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Latest Maastrichtian pachydiscid ammonites from The Netherlands and Poland

MARCIN MACHALSKI[1] & JOHN W. M. JAGT[2]

[1] *Institute of Paleobiology, Polish Academy of Sciences, ul. Twarda 51/55, PL-00-818 Warszawa, Poland. E-mail: mach@twarda.pan.pl*
[2] *Natuurhistorisch Museum Maastricht, P.O. Box 882, NL-6200 AW Maastricht, The Netherlands. E-mail: mail@nhmmaastricht.nl*

ABSTRACT:

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The pachydiscid ammonite *Menuites terminus* (WARD & KENNEDY, 1993) is described from the uppermost Maastrichtian deposits in the type area of the Maastrichtian Stage in southeast Netherlands (upper part of the Meerssen Member of the Maastricht Formation) and in central Poland (upper part of the Kazimierz Opoka). Variation in whorl section and ribbing in the material studied is documented. The presence of *M. terminus* places the upper parts of the Meerssen Member and of the Kazimierz Opoka in the highest Maastrichtian ammonite zone, the *M. terminus* Zone, defined originally in the Bay of Biscay region, and shows them to be equivalent to the interval from the upper part of Member IV to the top of Member V in the Bay of Biscay region. In the Maastricht area, the FAD (first appearance datum) of *M. terminus* approximately coincides with that of the latest Maastrichtian index belemnite *Belemnella kazimiroviensis* (SKOŁOZDRÓWNA, 1932). In Poland, the FAD of *M. terminus* is distinctly higher than that of *B. kazimiroviensis*, the latter species first appearing in the upper portion of marls underlying the Kazimierz Opoka.

INTRODUCTION

At present, there is no standard ammonite zonation of the Maastrichtian Stage (for reviews see HANCOCK 1991, KENNEDY 1993, SMITH & *al.* 1995), although recently the FAD (first appearance datum) of *Pachydiscus* (*P.*) *neubergicus* (VON HAUER, 1858) was accepted as the provisional marker of the base of the stage (ODIN & *al.* 1996). Recently proposed zonations, based mainly on representatives of the family Pachydiscidae SPATH, 1922, appear to have potential for future subdivisions of the Maastrichtian (WIEDMANN 1988, HANCOCK & KENNEDY 1993, WARD & KENNEDY 1993, IVANOV & STOYKOVA 1994, YAZIKOVA 1994, WARD & ORR 1997).

The recently established species, *Anapachydiscus terminus* WARD & KENNEDY, 1993, based on material from the Bay of Biscay sections of SW France and northern Spain, is the index of the latest Maastrichtian *Anapachydiscus terminus* Total Range Zone (WARD & KENNEDY 1993). The species has subsequently been referred to the genus *Menuites* SPATH, 1922, by HANCOCK & KENNEDY (1993) and JAGT (1995b, 1996), following COBBAN & KENNEDY's views (1993) that the genera *Anapachydiscus* and *Menuites* represented a dimorphic pair, and that the latter name had priority.

Menuites terminus has been identified at a number of Upper Maastrichtian localities in Europe: from Denmark (BIRKELUND 1993, WARD & KENNEDY 1993), the Maastrichtian type area (JAGT 1995a, b, 1996), and Bulgaria (IVANOV 1995, IVANOV & STOYKOVA 1994, 1995). It is also reported from Azerbaijan (WARD & KENNEDY 1993). The record of *Anapachydiscus* cf. *terminus* from the uppermost Maastrichtian of central Poland (MARCINOWSKI & RADWAŃSKI 1996) is based on a misidentification of a form similar to *Pachydiscus (P.) jacquoti* SEUNES, 1890 (MACHALSKI 1996).

The aim of the present paper is to provide a detailed description as well as taxonomic and stratigraphical discussion of hitherto recorded specimens of *M. terminus* from the SE Netherlands (JAGT 1995b, 1996) and of newly collected and/or recognised material from central Poland.

Specimens from the Netherlands are housed in the collections of the Natuurhistorisch Museum Maastricht (abbreviated NHMM), while Polish material is in the Museum of the Earth of the Polish Academy of Sciences (abbreviated VIII Mc), the Institute of Paleobiology of the Polish Academy of Sciences (abbreviated ZPAL) and in the private collection of Messrs T. PRASZKIER and K. DEMBICZ (students of the Department of Geology, Warsaw University).

PROVENANCE OF THE MATERIAL

The Netherlands

The specimens of *M. terminus* from the Netherlands reported herein come from the type area of the Maastrichtian Stage near Maastricht (Text-fig. 1), more precisely from the Meerssen Member of the Maastricht Formation (for general geological background and correlation of the key outcrops *see* FELDER 1975, KENNEDY 1987, JAGT 1995a, b, 1996, *in press*, and JAGT & *al.* 1996). The Meerssen Member, composed mainly of bioclastic calcarenites interrupted by several omission surfaces, is mainly of Late Maastrichtian age and represents the *Belemnitella junior* and *Belemnella kazimiroviensis* zones of the standard European scheme (*see* KENNEDY 1987 and literature quoted therein). The topmost unit of the Meerssen Member, IVf-7, is of Danian age according to recent investigations (*see* summary in SMIT & BRINKHUIS 1996).

Two specimens of *M. terminus* are known so far from the Meerssen Member. The better preserved one (NHMM 1993092) comes from the base of section IVf-4 of this member at Blom quarry (Text-fig. 1). The original specimen is in the private collection of Mr Martin Blom (Berg en Terblijt), NHMM 1993092 representing a plaster cast.

The other specimen, NHMM 001014, referred by KENNEDY (1987, pp. 174-175) to *Anapachydiscus fresvillensis* (SEUNES, 1890) is from the ENCI Maastricht BV quarry. It lacks precise stratigraphical location, but the yellowish-white, coarse-grained matrix suggests that it came from the middle/upper portion of the Meerssen Member (sections IVf-3, IVf-4 or base of IVf-5; *see* Text-fig. 1) rather than from the Nekum Member as claimed by KENNEDY (1987).

Poland

The Polish material of *Menuites terminus* comes from the Kazimierz Opoka, an informal lithostratigraphical unit composed of siliceous chalk ("opoka" of Polish workers) and exposed along the Vistula River near Kazimierz Dolny, Central Poland (Text-fig. 2). The Kazimierz Opoka is of Late Maastrichtian age, representing the *Belemnella kazimiroviensis* Zone (*see* ABDEL-GAWAD 1986; RADWAŃSKI 1996; MACHALSKI 1996 for reviews of the fossils and stratigraphy of the unit). The Kazimierz Opoka is underlain by unnamed marls (Text-fig. 2), the bulk of which represent the *Belemnitella junior* Zone, the uppermost portion belonging already to the *Belemnella kazimiroviensis* Zone (*see* KONGIEL 1962).

