricht (Natuurhistorisch Museum Maastricht): 27.

Christensen, W.K., 1975. Upper Cretaceous belemnites from the Kristianstad area in Scania. Fossils and Strata 7: 1-69.

Christensen, W.K., 1986. Upper Cretaceous belemnites from the Vomb Trough in Scania, Sweden. Sveriges geologiska Undersökning Ca57: 1-57.

Christensen, W.K., 1990. Upper Cretaceous belemnite stratigraphy of Europe. Cretaceous Research 11: 371-386.

Christensen, W.K., 1991. Belemnites from the Coniacian to Lower Campanian chalks of Norfolk and southern England. Palaeontology 34: 695-749.

Christensen, W.K., 1993. Upper Cretaceous belemnitellids from the Båstad Basin, southern Sweden. Geologiska Förenings i Stockholm Förhandlingar 115: 39-57.

Christensen, W.K., 1994. Upper Cretaceous belemnites from Lonzée (SE Belgium) and their stratigraphical significance. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre 64: 151-158.

Christensen, W.K., 1995. *Belemnitella* from the Upper Campanian and Lower Maastrichtian Chalk of Norfolk, England. Special Papers in Palaeontology 51: 1-84.

Christensen, W.K., 1996. A review of the Upper Campanian and Maastrichtian belemnite biostratigraphy of Europe. Cretaceous Research 17: 751-766.

Christensen, W.K., 1997a. The Late Cretaceous belemnite family Belemnitellidae: Taxonomy and evolutionary history. Bulletin of the Geological Society of Denmark 44: 59-88.

Christensen, W.K., 1997b. Palaeobiogeography and migration in the Late Cretaceous belemnite family Belemnitellidae. Acta palaeontologica polonica 42: 457-495.

Christensen, W.K., 1998. *Belemnitella* from the lowermost Maastrichtian of Scania, southern Sweden. Bulletin of the Geological Society of Denmark 45: 11-21.

Christensen, W.K., 1999. Upper Campanian and Lower Maastrichtian belemnites from the Mons Basin, Belgium. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre 69: 97-131.

Christensen, W.K., 2000a. *Belemnitella schulzi* sp. nov. from the uppermost Campanian and lowest Maastrichtian chalks of northwest Germany and Denmark. Acta geologica polonica 50: 55-66.

Christensen, W.K., 2000b. Gradualistic evolution in *Belemnitella* from the middle Campanian of Lower Saxony, NW Germany. Bulletin of the Geological Society of Denmark 47: 135-163.

Christensen, W.K., Ernst, G., Schmid, F., Schulz, M.-G. & Wood, C.J., 1975. *Belemnitella mucronata mucronata* (Schlottheim, 1813) from the Upper Campanian: Neotype, biometry, comparison and biostratigraphy. Geologisches Jahrbuch A28: 27-57.

Christensen, W.K., Hancock, J.M., Peake, N.B. & Kennedy, W.J., 2000. The base of the Maastrichtian. Bulletin of the Geological Society of Denmark 47: 81-85.

Christensen, W.K. & Schmid, F., 1987. The Belemnites of the Vaals Formation from the C.P.L. Quarry at Hallembaye in Belgium – Taxonomy, biometry and biostratigraphy. Geologisches Jahrbuch A94: 3-37.

Christensen, W.K. & Schulz, M.-G., 1976. First record of *Belemnellocamax balsvikensis* (Brotzen, 1960) from NW Germany. Neues Jahrbuch für Geologie und Paläontologie, Monatshefte 1976/9: 522-531.

Christopher, R.A. & Prowell, D.C., 2002. A palynological biozonation for the Maastrichtian Stage (Upper Cretaceous) of South Carolina, USA. Cretaceous Research 23: 639-669.

Cobban, W.A., 1962. Baculites (sic) from the lower part of the Pierre Shale and equivalent rocks in the Western Interior. Journal of Paleontology 36: 704-718.

Cobban, W.A., 1963. Occurrence of the late Cretaceous ammonite *Hoplitoplacenticeras* in Wyoming. United States Geological Survey, Professional Paper 475-C: iii + C60-C62.

Cobban, W.A., 1969. The Late Cretaceous Ammonites *Scaphites leei* Reeside and *Scaphites hippocrepis* (DeKay) in the Western Interior of the United States. United States Geological Survey, Professional Paper 619: 1-27.

Cobban, W.A., 1993. Diversity and distribution of Late Cretaceous ammonites, Western Interior, United States. *In:* Caldwell, W.G.E. & Kauffman, E.G. (eds): Evolution of the Western Interior Basin. Geological Association of Canada, Special Paper 39: 435-451.

Cobban, W.A. & Kennedy, W.J., 1991a. Some Upper Cretaceous ammonites from the Nacatoch Sand of Hempstead County, Arkansas. United States Geological Survey Bulletin 1985: iii + C1-C5.

Cobban, W.A. & Kennedy, W.J., 1991b. Upper Cretaceous (Maastrichtian) ammonites from the *Nostoceras alternatum* Zone in southwestern Arkansas. United States Geological Survey Bulletin 1985: iii + E1-E6.

Cobban, W.A. & Kennedy, W.J., 1992a. Campanian *Trachyscaphites spiniger* ammonite fauna in north-east Texas. Palaeontology 35: 63-93.

