

Upper Campanian and Lower Maastrichtian belemnites from the Mons Basin, Belgium

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Abstract

Upper Campanian *Belemnitella* and Lower Maastrichtian *Belemnella* and *Belemnitella* faunas from the chalks of the Mons Basin in Belgium are described, utilizing univariate and bivariate biometric analyses. The Upper Campanian belemnite faunas comprise six taxa of *Belemnitella*, including two left in open nomenclature: *B. mucronata*, *B. woodi*, *B. minor* I, *B. minor* II, *B. sp. 1* and *B. sp. 2*. The lower Lower Maastrichtian fauna includes *Belemnella (Pachybelemnella) obtusa* with subordinate *Belemnitella minor* II and *Belemnitella pulchra*. The Upper Campanian and Lower Maastrichtian lithostratigraphical formations are placed in the international stratigraphical framework on the basis of the belemnite faunas. The Upper Campanian chalks are subdivided into four *Belemnitella* zones, and these are in ascending order: the lower Upper Campanian *B. mucronata* Zone below and *B. woodi* Zone above, in addition to the upper Upper Campanian *B. minor* I Zone below and *B. minor* II Zone above. These zones are proposed as formal zones, because they have been recognized in widely spaced areas in northwest Europe. The Craie Phosphatée de Ciplly is placed in the *Belemnella obtusa/Belemnitella minor* II Zone, which is from the upper part of the lower Lower Maastrichtian.

Key-words: Belemnitellids, taxonomy, stratigraphy, Upper Campanian, Lower Maastrichtian, Mons Basin, Belgium.

Résumé

Les faunes de *Belemnitella* du Campanien supérieur et de *Belemnella* et *Belemnitella* du Maastrichtien inférieur, provenant des craies du Basin de Mons, sont décrites sur base d'analyses biométriques univariées et bivariées. Les faunes de bélemnites du Campanien supérieur incluent six taxa, dont deux laissés en nomenclature ouverte, appartenant au genre *Belemnitella*: *B. mucronata*, *B. woodi*, *B. minor* I, *B. minor* II, *Belemnitella* sp. 1 and *Belemnitella* sp. 2. La faune de la partie inférieure du Maastrichtien inférieur comprend *Belemnella (Pachybelemnella) obtusa* et, accessoirement, *Belemnitella minor* II et *B. pulchra*. Les formations du Campanien supérieur et Maastrichtien inférieur sont situées dans le tableau stratigraphique international sur base des faunes de bélemnites. Les craies du Campanien supérieur sont subdivisées en quatre zones à *Belemnitella* qui sont en ordre ascendant: les zones à *B. mucronata* et *B. woodi* de la partie inférieure du Campanien supérieur et les zones *B. minor* I et *B. minor* II de la partie supérieure du Campanien supérieur. Ces zones sont proposées comme zones formelles car elles ont été reconnues dans des aires largement distantes les unes des autres dans le nord-ouest de l'Europe. La Craie Phosphatée de Ciplly appartient à la zone à *Belemnella obtusa/Belemnitella minor* II qui fait partie du sommet de la partie supérieure du Maastrichtien inférieur.

Mots-clés: Bélemnitellidés, taxinomie, stratigraphie, Campanien supérieur-Maastrichtien inférieur, Basin de Mons, Belgique.

Introduction

The geology and stratigraphy of the Upper Cretaceous rocks of the Mons Basin in southern Belgium (Fig. 1) was reviewed by MARLIÈRE (1954, 1957), MARLIÈRE & ROBASYNSKI (1975), and, most recently, ROBASYNSKI & CHRISTENSEN (1989) and ROBASYNSKI (1995). Six lithostratigraphical formations of Campanian and Maastrichtian age have been recognized, and these are from below: the Craie de Trivières, Craie d'Obourg, Craie de Nouvelles and Craie de Spiennes of Campanian age, in addition to the Craie de Phosphatée de Ciplly and Tuffeau de Saint-Symphorien of Maastrichtian age (Fig. 2). These are discussed further below.

Very little attention has been paid to the Upper Cretaceous belemnites of the Mons Basin. Santonian to Maastrichtian species of the genera *Actinocamax* MILLER, 1823, *Goniot euthis* BAYLE, 1878, *Belemnitella* d'ORBIGNY, 1840 and *Belemnella* NOWAK, 1913 have been recorded by LERICHE (1929), JELETZKY (1948, 1951a, 1951b) and MARLIÈRE (1954, 1972), among others, but these authors did neither describe nor figur the species. CHRISTENSEN in ROBASYNSKI & CHRISTENSEN (1989) figured Upper Campanian and Lower Maastrichtian species of the genera *Belemnitella* and *Belemnella* in his preliminary study of the belemnites from the Mons Basin.

The aim of the present paper is to describe in detail the Upper Campanian and Lower Maastrichtian belemnites from the Mons Basin, utilizing biometric methods, and to place the lithostratigraphical formations in the international stratigraphical framework.

Earlier work

JELETZKY (1951b) recorded Upper Campanian and Maastrichtian belemnites from the Mons Basin on the basis of studies of material housed in various museums in northwest Europe and the literature. He listed *Belemnitella mucronata* mut. *senior* NOWAK, 1913 from the Craie d'Obourg; *B. mucronata* mut. *senior* and *B. mucronata* mut. *minor* JELETZKY, 1951 from the Craie de Nouvelles; *B. ex gr. mucronata* (SCHLOTHEIM, 1813), *B. junior*?

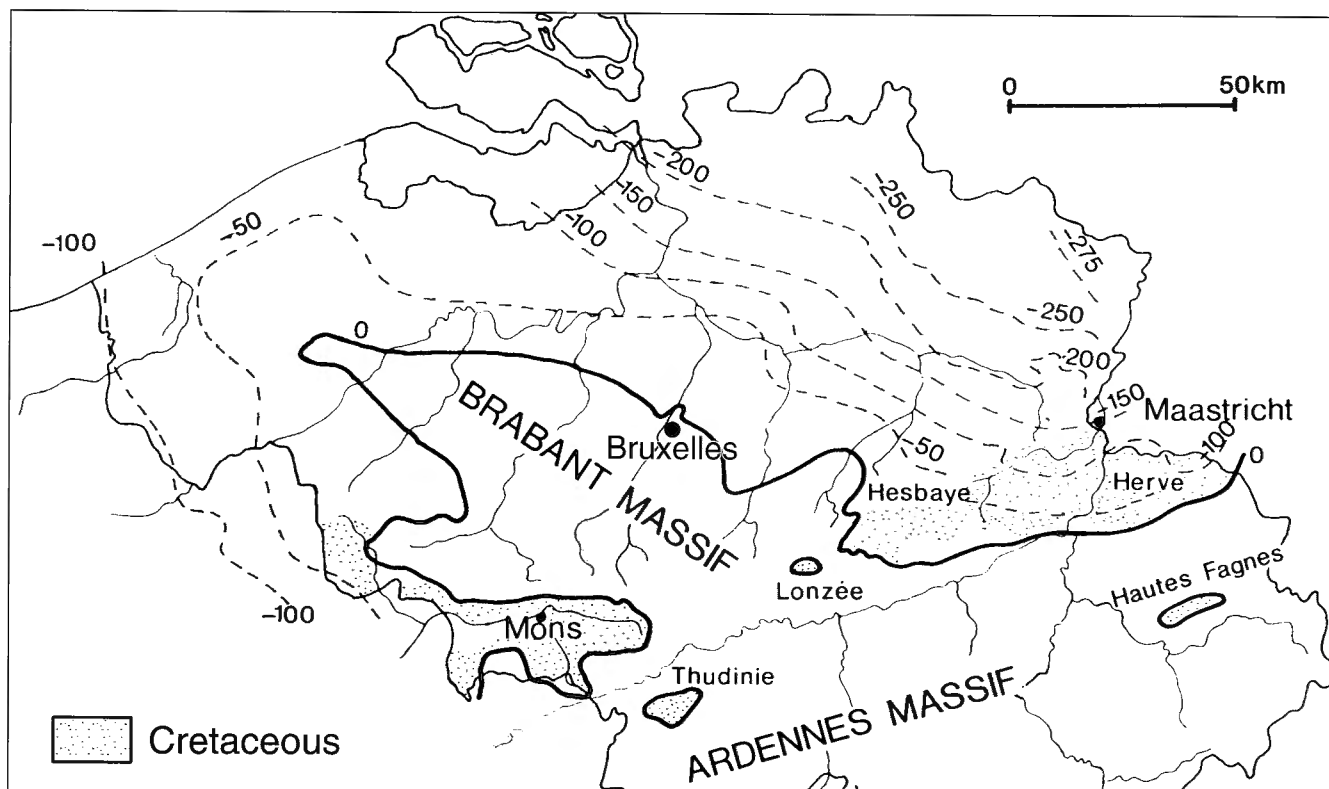


Fig. 1 – Map of Belgium, showing the distribution of marine Cretaceous sedimentary rocks and contour lines of the Palaeozoic basement (modified from LINGHAM-SOLIAR & NOLF, 1989).