The specimens studied, three in total, come from the upper part of the Kazimierz Opoka of the Nasiłów Quarry (Text-fig. 2). The section exposed in this quarry comprises about 15 m of siliceous chalk capped by an indurated limestone layer, the top of which is strongly burrowed. This layer ("hardground" of authors) is overlain by a greensand, the age of which is still a subject of controversy (*see* MACHALSKI & WALASZCZYK 1987 for review). Recent investigations suggest that 1) the indurated limestone layer is not a hardground; 2) the greensand is entirely of Danian age (MACHALSKI, *in preparation*).

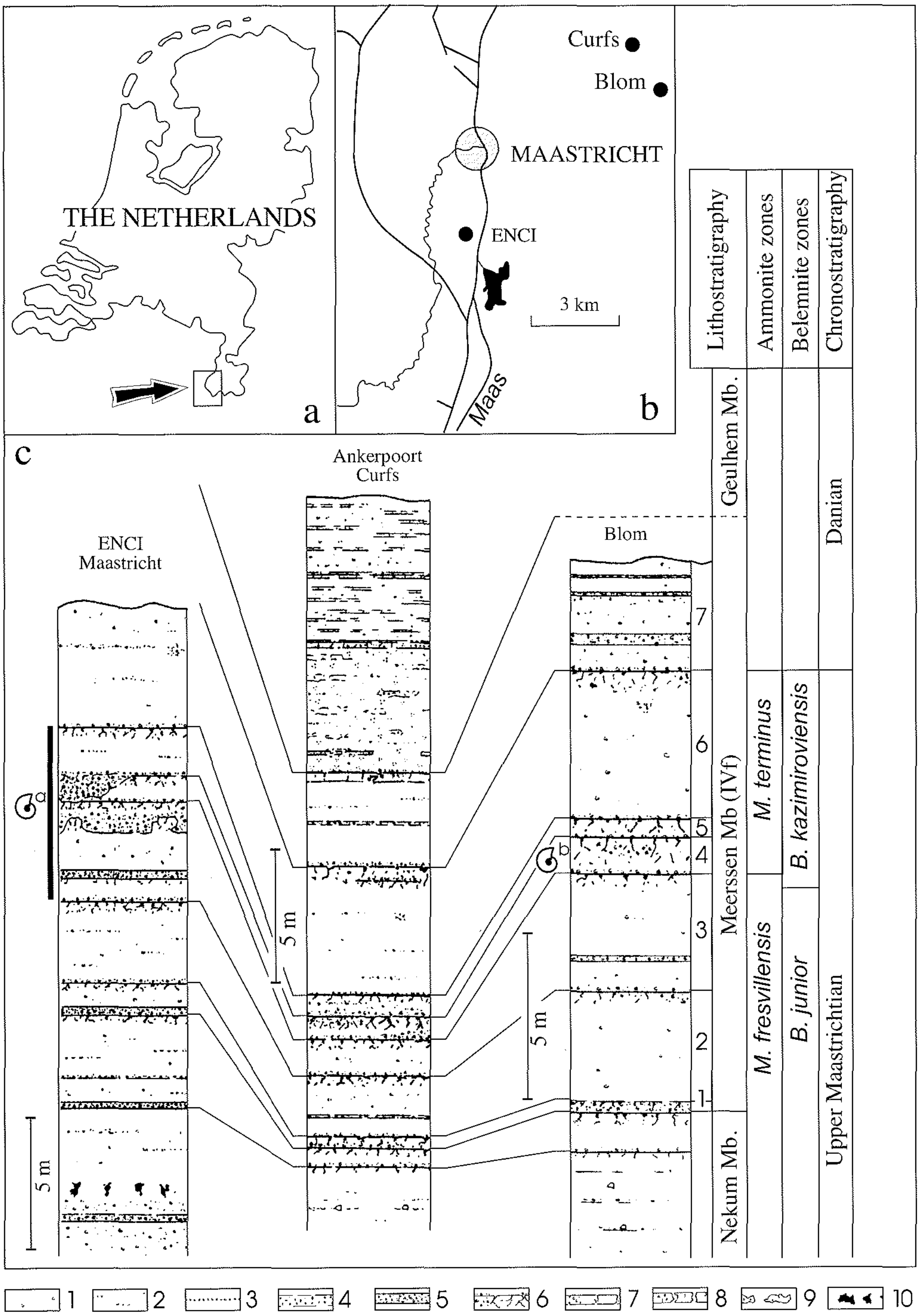

Fig. 1. Location of three Upper Maastrichtian key sections in The Netherlands (a) and in the Maastricht area (b), and detailed stratigraphy of these sections (c), which expose the upper part of the Maastricht Formation (Nekum and Meerssen members) and overlying lower portion of the Houthem Formation (Geulhem Member); correlations and stratigraphy based on JAGT *& al.* (1996); indicated is the provenance of the studied specimens of *Menuites terminus* (WARD & KENNEDY, 1993) (a – NHMM 001014, b – NHMM 1993092); explanations: 1 – scattered fossils, 2 – fossil hash lenses, 3 – thin fossil hash layer, 4 – poorly delimited fossil hash layer, 5 – well delimited fossil hash layer, 6 – hardground with burrows and borings, 7 – continuous indurated layer with or without fossils, 8 – discontinuous indurated layer with or without fossils, 9 – nodules with or without fossils, 10 – irregular flints; calcarenites are the dominant lithology in these sections

The specimen MZ VIII Mc 1426 was not precisely located within the sequence. However, the matrix of the specimen indicates it to be from the opoka below the indurated limestone. The same applies to the specimen collected by Messrs PRASZKIER and DEMBICZ.

Specimen ZPAL Am. XII/500, found by Mr M. ZAPALSKI, Warsaw, is precisely located, coming from the indurated limestone at the top of the Kazimierz Opoka.

