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Late Maastrichtian and Early Palaeocene index macrofossils in the Maastrichtian type area (SE Netherlands, NE Belgium)

John W.M. Jagt
Natuurhistorisch Museum Maastricht, P.O. Box 882, 6200 AW Maastricht, the Netherlands

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Abstract

The uppermost Cretaceous and lowest Palaeocene in the type area of the Maastrichtian yield several macrofossils which can be used as index species in correlations with northern and southern Europe. For a macrofossil zonation of the uppermost Maastrichtian, coleoid and ammonoid cephalopods and inoceramid bivalves are of prime importance, while biozonations for the lowermost Palaeocene rely particularly on echinoid and asteroid species. On coleoid and ammonoid evidence, the type Maastrichtian is coeval with the uppermost Maastrichtian as interpreted in the Tethyan realm (Bay of Biscay sections in particular) and the North Temperate realm (NW and NE Europe). The occurrence in the lower part of the Geulhem Member (Houthem Formation) of distinctive, exclusively Early Danian echinoderm species suggests that the entire Lower Danian of the Danian type area is represented in the Maastricht area, and that what is considered to be the uppermost part of the underlying Meerssen Member (Maastricht Formation) represents the equivalent of the Early Danian 'Cerithium Kalk' in Denmark.

Introduction

The type Maastrichtian strata have been affected by regional synsedimentary and Cainozoic tectonic movements (Bless 1991), and they are characterised by hardgrounds and other sedimentation breaks (Pollock 1975). The refined lithostratigraphic subdivision of these and overlying strata (W.M. Felder 1975a, b) is not matched by a comparably detailed biozonation, as was pointed out recently by Hancock (1990). Deposition is interpreted (Villain 1977) to have taken place on a shallow carbonate platform, protected from open marine influences, and for the uppermost part of the Maastricht Formation under high-energy conditions. Macrofossil correlations with the Maastrichtian white chalk elsewhere in Europe rely mainly on ammonites and belemnites. Most authors assumed the classic type Maastrichtian to be bounded by hiatuses, at its base as well as at its top, and they considered the hiatus at the Cretaceous/Tertiary (K/T) boundary in the area as relatively important.

The recent discovery near Geulhem of virtually complete sections spanning this boundary has revived the discussion on the ages of the uppermost part of the type Maastrichtian and of the lower part of the overlying Palaeocene. Fieldwork in the Maastricht area during the summer and autumn of 1994 concentrated on bed-by-bed collecting of coleoid and ammonoid cephalopods, and of echinoderms. The resolution in macrofossil zonation depends highly on sampling and preservation, as stressed by Surlyk (1990). The picture presented below will undoubtedly be refined as fieldwork continues.

Representatives of a few index macrofossil groups have been singled out for discussion, i.e. echinoderms, coleoid and ammonoid cephalopods, bivalves and some minor groups (brachiopods, cirripedes, decapod crustaceans and serpulids; Figure 1). The stratigraphic range of selected index species is discussed. For a location map and detailed lithostratigraphic logs the reader is referred to Jagt et al. (this issue).

The macrofossil content of a few samples from the calcarenitic deposits (IVf-7) above the Berg en Terblijt Horizon, as exposed in the underground workings of the Geulhemmerberg (point 251; Brinkhuis and Smit, this issue) has been analysed (Appendix). These sam-