NOWAK, 1913 and *Belemnella lanceolata* (SCHLOTHEIM, 1813) from the Craie de Spiennes; *B. ex gr. mucronata*, *B. junior* and *B. lanceolata* from the Craie Phosphatée de Ciplly; and *B. junior* from the Tuffeau de Saint-Symphorien. It seems, however, that some of the museum material may have been mixed or incorrectly labelled, because *Belemnella* does not occur in the Craie de Spiennes, and *Belemnitella junior* does not occur in the Craie de Spiennes and Craie Phosphatée de Ciplly.

The records of MARLIÈRE (1972) were based on material housed in the collections of the Faculté Polytechnique in Mons. He recorded *Gonioteuthis quadrata* (BLAINVILLE, 1827) and *Belemnitella praecursor* STOLLEY, 1897 from the Craie de Trivières, *B. mucronata* mut. *senior* from the Craie de Trivières, Craie d'Obourg and Craie de Nouvelles, *B. mucronata* mut. *minor* from the Craie d'Obourg and Craie de Nouvelles, *B. junior* from the Craie de Spiennes, *B. lanceolata* from the Craie Phosphatée de Ciplly, and *Belemnella kazimiroviensis* SKOŁOZDRÓWNA, 1932 (= *B. casimirovensis* of authors) from the Craie Phosphatée de Ciplly and Tuffeau de Saint-Symphorien. However, it appears that most of these species were incorrectly identified (see below).

Most of the Upper Campanian and Lower Maastrichtian species of *Belemnitella* and *Belemnella* recorded from the Mons Basin by CHRISTENSEN in ROBASZYNSKI & CHRISTENSEN (1989) were left in open nomenclature for two reasons. (1) The systematics of the majority of the

Upper Campanian and Lower Maastrichtian species of *Belemnitella* was in a state of chaos at that time. Consequently, species concepts differed from one author to another as discussed by CHRISTENSEN (1986, 1993). (2) Detailed biometric analyses were not performed in order to analyze to variation of critical characters of the species.

Material

The bulk of the belemnite material studied during the course of the present paper was collected in the field by the author in 1984-1986 and is housed in the Geological Museum, University of Copenhagen. Belemnites collected in the 1950s by F. Schmid, Gottmadingen, Germany are also included in the present study, as are belemnites collected recently by F. Robaszynski and Ph. Hoogstoel, Mons.

I have examined belemnites housed in the collections of the Faculté Polytechnique, Mons and Institut Royal des Sciences Naturelles de Belgique, Bruxelles. These were collected in the last part of the previous century and the beginning of this century and are inadequately labelled with only locality name and formation. Moreover, it seems that belemnites from different stratigraphical levels have been mixed. Since these belemnites do not provide additional information they are not included in the present study, except for a small sample of *Belemnitella minor* subspecies II CHRISTENSEN, 1995 from the André et Fils pit, ex IRSNB collection.

SUB-STAGES	NW GERMANY	MONS BASIN (this paper)		
	Biozones	Lithostratigraphy	Range of belemnites	Belemnite zones
LOWER MAASTRICHTIAN	upper	<i>fastigata</i>		
		<i>cimbrica</i>		
		<i>sumensis</i>		
	lower	<i>obtusa</i>	Craie de Ciply	— <i>Blt. minor II</i> — <i>Blt. pulchra</i> — <i>Bln. obtusa</i>
		<i>pseudobtusa</i>		
		<i>lanceolata</i>		
UPPER CAMPANIAN	upper	<i>grimmensis/granulosus</i>		
		<i>langei</i>	Craie de Spiennes	
		<i>polyplacum</i>		
	lower	<i>roemeri</i>	Craie de Nouvelles	
		<i>basiplana/spiniger</i>	Craie d'Obourg	
		<i>conica/mucronata</i>		
LOWER CAMPANIAN	upper	<i>gracilis/mucronata</i>		
		<i>conica/gracilis</i>		
		<i>papillosa</i>		
		<i>senonensis</i>	Craie de Trivières	
		<i>pilula/senonensis</i>		
		<i>pilula</i>		
	lower	<i>lingua/quadrata</i>		
		<i>granulataquadrata</i>		

Fig. 2 – Stratigraphical scheme of the Campanian and Lower Maastrichtian, showing biozones of NW Germany, and lithostratigraphy, range of belemnites and belemnite zones of the Mons Basin. The biozones of NW Germany are based on SCHULZ *et al.* (1984) and SCHULZ (1996). Abbreviations: *Blt.* = *Belemnitella*; *Bln.* = *Belemnella*. Vertical axis not to scale.

Geological setting

The Mons Basin is centered around the town of Mons in southern Belgium (Fig. 1). It is situated south of the Brabant Massif and west of the Ardennes Massif and can be regarded as a northern extension of the Paris Basin (MARLIÈRE, 1965, ALCAYDÉ *et al.*, 1980). It has, however, its own depositional history during the Late Campanian and Maastrichtian due to a number of phases of subsidence of the basement.

The Upper Cretaceous rocks of the Mons Basin are separated from the Upper Cretaceous deposits of the Maastricht-Aachen-Liège district by an about 50 km wide zone, where Upper Cretaceous rocks have not been found, with one exception. An outlier with Coniacian?, Santonian and Lower Campanian? sediments at Loncée near Gembloux was recorded by MALCHUS *et al.* (1994, 1996) (Fig. 1). CHRISTENSEN (1994) described Santonian and possibly basal Lower Campanian belemnites from this locality.

Lithostratigraphy of the Upper Campanian and Maastrichtian rocks of the Mons Basin

As mentioned above the Campanian and Maastrichtian sedimentary rocks of this basin have been subdivided into six lithostratigraphical formations and these are in ascending order (Fig. 2).

Craie de Trivières: A white to greyish chalk without flint-layers; it has a phosphatic conglomerate with sponges at the base and is terminated by a hardground. Several hardgrounds occur in the eastern part of the basin. The thickness is 40-120 m.

Craie d'Obourg: A fine-grained white chalk, with a phosphatic conglomerate at the base. It is slightly more grey than the superjacent Craie de Nouvelles. Flint bands do not occur in the southern part of the basin. There is a gradual transition between this formation and the overlying Craie de Nouvelles. The thickness is 15-25 m.

Craie de Nouvelles: A pure, fine-grained, white chalk without flint, except for three thin flint bands near the top. The formation is terminated by a prominent hardground at the border of the basin. The thickness is 20-25 m.

Craie de Spiennes: A white, rather coarse-grained chalk, with many thick flint bands. It becomes calcarenitic towards the top. There may be a thin layer of phosphatized pebbles at the base and a hardground at the top of the formation. The thickness is 25-50 m.

Craie Phosphatée de Ciplly: A grey to brownish calcarenite consisting of many phosphatic grains in a chalky matrix, usually with flint bands. At the southern border of the basin the *Poudingue de Cuesmes* (Cuesmes Conglomerate) forms the base of the formation. The top of the formation is capped by a prominent hardground, about one metre thick. The thickness varies from a few to 70 metres.