SYSTEMATIC ACCOUNT

Terminology and measurements: This follows ARKELL & *al.* (1957); D = diameter, Wb =

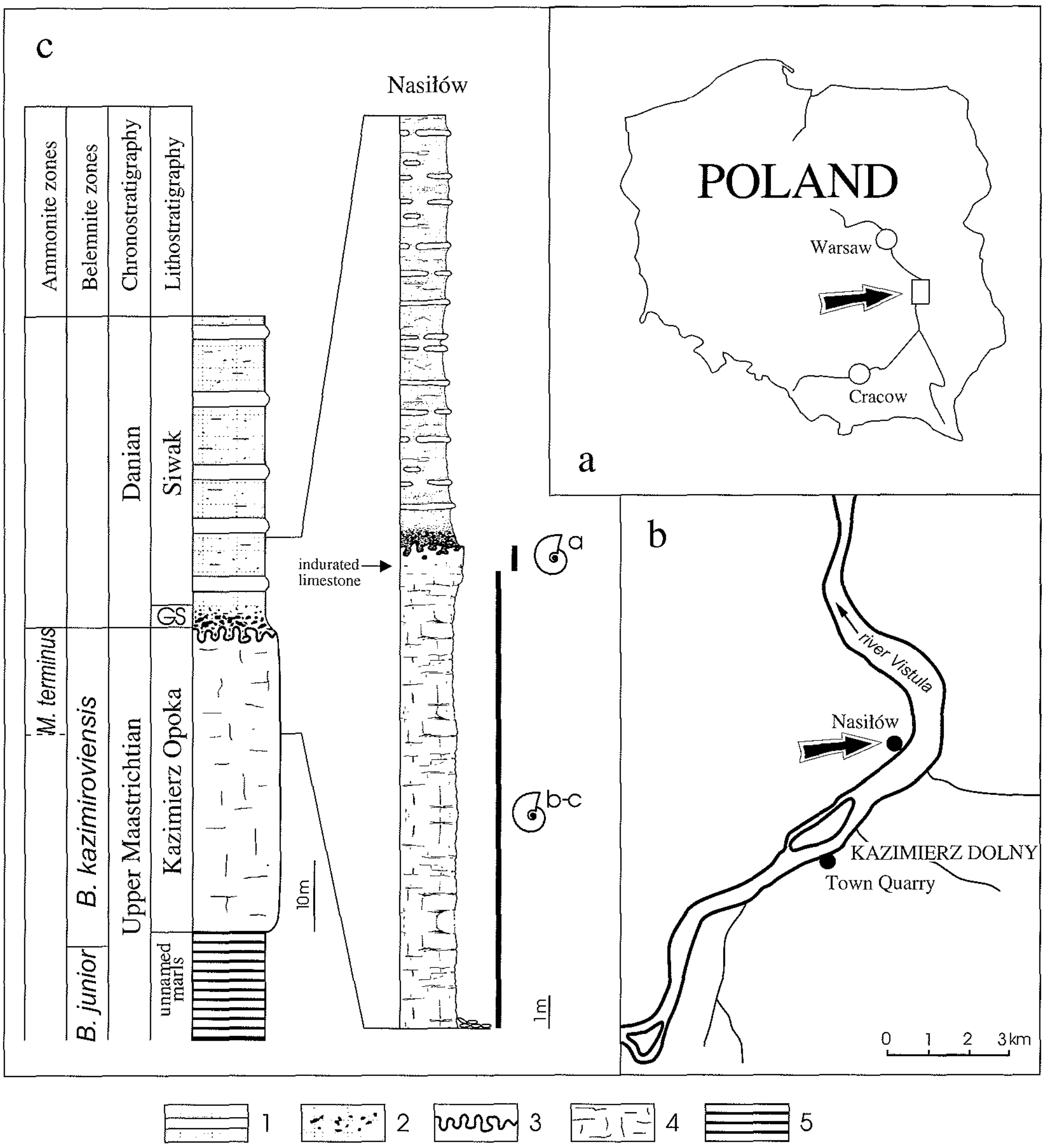

Fig. 2. Location of the Nasiłów section in Poland (a) and in the Kazimierz Dolny region (b), and detailed stratigraphy of the section against the general succession of the Upper Maastrichtian and Danian strata in the Kazimierz Dolny region (c); indicated is the provenance of the studied specimens of *Menuites terminus* (WARD & KENNEDY, 1993)(a – ZPAL Am. XII/500, b & c – MZ VIII Mc 1426 and the specimen in the PRASZKIER & DEMBICZ collection); explanations: **GS** – greensand, **1** – sandy gaizes with limestone intercalations, **2** – greensand with phosphorite nodules, **3** – burrowed surface of the indurated limestone layer, **4** – siliceous chalk (opoka), **5** – marls; the stratigraphy is based on data presented by KONGIEL (1962), ABDEL-GAWAD (1986), RADWAŃSKI (1996), MACHALSKI (1996), MACHALSKI (*in preparation*), and on the literature cited therein

whorl breadth, Wh = whorl height, U = umbilicus, Rv = number of ventral ribs per whorl. All dimensions are given in millimetres, with figures in parentheses being dimensions as a percentage of diameter. The measurements of the investigated specimens are given in Table 1.

Family Pachydiscidae SPATH, 1922

Genus *Menuites* SPATH, 1922
(= *Anapachydiscus* YABE & SHIMIZU, 1926;
Neopachydiscus YABE & SHIMIZU, 1926;
Besairites COLLIGNON, 1931;
Cobbanoscaphites COLLIGNON, 1969)

Type species: *Ammonites menu* FORBES, 1846, by original designation.

Menuites terminus
(WARD & KENNEDY, 1993)
Text-figs 3-5, Pls 1-3

1993. *Anapachydiscus terminus* n.sp.; P. WARD & W.J. KENNEDY, p. 48, Figs 39.2; 40.1,3,5-7, 9; 41.
1993. *Anapachydiscus* aff. *fresvillensis* (SEUNES, 1890); T. BIRKELUND, p. 49, Pl. 4, Figs 3-6; Pl. 5; Pl. 6, Figs 1-4; Pl. 7.
1995. *Anapachydiscus terminus* WARD & KENNEDY, 1993; M. IVANOV, p. 71, Pl. 2, Fig.1.
non 1996. *Anapachydiscus* cf. *terminus* WARD & KENNEDY, 1993; R. MARCINOWSKI & A. RADWAŃSKI, p. 138, Pl. 2.
? 1996. *Pachydiscus (Pachydiscus) gollevillensis* (D'ORBIGNY, 1850); R. MARCINOWSKI & A. RADWAŃSKI, p.138, Pl. 1.
1996. *Menuites terminus* (WARD & KENNEDY, 1993); J.W.M. JAGT, p. 154, Fig. 2.