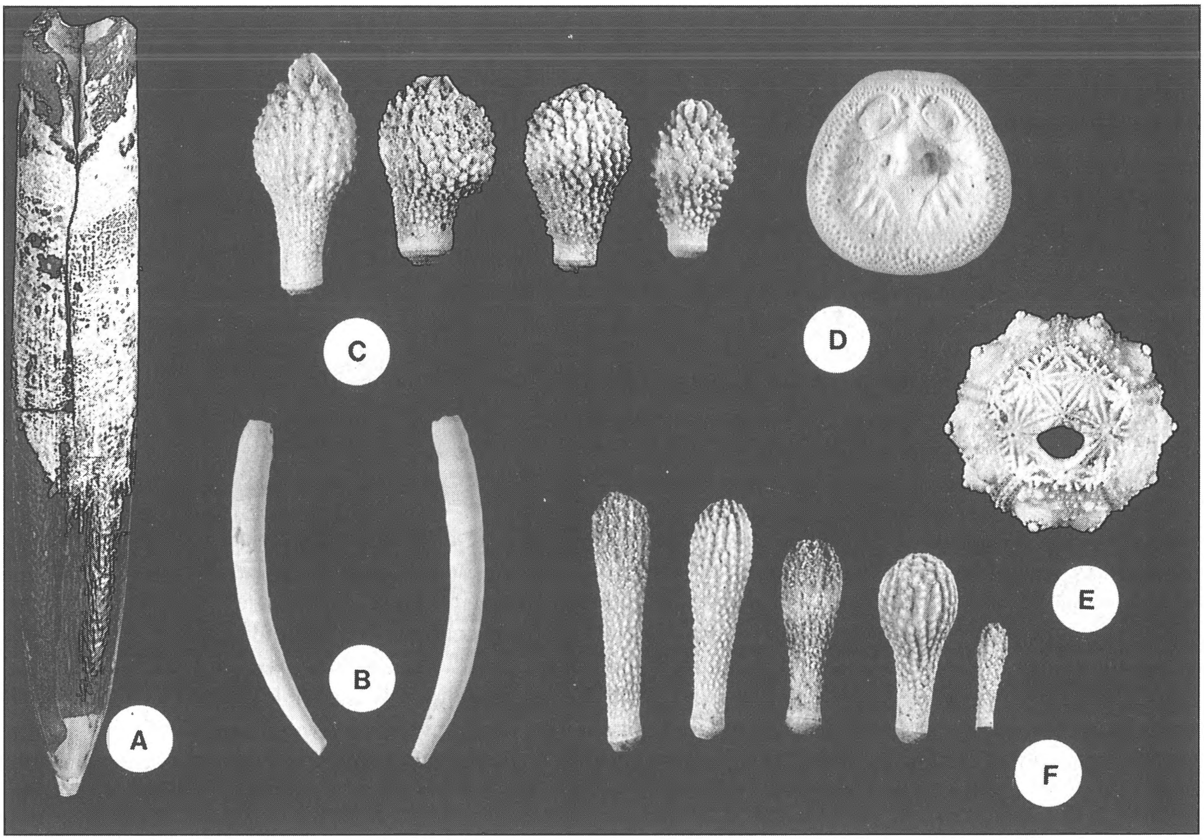

Figure 1. Characteristic Late Maastrichtian (A) and Early Palaeocene (B–F) macrofossil taxa from the Maastricht area: A – *Belemnella* gr. *casimirovensis* (nat. size), B – *Ditrupa schlotheimi* (× 5), C – *Tylocidaris* gr. *bruennichi* (× 2), D – *Danocrania geulhemensis* (× 3), E – saleniid echinoid *Hyposalenia heliophora* (× 3), F – *Tylocidaris hardouini* (× 2).

ples have yielded several typically late Maastrichtian macrofossil taxa, in addition to a single, exclusively Danian element.

Index macrofossils

Ammonoidea

Hancock (1991) rightly pointed out that the ammonite succession in the Maastrichtian Stage is still poorly known. In the Maastrichtian type area, this holds true for the ranges of most species, despite the fact that the museum-based revision of the ammonite faunas (Kennedy, 1986b, 1987) has greatly improved our knowledge. Data in recent papers on ammonoid ranges and patterns of extinction (Kennedy 1989, 1993; Ward 1990) may suffer from a lack of precision. In this respect, it is fortunate that it has proved possible to work out detailed ammonite zonations in other parts of Europe (Birkelund 1993; Ward and Kennedy 1993).

A total of eight species are known to date from the Meerssen Member (Maastricht Formation). Of these, the pachydiscid *Anapachydiscus terminus* (Ward and Kennedy 1993), now *Menuites terminus*, following Cobban and Kennedy (1993), recently recognised at the Blom quarry near Berg en Terblijt and at the ENCI Nederland BV quarry near Maastricht, is of particular interest. Ward and Kennedy (1993) described this short-ranging species from the uppermost Maastrichtian along the Bay of Biscay in SW France and NW Spain, where its first appearance datum (FAD) defines the base of their *terminus* Zone. More importantly, this species is also known from the uppermost Maastrichtian of Denmark (brachiopod zone 10 of Surlyk 1984; Birkelund 1993), and from the Maastrichtian of Azerbaijan (Ward and Kennedy 1993).

