Geologie en Mijnbouw **75:** 341–347, 1997.

Belemnella (Belemnella) cf. *praearkhangelskii* Naidin, 1964 from the Vijlen Member at Altembroeck (NE Belgium, Early Maastrichtian) *

N. Keutgen
Dienst KCO, Natuurhistorisch Museum, Postbus 882, NL–6200 AW Maastricht, the Netherlands

Received 10 July 1995; accepted in revised form 30 March 1996

Key words: Belemnella sumensis, biometrical analysis, late Early Maastrichtian, Gulpen Formation

Abstract

Biometrical analysis of a *Belemnella* faunule of 264 specimens from interval 0 of the Vijlen Member as exposed at Altembroeck (NE Belgium) shows that most specimens belong to *Belemnella* (*Pachybelemnella*) *sumensis* Jeletzky, 1949, the belemnite index of the early part of the late Early Maastrichtian. *Belemnella* (*Belemnella*) cf. *praearkhangelskii* Naidin, 1964 is restricted to a single level (Bm2). In NW Germany this species is confined to a narrow interval characterizing the middle *sumensis* Zone. It is concluded that the Bm2 level at Altembroeck is of special importance for long-distance correlation between the Vijlen Member and the Maastrichtian in NW Germany. In the Altembroeck section, belemnite guards are enriched at certain levels. The belemnite accumulations probably developed as a result of stratigraphic condensation.

Introduction

Felder & Bless (1994) have recently subdivided the Vijlen Member in its type area near Mamelis (Figure 1) into seven intervals (0–6), and correlated these intervals with the belemnite zones of the Vijlen Member as recognized by Keutgen & van der Tuuk (1991). The base of the member (lower part of interval 0) was dated as early Early Maastrichtian (*obtusa* Zone) and the succession from the top of interval 1 up to interval 6 as late Early and early Late Maastrichtian (upper *sumensis* to *junior* Zones of Keutgen & van der Tuuk 1991). Felder & Bless were unable to correlate the lower and middle *sumensis* Zones with their intervals 0–6, but it is obvious that these subzones are within interval 0 and/or 1.

Part of the lower Vijlen Member is exposed in an abandoned quarry at Altembroeck near 's-Gravenvoeren (Fouron-le-Comte), in the Belgian province of Limburg (Figure 1). It is exposure 62C–159 of the Geological Survey of the Netherlands, co-ordinates 183.500/303.410 (Felder & Bosch 1984). The Vijlen Member at Altembroeck yielded a diverse fauna of molluscs, brachiopods, echinoids and serpulids (Jagt et al. 1995). Judging from the joint occurrence of the ammonites *Hoploscaphites constrictus* (J. Sowerby, 1817) and *Acanthoscaphites tridens* (Kner, 1848), the echinoid *Galerites stadensis* (Lambert, 1911) and the brachiopod *Gisilina gisii* (Roemer, 1841), the Vijlen Member in the Altembroeck outcrop is correlatable with the middle part of the Early Maastrichtian.

The purpose of the present paper is to describe the *Belemnella* fauna of the Vijlen Member as exposed at Altembroeck and to correlate these strata with the intervals of Felder & Bless (1994) and the belemnite zones of Keutgen & van der Tuuk (1991). Belemnites have been shown to be of considerable importance in the biostratigraphic correlation of the Upper Cretaceous in Europe, especially for the Coniacian through Maastrichtian Stages. This study is based upon 264 belemnites collected by the so-called 'Vijlen Werkgroep' between November 1992 and October 1993 at the Altembroeck outcrop. The specimens are now housed in the Natuurhistorisch Museum at Maastricht. The genus *Belemnitella* co-occurs at Altembroeck with *Belemnella*, albeit rarely. *Belemnitella pulchra* Schulz, 1982 and a species closely related to or conspecific with *Belemnitella junior* Nowak, 1913 have been identified.

* Contribution no. 2 of the 'Vijlen Werkgroep', Maastricht.

Figure 1. Locality map showing location of Vijlen Member outcrops at Altembroeck, Bovenste Bos, Friedrichberg, and Mamelis.