DESCRIPTION:
Material from The Netherlands: NHMM 1993092 represents an internal/composite mould of a phragmocone and *ca.* 120° whorl of body chamber (Pl. 1, Figs 1-4; Table 1), and is apparently uncrushed and undistorted. Coiling involute, with the small, deep umbilicus comprising *ca.* 15% of total diameter, and with *ca.* 67% of the previous whorl covered in middle growth stages, but *ca.* 50% on the body chamber. The umbilical wall is very high and slightly undercut, the umbilical shoulder rather abruptly rounded. The whorl section (Wb/Wh body chamber = 0.92; Wb/Wh phragmocone = 0.95) is moderately depressed, trapezoidal, the greatest breadth apparently being just above the umbilical shoulder (Text-fig. 5a). The inner flanks are gently inflated, the outer flanks flattened and convergent to the broadly rounded venter.

The ornament on the earliest visible whorls starts with broad, strong prorsiradiate ribs with wide interspaces, which arise on the umbilical shoulder, and curve forwards at mid-flank. The sediment plug covering the inner whorls was removed and showed the presence of close-set growth lines of varying strength, best developed on the inner flank/umbilical shoulder, prorsiradiate, broadest and shallowest on the outer flank/ventrolateral shoulder. At D = 85, the ornament consists of prorsiradiate ribs arising singly at the umbilical shoulder with a faint bulla-like thickening, with a tendency to bifurcate at mid-flank, with 1-2 intercalatories of comparable strength or slightly weaker at mid-flank, and curving gently forwards at mid-flank, but flexing forwards more markedly on the outer flank, and crossing the venter in a broad convexity. The estimated total of ribs visible on the composite mould (Pl. 1, Fig. 4) amounts to 60-65 per whorl (D > 250). On the younger part of the phragmocone and on the body chamber, ribs tend to efface on the inner and middle flank (at D around 160), being visible only on the outer flank and ventrolateral shoulder, where they are most pronounced. The internal mould (Pl. 1, Fig. 1) shows only very faint ribs, and on the early portion of the body chamber only the strongest are visible, which are wide apart. The body chamber comprised at least *ca.* 300° whorl (Pl. 1, Fig. 4).

The specimen has some adnate oyster spat, as well as fully-grown specimens (Pl. 1, Figs 1-3), and a few bioimmured bryozoans.

NHMM 001014 is a composite mould of half a whorl of phragmocone (Text-fig. 3a, b; Table 1), still partially embedded in an indurated biocalcarenitic matrix, and is apparently uncrushed. In general, preservation is rather poor, but it can be seen that the umbilicus, which is sediment infilled, is deep with a high umbilical wall and rather abruptly rounded shoulder. The whorl section is moderately depressed, trapezoidal, with the greatest breadth just above the umbilical shoulder (Text-fig. 5b). The inner flanks are gently inflated, the outer flanks flattened and convergent to a broadly rounded venter (Text-fig. 3b).

The ornament consists of broad, strong prorsiradiate ribs with wide interspaces, which arise

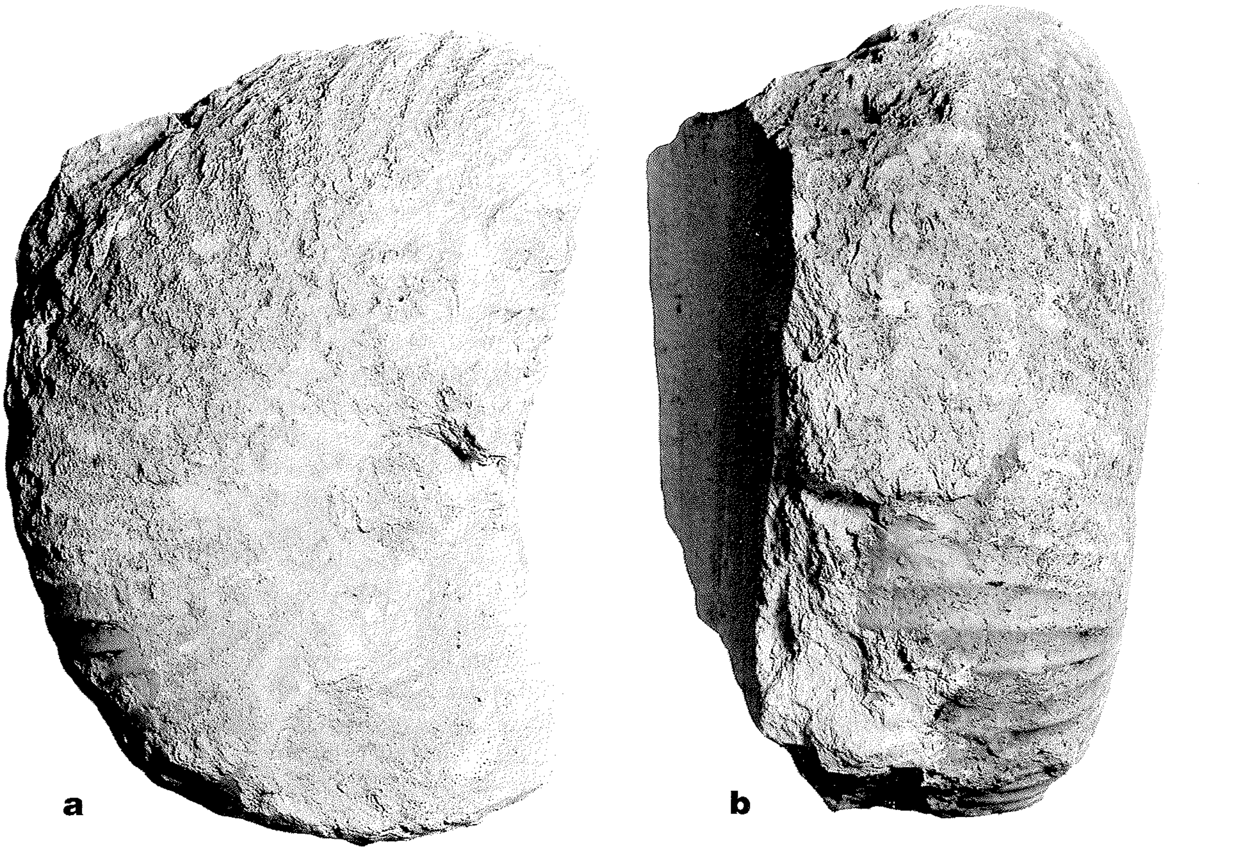

Fig. 3. *Menuites terminus* (WARD & KENNEDY, 1993), NHMM 001014; ENCI Maastricht BV quarry, Maastricht; Maastricht Formation, Meerssen Member (middle/upper part); **a** – lateral view; **b** – ventral view; × 0,55