Cobban, W.A. & Kennedy, W.J., 1992b. Campanian ammonites from the Upper Cretaceous Gober Chalk of Lamar County, Texas. Journal of Paleontology 66: 440-454.

Cobban, W.A. & Kennedy, W.J., 1993. Middle Campanian ammonites and inoceramids from the Wolfe City Sand in northeastern Texas. Journal of Paleontology 67: 71-82.

Cobban, W.A. & Kennedy, W.J., 1994a. Upper Cretaceous ammonites from the Coon Creek Tongue of the Ripley Formation at its type locality in McNairy County, Tennessee. Bulletin of the United States Geological Survey 2073-B: B1-B12.

Cobban, W.A. & Kennedy, W.J., 1994b. Middle Campanian (Upper Cretaceous) ammonites from the Pecan Gap Chalk of central and northeastern Texas. Bulletin of the United States Geological Survey 2073-D: D1-D9.

Cobban, W.A. & Kennedy, W.J., 1995. Maastrichtian ammonites chiefly from the Prairie Bluff Chalk in Alabama and Mississippi. The Paleontological Society Memoir 44: ii + 40 pp.

Cobban, W.A., Kennedy, W.J. & Scott, G.R., 1992. Upper Cretaceous heteromorph ammonites from the *Baculites compressus* Zone of the Pierre Shale in north-central Colorado. United States Geological Survey Bulletin 2024: iii + A1-A11.

Courville, P. & Odin, G.S., 2001. Les ammonites spiralées du Campanien et du Maastrichtien de Tercis les Bains (Landes, France). *In:* Odin, G.S. (ed.): The Campanian-Maastrichtian stage boundary. Characterisation at Tercis les Bains (France) and correlation with Europe and other continents. Amsterdam (Elsevier): 529-549.

Dollo, L., 1882. Note sur l'ostéologie des *Mosasauridæ* (sic). Bulletin du Musée d'Histoire naturelle de Belgique 1: 55-80.

Dollo, L., 1885a. Le Hainosaure. Revue des Questions scientifiques (1)18 : 285-289.

Dollo, L., 1885b. Première note sur le Hainosaure, mosasaurien nouveau de la Craie brune phosphatée de Mesvin-Ciply, près Mons. Bulletin du Musée d'Histoire naturelle de Belgique 4: 25-35 (1-11).

Dollo, L., 1889a. Note sur les vertébrés récemment offerts au Musée de Bruxelles par M. Alfred Lemonnier. Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie 3: 181-182.

Dollo, L., 1889b. Nouvelle note sur les vertébrés fossiles récemment offerts aux Musée de Bruxelles par M. Alfred Lemonnier. Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie 3: 214-215.

Dollo, L., 1889c. Première note sur les Mosasauriens de Mesvin. Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie 3: 271-304.

Dollo, L., 1892. Nouvelle note sur l'ostéologie des Mosasauriens. Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie 6: 219-259.

Dollo, L., 1904. Les Mosasauriens de la Belgique. Bulletin de la Société belge de Géologie, de Paléontologie et d'Hydrologie (2)18: 207-216.

Dollo, L., 1913. *Globidens Fraasi*, Mosasaurien mylodonte nouveau du Maestrichtien (Crétacé supérieur) du Limbourg, et l'Éthologie de la Nutrition chez les Mosasauriens. Archives de Biologie 28: 609-626.

Dollo, L., 1924. *Globidens alabamaensis*, Mosasaurien mylodonte américain retrouvé dans la Craie d'Obourg (Sénonien supérieur) du Hainaut, et les Mosasauriens de la Belgique, en général. Archives de Biologie 34: 167-213.

Dortangs, R.W., Schulp, A.S., Mulder, E.W.A., Jagt, J.W.M., Peeters, H.H.G. & de Graaf, D.T., 2002. A large new mosasaur from the Upper Cretaceous of The Netherlands. Netherlands Journal of Geosciences 81: 1-8.

Dupuis, C. & Vandycke, S., 1990. Tectonique et karstification profonde: un modèle de subsidence original pour le Bassin de Mons. Annales de la Société géologique de Belgique 112 (1989): 479-487.

Felder, W.M. & Bosch, P.W., 2001. Geologie van Nederland, deel 5. Krijt van Zuid-Limburg. TNO-NITG (Delft, Utrecht): 192 pp.

Gale, A.S., 1980. Penecontemporaneous folding, sedimentation and erosion in Campanian Chalk near Portsmouth, England. Sedimentology 27: 137-151.

Gallagher, W.B., 1993. The Cretaceous/Tertiary mass extinction event in the northern Atlantic Coastal Plain. The Mosasaur 5: 75-154.

Goolaerts, S., Kennedy, W.J., Dupuis, C. & Steurbaut, E., 2004. Terminal Maastrichtian ammonites from the Cretaceous-Paleogene Global Stratotype Section and Point, El Kef, Tunisia. Cretaceous Research 25: 313-328.

Hauschke, N., Hiß, M. & Wippich, M.G.E., 1999. Untercampan und tieferes Obercampan im Westteil der Baumberge (Münsterland, Nordwestdeutschland). Scriptum 4: 35-69.

Henderson, R.A., Kennedy, W.J. & McNamara, K.J., 1992. Maastrichtian heteromorph ammonites from the Carnarvon Basin, Western Australia. Alcheringa 16: 133-170.