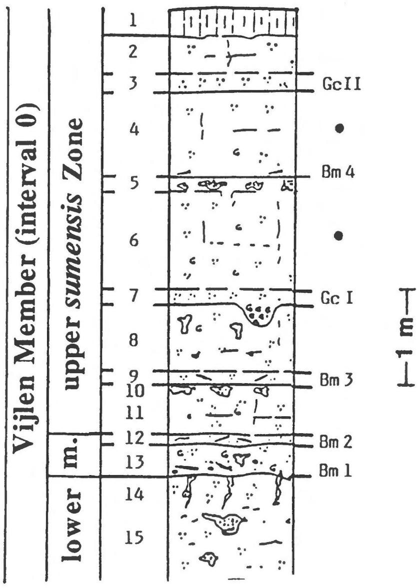

Figure 2. Lithological section of the Altembroeck outcrop (62C–159) with belemnite-bioclast peaks (●) and belemnite zonation. After Jagt et al. (1995: fig. 2). Bm = belemnite-rich bed, Gc = glauconite-rich bed, m = middle.

Lithostratigraphy

Figure 2 shows the lithological log of 5.5 m of Vijlen Member, the base of the member being about 14.5 m below the Altembroeck section. The profile was taken by W.M. Felder and J. Reynders (see Jagt et al. 1995). The lithological units are numbered 1 to 15 from top to base.

1	0.25 m	forest soil with stones.
2	0.35 m	light grey weathered marlstone with glauconite.
3	0.20 m	light grey marlstone, glauconite common (GcII).
4	0.85 m	light grey marlstone with glauconite and belemnites at its base (Bm4).
5	0.15 m	light grey marlstone with glauconite and some small light grey flints.
6	1.00 m	light grey marlstone with glauconite.
7	0.15 m	light grey marlstone, glauconite common. At the base two pockets filled with fossils were found (GcI).
8	0.70 m	light grey marlstone with glauconite and some small light grey flints.
9	0.15 m	light grey marlstone; glauconite and belemnites common (Bm3).
10	0.10 m	light grey marlstone with glauconite and some small light grey flints.
11	0.40 m	light grey marlstone with glauconite.
12	0.15 m	light grey marlstone with glauconite and local belemnite concentrations (Bm2).
13	0.30 m	light grey marlstone; glauconite and fossils are common. Belemnites are enriched at the base (Bm1). Vertical burrows, preserved as hardly visible grey flints, penetrate this unit. The burrows start from the base of unit 12 (Bm2), but do not reach the Bm1 level.
14	0.30 m	light grey marlstone with glauconite and frequent vertical flint-filled burrows.
15	0.80 m	light grey marlstone with glauconite and some small light grey flints.

The bases of the levels Bm1, Bm2, Bm3, Bm4, GcI, and GcII are distinct and irregularly developed. They represent evidence of non-deposition, for example boreholes or pockets extending into the underlying deposits, or fossil accumulations. Two prominent belemnite-bioclast peaks occur within the units 4 and 6. According to P. J. Felder (in Jagt et al. 1995), the exposed section of the Vijlen Member at Altembroeck was deposited in a high-energy shallow-marine environment.

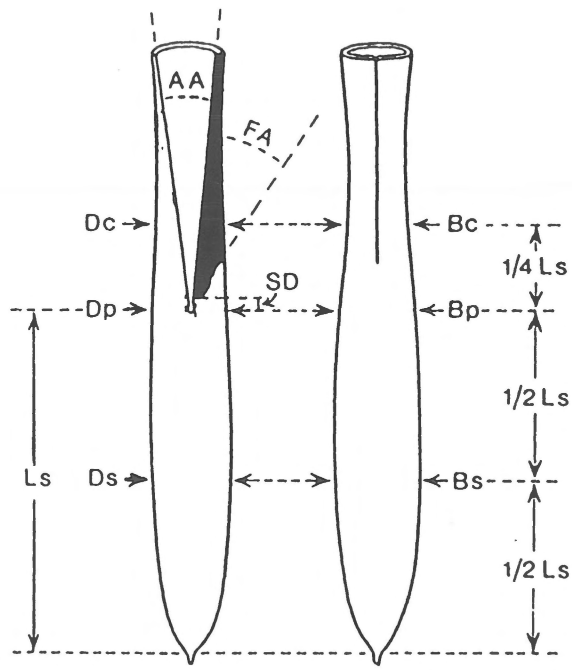

Figure 3. Diagram illustrating morphological elements of the belemnite guard (ventral view at right, lateral view of a split guard at left). AA = alveolar angle. FA = fissure angle. SD = Schatzky distance. Ls = length from apex to protoconch. D = dorso-ventral diameter. B = lateral diameter. After Christensen (1987: fig. 1).