Specimen	Dmax	Wb	Wh	Wb/Wh	U	Rv	Remarks
NHMM 1993092	315 (100)	143 (45.4)	155 (49.2)	0.92	48 (15.2)	60-65	
NHMM 001014	ca.190 (100)	ca.100 (52.6)	97 (51.0)	ca. 1.03	32 (16.8)	ca.60	
MZ VIII Mc 1426	290 (100)	80 (27.6)	142 (49)	0.56	49 (16.9)	ca.85	specimen strongly distorted laterally
PRASZKIER & DEMBICZ collection	300 (100)	104 (34.7)	145 (48.3)	0.72	56 (18.7)	–	
ZPAL Am. XII/500	–	72	87	0.83	–	–	fragmentary specimen
EMP A1186	148 (100)	72 (48.6)	77 (52.0)	0.94	31 (21.1)	ca.40*	lectotype of *M. fresvillensis* (see KENNEDY 1986, p. 44)
16/101	237 (100)	68 (28.7)	120.5 (50.8)	0.56	38.5 (16.2)	ca.70*	holotype of *P. haueri sersenis* (ATABEKYAN & AKOPYAN 1969, p. 17)

* taken from the photograph

Table 1. Measurements of the studied specimens of *Menuites terminus* (WARD & KENNEDY, 1993) in comparison with those of the types of *M. fresvillensis* (SEUNES, 1890) and *P. haueri sersensis* ATABEKYAN & AKOPYAN, 1969 [taken from KENNEDY (1986) and ATABEKYAN & AKOPYAN (1969), respectively]

singly at the umbilical shoulder and show a faint bulla-like thickening. Ribs show a tendency to bifurcate at mid-flank, with 1-2 intercalatories of comparable strength or slightly weaker. These ribs flex forward more clearly on the outer flank (Text-fig. 3a) and cross the venter in a broad convexity (Text-fig. 3b). There are *ca.* 29 ribs per half whorl, giving a total rib number per whorl of *ca.* 60.

Material from Poland: Specimen MZ VIII Mc 1426 (Pl. 2, Figs 1-4; Table 1) is the best preserved of the Polish specimens discussed herein; it is a composite mould of a phragmocone (D max = 290), laterally strongly compressed. Coiling involute, the umbilicus comprising *ca.* 17% of the diameter, with *ca.* 73% of the previous whorl covered. Whorl section is compressed (Wb/Wh = 0.56), high-ovate, significantly influenced by *post mortem* deformation of the specimen (Text-fig. 5f). The umbilical wall is high and the umbilical shoulder abruptly rounded (this is well visible at D between 160 and 235, being obliterated by deformation in the remaining part of the specimen). The greatest breadth of the last preserved whorl is above the umbilical shoulder, at a distance approximately 20% whorl height out from the umbilical shoulder.

The ornament consists of umbilical bullae and ribs. The bullae, visible on the inner whorls of the specimen, disappear gradually at the beginning of the last preserved whorl. The ribs are narrow and prorsiradiate, rounded, separated by wider interspaces. Primaries arise at the umbilical shoulder, and may be single or branch. Secondaries intercalate at various points on the flank, giving a total of about 85 (estimated due to absence of some portions of the specimen) ventral ribs on the last whorl. Starting from a diameter of about 180 mm, flank ribbing effaces progressively and the shell is ornamented with ventrolateral and ventral ribs only. These tend to efface towards the aperture but are still visible almost to the end of the last preserved whorl.

The specimen in the PRASZKIER & DEMBICZ collection (Pl. 3, Figs 1-4; Table 1) is not so well preserved as MZ VIII Mc 1426. It is an internal mould with traces of ornamentation visible only on one side (*compare* Pl. 3, Fig. 1 *and* Pl. 3, Fig. 4). The specimen comprises the phragmocone

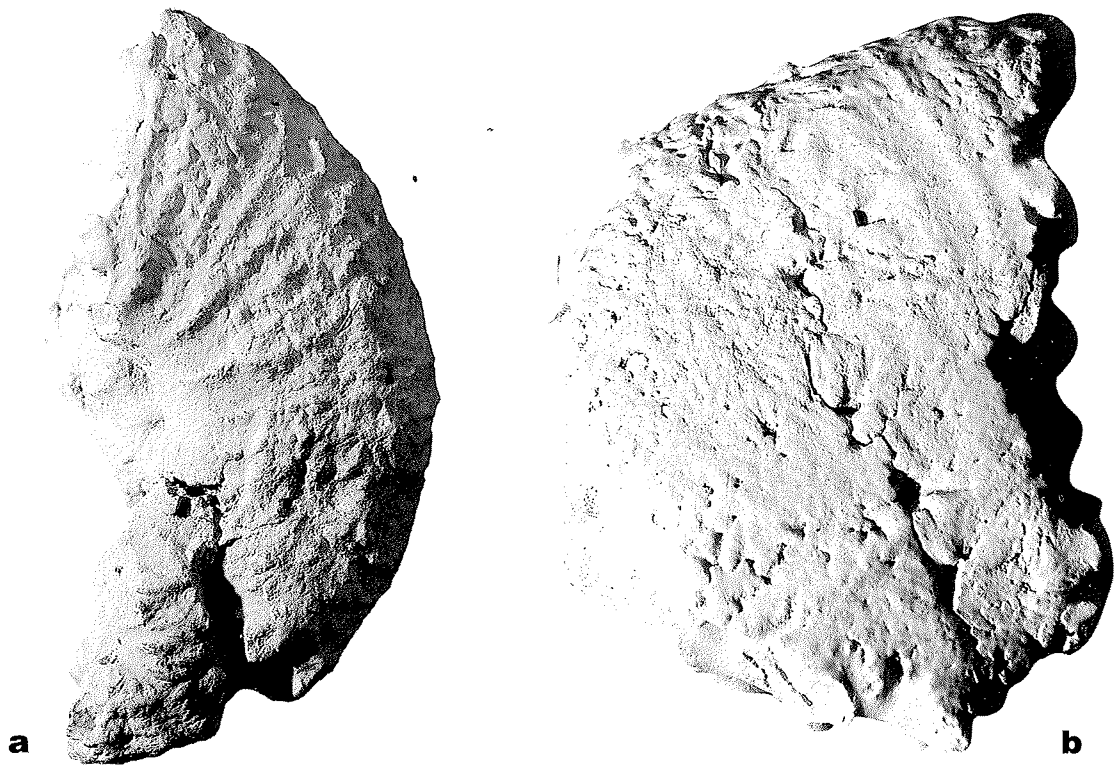

Fig. 4. *Menuites terminus* (WARD & KENNEDY, 1993), ZPAL Am. XII/500; Nasiłów quarry, indurated limestone layer at the top of the Kazimierz Opoka unit; **a** – half of the smaller whorl in lateral view, **b** – fragment of the larger whorl in lateral view; × 1