Ifrim, C., Stinnesbeck, W. & López-Oliva, J.G., 2004. Maastrichtian cephalopods from Cerralvo, north-eastern Mexico. Palaeontology 47: 1575-1627.

Jagt, J.W.M., 2002. Late Cretaceous ammonite faunas of the Maastrichtian type area. *In:* Summesberger, H., Histon, K. & Daurer, A. (eds): Cephalopods – present and past. Abhandlungen der geologischen Bundesanstalt Wien 57: 509-522.

Jagt, J.W.M., Burnett, J. & Kennedy, W.J., 1995a. Campanian ammonites and nannofossils from southern Limburg, the Netherlands. Mededelingen van de Rijks Geologische Dienst 53: 49-63.

Jagt, J.W.M., Deckers, M., Dhondt, A.V., Dortangs, R.W., Felder, P.J., Felder, W.M., Jäger, M., Keutgen, N., Kuypers, M., Michels, G., Reynders, J., Simon, E., van der Ham, R., van Knippenberg, P. & van Neer, R., 1995b. Preliminary report of field work at Altembroeck (NE Belgium; Early Maastrichtian) by the Working Group Beutenaken/Vijlen members. Service géologique de Belgique, Professional Paper 1995/1 (276): 1-20.

Jagt, J.W.M. & Felder, W.M., 2003. The stratigraphic range of the index ammonite *Pachydiscus neubergicus* (von Hauer, 1858) in the type area of the Maastrichtian Stage. Netherlands Journal of Geosciences 82: 261-268.

Jagt, J.W.M. & Kennedy, W.J., 1994. *Jeletzkytes dorfi* Landman & Waage 1993, a North American ammonoid marker from the lower Upper Maastrichtian of Belgium, and the numerical age of the Lower/Upper Maastrichtian boundary. Neues Jahrbuch für Geologie und Paläontologie, Monatshefte 1994/4: 239-245.

Jagt, J.W.M. & Kennedy, W.J., 2003. First record of *Pachydiscus noetlingi* Kennedy, 1999 (Ammonoidea) from the Maastrichtian type area (the Netherlands). Netherlands Journal of Geosciences 82: 303-307.

Jagt, J.W.M., Kennedy, W.J. & Machalski, M., 1999. Giant scaphitid ammonites from the Maastrichtian of Europe. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre 69: 133-154.

Jagt, J.W.M., Lindgren, J., Machalski, M. & Radwański, A., 2005. New records of the tylosaurine mosasaur *Hainosaurus* from the Campanian-Maastrichtian (Late Cretaceous) of central Poland. *In:* Schulp, A.S. & Jagt, J.W.M. (eds): Proceedings of the First Mosasaur Meeting. Netherlands Journal of Geosciences 84: 303-306

Jagt, J.W.M., Mulder, E.W.A., Dortangs, R.W., Kuypers, M.M.M., Peeters, H.H.G. & Verding, L., 2002. Recent additions to the Late Maastrichtian mosasaur faunas of Liège-Limburg (the Netherlands, Belgium). Sargeția 19: 13-26.

Jagt, J.W.M., Walaszczyk, I., Yazykova, E.A. & Zatoń, M., 2004. Linking southern Poland and northern Germany: Campanian cephalopods, inoceramid bivalves and echinoids. *In:* Wood, C.J., Walaszczyk, I., Marcinowski, R. & Tröger, K.-A. (eds): Gundolf Ernst Memorial Volume. Acta geologica polonica 54: 573-586.

Johansen, M.B. & Surlyk, F., 1990. Brachiopods and the stratigraphy of the Upper Campanian and Lower Maastrichtian chalk of Norfolk, England. Palaeontology 33: 823-872.

Kaplan, U., Kennedy, W.J. & Ernst, G., 1996. Stratigraphie und Ammonitenfaunen des Campan im südöstlichen Münsterland. Geologie und Paläontologie in Westfalen 43: 1-133.

Kaplan, U., Kennedy, W.J. & Hiß, M., in press. Stratigraphie und Ammonitenfaunen des Campan im nordwestlichen und zentralen Münsterland. Geologie und Paläontologie in Westfalen 64.

Kelly, S.R.A., Kennedy, W.J. & Whitham, A.G., 2004. Kangerlussuaq and the latest Cretaceous ammonite faunas of East Greenland. The Palaeontogical Association, Newsletter 57: 161.

Kennedy, W.J., 1986a. The ammonite fauna of the Calcaire à *Baculites* (Upper Maastrichtian) of the Cotentin Peninsula (Manche, France). Palaeontology 29: 25-83.

Kennedy, W.J., 1986b. Campanian and Maastrichtian ammonites from northern Aquitaine, France. Special Papers in Palaeontology 36: 1-145.

Kennedy, W.J., 1987. The ammonite fauna of the type Maastrichtian with a revision of *Ammonites colligatus* Binkhorst, 1861. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre 56(1986): 151-267.

Kennedy, W.J., 1993. Campanian and Maastrichtian ammonites from the Mons Basin and adjacent areas (Belgium). Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre 63: 99-131.

Kennedy, W.J. & Bilotte, M., 1995. A new ammonite fauna from the Sub-Pyrenean Campanian (Upper Cretaceous). Geobios 28: 359-370.

Kennedy, W.J., Bilotte, M., Lepicard, B. & Segura, F., 1986. Upper Campanian and Maastrichtian ammonites from the Petites-Pyrénées, southern France. Eclogae geologicae Helvetiae 79: 1001-1027.