Tuffeau de Saint-Symphorien: A yellowish, loose, calcarenite

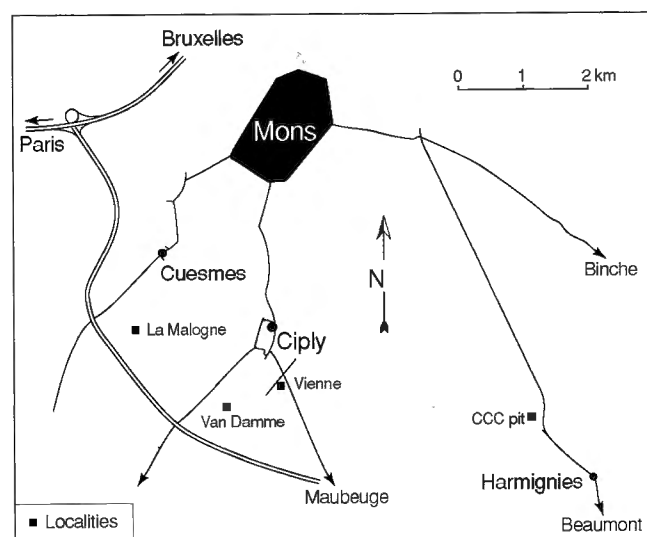


Fig. 3 – Locality map for the Mons Basin (modified after ROBASYNSKI & CHRISTENSEN, 1989).

with many flint bands. It has a phosphatic conglomerate at the base and is terminated by a hardground. The thickness is 10-35 m.

ROBASZYNSKI & CHRISTENSEN (1989, Fig. 5) placed the formations, except the Tuffeau de Saint-Symphorien, in the international stratigraphical framework on the basis of a preliminary study of foraminifera and belemnites. They showed that the Craie de Spiennes is of late Late Campanian age, whereas previous authors, including LERICHE (1929), JELETZKY (1951a, 1951b), MARLIÈRE (1954) and HOFKER (1959, 1961, 1966), placed this formation in the Lower Maastrichtian.

KENNEDY (1993) described the ammonites from the Mons Basin and showed that the biostratigraphical dating of the formations on ammonite evidence is compatible with that based on belemnites and foraminifera by ROBASYNSKI & CHRISTENSEN (1989).

Locality details

The localities from which belemnites have been studied are discussed below in alphabetical order (Fig. 3).

André et Fils pits, Ciplly (Fig. 4): Three abandoned pits, referred to as pits nos 4, 5 and 6 by F. Schmid (unpublished

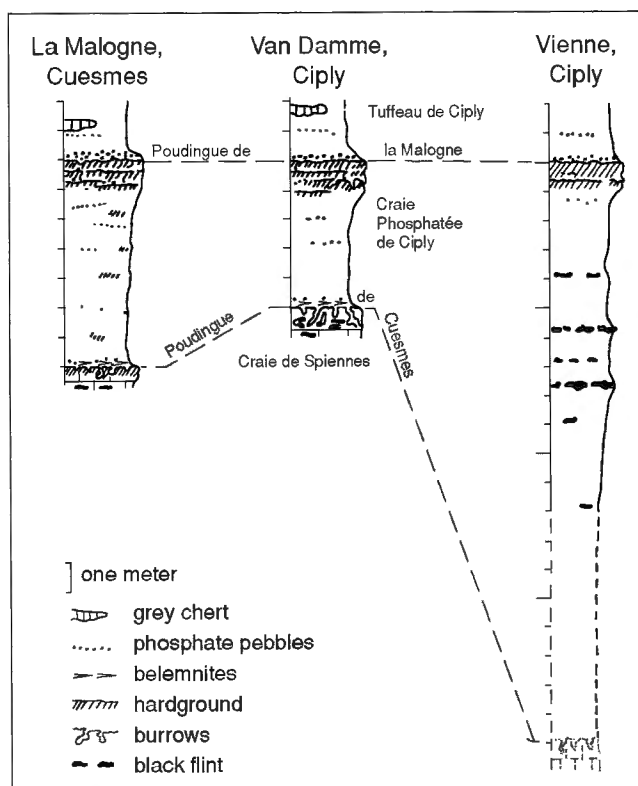


Fig. 4 – Sections of the abandoned underground workings at La Malogne near Cuesmes, and the abandoned Van Damme and Vienne pits at Ciplly (modified after ROBASYNSKI & CHRISTENSEN, 1989).

report 1957) and HOFKER (1966, Figs 115, 119-120), are situated immediately south of Ciplly, east of the road from Ciplly to Bavay. Pit no. 4 is now backfilled and pit no. 6 was subsequently referred to as the Van Damme pit (F. Robaszynski, personal communication May 1997). According to Schmid (unpublished) pit no. 4 showed only the Danian Tuffeau de Ciplly. In pit no. 5 about 0.5 m of the Tuffeau de Saint-Symphorien is sandwiched between the Craie Phosphatée de Ciplly and the Tuffeau de Ciplly (HOFKER 1966, Fig. 120). In pit no. 6 the succession is as follows, bottom to top, Craie de Spiennes, Craie Phosphatée de Ciplly and Tuffeau de Ciplly. According to ROBASZYSKI & CHRISTENSEN (1989) the thickness of the Craie Phosphatée de Ciplly is about 5-6 m.

I have examined numerous belemnites, *ex F.* Schmid Collection, from the Poudingue de Cuesmes and Craie Phosphatée de Ciplly of pit no. 6. Moreover, belemnites, *ex IRSNB* Collection, from the Craie Phosphatée de Ciplly were also studied. These are labelled only André et Fils pit.

The Poudingue de Cuesmes and Craie Phosphatée de Ciplly yielded *Belemnella (Pachybelemnella) obtusa* SCHULZ, 1979 with subordinate *Belemnitella minor* II CHRISTENSEN, 1995. In addition, a single specimen of *Belemnitella pulchra* SCHULZ, 1982 was obtained from the Poudingue de Cuesmes.

CCC (Crayères, Cimenteries et Chaux) pit, Harmignies (Fig. 5): This pit is situated near Harmignies, southeast of Mons, west of the road from Mons to Beaumont. The section is a little less than 60 m thick and shows the topmost 6 m of the Craie de Trivières, about 35 m of the Craie d'Obourg and Craie de Nouvelles and about 18 m of the Craie de Spiennes (Fig. 5). There is gradual transition from the Craie d'Obourg to the Craie de Nouvelles in this pit. Belemnites are common immediately below and above the hardground at the top of the Craie de Trivières, below the hardground at the top of the Craie de Nouvelles, and in the Craie de Spiennes.

The stratigraphical ranges of the belemnites are shown in Figure 5. The top 6 m of the Craie de Trivières and basal 1.2 m of the Craie d'Obourg yielded only *B. mucronata*, apart from a single specimen of *Goniot euthis* encrusted by an oyster from 40 cm below the top of the Craie de Trivières. However, this belemnite may have been redeposited. Only very few belemnites were collected from the interval 1.2 m above the base of the Craie d'Obourg to 4 m below the top of the Craie de Nouvelles, because this interval is poorly accessible and belemnites are rare. The belemnites from this interval are either *B. mucronata* or *B. woodi* CHRISTENSEN, 1995 (pl. 1, figs 21-23), but a specific determination is not possible due to small number of specimens.

The uppermost 4 m of the Craie de Nouvelles, except the hardground at the top of the formation, yielded *B. woodi*. *Belemnitella* sp. 2, which probably belongs to the *B. langei* group, occurs rarely 80-300 cm below the hardground at the top of the Craie de Nouvelles.

B. minor I appears in the hardground at the top of the Craie de Nouvelles and ranges into the basal 10 m of the Craie de Spiennes. Two specimens of *Belemnitella* sp. 1, which belongs to the *B. mucronata* group, were obtained from the Craie de Spiennes, 180 cm above the base of the formation.