and a small portion of the body chamber (Pl. 3, Fig. 4). It appears to be only slightly deformed and thus approximates to the original shell proportions. Only the last part of the last preserved whorl seems to be significantly distorted. Coiling is involute, the deep umbilicus comprising *ca.* 19% of the maximum diameter, the last whorl covering *ca.* 74% of the previous one. Cross section of the last whorl, taken at D = 260, is oval (Text-fig. 5e; Wb/Wh = 0.72). The umbilical wall high and the umbilical shoulder rounded. The position of the greatest breadth of the last whorl cannot be assessed precisely due to the slight asymmetry of its cross section (Text-fig. 5e); it seems that it is

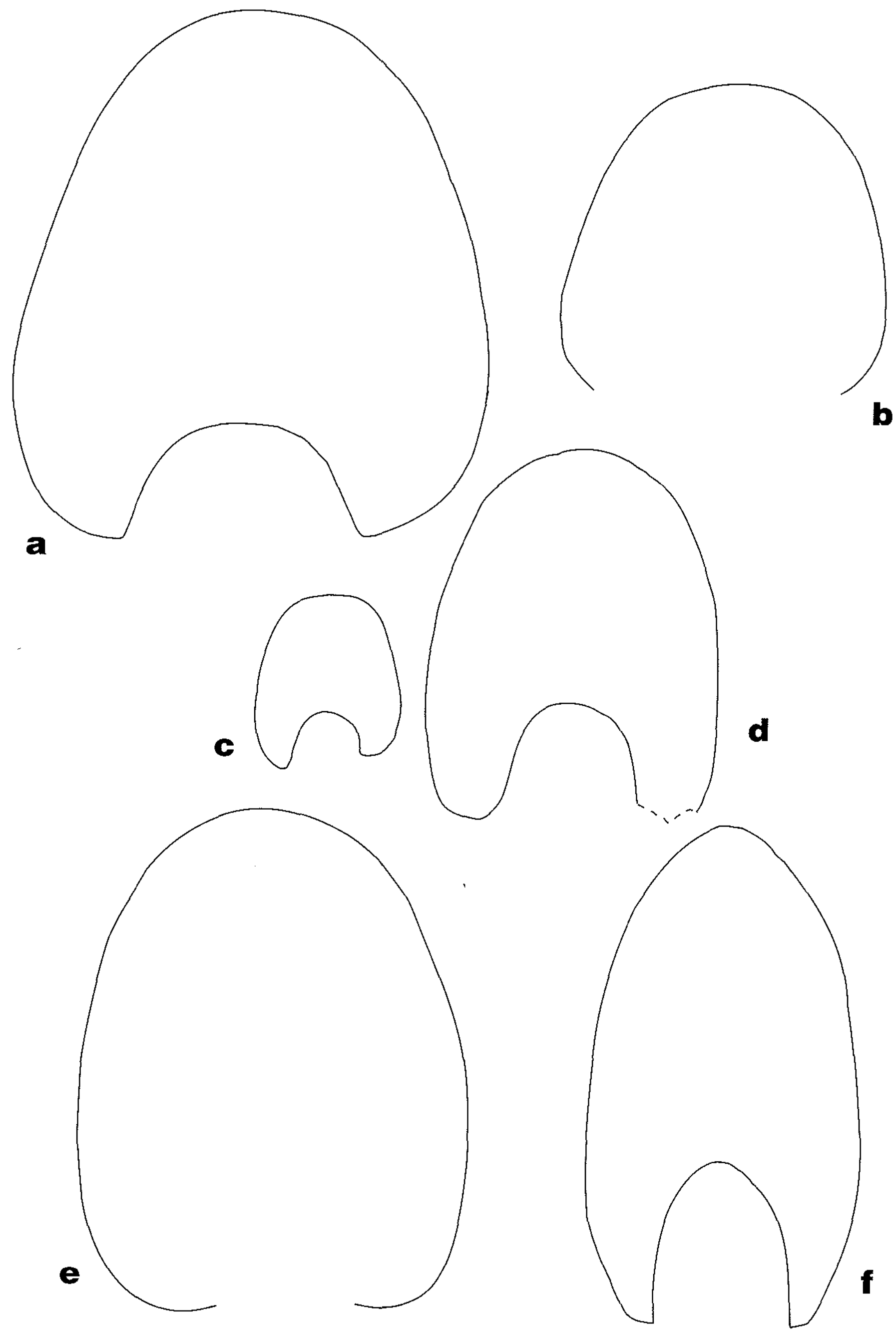

Fig. 5. *Menuites terminus* (Ward & Kennedy, 1993), whorl sections; **a** – NHMM 1993092, at D = 315, **b** – NHMM 001014, at D = 190; **c-d** – ZPAL Am. XII/500, c taken at D = 100; **e** – specimen from the Praszkier & Dembicz collection, at D = 260; **f** – MZ VIII Mc 1426, at D = 300; all whorl sections × 0.45

at a distance corresponding to 20 or 25% of the whorl height from the umbilical shoulder.

One side of the specimen retains traces of ornament (Pl. 3, Fig. 1), while the other shows the suture only (Pl. 3, Fig. 4). As preserved, the ornament consists of distinct umbilical tubercles and bullae (which are visible on the exposed parts of the inner whorls) and of ventrolateral and ventral ribs on the first quarter of the last preserved whorl, being approximately present up to a diameter of 180 mm. The number of the preserved ribs is *ca*. 16. Provided that the ribs were actually present on the entire whorl the inferred number of ribs in the last whorl should be 68.

The ornament-bearing side of the specimen shows numerous sediment-filled borings of clionid sponges and "worms" which probably obliterated the original sculpture.

ZPAL Am. XII/500 (Text-fig. 4a-b; Table 1) consists of two fragments of a phragmocone in a composite mould preservation: one half of a whorl (D = 100) with a fragment of the preceding whorl preserved (Text-fig. 4a) and a small fragment of a larger whorl (Text-fig. 4b), both belonging originally to a single specimen, broken during the extraction, according to the collector.