Systematic description

Genus *Belemnella* Nowak, 1913

Schulz (1979) studied the genus *Belemnella* from the Lower Maastrichtian of NW Europe in great detail and introduced a set of parameters for identifying species of the genus. The Schatzky distance (SD) is defined as the distance between the anterior part of the protoconch and the posterior end of the ventral fissure measured along the axis of the guard (Figure 3). The fissure angle (FA) is the angle between the wall of the alveolus and the straight line connecting the intersection points of the bottom of the ventral fissure on the wall of the alveolus and the outer margin of the guard. The alveolar angle (AA) is the angle of the alveolus wall measured in the median plane. The alveolar angle is measured in the anterior part of the alveolus. Schulz (1979) stressed the importance of the shape of the guard in ventral view compared to the length from apex to protoconch (Ls). In order to compare specimens of different size he introduced the term standardized length (Lsn):

$Lsn = Ls + WQs(13.5 - Dp)$ in mm, where D is the dorso-ventral diameter (Figure 3).

The shape of the guard is defined by two indices (AV, AL):

$AV = (Bs - Bc)/Bp$ in %, where B is the lateral diameter (Figure 3),

$AL = (Ds - Dc)/Dp$ in %.

The late-ontogenetic growth quotient (WQs) is calculated on the basis of measurements obtained from growth stages of single specimens:

$WQs = (Ls_2 - Ls_1)/(Dp_2 - Dp_1)$, $(Dp_2 > Dp_1 > 6$ mm$)$.

Subgenus *Belemnella* Nowak, 1913

The genus *Belemnella* is characterized by a long and slender juvenile guard, small Schatzky distance (generally < 4 mm), undulating dorso-lateral double furrows, and the vascular imprints which branch off the dorsolateral furrows posteriorly at an angle exceeding 30°. Species of the subgenus *Belemnella* are very slender ($Lsn > 0.4AV + 60$).

Belemnella (*Belemnella*) cf. *praearkhangelskii* Naidin, 1964 (Figure 4)

cf. 1964 *Belemnella sumensis praearkhangelskii* Naidin; p. 95; pl. 2, fig. 7

1979 *Belemnella* (? *Belemnella*) cf. *praearkhangelskii* Naidin, 1964 - Schulz; p. 104; text-fig. 58; pl. 5.

In the Altembroeck section, *B.* cf. *praearkhangelskii* is restricted to the Bm2 level (10 specimens). The species is characterized by a large, slender guard which is slightly to distinctly lanceolate in ventral, and cylindrical to slightly lanceolate in lateral view. The vascular imprints on the surface of the guard are usually faint, but more distinct in adult specimens. The apical angle is usually acute and the mucro is distinct. The Schatzky distance and the alveolar angle are small. The mean values of the diagnostic characteristics are reported in Table 1. The values of Lsn and AV are plotted in Figure 6.

The guards of *B.* cf. *praearkhangelskii* fall outside the range of variation of specimens of *Belemnella* (*Pachybelemnella*) *sumensis* Jeletzky, 1949 from both below and above the Bm2 level at Altembroeck (Figures 5–7). They also fall outside the range of variation of *B. sumensis* from 1) the lower to middle *sumensis* Zone of the Bovenste Bos quarry in the Netherlands (Figure 5), 2) from upper *sumensis* Zone strata near Aachen in western Germany (Keutgen & van der Tuuk 1991), and 3) from the *sumensis* Zone of Kronsmoor