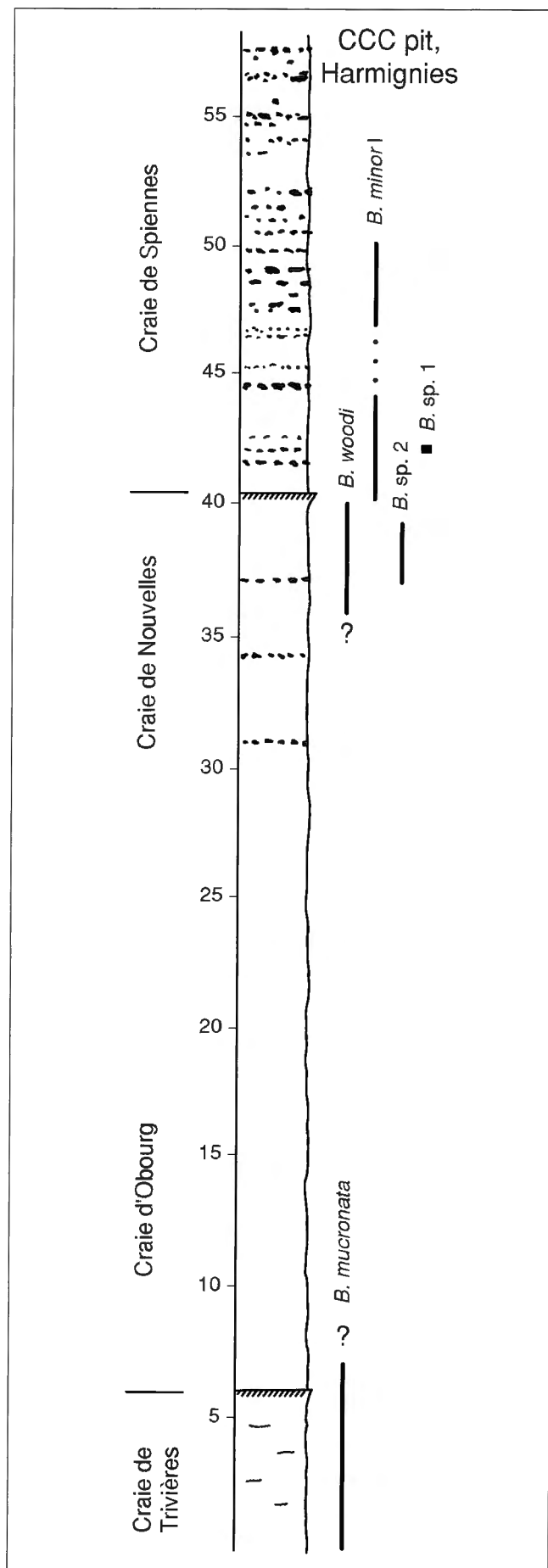


Fig. 5 – Section of the CCC pit at Harmignies, showing range of belemnites. Section after ROBASZYSKI & CHRISTENSEN (1989).

La Malogne at Cuesmes (Fig. 4): The huge, abandoned underground workings show the following succession, bottom to top. The topmost 1 m of the Craie de Spiennes is succeeded upwards by about 8 m of the Craie Phosphatée de Ciplly. The Poudingue de Cuesmes occurs at the base of the Craie Phosphatée de Ciplly and the formation is terminated by a prominent hardground, about 1 m thick. The Craie Phosphatée de Ciplly is overlain by the Danian Tuffeau de Ciplly.

Belemnites are common in the Craie de Spiennes, very common in the Poudingue de Cuesmes and common in the Craie Phosphatée de Ciplly. *Belemnitella minor* II occurs in the Craie de Spiennes, and *Belemnella (Pachybelemnella) obtusa* (common) and *Belemnitella minor* II (rare) occur in the Poudingue de Cuesmes and Craie Phosphatée de Ciplly.

Vienne pit, Ciplly (Fig. 4): This abandoned pit is situated immediately south of Ciplly and shows 13-14 m of the Craie Phosphatée de Ciplly. According to F. Robaszynski (personal communication, May 1997) the Craie Phosphatée de Ciplly of this pit may be slightly younger than that of the André et Fils, pit no. 6. The Craie Phosphatée de Ciplly yielded *Belemnella*

(*Pachybelemnella*) *obtusa* and a single specimen of *Belemnitella pulchra*.

Biostratigraphy

At the Brussels Symposium on Cretaceous Stage Boundaries in 1995, it was provisionally recommended that the boundary marker for the base of the Campanian should be placed at the first appearance datum (FAD) of the ammonite *Placenticerus bidorsatum* (ROEMER), which is compatible with the extinction level of the crinoid *Marsupites testudinarius* (SCHLOTHEIM), and to endeavour to subdivide the stage into three substages, Lower, Middle and Upper (HANCOCK & GALE, 1996). However, it was not possible at that time to make formal definitions for the bases of the Middle and Upper Campanian.

Following the suggestion by JELETZKY (1958, pp. 47-48) most authors in Europe have subdivided the Campanian into two substages, Lower and Upper, and placed the base of the Upper Campanian at the extinction level of the belemnitellid genus *Goniot euthis* and not at the FAD of *Belemnitella mucronata* (Fig. 6). The *Goniot euthis quadrata gracilis/Belemnitella mucronata* Zone of ERNST (1963a, 1963b) (= "Overlap Zone" of SCHMID 1953, 1955, 1956) is thus the uppermost belemnite zone of the Lower Campanian.

The timespan of the Campanian Stage was long, about 12 Ma (= Mega annum, 10^6 years), and the duration of the Early Campanian was *c.* 3 Ma, about one third of the length of the Late Campanian (OBRADOVICH, 1994).

At the Brussels Symposium it was decided to recommend the FAD of the ammonite *Pachydiscus neubergicus* (VON HAUER) in the abandoned Tercis pit, Landes, southern France as the boundary stratotype for the Maastrichtian, and to subdivide the stage into two substages, Lower and Upper (ODIN, 1996). It was not possible at that time to make a formal proposal for the definition of the Upper Maastrichtian. In belemnite terms, the base of the Maastrichtian is defined by the FAD of *Belemnella lanceolata* (Fig. 6) and the base of the Upper Maastrichtian by the FAD of *Belemnitella junior* (see discussion by CHRISTENSEN, 1996). The FAD of *B. lanceolata* in the Kronsmoor pit, northwest Germany equates with the FAD of *P. neubergicus* in the Tercis pit within the current limits of biostratigraphical correlation. Following the definition based on belemnites, the timespan of the Maastrichtian was *c.* 6 Ma and the duration of the Early Maastrichtian was *c.* 1.5 Ma (OBRADOVICH, 1994). JAGT & KENNEDY (1994) suggested that the timespan of the Early Maastrichtian was about 2 Ma. Thus, the timespan of the Early Maastrichtian is about half the length or less of the Late Maastrichtian.

The Campanian and Lower Maastrichtian chalks of Lägerdorf, Kronsmoor and Hemmoor, northwest Germany, have been subdivided into 20 zones on the basis of belemnites, ammonites, echinoids and the inoceramid bivalve *Sphenocerasmus lingua* (GOLDFUSS) (SCHULZ *et*

SUB-STAGE	BELEMNITE ZONES		
	Conventional ¹	Russian Platform ²	NW Europe ³
LOWER MAASTRICHTIAN	upper <i>Belemnella occidentalis</i>	<i>Belemnella sumensis</i>	<i>Belemnella fastigata</i>
	lower <i>Belemnella lanceolata</i>		<i>Belemnella cimbrica</i>
UPPER CAMPAIAN	upper <i>Belemnitella langei</i>	<i>Belemnitella B.l. najdini</i>	<i>Belemnitella sumensis</i>
	lower <i>Belemnitella minor</i>	<i>Belemnitella B.l. langei</i>	<i>Belemnitella obtusa</i>
LOWER CAMPAIAN	upper <i>Belemnitella mucronata</i>	<i>Belemnitella B.l. minor</i>	<i>Belemnitella pseudobtusa</i>
	lower	<i>Belemnitella mucronata</i>	<i>Belemnitella lanceolata</i>
LOWER CAMPAIAN	upper		<i>G. quadrata gracilis/Belemnitella mucronata</i>
	lower		<i>Goniot euthis quadrata gracilis</i>
			<i>Goniot euthis quadrata quadrata</i> U
			<i>Goniot euthis granulataquadrata</i> L

Fig. 6 – Stratigraphical scheme, showing conventional Upper Campanian *Belemnitella* and Lower Maastrichtian *Belemnella* zones, Upper Campanian and Lower Maastrichtian belemnite zones of the Russian Platform, and Campanian and Lower Maastrichtian belemnite zones of northwest Europe. Sources: column 1, JELETZKY (1951b, 1958) and BIRKELUND (1957); column 2, NAIDIN (1979); column 3; ERNST (1964) for the Lower Campanian, CHRISTENSEN (1995, this paper) for the Upper Campanian, and SCHULZ (1979) for the Lower Maastrichtian. Vertical axis not to scale.

al., 1984; SCHULZ, 1996). This stratigraphical framework is shown in Figure 2.

The conventional Campanian and Lower Maastrichtian belemnite zonation

The belemnite zonation of northwest Europe is based upon species of *Goniatoteuthis* for the Lower Campanian, species of *Belemnitella* for the uppermost Lower Campanian and Upper Campanian and species of *Belemnella* for the Lower Maastrichtian (see reviews by CHRISTENSEN, 1990, 1996) (Fig. 6).