Kennedy, W.J. & Christensen, W.K., 1997. Santonian to Maastrichtian ammonites from Scania, southern Sweden. Fossils & Strata 44: 75-128.

Kennedy, W.J. & Cobban, W.A., 1993a. Maastrichtian ammonites from the Corsicana Formation in northeast Texas. Geological Magazine 130: 57-67.

Kennedy, W.J. & Cobban, W.A., 1993b. Upper Campanian ammonites from the Ozan-Annona Formation boundary in southwestern Arkansas. Bulletin of the Geological Society of Denmark 40: 115-148.

Kennedy, W.J. & Cobban, W.A., 1993c. Ammonites from the Saratoga Chalk (Upper Cretaceous), Arkansas. Journal of Paleontology 67: 404-434.

Kennedy, W.J. & Cobban, W.A., 1993d. Lower Campanian (Upper Cretaceous) ammonites from the Merchantville Formation of New Jersey, Maryland, and Delaware. Journal of Paleontology 67: 828-849.

Kennedy, W.J. & Cobban, W.A., 1994a. Ammonite fauna from the Wenonah Formation (Upper Cretaceous) of New Jersey. Journal of Paleontology 68: 95-110.

Kennedy, W.J & Cobban, W.A., 1994b. Upper Campanian ammonites from the Mount Laurel Sand at Biggs Farm, Delaware. Journal of Paleontology 68: 1285-1305.

Kennedy, W.J. & Cobban, W.A., 1996. Maastrichtian ammonites from the Hornerstown Formation in New Jersey. Journal of Paleontology 70: 798-804.

Kennedy, W.J. & Cobban, W.A., 1997. Upper Campanian (Upper Cretaceous) ammonites from the Marshalltown Formation-Mount Laurel boundary beds in Delaware. Journal of Paleontology 71: 62-73.

Kennedy, W.J. & Cobban, W.A., 1999. Campanian (Late Cretaceous) ammonites from the Bergstrom Formation in Central Texas. Acta geologica polonica 49: 67-80.

Kennedy, W.J. & Cobban, W.A., 2000. Maastrichtian (Late Cretaceous) ammonites from the Owl Creek Formation in northeastern Mississippi, U.S.A. Acta geologica polonica 50: 175-190.

Kennedy, W.J. & Cobban, W.A., 2001. Campanian (Late Cretaceous) ammonites from the upper part of the Anacacho Limestone in south-central Texas. Acta geologica polonica 51: 15-30.

Kennedy, W.J., Cobban, W.A. & Landman, N.H., 1997a. Campanian ammonites from the Tomigbee Sand Member of the Eutaw Formation, the Mooreville Formation, and the basal part of the Demopolis Formation in Mississippi and Alabama. American Museum Novitates 3201: 1-44.

Kennedy, W.J., Cobban, W.A. & Landman, N.H., 1997b. Maastrichtian ammonites from the Severn Formation of Maryland. American Museum Novitates 3210: 1-30.

Kennedy, W.J., Cobban, W.A., Landman, N.H. & Scott, G.R., 1997c. New ammonoid records from the Merchantville Formation (Upper Cretaceous) of Maryland and New Jersey. American Museum Novitates 3193: 1-17.

Kennedy, W.J., Cobban, W.A. & Scott, G.R., 1992a. Ammonite correlation of the uppermost Campanian of Western Europe, the U.S. Gulf Coast, Atlantic Seaboard and Western Interior, and the numerical age of the base of the Maastrichtian. Geological Magazine 129: 497-500.

Kennedy, W.J., Cobban, W.A. & Scott, G.R., 2000a. Heteromorph ammonites from the Upper Campanian (Upper Cretaceous) *Baculites cuneatus* and *Baculites reesidei* zones of the Pierre Shale in Colorado, USA. Acta geologica polonica 50: 1-20.

Kennedy, W.J., Gale, A.S. & Hansen, T.A., 2001. The last Maastrichtian ammonites from the Brazos River sections in Falls County, Texas. Cretaceous Research 22: 163-171.

Kennedy, W.J. & Hancock, J.M., 1993. Upper Maastrichtian ammonites from the Marnes de Nay between Gan and Rébénacq (Pyrénées-Atlantiques), France. Geobios 26: 575-594.

Kennedy, W.J., Hansotte, M., Bilotte, M. & Burnett, J., 1992b. Ammonites and nannofossils from the Campanian of Nalzen (Ariège, France). Geobios 25: 263-278.

Kennedy, W.J. & Henderson, R.A., 1992a. Non-heteromorph ammonites from the Upper Maastrichtian of Pondicherry, south India. Palaeontology 35: 381-442.

Kennedy, W.J. & Henderson, R.A., 1992b. Heteromorph ammonites from the Upper Maastrichtian of Pondicherry, south India. Palaeontology 35: 693-731.

Kennedy, W.J. & Jagt, J.W.M., 1995. Lower Campanian heteromorph ammonites from the Vaals Formation around Aachen, Germany, and adjacent parts of Belgium and the Netherlands. Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen 197: 275-294.

Kennedy, W.J. & Jagt, J.W.M., 1998. Additional Late Cretaceous ammonite records from the Maastrichtian type area. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre 68: 155-174.