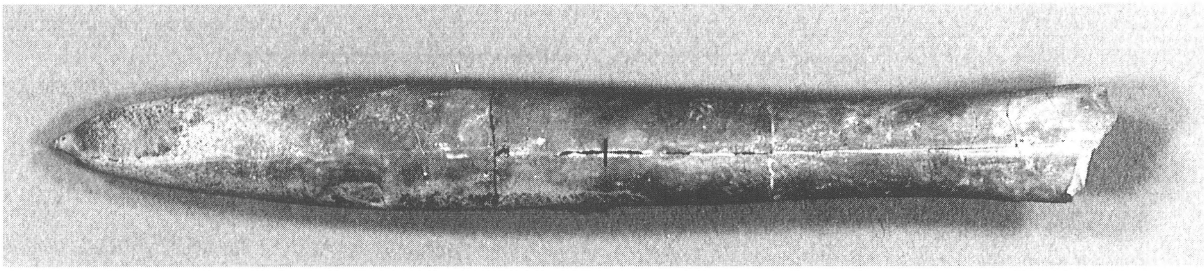

Figure 4. Belemnella (Belemnella) cf. *praearkhangelskii* Naidin, 1964 from the Vijlen Member (Gulpen Formation) at Altembroeck, Bm2 level. Lower Maastrichtian, middle *sumensis* Zone. Ventral view. × 0.92.

Table 1. Mean values of the diagnostic characteristics of *Belemnella (Belemnella)* cf. *praearkhangelski* Naidin, 1964 (Ls = length from apex to protoconch, Dp = dorso-ventral diameter at protoconch, SD = Schatzky distance, AA = alveolar angle, FA = fissure angle, WQs = growth quotient, Lsn = standardized length, AV = shape characteristic of the guard in ventral view, AL = shape characteristic of the guard in lateral view, *n* = number of specimens, ST = standard deviation, OR = observed range).

	n	Mean	ST	OR
Ls (mm)	10	65.2	7.2	56.5 to 79.0
Dp (mm)	10	12.1	2.4	9.1 to 16.5
SD (mm)	9	1.1	0.6	0.5 to 2.5
AA (°)	9	13.3	1.5	12 to 16
FA (°)	9	27.2	11.0	11 to 50
WQs	8	3.2	0.7	1.9 to 3.8
Lsn (mm)	10	70.2	2.4	67.3 to 74.3
AV (%)	10	18.2	4.2	13.2 to 28.0
AL (%)	10	0.2	4.3	–5.4 to 9.0

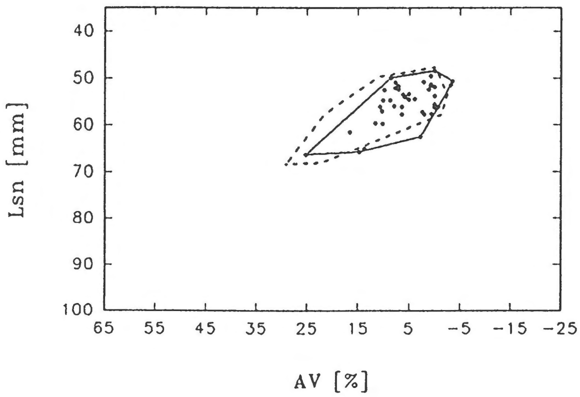

Figure 5. Relationship AV versus Lsn in *Belemnella sumensis* from the lower *sumensis* Zone at Altembroeck (solid line). For comparison, the range of variation of *B. sumensis* at the Bovenste Bos quarry is indicated (dashed line).

and Hemmoor in NW Germany (Schulz 1979). The specimens correspond well with *B.* cf. *praearkhangelskii* as recorded by Schulz (1979) from the middle *sumensis* Zone of Kronsmoor and Hemmoor.

Belemnella cf. *praearkhangelskii* differs from species of the subgenus *Pachybelemnella* in being more slender. *Belemnella (Belemnella) longissima* Schulz, 1979 is far more slender and lanceolate in ventral view, and *Belemnella (Belemnella) fastigata* Schulz, 1979 is far more cylindrical in ventral view than *B.* cf. *praearkhangelskii. Belemnella (Belemnella)lanceolata* (Schlotheim 1813) and *Belemnella (Belemnella)gracilis* (Arkhangelsky 1912) bear a close resemblance to *B.* cf. *praearkhangelskii*, but the latter is slightly stouter. Moreover, *B. lanceolata* is more, and *B. gracilis* less lanceolate in ventral view.