CHRISTENSEN (1997a, b) showed that the belemnitellids suffered a major extinction event around the Lower and Upper Campanian boundary. Three out of four genera became extinct at or close to this boundary: *Goniatoteuthis* at the boundary, *Actinocamax* slightly below and *Belemnelloamax* NAIDIN, 1964b slightly above. Only the genus *Belemnitella* survived this extinction event. However, the lower Upper Campanian *Belemnelloamax balsvikensis* (BROTZEN, 1960) has a very limited area of distribution and occurs essentially in Scania in southern Sweden (CHRISTENSEN 1997a, 1997b). Thus, the Upper Campanian belemnite faunas of the remaining part of the North European Province consist only of species of *Belemnitella*.

The genus *Belemnitella* is represented by only one species, *B. mucronata*, in the basal part of the Upper Campanian, that is a period of about 1.5 Ma (CHRISTENSEN, 1997a, 1997b). The belemnite diversity increased during the later part of the Late Campanian, and several small to very large species of *Belemnitella* occur in the middle and upper Upper Campanian (CHRISTENSEN, 1997a, 1997b).

The conventional Upper Campanian *Belemnitella* zonation includes three interval zones, and these are in ascending order: the lower Upper Campanian *B. mucronata* Zone and the upper Upper Campanian *B. minor* and *B. langei* Zones (Fig. 6). This zonation was introduced by JELETZKY (1951b) and has been used subsequently by numerous authors. It was critically assessed by CHRISTENSEN (1995, 1996), who argued that the *B. minor* and *B. langei* Zones *sensu* JELETZKY should not be maintained for the following reasons:

1) The concept of *B. minor* was based previously on the diagnosis and not on the holotype, and the two concepts are markedly different. CHRISTENSEN (1995) interpreted *B. minor* on the basis its holotype and in this respect it is a very large species, which belongs to the *B. mucronata* group *sensu* CHRISTENSEN (1995). Therefore, it should not be considered as a subspecies of *B. langei* JELETZKY, 1948 as done by NAIDIN (1979) (Fig. 6) or placed in the *B. langei* group as done by KONGIEL (1962).

2) CHRISTENSEN (1995) recognized three chronological subspecies of *B. minor*, which were considered to form an evolutionary lineage, from the upper Upper Campanian and lower Lower Maastrichtian. These are in ascending order, *B. minor* I JELETZKY, 1951a, the nominotypical

subspecies, which occurs in the lower part of the upper Upper Campanian; *B. minor* subspecies II CHRISTENSEN, 1995, which occurs in the upper part of the upper Upper Campanian; and the lower Lower Maastrichtian *B. minor* subspecies III CHRISTENSEN, 1995. It is shown below, however, that *B. minor* III cannot be distinguished from *B. minor* II and it is consequently placed in synonymy with *B. minor* II.

3) *B. langei* is understood only in the sense of the holotype and paratype. The variation of the critical characters are unknown, because statistically evaluated samples of this species from the type locality in Ukraine are not available (CHRISTENSEN *et al.*, 1975). The concept of this species is therefore open to question, and CHRISTENSEN (1995) showed that it differs from one author to another. Neither *B. langei* of SCHULZ (1978) nor *B. langei* of BIRKELUND (1957) are conspecific with *B. langei* JELETZKY, 1948. Moreover, it has been shown recently that *B. langei* does not occur in the Maastricht-Aachen-Liège district (KEUTGEN, 1996), the Höver-Misburg-Ahlten area near Hannover (NIEBUHR *et al.*, 1997) and the Mons Basin (this paper).

The genus *Belemnella* appeared suddenly at the base of the Maastrichtian and almost ousted the genus *Belemnitella* in the Lower Maastrichtian (CHRISTENSEN 1997a, 1997b). The Lower Maastrichtian belemnite zonation is therefore based upon species of *Belemnella* (Fig. 6). JELETZKY (1951b, 1958) and BIRKELUND (1957) subdivided the Lower Maastrichtian into two *Belemnella* zones, the *B. lanceolata* Zone below and the *B. occidentalis* Zone above. SCHULZ (1979) subdivided the Lower Maastrichtian of northwest Europe into six *Belemnella* zones on the basis of species of two subgenera, the slender subgenus *Belemnella* (*Belemnella*) and the stout subgenus *Belemnella* (*Pachybelemnella*) SCHULZ, 1979 (Fig. 6). The lowermost Maastrichtian *B. lanceolata* Interval Zone, is based on *B. (B.) lanceolata*, whereas the remaining zones are based upon species of *B. (Pachybelemnella)*. The *B. lanceolata* Zone is defined by the FAD of its eponymous species to the FAD of *B. (P.) pseudobtusa*. According to SCHULZ (1979) *B. (B.) lanceolata* occurs also in the *B. pseudobtusa* Zone and the basal part of the *B. obtusa* Zone (Fig. 8).

The *Belemnella* zones of SCHULZ (1979) and their correlation with the *Belemnella* zones of JELETZKY (1951b, 1958) and BIRKELUND (1957) were critically assessed by CHRISTENSEN (1996). The following points are worthy of note: 1) The conventional *B. lanceolata* Zone equates broadly with the *B. lanceolata*, *B. pseudobtusa* and *B. obtusa* Zone of SCHULZ (1979); 2) the conventional *B. occidentalis* Zone equates roughly with the *B. sumensis*, *B. cimbrica* and *B. fastigata* Zones of SCHULZ (1979); 3) SCHULZ (1979) placed *B. occidentalis* BIRKELUND, 1957 in synonymy with *B. sumensis* JELETZKY, 1949 and raised *B. occidentalis cimbrica* BIRKELUND, 1957 to full species rank; 4) SCHULZ (1979) showed that *B. sumensis* is confined to the *B. sumensis* Zone (Fig. 8), in contrast to BIRKELUND (1957), who considered that her concept of *B. occidentalis*

lis occidentalis ranges to the top of the Lower Maastrichtian.

Belemnella licharewi JELETZKY, 1941 is used as a zonal index for the basal Lower Maastrichtian on the Russian Platform (Fig. 6). *B. licharewi* was placed in synonymy with *B. desnensis* JELETZKY, 1941 by SCHULZ (1979), who recorded this species from the middle part of the *B. lanceolata* Zone of Krons Moor.

The Upper Campanian and Lower Maastrichtian belemnite succession of the chalks of northwest Germany

SCHULZ (1978, 1996) and SCHULZ *et al.* (1984) recorded the following species of *Belemnitella* from the Upper Campanian chalk of Lägerdorf and Krons Moor in northwest Germany. *B. ex gr. mucronata* from the uppermost

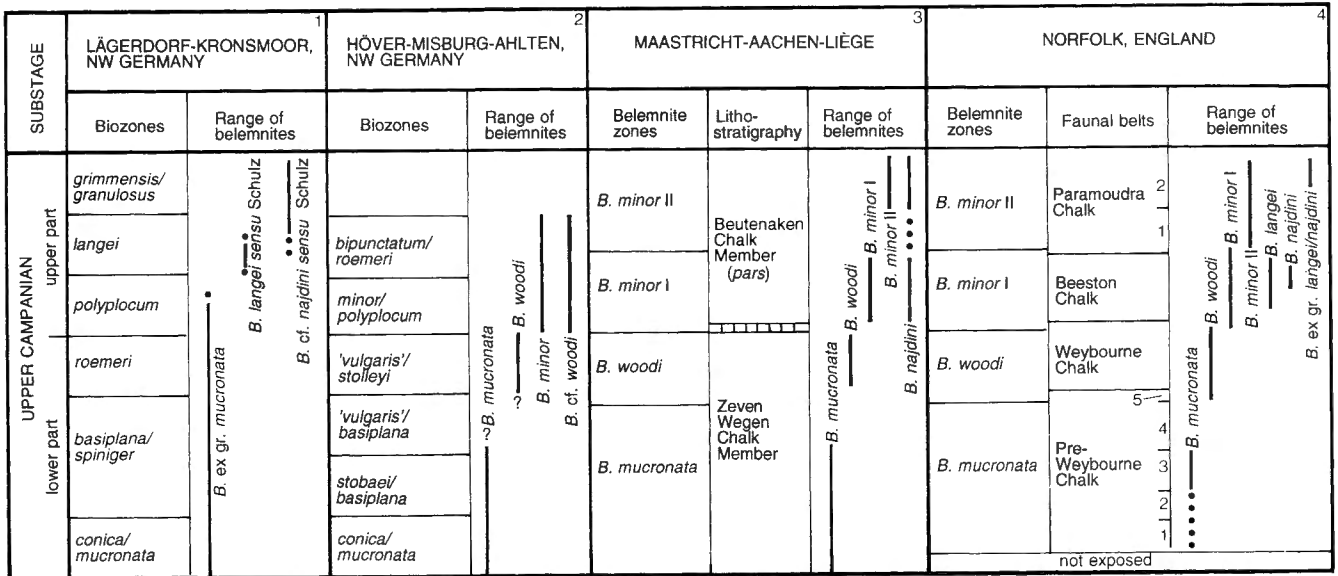


Fig. 7 – Stratigraphical correlation diagram of the Upper Campanian. Sources: column 1, SCHULZ (1979, 1985, 1996) and SCHULZ *et al.* (1984); column 2, NIEBUHR *et al.* (1997) and ERNST *et al.* (1997a, 1997b); column 3, KEUTGEN (1995, 1996) and KEUTGEN & JAGT (in press); column 4, CHRISTENSEN (1995). The four Upper Campanian units of Norfolk are neither biozones nor lithostratigraphical units, but can be characterized as faunal belts (WOOD, 1988). Vertical axis not to scale.