Kennedy, W.J., Johnson, R.O. & Cobban, W.A., 1995. Upper Cretaceous ammonite faunas of New Jersey. *In:* Baker, J.E.B. (ed.): Contributions to the Paleontology of New Jersey. Geological Society of New Jersey 12: 24-55.

Kennedy, W.J. & Kaplan, U., 1995. *Parapuzosia (Parapuzosia) seppenradensis* (Landois) und die Ammonitenfauna der Dülmener Schichten, unteres Unter-Campan, Westfalen. Geologie und Paläontologie in Westfalen 33: 1-127.

Kennedy, W.J. & Kaplan, U., 1997. Ammoniten aus dem Campan des Stemweder Berges, Dammer Oberkreidemulde, NW-Deutschland. Geologie und Paläontologie in Westfalen 50: 31-245.

Kennedy, W.J., Landman, N.H., Christensen, W.K., Cobban, W.A. & Hancock, J.M., 1998. Marine connections in North America during the late Maastrichtian: palaeogeographic and palaeobiogeographic significance of *Jeletzkytes nebrascensis* Zone cephalopod fauna from the Elk Butte Member of the Pierre Shale, SE South Dakota and NE Nebraska. Cretaceous Research 19: 745-775.

Kennedy, W.J., Landman, N.H., Cobban, W.A. & Johnson, R.O., 2000b. Additions to the ammonite fauna of the Upper Cretaceous Navesink Formation of New Jersey. American Museum Novitates 3306: 1-30.

Kennedy, W.J., Landman, N.H., Cobban, W.A. & Scott, G.R., 2000c. Late Campanian (Cretaceous) heteromorph ammonites from the Western interior of the United States. Bulletin of the American Museum of Natural History 251: 1-88.

Kennedy, W.J., Nøhr-Hansen, H. & Dam, G., 1999. The youngest Maastrichtian ammonite faunas from Nuussuaq, West Greenland. Bulletin of Geology of Greenland Survey 184: 13-17.

Kennedy, W.J. & Summesberger, H., 1984. Upper Campanian ammonites from the Gschliefgraben (Ultrahelvetic, Upper Austria). Beiträge zur Paläontologie von Österreich 11: 149-206.

Kennedy, W.J. & Summesberger, H., 1986. Lower Maastrichtian ammonites from Neuberg, Steiermark, Austria. Beiträge zur Paläontologie von Österreich 12: 181-242.

Kennedy, W.J. & Summesberger, H., 1987. Lower Maastrichtian ammonites from Nagoryany (Ukrainian SSR). Beiträge zur Paläontologie von Österreich 13: 25-78.

Kennedy, W.J. & Summesberger, H., 1999. New Late Campanian ammonites from the Gschliefgraben near Gmunden (Ultrahelvetic, Austria). Beiträge zur Paläontologie 24: 23-39.

Kennedy, W.J. & Summesberger, H., 2001. Additional ammonites from the Upper Campanian (Upper Cretaceous) of the Gschliefgraben (Ultrahelvetic; Austria). Annalen des Naturhistorischen Museum in Wien 102A: 85-107.

Keutgen, N., 1996. Biostratigraphie, Paläoökologie und Invertebratenfauna des Untermaastricht von Aachen (Westdeutschland) und angrenzenden Gebieten (Südostniederlande, Nordostbelgien). Aachen (Shaker Verlag): iv + 213 pp.

Keutgen, N., 1997. *Belemnella (Belemnella)* cf. *praearkhangelskii* Naidin, 1964 from the Vijlen Member at Altembroeck (NE Belgium, Early Maastrichtian). Geologie en Mijnbouw 75: 341-347.

Keutgen, N. & Jagt, J.W.M., 1999. Late Campanian belemnite faunas from Liège-Limburg (NE Belgium, SE Netherlands). Geological Survey of Belgium, Professional Paper 1998/2 (287): 1-31.

Keutgen, N. & van der Tuuk, L.A., 1991. Belemnites from the Lower Maastrichtian of Limburg, Aachen and Liège. Mededelingen van de Rijks Geologische Dienst 44 (1990): 1-39.

Kiernan, C.R., 2002. Stratigraphic distribution and habitat segregation of mosasaurs in the Upper Cretaceous of western and central Alabama, with an historical review of Alabama mosasaur discoveries. Journal of Vertebrate Paleontology 22: 91-103.

Klinger, H.C. & Kennedy, W.J., 1993. Cretaceous faunas from Zululand and Natal, South Africa. The heteromorph ammonite genus *Eubaculites* Spath, 1926. Annals of the South African Museum 102: 185-264.

Klinger, H.C. & Kennedy, W.J., 1997. Cretaceous faunas from Zululand and Natal, South Africa. The ammonite family Baculitidae Gill, 1871 (excluding the genus *Eubaculites*). Annals of the South African Museum 105: 1-206.

Klinger, H.C. & Kennedy, W.J., 2001. Stratigraphic and geographic distribution, phylogenetic trends and general comments on the ammonite family Baculitidae Gill, 1871 (with an annotated list of species referred to the family). Annals of the South African Museum 107: 1-290.

Klinger, H.C. & Kennedy, W.J., 2003a. Observations on the systematics, geographic and stratigraphic distribution and origin of *Diplomoceras cylindraceum* (Defrance, 1816) (Cephalopoda: Ammonoidea). Annals of the South African Museum 110: 171-198.