In NW Germany, *B.* cf. *praearkhangelskii* characterizes the middle *sumensis* Zone (late Early Maastrichtian). In the Vijlen Member of NE Belgium the taxon is restricted to the same stratigraphical level, and is extremely rare. According to Schulz (1979), *B. praearkhangelskii* and the closely related or conspecific *Belemnella postsumensis* Naidin, 1964 were originally described from the late Early Maastrichtian and possibly also from the earliest Late Maastrichtian of W Kazakhstan and Azerbaydzhan.

Subgenus *Pachybelemnella* Schulz, 1979

Species of *Pachybelemnella* are distinguished from species of the nominate subgenus by their stouter guards (Lsn < 0.4AV + 60).

Belemnella (Pachybelemnella) sumensis Jeletzky, 1949

1949 *Belemnella lanceolata* (Schloth.) mut. *sumensis* Jeletzky; p. 268; figs. 1–3, 11.

1979 *Belemnella (Pachybelemnella) sumensis* Jeletzky, 1949 - Schulz; p. 118; text-fig. 63; pl. 10. (with synonymy).

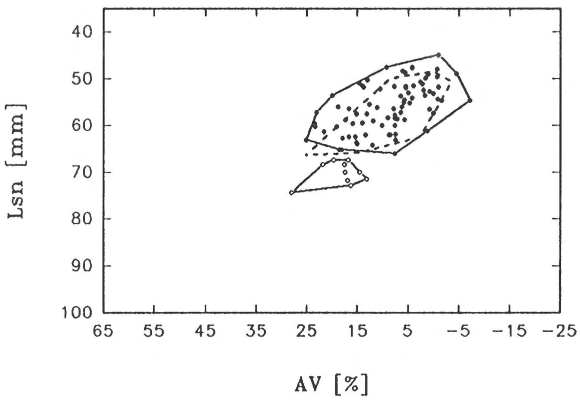

Figure 6. Relationship AV versus Lsn in *Belemnella sumensis* (above) and *Belemnella* cf. *praearkhangelskii* (below) from the middle *sumensis* Zone at Altembroeck (solid lines). For comparison, the range of variation of *B. sumensis* from the lower *sumensis* Zone at Altembroeck is indicated (dashed line).

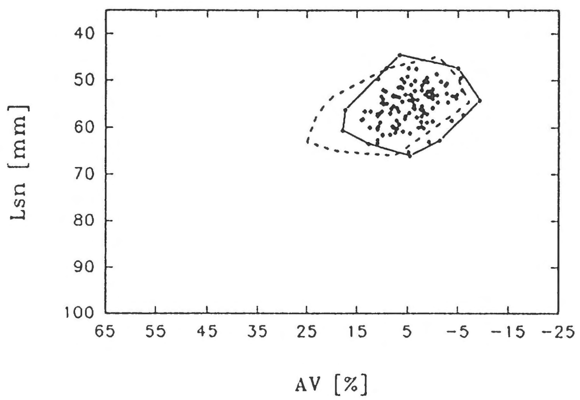

Figure 7. Relationship AV versus Lsn in *Belemnella sumensis* from the upper *sumensis* Zone at Altembroeck (solid line). For comparison, the range of variation of *B. sumensis* from the middle *sumensis* Zone at Altembroeck is indicated (dashed line).

1991 *Belemnella* (*Pachybelemnella*) *sumensis* Jeletzky, 1949 - Keutgen & van der Tuuk; p. 20; pl. 3, fig. 6; pl. 4, figs. 1–2.

Belemnella (*Pachybelemnella*) *sumensis* Jeletzky, 1949 is the index species of the late Early Maastrichtian *sumensis* Zone. It has been described in great detail from NW Germany by Schulz (1979), and from the Vijlen Member in the Maastricht–Aachen area by Keutgen & van der Tuuk (1991). The reader is referred to those authors for a characterization of the species. In the present paper the change of the most important characters in the genus *Belemnella* (Lsn, AV, WQs) from the top of the lower *sumensis* Zone to the base of the upper *sumensis* Zone is discussed using extensive material from Altembroeck (Table 2).