Two specimens, of which detailed descriptions will be published elsewhere, are known from the Meerssen

Figure 2. Menuites terminus (Ward and Kennedy 1993), Blom quarry (Berg en Terblijt), Maastricht Fm (Meerssen Mbr, base of unit IVf-4) (Natuurhist. Museum Maastricht coll. NHMM 1993092). The portion between arrows restored in plaster.

Member of the quarries Blom (Figure 2) and ENCI Nederland BV. In both quarries, the belemnite *Belemnella* gr. *casimirovensis* predominates at the levels from which the specimens were collected.

Amongst ammonites from the top of the Meerssen Member at the ENCI quarry, *Hoploscaphites constrictus* is the most common. It includes forma *crassus*, which is usually considered to be confined to the topmost Maastrichtian (Błaszkiewicz 1980), but which also occurs lower in the Maastrichtian (Kennedy 1986a; Kennedy and Summesberger 1987). It should be noted that Błaszkiewicz (1980: 17) remarked that the FAD of *Belemnella* gr. *casimirovensis* in central Poland was assumed to be decidedly later than the FAD of the marker species of the *Hoploscaphites constrictus crassus* Zone. The *crassus* form is also well represented at the Curfs-Ankerpoort quarry near Geulhem, where it is associated with other ammonites such as *Menuites fresvillensis, Baculites vertebralis, Sphenodiscus binckhorsti* and *Hoploscaphites* sp. It is not unlikely that the widely distributed, (near-)smooth representatives of the genus *Sphenodiscus* known from Europe, India, the United States, Mexico, the Middle East and West Africa, represent but a single species (Kennedy and Henderson 1992; Kennedy and Cobban 1993).

With the exception of a single external mould of *Baculites vertebralis*, found in unit IVf-6, in the upper part of the Meerssen Member, the Geulhemmerberg section has not yet yielded any ammonites.

Belemnoidea

Belemnella (Neobelemnella) gr. *casimirovensis* (Figure 1A) is amongst the last belemnitellid species to occur in the uppermost Maastrichtian. Birkelund

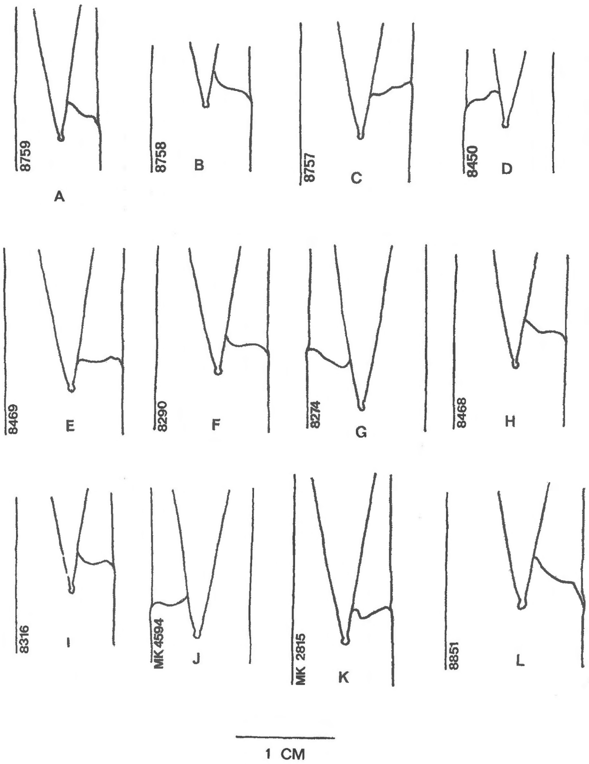

Figure 3A–L. Camera-lucida drawings of split anterior ends of guards of *Belemnella* gr. *casimirovensis*. All specimens from middle and upper Meerssen Mbr (IVf-4 onwards, Maastricht Fm), ENCI NV quarry, Maastricht. Specimens with MK registration numbers are in Natuurhistorisch Museum Maastricht collections (W.M. Felder Coll.), others in Jagt Coll.