Klinger, H.C. & Kennedy, W.J., 2003b. Cretaceous faunas from Zululand and Natal, South Africa. The ammonite families Nostoceratidae Hyatt, 1894 and Diplomoceratidae Spath, 1926. Annals of the South African Museum 110: 219-336.

Klinger, H.C., Kennedy, W.J., Lees, J.A. & Kitto, S., 2001. Upper Maastrichtian ammonites and nannofossils and a Palaeocene nautiloid from Richards Bay, KwaZulu, South Africa. Acta geologica polonica 51: 273-291.

Küchler, T., 2000. Upper Cretaceous of the Barranca (Navarra, northern Spain); integrated litho-, bio- and event stratigraphy. Part II: Campanian and Maastrichtian. Acta geologica polonica 50: 441-499.

Küchler, T., Kutz, A. & Wagreich, M., 2001. The Campanian-Maastrichtian boundary in northern Spain (Navarra province): the Imiscoz and Erro sections. *In:* Odin, G.S. (ed.): The Campanian-Maastrichtian Stage Boundary. Characterisation at Tercis les Bains (France) and Correlation with Europe and other Continents (Developments in Palaeontology and Stratigraphy 19). Elsevier (Amsterdam): 723-744.

Küchler, T. & Odin, G.S., 2001. Upper Campanian-Maastrichtian ammonites (Nostoceratidae, Diplomoceratidae) from Tercis les Bains (Landes, France). *In:* Odin, G.S. (ed.): The Campanian-Maastrichtian Stage Boundary. Characterisation at Tercis les Bains (France) and Correlation with Europe and other Continents (Developments in Palaeontology and Stratigraphy 19). Elsevier (Amsterdam): 500-528.

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 mosasauriers uit Luik-Limburg: nieuwe vondsten leiden tot nieuwe inzichten. Publicaties van het Natuurhistorisch Genootschap in Limburg 41: 4-47.

Laga, P., Louwye, S. & Geets, S., 2002. Paleogene and Neogene lithostratigraphic units (Belgium). *In:* Bultynck, P. & Dejonghe, L. (eds): Guide to a revised lithostratigraphic scale of Belgium. Geologica Belgica 4 (2001): 135-152.

Landman, N.H. & Cobban, W.A., 2003. Ammonites from the Upper Part of the Pierre Shale and Fox Hills Formation of Colorado. American Museum Novitates 3388: 1-45.

Landman, N.H., Johnson, R.O. & Edwards, L.E., 2004. Cephalopods from the Cretaceous/Tertiary boundary in New Jersey and Maryland, with a description of the highest ammonite zones in North America. Part 2. Northeastern Monmouth County, New Jersey. American Museum Novitates 3454: 1-64.

Landman, N.H. & Waage, K.M., 1993. Scaphitid ammonites of the Upper Cretaceous (Maastrichtian) Fox Hills Formation in South Dakota and Wyoming. Bulletin of the American Museum of Natural History 215: 1-257.

Lindgren, J., 2004a. An intercontinental mosasaur extinction event at the early/late Campanian boundary. *In:* Schulp, A.S. & Jagt, J.W.M. (eds): First Mosasaur Meeting, Maastricht, 8-12 May 2004, Abstract book and Field guide. Maastricht (Natuurhistorisch Museum Maastricht): 57-58.

Lindgren, J., 2004b. Stratigraphical distribution of Campanian and Maastrichtian mosasaurs in Sweden – evidence of an intercontinental marine extinction event? GFF 126: 221-229.

Lindgren, J. & Jagt, J.W.M., 2005. Danish mosasaurs. *In:* Schulp, A.S. & Jagt, J.W.M. (eds). Proceedings of the First Mosasaur Meeting. Netherlands Journal of Geosciences 84: 315-320.

Lindgren, J. & Siverson, M., 2002. *Tylosaurus ivoensis*: a giant mosasaur from the early Campanian of Sweden. Transactions of the Royal Society of Edinburgh, Earth Sciences 93: 73-93.

Lindgren, J. & Siverson, M., 2004. The first record of the mosasaur *Clidastes* from Europe and its palaeogeographical implications. Acta palaeontologica polonica 49: 219-234.

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.

Lingham-Soliar, T., 1993. The mosasaur *Leiodon* bares its teeth. *In:* Sarjeant, W.A.S. (ed.): Fossil vertebrates: faunas and concepts. Modern Geology 18: 443-458.

Lingham-Soliar, T., 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.

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

Lingham-Soliar, T., 1996. The first description of Halisaurus (sic) (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.

Lingham-Soliar, T., 1999. The Durophagous Mosasaurs (Lepidosauromorpha, Squamata) *Globidens* and *Carinodens* from the Upper Cretaceous of Belgium and The Netherlands. Paleontological Journal 33: 638-647.

Lingham-Soliar, T., 2000. The Mosasaur *Mosasaurus lemonnieri* (Lepidosauromorpha, Squamata) from the Upper Cretaceous of Belgium and the Netherlands. Paleontological Journal 34(Suppl. 2): S225-S237.

Lingham-Soliar, T. & 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.

Machalski, M., 1996. Scaphitid ammonite correlation of the Late Maastrichtian deposits in Poland and Denmark. Acta palaeontologica polonica 41: 369-383.

Machalski, M. & Jagt, J.W.M., 1998. Latest Maastrichtian pachydiscid ammonites from The Netherlands and Poland. Acta geologica polonica 48: 121-133.