Table 2. Mean values of the most important diagnostic characteristics of *Belemnella* (*Pachybelemnella*) *sumensis* Jeletzky, 1949. Abbreviations as in Table 1.

	n	Mean	ST	OR
upper *sumensis* Zone, Bm4 level				
Lsn (mm)	29	54.7	4.2	47.3 to 65.2
AV (%)	29	2.1	4.8	−6.1 to 10.2
WQs	10	2.5	0.4	2.0 to 3.3
upper *sumensis* Zone, top GcI to base Bm4				
Lsn (mm)	19	54.6	3.7	49.4 to 61.2
AV (%)	19	2.2	6.5	−9.4 to 18.0
WQs	5	2.8	0.5	2.2 to 3.5
upper *sumensis* Zone, GcI level				
Lsn (mm)	42	54.1	3.5	44.4 to 61.5
AV (%)	42	5.4	4.2	−3.9 to 13.5
WQs	6	2.4	0.4	2.1 to 3.0
upper *sumensis* Zone, Bm3 level				
Lsn (mm)	42	57.2	4.3	47.3 to 66.0
AV (%)	42	7.4	4.2	0.0 to 17.4
WQs	11	2.4	0.5	1.8 to 3.2
middle *sumensis* Zone, Bm2 level				
Lsn (mm)	81	56.0	5.1	44.9 to 66.0
AV (%)	81	8.7	7.3	−7.2 to 25.2
WQs	44	2.4	0.6	1.1 to 3.5
lower *sumensis* Zone, Bm1 level				
Lsn (mm)	41	55.2	4.4	48.4 to 66.4
AV (%)	41	5.7	5.8	−3.5 to 25.3
WQs	1	2.6		

The mean values of c. 2.4 for WQs in most samples, and the values for Lsn and AV allow the specimens to be assigned to *B. sumensis.* Specimens from the Bm1 level are early forms of *B. sumensis*, because they fit well into the population recorded by Schulz (1979) from the interval 28–35 m above base Maastrichtian (lower *sumensis* Zone) at Kronsmoor. The middle *sumensis* Zone, which is interval 35–38 m above base Maastrichtian at Kronsmoor, is characterized by the co-occurrence of early forms of *B. sumensis* and of *B.* cf. *praearkhangelskii.* At Altembroeck, *B.* cf. *praearkhangelskii* occurs exclusively at the Bm2 level. *Belemnella sumensis* from this level shows a slightly larger mean value of Lsn and a distinctly larger mean value of AV (8.7 %) in comparison with the Bm1 level. At Kronsmoor and Hemmoor, a mean in excess of 8 % for AV occurs only in the middle *sumensis* Zone. Apart from the presence of *B.* cf. *praearkhangelskii*, the mean AV value of *B. sumensis* from the Bm2 level points to the middle *sumensis* Zone. The stratigraphically lowest *Belemnella* sample, which is referred to the upper *sumensis* Zone because of the disappearance of *B.* cf. *praearkhangelskii*, was collected from the Bm3 level at Altembroeck. Nevertheless, the mean AV value of *Belemnella* from the Bm3 level is typical of early forms of *B. sumensis* and most similar to, but slightly smaller than the mean value of *Belemnella* from the Bm2 level. The Lsn value of the Bm3 sample is slightly larger than that of the Bm2 sample, being the largest in all samples from Altembroeck. Within the youngest *B. sumensis* samples (GcI, top interval GcI to base Bm4, and Bm4), the shape of the guards in ventral view (AV) becomes less lanceolate and the mean standardized length (Lsn) is reduced to 54–55 mm. Especially the latest samples are typical of late forms of *B. sumensis*.