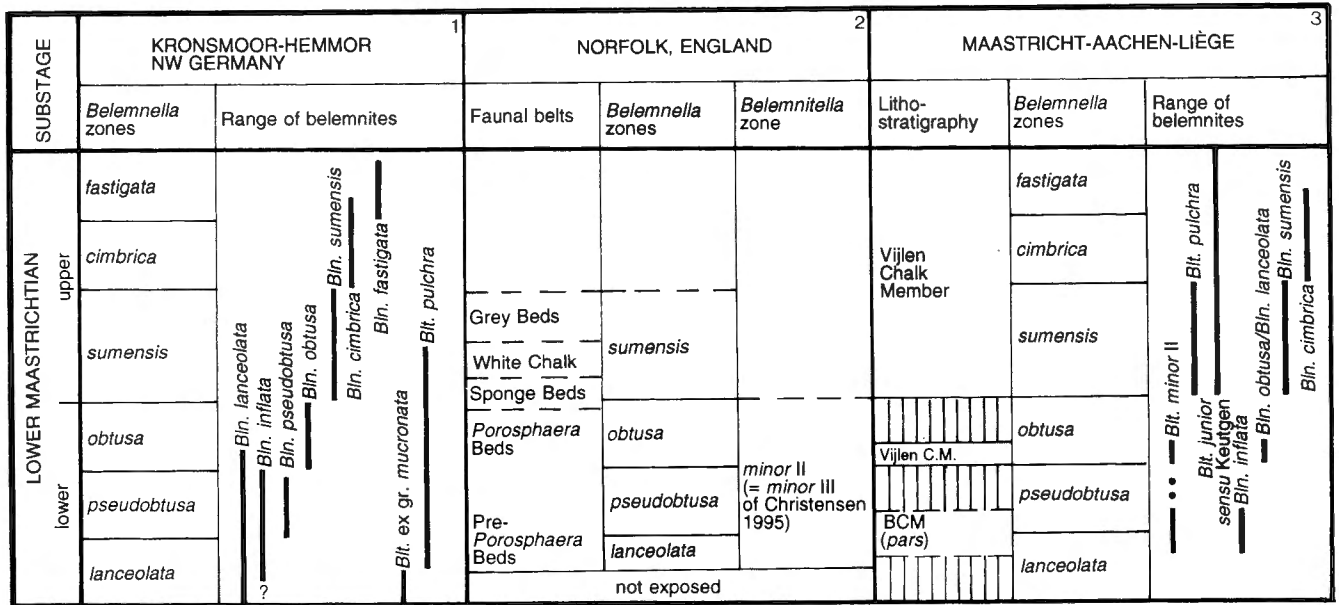


Fig. 8 – Stratigraphical correlation diagram of the Lower Maastrichtian. Sources: column 1, SCHULZ (1978, 1979, 1982, 1996); column 2, CHRISTENSEN (1995); column 3, KEUTGEN (1996). Abbreviations: *Bln.* = *Belemnella*; *Blt.* = *Belemnitella*; BCM = Beutenaken Chalk Member. The five Lower Maastrichtian units of Norfolk are neither biozones nor lithostratigraphical units, but can be characterized as faunal belts (WOOD, 1988). Vertical axis not to scale.

Lower Campanian *G. quadrata gracilis*-*B. mucronata* Zone to the middle Upper Campanian, middle part of the *polyplacum* Zone, *B. langei sensu* SCHULZ (1978) from the lower part of the *langei* Zone and *B. cf. najdini sensu* Schulz (1978) from the upper half of the *langei* Zone to the *grimmensis-granulosus* Zone, except the uppermost 5 m, which have not yielded belemnites (Fig. 7). CHRISTENSEN (1995, 1996) noted that this *Belemnitella* succession differs from that of Norfolk, but stressed that the Upper Campanian species of *Belemnitella* of Lägerdorf and Kronsmoor have not been revised recently.

The Lower Maastrichtian belemnite zonation is based upon species of *Belemnella* (see above and Fig. 8). In addition, SCHULZ (1982) recorded *Belemnitella ex gr. mucronata* from the lower half of the *lanceolata* Zone and *B. pulchra* SCHULZ, 1982 from the upper half of the *lanceolata* Zone to the middle part of the *sumensis* Zone (Fig. 8). These taxa of *Belemnitella* are very rare. Thus, *B. pulchra* constitutes only c. 0.3% of the belemnite fauna of the chalk of Kronsmoor (SCHULZ 1982, p. 282).

The Upper Campanian and Lower Maastrichtian belemnite zonation of Norfolk

CHRISTENSEN (1995) subdivided the Upper Campanian chalks of Norfolk into four informal *Belemnitella* zones on the basis of large to very large species of *Belemnitella*. These are in ascending order: the lower Upper Campanian *B. mucronata* Zone below and *B. woodi* Zone above, and the upper Upper Campanian *B. minor* I Zone below and *B. minor* II Zone above (Fig. 7). The *B. minor* I zone was subdivided into three informal subzones and the *B. minor* II zone into two informal subzones, mainly on the basis of small species of *Belemnitella*, that is *B. langei*, *B. najdini* KONGIEL, 1962 and *B. ex gr. langei/najdini*. The upper Upper Campanian *Belemnitella* succession of Norfolk may be explained by three successive immigrations of small species of *Belemnitella* into the Norfolk area: 1) *B. langei* in the middle Upper Campanian, 2) *B. najdini* slightly later in the middle Upper Campanian and 3) *B. ex gr. langei/najdini* in the uppermost Upper Campanian (CHRISTENSEN 1997a, b).

The Upper Campanian zones and subzones were regarded as informal for the following reasons. The bases of most of the zones and subzones could not be precisely defined as there are gaps between the exposures, and it was not known if the zonation could be extended to other areas in northwest Europe. It has been shown subsequently, however, that the Upper Campanian *Belemnitella* zones of Norfolk are applicable elsewhere in northwest Europe (see discussion below).

The lower Lower Maastrichtian *B. minor* III zone of Norfolk (CHRISTENSEN 1995) is renamed the *B. minor* II Zone (Fig. 8), because *B. minor* subspecies III CHRISTENSEN, 1995 is placed in synonymy with *B. minor* II (see below). The lower Lower Maastrichtian belemnite sequence of Norfolk is totally anomalous and not repeated

elsewhere in Europe (CHRISTENSEN 1996). It is in ascending order: 1) a mixed *Belemnella/Belemnitella minor* II assemblage, Overstrand Hotel Upper Mass, Pre-*Porosphaera* Beds; 2) only *Belemnitella minor* II, basal part of the Sidestrand succession, Pre-*Porosphaera* Beds; 3) a mixed *Belemnella/Belemnitella minor* II assemblage, Sidestrand, between Flint W and Flint P, Pre-*Porosphaera* Beds and *Porosphaera* Beds; and 4) *Belemnella*, Sidestrand, above Flint P, Sponge Beds. This belemnite sequence may be explained by two successive immigrations of *Belemnella* into the Norfolk area (CHRISTENSEN 1997b).