Machalski, M., Jagt, J.W.M., Dortangs, R.W., Mulder, E.W.A. & Radwański, A., 2003. Campanian and Maastrichtian mosasaurid reptiles from central Poland. Acta palaeontologica polonica 48: 397-408.

Machalski, M., Kennedy, W.J. & Kin, A., 2004. Early Late Campanian ammonite fauna from Busko Zdrój, Nida Trough, central Poland. *In:* Wood, C.J., Walaszczyk, I., Marcinowski, R. & Tröger, K.-A. (eds). Gundolf Ernst Memorial Volume. Acta geologica polonica 54: 447-471.

Machalski, M. & Odin, G.S., 2001. Scaphitid ammonites of the Campanian-Maastrichtian at Tercis les Bains (Landes, France). *In:* Odin, G.S. (ed.): The Campanian-Maastrichtian Stage Boundary. Characterisation at Tercis les Bains (France) and correlation with Europe and other continents. Amsterdam (Elsevier): 487-499.

McArthur, J.M., Thirlwall, M.F., Chen, M., Gale, A.S. & Kennedy, W.J., 1993. Strontium isotope stratigraphy in the Late Cretaceous: numerical calibration of the Sr isotope curve and intercontinental correlation for the Campanian. Paleoceanography 8: 859-873.

McArthur, J.M., Kennedy, W.J., Chen, M., Thirlwall, M.F. & Gale, A.S., 1994. Strontium isotope stratigraphy for Late Cretaceous time: direct numerical calibration of the Sr isotope curve based on the US Western Interior. Palaeogeography, Palaeoclimatology, Palaeoecology 108: 95-119.

Mulder, E.W.A., 1999. Transatlantic latest Cretaceous mosasaurs (Reptilia, Lacertilia) from the Maastrichtian type area and New Jersey. Geologie en Mijnbouw 78: 281-300.

Mulder, E.W.A., 2003a. On latest Cretaceous tetrapods from the Maastrichtian type area. Publicaties van het Natuurhistorisch Genootschap in Limburg 44: 1-188.

Mulder, E.W.A., 2003b. On the alleged presence of *Halisaurus* (Squamata, Mosasauridae) in the latest Cretaceous of the Maastrichtian type area. Netherlands Journal of Geosciences 82: 269-273.

Mulder, E.W.A., Cornelissen, D. & Verding, L., 2004. Is *Mosasaurus lemonnieri* a juvenile *Mosasaurus hoffmanni*? A discussion. *In:* Schulp, A.S. & Jagt, J.W.M. (eds): First Mosasaur Meeting, Maastricht, 8-12 May 2004, Abstract book and Field guide. Maastricht (Natuurhistorisch Museum Maastricht): 62-66.

Mulder, E.W.A. & Mai, H., 1999. The oldest tylosaurine mosasaur (Reptilia, Lacertilia) from the Late Cretaceous of Belgium: Hermann von Meyer (1860) revisited. *In:* Vergoossen, J.M.J. & Lambers, P.H. (eds): Actual paleontology – paleontology in action: a tribute to Bert Boekschoten. Geologie en Mijnbouw 78: 207-213.

Niebuhr, B., 1996. Die Scaphiten (Ammonoidea, Ancyloceratina) des höheren Obercampan der Lehrter Westmulde östlich Hannover (N. Deutschland). Berliner geowissenschaftliche Abhandlungen E18: 267-287.

Niebuhr, B., 2003. Late Campanian and Early Maastrichtian ammonites from the white chalk of Kronsmoor (northern Germany) – taxonomy and stratigraphy. Acta geologica polonica 53: 257-281.

Niebuhr, B., 2004. Late Campanian nostoceratid ammonites from the Lehrte West Syncline near Hannover, northern Germany. *In:* Wood, C.J., Walaszczyk, I., Marcinowski, R. & Tröger, K.-A. (eds): Gundolf Ernst Memorial Volume. Acta geologica polonica 54: 473-487.

Niebuhr, B., Volkmann, R. & Schönfeld, J., 1997. Das obercampane *polyplocum*-Event der Lehrter Westmulde (Oberkreide, N-Deutschland): Bio-/Litho-/Sequenzstratigraphie, Fazies-Entwicklung und Korrelation. Freiberger Forschungshefte C468: 211-243.

Odin, G.S., Courville, P., Machalski, M. & Cobban, W.A., 2001. The Campanian-Maastrichtian ammonite fauna from Tercis (Landes, France); a synthetic view. *In:* Odin, G.S. (ed.): The Campanian-Maastrichtian Stage Boundary. Characterisation at Tercis les Bains (France) and correlation with Europe and other continents. Amsterdam (Elsevier): 550-567.

Robaszynski, F. & Christensen, W.K., 1989. The upper Campanian-Lower Maastrichtian chalks of the Mons basin, Belgium: a preliminary study of belemnites and foraminifera in the Harmignies and Ciply areas. Geologie en Mijnbouw 68: 391-408.

Robaszynski, F. & Martin, M., 1988. Late Cretaceous phosphate stratiform deposits of the Mons Basin (Belgium). *In:* Boissonnas, J. & Omenetto, P. (eds): Mineral deposits within the European Community. Springer (Berlin/Heidelberg): 515-529.