Discussion

At the Mamelis section, the stratotype of the Vijlen Member, Felder & Bless (1994: 70) recognized the oldest distinct belemnite-bioclast peaks about 1.7 m (interval 0) and 13–23 m (interval 2) above the base of the member (Fig. 1). At Friedrichberg near Aachen, about 7 km southeast of Mamelis, Ebensberger (1962) recorded the oldest belemnite concentration at about 2.2–2.8 m above the base. This belemnite concentration was not described as a belemnite-bioclast peak sensu Felder & Bless (many small belemnite fragments), but belemnite-bioclast peaks are frequently accompanied by belemnite concentrations, consisting of almost complete guards and larger fragments (see Felder & Bless 1994). Therefore, the belemnite concentration at Friedrichberg can roughly be correlated with the belemnite-bioclast peak 1.7 m above the base of the Vijlen Member at Mamelis. Ebensberger collected 13 *B. sumensis* from the belemnite-rich interval at Friedrichberg. The mean value of AV (4.0 %), the range of this characteristic (–0.9 to 17.7 %), and the mean value of Lsn (54.0 mm) indicate upper *sumensis* Zone. The mean value and the range of AV are nearly identical with the corresponding values of the upper *sumensis* Zone specimens from Altembroeck (AV = 4.8 %, Lsn = 55.3 mm, n = 132), but they are more primitive than the mean values and the observed range of the specimens described by Keutgen & van der Tuuk (1991) from interval 1 (uppermost part) and younger deposits. It is concluded that the two prominent belemnite-bioclast peaks in the uppermost 2 m of the Vijlen Member at Altembroeck are correlatable with the belemnite peak at Friedrichberg and with the belemnite-bioclast peak about 1.7 m above the base of the Vijlen Member at Mamelis. The 5.5 m of Vijlen Member currently exposed at Altembroeck represent the upper part of interval 0 of Felder & Bless (1994). The underlying 14.5 m of the member also belong to interval 0 and probably reach the early Early Maastrichtian *obtusa* Zone (see Felder & Bless 1994). In the Altembroeck area, deposits of interval 0 sensu Felder & Bless are at least 20 m thick, whereas in the Mamelis area they account for only 3.2 m.

At Altembroeck, belemnite concentrations are not restricted to the prominent belemnite-bioclast peaks, but occur also at the related Bm1, Bm2, Bm3, GcI and Bm4 levels. These levels represent 'belemnite battlefields' sensu Doyle & MacDonald (1993). These authors discussed five possible origins of such 'battlefields': post-spawning mortality, catastrophic mass mortality, predation concentration, stratigraphical condensation, and mass-transport of belemnite concentrations. The origin of the 'belemnite battlefields' at Altembroeck can be explained by comparing the levels GcI and Bm4 with the interval between GcI and Bm4. The bases of levels GcI and Bm4 are distinct, and show evidence of non-deposition, for example pockets extending from the GcI level into the underlying deposit, or fossil accumulations. The *Belemnella* sample from level GcI should be more similar to the sample from the interval between GcI and Bm4 than the sample from level Bm4, if it is assumed that the belemnites from levels GcI and Bm4 are not reworked. Nevertheless, the *B. sumensis* sample from the Bm4 level is characterized by almost the same mean values for Lsn and AV as the sample from the interval between GcI and Bm4, and a comparison of the sample GcI with the sample from the interval between GcI and Bm4 shows significant differences. It is concluded that the *B. sumensis* from the GcI and Bm4 levels are reworked from underlying deposits. According to Doyle & MacDonald (1993) this is a typical feature of stratigraphical condensation or mass-transport. The common appearance of belemnite guards with epifaunal colonisation by boring or encrusting organisms (bivalves, serpulids, brachiopods) supports the interpretation of the Altembroeck 'belemnite battlefields' as condensation accumulates.

The belemnite guards from the levels Bm1, Bm2, Bm3, GcI and Bm4 may not have been reworked from Vijlen Member deposits at Altembroeck, but probably came from another region. The results of P. J. Felder (in Jagt et al. 1995) support transport by bottom currents. Considering the unusual thickness of interval 0 of the Vijlen Member at Altembroeck (> 20 m) in comparison with the Mamelis section (3.2 m), the following model is proposed: The belemnite guards were transported by bottom currents from a shallow environment, which was characterized by a very slow sedimentation. Because of this reduced sedimentation in the region of belemnite origin, it is likely that, in the Altembroeck section, a 'battlefield' level contains belemnites from the interval 'base of the battlefield level' to 'base of the underlying battlefield level'. This interpretation is supported by the development of the Lsn and AV characteristics in *B. sumensis* at Altembroeck, which corresponds to the development in the Kronsmoor and Hemmoor sections (Schulz 1979). Should the 'battlefield' levels be shown to contain belemnite specimens of different ages, such a similar development could be excluded.