The half whorl is rather worn and slightly deformed obliquely to the mid axis of the conch. The original cross section of the whorl seems to have been trapezoidal (Wb/Wh = 0.95) at maximum preserved diameter (D = 100), with the maximum breadth just above the umbilical shoulder (Text-fig. 5c). The ornament consists of narrow prorsiradiate ribs with wider interspaces. The ribs arise singly with bullae at the umbilical shoulder and tend to bifurcate on the inner flank, with some less strong intercalatories added at mid-flank, giving in total *ca*. 20 ribs on the ventral side, allowing an estimate of Rv = 40 at D = 100.

The fragment of larger whorl (Text-fig. 4b) is compressed oval in cross-section (Text-fig. 5d) and densely ribbed. There are *ca*. 8 ribs visible. As the fragment represents approximately 45° of the whorl, this allows calculation of the total number of ribs per whorl in the original specimen to be *ca*. 64.

DISCUSSION: As the type material of *M. terminus* is crushed and distorted, the original diagnosis of this species as given by WARD & KENNEDY (1993, p. 48) is based mainly on the ribbing pattern: "A large species of *Anapachydiscus* in which early and middle growth stages have 60 or more crowded flexuous prorsiradiate ribs per whorl". This diagnosis, however, disregards the ontogenetic changes in the ribbing pattern in *M. terminus*. This is evident from illustrations of the specimens of *M. terminus* from the Biscay region (WARD & KENNEDY 1993, Figs 40.1,3,5-7), which show up to 40 ribs per whorl in early stages. *M. terminus* does not differ very much at this growth stage from *M. fresvillensis* (SEUNES, 1890), which seems to be its closest ally in the European Maastrichtian (compare *M. fresvillensis* in WARD & KENNEDY 1993, Fig. 40.8 and *M. terminus* in WARD & KENNEDY 1993, Fig. 40.7). Starting from middle ontogenetic stages, corresponding to diameters in excess of 110 mm, *M. terminus* may acquire denser ribbing, around 60 per whorl, as exemplified by the holotype (WARD & KENNEDY 1993, Fig. 39.2). Some of the specimens of *M. terminus* representing the middle growth stage, however, show fewer ribs, e.g. that with *ca*. 50 ribs at a diameter around 110 mm from the Biscay region in WARD & KENNEDY (1993, Fig. 40.9). This seems to reflect the natural variation of this species. The largest specimens of *M. terminus* from the Biscay region with diameter more than 350 mm, are said to have over 60 ribs per whorl, although the ribbing weakens or effaces totally towards the adult aperture in these specimens (WARD & KENNEDY 1993).

Based on the above discussion of the type material, we propose a new, albeit provisional diagnosis of the species: "*M. terminus* is a large species of *Menuites* in which the number of ribs per whorl increases during ontogeny, with around 60 ribs in middle and late growth stages. The ribs at these stages are crowded, flexuous, and prorsiradiate". All identifications of the species should be based first of all on a comparison with its type and topotypical material from the Biscay region.

The most important diagnostic features of *M. terminus* are style and density of ribbing. The specimens from the Netherlands have around 60 ribs per whorl at the middle (specimen NHMM 001014) and late growth stages (NHMM 1993092) and thus fit the diagnosis very well. The rib number in late growth stages in two of the Polish specimens (that in the DEMBICZ & PRASZKIER collection and ZPAL Am. XII/500) also correspond to the figures given by WARD & KENNEDY (1993) for the Bay of Biscay material. The third of the Polish specimens, MZ VIII Mc 1426 (Pl. 2), has about 85 ribs and this figure exceeds that given for the largest specimens of

M. terminus from the Biscay region (WARD & KENNEDY 1993). However, one of the specimens from the White Chalk succession in Denmark seems to be exceptionally densely ribbed, having around 80 ribs per whorl at the diameter of about 130 mm (BIRKELUND 1993, Pl. 6, Fig. 1). It is thus reasonable to treat MZ VIII Mc 1426 as a densely ribbed specimen of *M. terminus*. An increase in ribbing density during growth from about 40 to 64 in specimen ZPAL Am. XII/500 is also consistent with the trend observed in the type material of *M. terminus*.

According to WARD & KENNEDY (1993), the flank ribbing in the Bay of Biscay material of *M. terminus* declines progressively from 120 mm diameter onwards, and the adult shells are ornamented by closely spaced ventrolateral and ventral ribs only. In MZ VIII Mc 1426, the ribbing on the flanks effaces at a later stage (at D = 180) than in material from the Bay of Biscay sections (Pl. 2). The two remaining specimens from Nasiłów are not sufficently well preserved to determine whether or not this is a typical feature of the Polish material. The better of the Maastricht specimens, NHMM 1993092, is intermediate in this respect between the Bay of Biscay and the Polish specimens as its flank ribs efface at D = *ca*. 160 (Pl. 1).

Nothing certain is known about the original shell proportions, especially whorl cross section, of the type material of *M. terminus* from the Bay of Biscay sections. No comparison with the material studied herein is thus possible. It should be noted, however, that the specimens from The Netherlands appear more massive, with trapezoidal cross section, while those from Poland are more compressed and have rather ovate whorl sections (*see* Text-fig. 5, Table 1). The Maastricht material is closely comparable in this respect to *M. fresvillensis* (*e.g.* KENNEDY 1986, 1987; *see also* Table 1). The lack of data on the variation in whorl section in the type material does not allow the significance of these differences to be evaluated.

At this time, we consider all the material studied herein to be best assigned to a single species, *M. terminus*, which could well be more variable than previously thought, with regard to proportions of shell and density and character of ribbing. Future work will have to show whether the taxon may be subdivided into temporal and/or geographic subspecies, but for the moment we have no reason to do so.