Robaszynski, F., Poels, J.P. & Martin, M., 1988. Le gisement de craie phosphatée de Ciply: données nouvelles. Bulletin de la Société belge de Géologie 97: 9-24.

Robaszynski, F., Dhondt, A.V. & Jagt, J.W.M., 2002. Cretaceous lithostratigraphic units (Belgium). *In:* Bultynck, P. & Dejonghe, L. (eds): Guide to a revised lithostratigraphic scale of Belgium. Geologica Belgica 4(2001): 121-134.

Russell, D.A., 1967. Systematics and morphology of American mosasaurs (Reptilia, Sauria). Peabody Museum of Natural History, Yale University, Bulletin 23: viii + 240 pp.

Russell, D.A., 1975. A new species of *Globidens* from South Dakota, and a review of globidentine mosasaurs. Fieldiana (Geology) 33: 235-256.

Schulp, A.S., Jagt, J.W.M. & Fonken, F., 2004. New material of the mosasaur *Carinodens belgicus* from the Upper Cretaceous of The Netherlands. Journal of Vertebrate Paleontology 24: 744-747.

Schulz, M.-G., 1979. Morphometrisch-variationsstatistische Untersuchungen zur Phylogenie der Belemniten-Gattung *Belemnella* im Untermaastricht NW-Europas. Geologisches Jahrbuch A47: 3-157.

Schulz, M.-G., 1982. Erster Nachweis der Belemnitengattung *Belemnitella* (*B. pulchra* n. sp.) im mittleren Untermaastricht NW-Deutschlands. Geologisches Jahrbuch A61: 279-293.

Schulz, M.-G. & Schmid, F., 1983. Das Ober-Maastricht von Hemmoor (N-Deutschland): Faunenzonen-Gliederung und Korrelation mit dem Ober-Maastricht von Dänemark und Limburg. Newsletter on Stratigraphy 13: 21-39.

Simon, E., 1998. Maastrichtian brachiopods from Ciply: palaeoecological and stratigraphical significance. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre 68: 181-232.

Simon, E., 2000. Upper Campanian brachiopods from the Mons Basin (Hainaut, Belgium): the brachiopod assemblage from the *Belemnitella mucronata* Zone. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre 70: 129-160.

Simon, E. & Owen, E.F., 2001. A first step in the revision of the genus *Cretirhynchia* Pettitt, 1950. Bulletin de l'Institut royal des Sciences naturelles de Belgique, Sciences de la Terre 71: 53-118.

Sullivan, R.M., 1987. A reassessment of reptilian diversity across the Cretaceous-Tertiary boundary. Contributions in Science, Natural History Museum of Los Angeles County 391: 1-26.

Summesberger, H. & Kennedy, W.J., 2004. More ammonites (Puzosiinae, Pachydiscidae, Placenticeratidae, Nostoceratidae, Diplomoceratidae) from the Campanian (Late Cretaceous) of the Gschliefgraben (Ultrahelvetic Nappe; Austria). Annalen des Naturhistorischen Museums in Wien 106A: 167-211.

Surlyk, F., 1984. The Maastrichtian Stage in NW Europe, and its brachiopod zonation. Bulletin of the Geological Society of Denmark 33: 217-223.

Van der Tuuk, L.A. & Zijlstra, J.J.P., 1979. Eerste vondst van een Nostoceras (sic) (orde Ammonoidea) in Nederland. Grondboor en Hamer 33: 116-120.

Wagreich, M., Küchler, T. & Summesberger, H., 2003. Correlation of calcareous nannofossil zones to the local first occurrence of *Pachydiscus neubergicus* (von Hauer, 1858) (Ammonoidea) in European Upper Cretaceous sections. Netherlands Journal of Geosciences 82: 283-288.

Walaszczyk, I., 2004. Inoceramids and inoceramid biostratigraphy of the Upper Campanian to basal Maastrichtian of the Middle Vistula River section, central Poland. Acta geologica polonica 54: 95-168.

Walaszczyk, I., Cobban, W.A. & Harries, P.J., 2001. Inoceramids and inoceramid biostratigraphy of the Campanian and Maastrichtian of the United States Western Interior Basin. Revue de Paléobiologie 20: 117-234.

Walaszczyk, I., Cobban, W.A. & Odin, G.S., 2002a. The inoceramid succession across the Campanian-Maastrichtian boundary. Bulletin of the Geological Society of Denmark 49: 53-60.

Walaszczyk, I., Odin, G.S. & Dhondt, A.V., 2002b. Inoceramids from the Upper Campanian and Lower Maastrichtian of the Tercis section (SW France), the Global Stratotype Section and Point for the Campanian-Maastrichtian boundary; taxonomy, biostratigraphy and correlation potential. Acta geologica polonica 52: 269-305.

Walaszczyk, I., Smirnov, J.P. & Tröger, K.-A., 1996. Trochoceramid bivalves (Inoceramidae) from the Lower Maastrichtian of Daghestan (Aimaki section, NE Caucasus) and south-central Poland. Acta geologica polonica 46: 141-164.

Ward, P.D. & Kennedy, W.J., 1993. Maastrichtian Ammonites from the Biscay Region (France, Spain). The Paleontological Society Memoir 34: 1-58.

Wippich, M.G.E., 1995. Ammoniten aus dem oberen Untercampan des nordwestlichen Münsterlandes (Nordwestdeutschland). Geologie und Paläontologie in Westfalen 38: 43-87.

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.