The Upper Campanian and Lower Maastrichtian belemnite succession of the Maastricht-Aachen-Liège (MAL) district

The Upper Campanian and Lower Maastrichtian of this area have been subdivided into three members: the lower Upper Campanian Zeven Wegen Chalk Member, the upper Upper Campanian and lower Lower Maastrichtian Beutenaken Chalk Member and the upper Lower Maastrichtian Vijlen Chalk Member (Figs 7-8). These members belong to the Gulpen Formation. The upper Upper Campanian and lower Lower Maastrichtian rocks are highly condensed (KEUTGEN, 1996).

KEUTGEN (1995) and KEUTGEN & JAGT (in press) recorded the following *Belemnitella* succession from the Zeven Wegen Member (= craie blanche of previous authors) of the Gulpen Formation in the CPL pit at Hallembaye in northeast Belgium (Fig. 7). *B. mucronata* occurs in the basal 5 m of the member. Belemnites were not recorded from the 5-10 m interval above the base of the member. *B. woodi* occurs in the 10-28 m interval above the base of the member. The early form of *B. woodi* occurs in the interval 10-16 m and the late form of *B. woodi* occurs in interval 17-28 m above the base of the member. Belemnites were not recorded from the 1 m thick Froidmont Hardground at the top of the member.

KEUTGEN (1996) recorded *B. minor* I and *B. najdini* from the lower part of the overlying Beutenaken Member of the Gulpen Formation at Teuven, northeast Belgium (Fig. 7). He recorded *B. minor* II and *B. najdini* from the upper, but not uppermost, part of the Beutenaken Member at Slenaken and Bovenste Bos in the southeastern part of the Netherlands.

Since *B. langei* does not occur in the MAL district the *Belemnitella* "*langei*" Zone of KEUTGEN & VAN DER TUUK (1990) was substituted by the *B. minor* Zone by KEUTGEN (1996).

In conclusion, the Upper Campanian *Belemnitella* succession of the MAL district is very closely similar to that of Norfolk (see above).

KEUTGEN (1996) recorded *Belemnitella minor* II (common) and *Belemnella inflata* (ARKHANGELSKY, 1912) (very rare) from the uppermost part of the Beutenaken Chalk Member (Fig. 8), from the outcrop at Pesaken-Crapoel in the southeastern part of the Netherlands. The

entry of *B. inflata* is thus the first appearance datum of the genus *Belemnella* in the MAL district. *Belemnella lanceolata*, which is usually used as the zonal index fossil for the basal Maastrichtian, occurs slightly later in the MAL district, that is in the *Belemnella obtusa* Zone (see below). KEUTGEN (1996) recorded *Belemnella obtusa*, *Belemnella lanceolata* and *Belemnitella minor* II from burrows filled with greensand in the uppermost part of the Beutenaken Chalk Member of the abandoned pit at Bovenste Bos in the southeastern part of the Netherlands (Fig. 8). He regarded the burrow fills as belonging to the basal part of the Vijlen Chalk Member. This belemnite assemblage was placed in the middle Lower Maastrichtian *Belemnella obtusa* Zone.

According to KEUTGEN (1996) the Vijlen Chalk Member *sensu stricto* has yielded two belemnite assemblages: a lower assemblage with *Belemnella sumensis* JELETZKY, 1949, *Belemnitella junior* NOWAK, 1913 and *Belemnitella pulchra* SCHULZ, 1982, and an upper assemblage with *Belemnella cimbrica* BIRKELUND, 1957 and *Belemnitella junior* (Fig. 8). He placed the lower assemblage in the *Belemnella sumensis* Zone and the upper assemblage in the *Belemnella cimbrica* Zone and the lower part of the *Belemnella fastigata* Zone, although *B. fastigata* SCHULZ, 1979 has not been recorded from the MAL district. The uppermost 8-9 m of the Vijlen Chalk Member has not yielded *Belemnella*, *Belemnitella junior* being the sole species represented in this interval (KEUTGEN, 1996).

Belemnitella junior has been used as a zonal index fossil for the lower Upper Maastrichtian of northwest Europe for almost half a century (see review by CHRISTENSEN, 1996). However, KEUTGEN (1996: 61-62, 67, 96-97, 157) discarded *B. junior* as an index fossil, because he argued that it appeared in the upper Lower Maastrichtian and persisted into the the Upper Maastrichtian in the MAL district. It is, however, questionable if the upper Lower Maastrichtian form is conspecific with *B. junior*. KEUTGEN (1996: 62) noted that he had compared statistically specimens of *Belemnitella* of late Early Maastrichtian age with a small sample of *B. junior*, consisting of only 16 specimens, from the Upper Maastrichtian Nekum Chalk Member. According to this comparison the two samples did not differ in any of their critical characters, that is the size and shape of the guard, as well as Schatzky distance, fissure angle and alveolar angle. I suspect, however, that it might be possible to detect significant differences between the upper Lower and Upper Maastrichtian samples of *Belemnitella* when large samples are compared, or to detect evolutionary trends when several closely spaced samples are analyzed. For instance, KEUTGEN & VAN DER TUUK (1990) distinguished samples of *B. ex gr. junior* from the lower and upper part of the Vijlen Chalk Member *s. str.* on the basis of the slenderness of the guard. The specimens from the upper part of the member are more slender. It should be mentioned in passing that KEUTGEN & VAN DER TUUK (1990) placed the upper part of the Vijlen Chalk Member in the lower Upper Maastrichtian, in contrast to KEUTGEN (1996), who placed the entire Vijlen Chalk in the Lower Maastrichtian.

In any case, *B. junior* has not been recorded from the Lower Maastrichtian elsewhere, except Poland, where KONGIEL (1962) described this species from the entire Lower Maastrichtian. The record from Poland is dubious, however. As a matter of fact, KONGIEL (1962) described seven species of *Belemnitella* from the Lower Maastrichtian of Poland, and this genus was thus the subject of excessive subdivision.

In the Hemmoor pit in northwest Germany, *B. junior* appears about 5 m above marl bed M900, which for practical reasons was taken as the base of the Upper Maastrichtian by SCHULZ & SCHMID (1983b).

In conclusion, *Belemnitella minor* II co-occurs with species of *Belemnella* in the lower Lower Maastrichtian of the MAL district, as in Norfolk and the Mons Basin. *B. minor* II is common and *Belemnella (Pachybelemnella) inflata* is very rare in the earliest Maastrichtian of the MAL district.

The Upper Campanian belemnite succession of the Höver-Misburg-Ahlten area at Hannover

The Upper Campanian *Belemnitella* succession of this area is as follows, in ascending order. *B. mucronata* occurs in the *conica/mucronata* and *stobaei/basiplana* Zones (CHRISTENSEN, 1995, Table 12) (Fig. 7). *B. woodi* occurs in the "*vulgaris*"/*stolleyi* Zone (ERNST *et al.*, 1997b; NIEBUHR *et al.*, 1997). It co-occurs with a small species of *Belemnitella*, which has a large fissure angle (= *B. minor* of German authors) (ERNST *et al.*, 1997b, pp. 94-95). *B. minor* occurs in the *minor/polyplocum* and *bipunctatum/roemeri* Zones (NIEBUHR *et al.*, 1997). NIEBUHR *et al.* also recorded rare specimens of a large species of *Belemnitella* from the upper part of the *minor/polyplocum* Zone and the *bipunctatum/roemeri* Zone and these were tentatively referred to as *B. cf. woodi*.

It appears that NIEBUHR *et al.* (1997) determined the *Belemnitella* species mainly on the basis of external characters. Therefore, the specimens referred to as *B. cf. woodi* might be *B. minor*.

The *bipunctatum/roemeri* Zone equates broadly with the *langei* Zone of Lägerdorf. Since *B. langei* does not occur in the Höver-Misburg-Ahlten area in the Lehrte West Syncline, the *langei* Zone of Lägerdorf was substituted by the *bipunctatum/roemeri* Zone by NIEBUHR *et al.* (1997).

It should be mentioned in passing that SCHULZ (1985) replaced the *Galerites vulgaris* Zone of ERNST (1963a, 1963b) by the new *G. roemeri* Zone. However, ERNST *et al.* (1997a, 1997b) and NIEBUHR *et al.* (1997) showed that *G. roemeri* occurs only in the *bipunctatum/roemeri* Zone, whereas *G. vulgaris* occurs in the "*vulgaris*"/*basiplana* and "*vulgaris*"/*stolleyi* Zones, in addition to the lower and middle part of the *minor/polyplocum* Zone in the Höver-Misburg-Ahlten area.

In conclusion, the Upper Campanian *Belemnitella* succession of Höver-Misburg-Ahlten is very closely similar to that of Norfolk, MAL district and the Mons Basin.