The 1 m of Vijlen Member exposed below the Bm1 level must be correlated with the upper part of the lower *sumensis* Zone, and the interval between the base of the Bm1 level and the top of the Bm2 level with the middle *sumensis* Zone (Figure 2). The top of this middle *sumensis* Zone is placed at the top of level Bm2, because it cannot be excluded that the subzonal index species *B.* cf. *praearkhangelskii*, found in level Bm2, occurred until the end of the sedimentation of this level. The base of the upper *sumensis* Zone corresponds to the base of the interval above level Bm2 and is situated slightly below the belemnite-bioclast peaks, which occur in the upper part of interval 0 of Felder & Bless (1994) in the Altembroeck (units 4 and 6) and Mamelis sections.

Acknowledgements

J. W. M. Jagt (Natuurhistorisch Museum, Maastricht) critically read the manuscript, arranged for photographs to be taken and offered helpful suggestions. W. M. Felder (Rijks Geologische Dienst, Heerlen) and J. Reynders recorded the profile of the Altembroeck section. I wish to express my sincere thanks for their help. I gratefully acknowledge the support of G. J. Boekschoten (Vrije Universiteit, Amsterdam) and of the 'Vijlen Werkgroep' members M. Deckers, A. V. Dhondt (Koninklijk Belgisch Instituut voor Natuurwetenschappen, Brussel), R. W. Dortangs, P. J. Felder (Université de Liège, Liège), W. M. Felder (Heerlen), M. Jäger, M. Kuypers, G. Michels, J. Reynders, E. Simon (Koninklijk Belgisch Instituut voor Natuurwetenschappen, Brussel), R. van der Ham, P. van Knippenberg and R. van Neer.

References

Christensen, W.K. 1987 *Belemnella* (*Pachybelemnella*) *inflata* (Arkhangelsky) from Nagorýany, USSR – Beitr. Paläont. Österr. 13: 79–84

Doyle, P. & D.I.M. MacDonald 1993 Belemnite battlefields – Lethaia 26: 65–80

Ebensberger, H. 1962 Stratigraphische und mikropaläontologische Untersuchungen in der Aachener Oberkreide, besonders der Maastricht-Stufe – Palaeontographica A120: ii+120 pp

Felder, W.M. & P.W. Bosch 1984 Geologische kaart van Zuid-Limburg en omgeving. Pré-Kwartair. Rijks Geol. Dienst, Haarlem; Staatsuitgeverij, Den Haag

Felder, P.J. & M.J.M. Bless 1994 The Vijlen Chalk (early Early to early Late Maastrichtian) in its type area around Vijlen and Mamelis (Southern Limburg, The Netherlands) – Ann. Soc. géol. Belg. 116 (1): 65–90

Jagt, J.W.M., M. Deckers, A.V. Dhondt, R.W. Dortangs, P.J. Felder, W.M. Felder, M. Jäger, N. Keutgen, M. Kuypers, G. Michels, J. Reynders, E. Simon, R. van der Ham, P. van Knippenberg & R. van Neer 1995 Preliminary Report of field work at Altembroeck (NE Belgium, Early Maastrichtian). Belg. Geol. Dienst, Prof. paper 1995/1 (N.276): 20 pp

Jeletzky, J.A. 1949 Über den taxonomischen Wert einiger morphologischer Elemente des Rostrums der belemnitellenartigen Formen (Familie Belemnitellidae Pavlow, 1913) sowie über die Gattung *Belemnella* (Nowak, 1913 subg.) Jeletzky, 1941, ihre Phylogenie und einige Vertreter – Neues Jb. Min. Geol. Paläont. B Monatsh. 9: 257–287

Keutgen, N. & L.A. van der Tuuk 1991 Belemnites from the Lower Maastrichtian of Limburg, Aachen and Liège – Meded. Rijks Geol. Dienst 44 (4): 27 pp

Naidin, D.P. 1964 [Upper Cretaceous *Belemnitella* and *Belemnella* from Russian Platform and some adjacent regions] (in Russian) – Byull. Mosk. Obshch. Ispyt. Prir. Otd. Geol. 39: 85–97

Schulz, M.-G. 1979 Morphometrisch-variationsstatistische Untersuchungen zur Phylogenie der Belemnitengattung *Belemnella* im Untermaastricht NW-Europas – Geol. Jb. A47: 3–157

Address for correspondence: Schildstraße 17, D–52062 Aachen, Germany