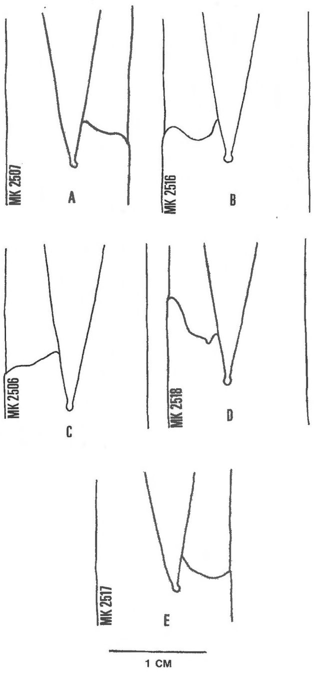

Figure 4A–E. Camera-lucida drawings of split anterior ends of guards of *Belemnella* gr. *casimirovensis*. All specimens from upper part (IVf-6) of Meerssen Mbr (Maastricht Fm), Geulhemmerberg sections, Geulhem. Registration numbers as in Figure 3.

(1957) first recorded its occurrence in the type Maastrichtian, which was an important discovery since in 1951 Jeletzky had assumed an extensive stratigraphic gap at the top of the type Maastrichtian to represent the *casimirovensis* Zone. Jeletzky discussed in detail the geographical and stratigraphical distribution of *Belemnella casimirovensis* (= *Belemnitella kazimiroviensis* Skolozdrówna 1932, *Belemnitella americana* sensu Arkhangelsky 1912 non Morton 1829), and distinguished two varieties, *archangelskyi* and *skolozdrownae*.

Schmid (1959) confirmed Birkelund's record, and demonstrated that *B.* gr. *casimirovensis* (including var. *archangelskyi*) co-occurs with slender varieties of *Belemnitella* gr. *junior* Nowak 1913 in a number of outcrops in Belgium and Netherlands Limburg.

Representatives of the *casimirovensis* group are well known from NE Europe (Kongiel 1962; Naidin 1975, 1987, 1990; Machalski and Walaszczyk 1987, H.J. Hansen et al. 1989), being typical of the eastern part of the Central European Subprovince of Christensen (1976). This group is not found in the Upper Maastrichtian of Hemmoor (northern Germany). It appears that all but the highest part of the Maastricht Formation (upper half of Meerssen Member, IVf-4 upwards) corresponds to Schulz and Schmid's (1983) *argentea/junior* Zone. The index taxa of the overlying *danica/argentea* and *baltica/danica* zones are unknown from the type Maastrichtian, with the exception of the bivalve *Tenuipteria argentea* (discussed below).

During the 1994 fieldwork, most of the key sections in the Maastricht area were re-measured and reasonably preserved belemnites collected (Figures 3, 4). The FADs of the *casimirovensis* group, as known to date, are indicated in Figure 5. Van der Tuuk and Bor's (1980) observation that the Limburg 'populations' consisted mainly of juvenile specimens is confirmed. In addition, these 'populations' appear to comprise all the 'species' recognised by Kongiel (1962), but it should be noted that the group is in need of revision.

In comparison with the patchy distribution of the *casimirovensis* group at other localities in the Maas-