It may also be noted that the best of the Polish specimens, MZ VIII Mc 1426, in its retarded effacing of flank ribbing and more compressed shell resembles *Pachydiscus haueri sersensis* ATABEKYAN & AKOPYAN, 1969. The latter is based on a single specimen from the Upper Maastrichtian of Armenia described by ATABEKYAN & AKOPYAN (1969, p. 17; Pl. 8, Fig. 2; Pl. 10, Fig. 1; Pl. 11, Fig. 1; *see* Table 1 for dimensions of the type). KENNEDY & SUMMESBERGER (1986) regarded *Pachydiscus haueri sersensis* ATABEKYAN & AKOPYAN, 1969 as a finely ribbed ally of the early Maastrichtian *Pachydiscus* (*Pachydiscus*) *epiplectus* (REDTENBACHER, 1873). WARD & KENNEDY (1993, p. 48) commented on ATABEKYAN & AKOPIAN's form and stated, on the basis of a cast of the type specimen, that this had an estimated rib number of 50-60 at D = 200 (about 70 in our opinion), but that the inner whorls lacked bullae or spines, and that the ribbing was persistent and much finer at large diameters than in *M. terminus*. Although we have no cast of this species before us, the preservation of ATABEKYAN & AKOPYAN's (1969, Pl. 10, Fig. 1) specimen is such that it cannot be determined whether this form had umbilical bullae or not. It may well be that *P. sersensis* and *M. terminus* turn out to be conspecific after all. This can only be determined on the basis of more, and better preserved material from Poland and Armenia.

Besides the specimens described in this paper there are only two other pachydiscid records in the Kazimierz Opoka, both from its upper part exposed in the Nasiłów section (Text-fig. 2). They were reported by MARCINOWSKI & RADWAŃSKI (1996) as *Anapachydiscus* cf. *terminus* and *Pachydiscus* (*P.*) *gollevillensis* (D'ORBIGNY, 1850). The first specimen is closer to *Pachydiscus* (*P.*) *jacquoti* SEUNES, 1890 and is unrelated to the true *M. terminus* (MACHALSKI 1996). The *P.* (*P.*) *gollevillensis* of MARCINOWSKI & RADWAŃSKI (1996) is based on the same fragmentary specimen which RADWAŃSKI (1985) and MACHALSKI & WALASZCZYK (1988) referred to *Pachydiscus sersensis* ATABEKYAN & AKOPYAN, 1969. We consider the identification by MARCINOWSKI & RADWAŃSKI (1996) to be erroneous; the style of ribbing of typical *P. gollevillensis* (*see e.g.* KENNEDY 1986, 1987; WARD & KENNEDY 1993) is considerably different. The specimen in question is best compared with the material here referred to *M. terminus*, although its fragmentary preservation precludes firm taxonomic assignment.

STRATIGRAPHICAL IMPLICATIONS

The presence of *Menuites terminus* in the Maastricht area and in central Poland enables the recognition in both regions of the highest Maastrichtian ammonite zone, the *M. terminus* Zone as defined by WARD & KENNEDY (1993). In The Netherlands, this zone encompasses the upper portion of the Meerssen Member of the Maastricht Formation (Text-fig. 1), in Poland the upper portion of the Kazimierz Opoka exposed in the Nasiłów section (Text-fig. 2). The index taxon of the preceding ammonite zone, the *M. fresvillensis* Zone, also defined by WARD & KENNEDY (1993), is present in the Nekum Member which underlies the Meerssen Member. It was also reported from the Meerssen Member, but with no precise indication of the level (KENNEDY 1987). JAGT (1995b) mentioned *M. fresvillensis* from the top of the Meerssen Member, but this record (Ankerpoort-Curfs Quarry, top of the unit IVf-6, E. MAGNÉE collection) is based on fragmentary, rather poorly preserved early part of phragmocone, which may belong to *M. terminus*. This taxon has not yet been found in Poland. Unfortunately, no pachydiscids have been found either in the lower part of the Kazimierz Opoka, which is best exposed in the Town Quarry south of Kazimierz Dolny, or in the underlying marls (Text-fig. 2).

In the Biscay region, the *M. terminus* Zone ranges from the upper part of the "Member IV to the top of Member V" (WARD & KENNEDY 1993). The upper portion of the Meerssen Member in The Netherlands and of the Kazimierz Opoka in Poland can be thus correlated with the above units in the Bay of Biscay region.

It is interesting to compare the distribution of *M. terminus* with that of the classic Upper Maastrichtian guide fossil, the belemnite *Belemnella* (*Neobelemnella*) *kazimiroviensis* (SKOŁOZDRÓWNA, 1932). Recent field work at the ENCI Maastricht BV quarry has yielded a specimen of *B. kazimiroviensis* from the top of section IVf-3 (W.M. FELDER collection) of the Meerssen Member (Text-fig. 1). This is the FAD of the taxon known to date in the area, and allows recognition of the lower boundary of the highest Maastrichtian belemnite *Belemnella kazimiroviensis* Zone. As noted by JAGT (1996, *in press*), the FAD of *B. kazimiroviensis* in the type Maastrichtian more or less coincides with the demise of rudistid bivalves and the majority of hermatypic scleractinian corals. This faunal change suggests an incursion of cold-water forms to have occurred in the shallow, subtropical settings represented by the Meerssen Member of the Maastricht Formation.

As the FAD of *M. terminus* in the Maastricht area lies at the base of section IVf-4 (precisely located specimen NHMM 1993092) or even in section IVf-3 (lowest possible location of the unprecisely located NHMM 001014), it seems that the FADs of *M. terminus* and *B. kazimiroviensis* almost coincide in the Maastricht area. This differs from the situation in Poland, where *B. kazimiroviensis* first appears in the topmost marls underlying the Kazimierz Opoka (KONGIEL 1962, Text-fig. 2), and thus significantly below the FAD of *M. terminus*. CHRISTENSEN (1996, 1997a, b) and MACHALSKI (1995, 1996) have recently shown the distribution of the *B. kazimiroviensis* across Europe to be highly diachronous, reflecting its slow westward migration. The near-coincidence of the FADs of *B. kazimiroviensis* and *M. terminus* in the Maastricht area in comparison with the significantly lower position of the former with respect to the latter in Poland, may provide additional support for the documentation of this geographic/temporal trend.

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Plate 1

Menuites terminus (WARD & KENNEDY, 1993)
NHMM 1993092

Blom quarry, Berg en Terblijt
Maastricht Formation, Meerssen Member, base of section IVf-4
1, 4 - lateral views, 2 - ventral view, 3 - apertural view; × 0.35


1
2
3
4

Plate 2

Menuites terminus (WARD & KENNEDY, 1993)
MZ VIII Mc 1426

Nasiłów quarry, upper part of Kazimierz Opoka
1 - ventral view, 2-3 - lateral views, 4 - apertural view; × 0.35


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2
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4

Plate 3

Menuites terminus (WARD & KENNEDY, 1993)
PRASZKIER & DEMBICZ collection

Nasiłów, the upper part of Kazimierz Opoka
1, 4 - lateral views, 2 - apertural view, 3 - ventral view; × 0.4


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4