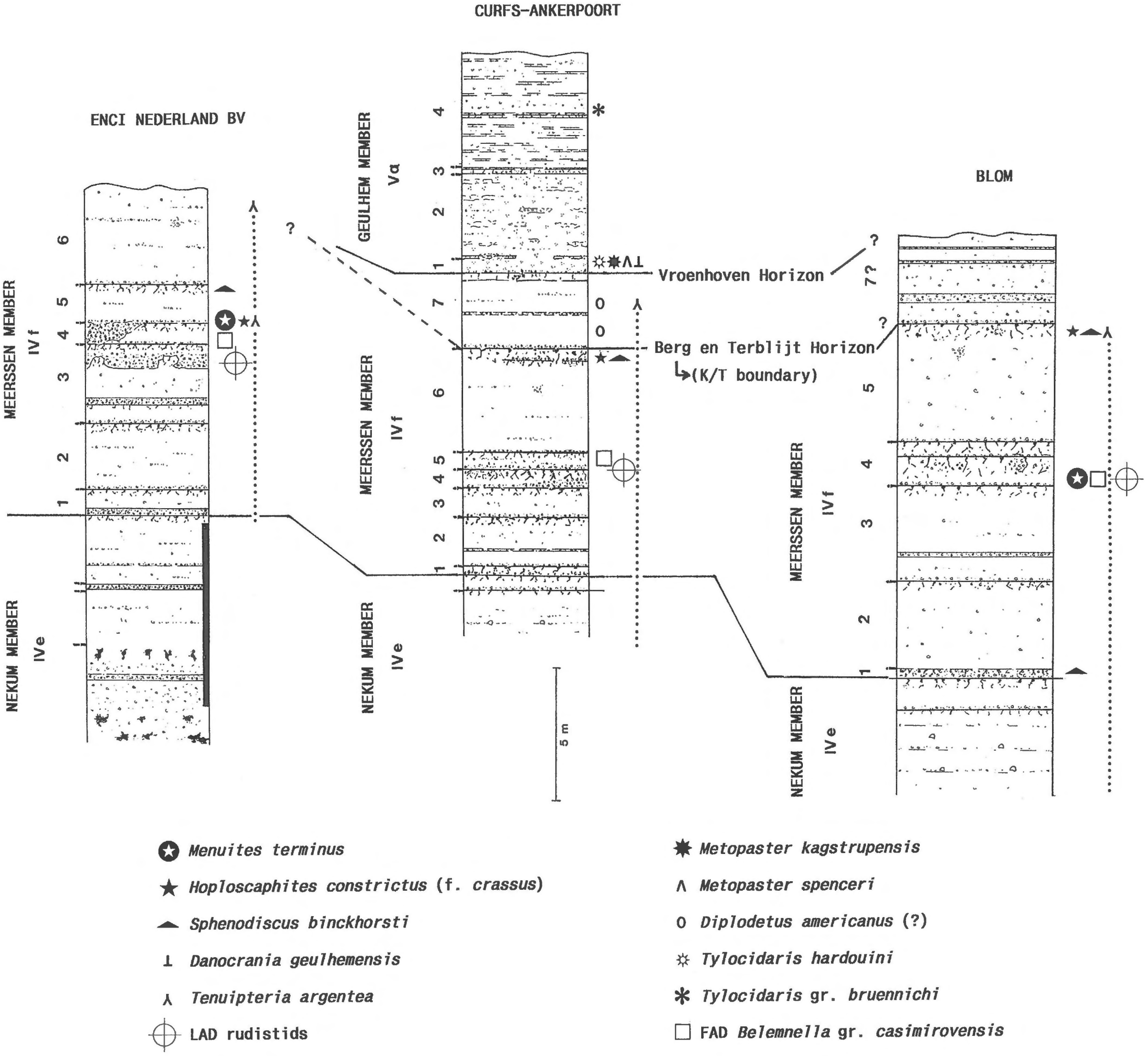

Figure 5. Lithologic logs of three key sections (ENCI-Maastricht, Blom and Curfs-Ankerpoort, Geulhem) showing stratigraphic provenance of selected index macrofossils discussed in text. FAD = first appearance datum. Key to lithology and locality map are shown in Jagt et al. (this issue).

tricht area, the mass occurrence in parts of the ceiling in the underground workings at the Geulhemmerberg corresponds to the 'resedimented accumulate type' of Doyle and Macdonald (1993), which implies considerable 'time averaging' to have taken place (Fürsich and Aberhan 1990; Kidwell and Bosence 1991).

Echinodermata

The stratigraphic potential of the diverse echinoderm faunas which characterise the upper members of the Maastricht Formation has generally been considered low. Nevertheless, the author (Jagt, in preparation) plans to present a detailed discussion with descriptions of several new taxa, especially amongst asteroids, ophiuroids and crinoids. Noteworthy is the recently discovered representative of the genus *Tylocidaris* in the lowermost Meerssen Member (base IVf-1; *junior* Zone of authors), described by Jagt and Van der Ham (1995). Species of this genus of psychocidarine echinoid have traditionally been used as index fossils for the Danian of Denmark and southern Sweden (Brotzen 1959). Although J.M. Hansen (1977) showed the tylocidarid zonation in Denmark to be facies-controlled and diachronous relative to dinoflagellate biostratigraphy, Gravesen (1993) has recently put forward arguments in favour of the use of the various tylocidarid species as zonal markers. In addition, Gravesen pointed out the extreme rarity of members of this genus in the 'Cerithium Kalk', which directly overlies the K/T boundary in Sjælland (Denmark). The first representatives of *T. oedumi* Brünnich Nielsen 1938 (Gravesen 1993: pl. 2, figs 4–6), defining the base of the early Early Danian *oedumi* Zone, closely resemble *T. hardouini* (Desor 1855; Figure 1F), which occurs in the lower part (Va-1 to Va-3) of the Geulhem Member in the Maastricht area (Van der Ham 1988). Via 'intermediate types', *T. oedumi* in Sjælland is linked with its successor, *T. abildgaardi* Ravn 1928, which first appears some 3 m above the K/T boundary (Gravesen 1993). Typical *abildgaardi*-type spines are unknown from the Maastricht area, which may suggest a hiatus within the Geulhem Member (cf. Verbeek 1986). The upper part (Va-4) of this member yields *T.* gr. *bruennichi* Ravn 1928 (Figure 1C), which in Denmark and southern Sweden marks the Middle Danian.

Whether or not the extra-Danish records of *oedumi*-type spines (Kongiel 1958; Rosenkrantz 1970) are conspecific with Danish occurrences remains to be determined. It seems reasonable to assume *T. hardouini* from the Maastricht area to be closely related with (early populations of) *T. oedumi* from the type Danian, but at present it cannot be decided whether their overall similarity is a matter of convergence or an expression of their having the same origin.

The uppermost Meerssen Member (IVf-7 in Figure 5; cf. Jagt et al., Brinkhuis and Smit, this issue) in the Curfs-Ankerpoort quarry has not yielded any tylocidarids yet, nor the distinctive asteroid species *Metopaster kagstrupensis* Brünnich Nielsen 1943 and *M. spenceri* Brünnich Nielsen 1943, which in Denmark are confined to the Early Danian. Unfortunately, it is not clear from the literature (Brünnich Nielsen 1943; Rasmussen 1950, 1971, 1979) whether these species first appear in the *oedumi* Zone or in the overlying *abildgaardi* Zone, some metres above the K/T boundary, and whether or not they occur in the 'Cerithium Kalk'. Their common occurrence in the lower part (Va-1 and Va-2) of the Geulhem Member (Rasmussen 1965) suggests that the lower part of the Lower Danian of Denmark is in fact present in the Maastricht area.

Of note in the uppermost part (IVf-7) of the Meerssen Member at the Curfs-Ankerpoort quarry (Figure 5) is the occurrence of representatives of the brissid genus *Diplodetus* not hitherto recorded from this part. At first, this echinoid was held to be conspecific with one of the Early Palaeocene brissids recorded from eastern Europe (Kongiel and Matwiejewówna 1937; Kongiel 1950; Petrova 1980; Machalski and Walaszczyk 1987), but A.B. Smith and C. Jeffery (personal communication, August 1995) have recently suggested it to be conspecific with the late Maastrichtian *Micraster (Plesiaster) americanus* Stephenson 1941 from Texas, Arkansas and Mississippi (Cooke 1953).

In a broader context, Bignot (1993) provided evidence of two successive Danian transgressions in the Paris Basin, one during the Early, and a second during the Middle Danian (Montian). This second transgressive pulse appears related to the upper part (top Va-3 ?, Va-4 onwards) of the Geulhem Member, which yields a distinctive 'Montian' echinoid fauna (Van der Ham, 1988).

Bivalvia

An important marker for the top of the Maastrichtian is the inoceramid *Tenuipteria argentea* (Conrad 1858) (Dhondt 1983, 1992). Ward et al. (1986) and Ward (1988) first claimed this species to have a restricted range in the Bay of Biscay sections, but Ward and Kennedy (1993) and MacLeod (1994) subsequently showed it to range through most of the Maastrichtian. In the Maastrichtian type area, the first representatives of tegulated inoceramids may occur in the Lixhe 1 (?) Member (Gulpen Formation). 'True', i.e. non-tegulated, inoceramids do not appear to reach higher than the upper 'Vijlen' Member (= early Late Maastrichtian), as exposed near Haccourt and Lixhe in NE Belgium. This pattern thus roughly corresponds with that discussed by MacLeod and Ward (1990) and MacLeod (1994) for the Bay of Biscay sections. In the Geulhemmerberg sections, articulated specimens of *T. argentea* occur in unit IVf-7 (Meerssen Member), some 80–100 cm above clay layer A. These specimens, together with other typically late Maastrichtian echinoid and bivalve species are associated in pockets and lenses with abraded spines of *T. hardouini* (Appendix). At the Curfs-Ankerpoort quarry, this species ranges up to the middle of unit IVf-7 (Jagt and Fraaye 1995), thus apparently crossing the K/T boundary (= Berg en Terblijt Horizon) as now understood (Brinkhuis and Smit, this issue).

The pteriid bivalve *Hypoxytoma danica* (Ravn 1902), which in NW Germany is used as marker for the two uppermost zones of the Maastrichtian (Schulz and Schmid 1983; Schulz et al. 1984; see also Abdel-Gawad 1986 for Poland), does occur in the type Maastrichtian (Jagt, 1986) but is apparently restricted to the uppermost Lanaye Member (Gulpen Formation) and the basal part of the overlying Valkenburg Member (Maastricht Formation).

The demise of rudistid bivalves in the latest Maastrichtian has been the subject of many papers (Philip 1986; Jones and Nicol 1986; Masse and Philip 1986). In the Maastrichtian type area, the first rudistids (with the exception of the monopleurid genus *Gyropleura*, which occurs already in the Campanian) appear in the middle portion of the Nekum Member, but the rudist group as a whole does not reach its acme until the lower and middle part (IVf-1 to IVf-4) of the Meerssen Member (Figure 5). Available evidence suggests that they disappeared from the area well below the K/T boundary. The lowermost part of unit IVf-4 of the same member ('*casimirovensis* Zone') yields the last representatives.

The stratigraphic potential of the fairly diverse Early Palaeocene molluscan faunas from the middle part (Va-3) of the Geulhem Member as exposed in the Geulhem area has so far not been investigated. That they have received little attention is undoubtedly due to their being almost exclusively preserved as internal and external moulds. Jagt and Wesselingh (1988) recorded nuculid, arcid, glycymerid, crassatellid, carditid, lucinid, venerid, mytilid, lithophagid, pholadid, cuspidariid and corbulid bivalves as well as naticid, turritellid, turrid and ringiculid gastropods.

Brachiopoda

Surlyk's (1984) micromorph brachiopod zonation for the white chalk facies of northern Europe cannot be applied to the type Maastrichtian because of great differences in substrate nature and microhabitats.

Johansen (1987) described in detail the articulate brachiopod faunas spanning the K/T boundary at Nye Kløv (Jylland, Denmark), illustrating the abrupt increase some metres above the boundary in number of taxa, especially of cancellothyridinid and megathyridid species. Unfortunately, the fauna of the Geulhem Member has not yet been studied in similar detail, but the common occurrence in this member of the two groups mentioned suggests that it may prove possible to work out a biozonation, which may provide additional arguments for correlating the member with the type Danian (cf. Johansen 1989a, b).

Kruytzer and Meijer (1958) described from the Geulhem Member a craniid brachiopod, now known as *Danocrania geulhemensis* (Figure 1D), and on this occurrence assigned a (Middle) Danian age to this member. This species also occurs in the lower metres of the member (Va-1 and Va-2), where it is associated with the typically Early Danian asteroid species mentioned above.

Cirripedia

Jagt and Collins (1988) recorded the Middle Danian *Pycnolepas bruennichi* Withers, 1914 from the Geulhem Member, and showed it to occur also in the basal metres (Va-1) of this member, which as mentioned above are of Early Danian age.

Decapoda

Of the diverse Middle Danian decapod crustacean fauna known from Fakse (Sjælland, Denmark), currently under revision, a species of raninid crab, *Raniliformis baltica* (Segerberg 1900), has recently been described from the basal, Early Danian part (Va-1 or lower part Va-2) of the Geulhem Member at the Curfs-Ankerpoort quarry (Jagt et al. 1993).

Serpulida

Jäger (1993), on the basis of a thorough study of serpulid faunas, assumed a Middle and Late rather than an Early Danian age for the Geulhem Member. One of the commonest Geulhem Member serpulid species, *Ditrupa schlotheimi* Rosenkrantz 1920 (Figure 1B), appears to be confined to the younger Danian in Denmark.

Conclusions

On macrofossil evidence, and on ammonites and belemnites in particular, the uppermost part of the Maastricht Formation (Meerssen Member) is correlatable with sections in northern and southern Europe. The equivalent of the latest Maastrichtian *terminus* ammonite zone of the Bay of Biscay sections occurs at the Blom and ENCI quarries in southern Limburg.

The FAD of the belemnite *Belemnella* gr. *casimirovensis* appears to correspond with the demise of rudistids in the type Maastrichtian, and correlates well with the Danish belemnite zonation. This is corroborated by ammonite evidence. The occurrence in the lower part (Va-1 and Va-2) of the Geulhem Member of echinoid and asteroid species typical of the Lower Danian in Denmark suggests that this part may be correlated with the Danish Early Danian *oedumi* and *abildgaardi* echinoid zones. This may imply that at the Curfs-Ankerpoort quarry unit IVf-7 of the Meerssen Member, between the last occurrence datums of *in situ* ammonites and belemnites on the one hand and the Vroenhoven Horizon on the other, corresponds to the Danish 'Cerithium Kalk', one of the lower units of the type Danian.

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Appendix

Macrofossil taxa of Late Maastrichtian (*) and Early Palaeocene (**) age identified in samples collected in unit IVf-7 (Meerssen Member), 80–100 cm above clay layer A, at the Geulhemmerberg section (near point 251; Brinkhuis and Smit, this issue). Dortangs and Jagt collections.

- Foraminifera
  - *Lepidorbitoides minor* (Schlumberger 1901)*
  - *Siderolites calcitrapoides* Lamarck 1801*
- Porifera indet.
- Anthozoa
  - *Graphularia* sp.
- Bivalvia
  - Exogyrinae*
  - *Acutostrea* sp.
  - *Agerostrea ungulata* (von Schlottheim 1813)*
  - Anomiidae
  - *Microchlamys pulchella* (Nilsson 1827)?
  - *Syncyclonema haeggi* Dhondt 1971?
  - *Tenuipteria argentea* (Conrad 1858)*
- Polychaeta sedentaria
  - *Pyrgopolon (P.) mosae mosae* de Montfort 1808
  - *Pyrgopolon (Septenaria)* sp.?
- Brachiopoda
  - Cancellothyridinae (? n. sp.)*
  - *Terebratulina* gr. *chrysalis* (von Schlottheim 1813)
  - *Thecidea papillata* (von Schlottheim 1813)*
  - *Lacazella*? sp.
- Bryozoa indet.
- Crustacea
  - Decapoda indet.
  - Calappidae
- Echinoidea
  - *Temnocidaris (T.) danica* (Desor 1855)
  - Cidaroida (spines)
  - *Tylocidaris (T.) hardouini* (Desor 1855)**
  - Phymosomatoida (spines)
  - *Gauthieria* sp. (spine)
  - *Echinogalerus transversus* (Smiser 1935)*
  - *Faujasia apicalis* (Desor 1847)*
  - *Procassidulus lapiscancri* (Leske 1778)*
  - *Nucleopygus scrobiculatus* (Goldfuss 1829)*
  - *Hemipneustes striatoradiatus* (Leske 1778)*
  - *Hemiaster (Bolbaster) prunella* (Lamarck 1816)*
  - *Hemiaster (Leymeriaster) maestrichtensis* Schlüter 1897*
  - *Diplodetus americanus* (Stephenson 1941) ? (pers. comm. A.B. Smith and C. Jeffery, August 1995)
- Crinoidea, Asteroidea and Ophiuroidea
  - Comatulida (brachials)
  - *Applinocrinus* sp.*
  - ophiuroids indet.
  - asteroids indet.
- Pisces
  - *Palaeohypotodus bronni* (Agassiz 1843)
  - *Squalicorax pristodontus* (Agassiz 1843)*
  - *Rhombodus binckhorsti* Dames 1881*
  - Teleostei indet.

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