The Upper Campanian and Lower belemnite zonation of the Mons Basin

The *Belemnitella mucronata* Zone includes at least the topmost 6 metres of the Craie de Trivières and basal 120 cm of the Craie d'Obourg (Fig. 2). This zone has yielded only the eponymous species. The zone is poorly defined, because neither the base nor the top have been established. The top of the uppermost Lower Campanian *Goniot euthis quadrata gracilis/Belemnitella mucronata* Zone, that is the boundary between the Lower and Upper Campanian, has not been recognized in the Mons Basin.

The next higher zone is the *Belemnitella woodi* zone, which includes at least the uppermost 4 m of the Craie de Nouvelles, except the hardground at the top of the formation. The base of the *B. woodi* zone cannot be precisely defined, because insufficient belemnite material is available from the interval from 1.2 m above the base of the Craie d'Obourg to 4 m below the top of the Craie de Nouvelles of the CCC pit. *B. sp. 2*, which probably belongs to the *B. langei* group, occurs very rarely in the upper part of the *B. woodi* Zone.

The base of the *Belemnitella minor* I zone is defined by the FAD of *B. minor* I in the hardground at the top of the de Nouvelles, and this zone includes at least the basal 10 m of the Craie de Spiennes. *B. sp. 1* of the *B. mucronata* group occurs very rarely in this zone.

The *Belemnitella minor* II zone includes at least the topmost 1 m of the Craie de Spiennes. The base of the zone is poorly defined, because the lower limit of the index species has not been established. This zone has yielded only the index species.

The *Belemnella obtusa/Belemnitella minor* II zone comprises the lower Lower Maastrichtian Craie Phosphatée de Ciplly. In addition to the index species, *Belemnitella pulchra* occurs very rarely in this zone.

There is thus a non-sequence at the Maastrichtian-Danian boundary in the Mons Basin, spanning the lower Lower Maastrichtian *Belemnella lanceolata* and *B. pseudobtusa* Zones and possibly also part of the uppermost Campanian.

Towards a new, formal Upper Campanian *Belemnitella* zonation of northwest Europe

The subdivision of the Upper Campanian chalks of Norfolk into four informal *Belemnitella* zones on the basis of large to very large species by CHRISTENSEN (1995) has subsequently been shown to be applicable elsewhere in northwest Europe, namely in the Mons Basin, the Maastricht-Aachen-Liège district and the Misburg-Höver-Ahlten area at Hannover (see above).

These zones are, in ascending order, the lower Upper Campanian *B. mucronata* Zone below and *B. woodi* Zone above, and the upper Upper Campanian *B. minor* I Zone below and *B. minor* II Zone above. These may be regarded now as formal zones, because they have been

recognized in widely spaced areas in northwest Europe (Fig. 2).

The base of the *B. mucronata* Zone is defined by the extinction level of the genus *Goniot euthis*. The base of this zone cannot be defined in Norfolk, since the lowermost Upper Campanian is not exposed (see discussion by CHRISTENSEN 1995). In the Mons Basin, the base of the zone probably lies in the uppermost part of the Craie de Trivières, but it has not yet been established. In the marls and marly limestones of the Germania IV and Teutonia I pits at Misburg near Hannover, northwest Germany, the frequency of *Goniot euthis quadrata gracilis* (STOLLEY, 1892) decreases gradually upwards in the uppermost Lower Campanian *gracilis/mucronata* Zone, whereas the frequency of *B. mucronata* first increases and thereafter decreases (KHOSROVSHAHIAN, 1972, Figs 11-12). In the chalk of Lägerdorf *B. mucronata* is very rare in the *gracilis/mucronata* Zone, while *G. quadrata gracilis* is relatively common until its extinction at the top of the zone (SCHULZ, 1978).

The base of the *B. woodi* Zone cannot be precisely defined, because the lower boundary of the index species has nowhere been established.

The base of the *B. minor* I Zone is placed at the base of the Catton Sponge Bed in Norfolk, at the base of the hardground at the top of the Craie de Nouvelles in the Mons Basin and at the base of the Beutenaken Member in the Maastricht-Aachen-Liège area.

The base of the *B. minor* II Zone cannot be precisely defined, because the lower boundary of the index species has not been established in Norfolk, the Mons Basin and the Maastricht-Aachen-Liège district. Moreover, NIEBUHR *et al.* (1997) did not distinguish subspecies of *B. minor* from the Höver-Misburg-Ahlten area.

In contrast, the upper Upper Campanian subzones of Norfolk (CHRISTENSEN, 1995), which are based mainly on small species of *Belemnitella*, that is *B. langei*, *B. najdini* and *B. ex gr. langei/najdini*, have not been recognized elsewhere. *B. langei* and *B. najdini* do not occur in the Mons Basin (this paper), and *B. langei* has been recorded neither from the Maastricht-Aachen-Liège district (KEUTGEN, 1996) nor the Misburg-Höver-Ahlten area (NIEBUHR *et al.*, 1997).

Small species of *Belemnitella* do occur, in fact, in the Upper Campanian of the Mons Basin and Maastricht-Aachen-Liège district. KEUTGEN (1996) recorded *B. najdini* from both the *B. minor* I and *B. minor* II Zones of the Maastricht-Aachen-Liège district (Fig. 7) and *Belemnitella sp. 2*, which probably belongs to the *B. langei* group, occurs in the upper part of the *B. woodi* Zone of the Mons Basin (Fig. 2).

The timespan of the Late Campanian was long, *c.* 9 Ma (see above), and hence each of the four *Belemnitella* zones represents an average of more than 2 Ma. CHRISTENSEN (1996) noted that the Upper Campanian should be divided into a dozen zones in comparison with the Santonian and Lower Campanian *Goniot euthis* zones and 15-75 zones in comparison with the Lower Maastrichtian *Belemnella* zones.

It is noteworthy that the Upper Campanian ammonite zonation of northwest Europe is as poor as the belemnite zonation. BŁASZKIEWICZ (1980) recognized only four ammonite zones in Poland and these were tentatively correlated with the biozonation of Lägerdorf and the belemnite zonation of Norfolk by CHRISTENSEN (1995, 1998). The uppermost Lower Campanian and Upper Campanian of the Höver-Misburg-Ahlten area have been subdivided into three scaphitid zones by SCHMID & ERNST (1975) and NIEBUHR (1996). In contrast, the Upper Campanian of the Western Interior of the United States is subdivided into 18 ammonite zones (KENNEDY & COBBAN, 1993). The uppermost Upper Campanian *Baculites eliasi* Zone of KENNEDY & COBBAN (1993) was subsequently placed in the basal Maastrichtian by COBBAN & KENNEDY (1995). HANCOCK (1991) remarked that the Campanian should be divided into 20-25 ammonite zones in comparison with earlier Cretaceous stages.

It therefore seems that the actual rate of evolution amongst the belemnites and ammonites was relatively slow during the Late Campanian.

Middle Upper Campanian hardgrounds

Hardgrounds of middle Late Campanian age occur in the Mons Basin, Maastricht-Aachen-Liège district, Norfolk in eastern England and Northern Ireland. At the border of the Mons Basin, e.g. the CCC pit at Harmignies, the Craie de Nouvelles is terminated by a hardground, which is overlain by the Craie de Spiennes (Fig. 2). *Belemnitella woodi* occurs in the uppermost four metres of the Craie de Nouvelles, except in the hardground, and *B. minor* I appears in the hardground and continues into the lower part of the Craie de Spiennes. In the MAL district *B. woodi* occurs in the upper part of the Zeven Wegen Chalk Member, except the Froidmont Hardground at the top of the member, and this species is followed upwards by *B. minor* I in the basal part of the Beutenaken Chalk Member (KEUTGEN, 1995, 1996; KEUTGEN & JAGT, in press) (Fig. 7). The Weybourne Chalk of Norfolk is terminated by a hardground, referred to as the main Catton Catton Sponge Bed, and is followed upwards by the Beeston Chalk. *B. woodi* occurs in the Weybourne Chalk, except the main Catton Sponge Bed, and *B. minor* I appears in the Catton Sponge Bed (CHRISTENSEN, 1995) (Fig. 7). The North Antrim Hardground complex in Northern Ireland lies at the base of unit β of the Glenarm Chalk Member, and the terminal hardground was correlated with the main Catton Sponge Bed of Norfolk on faunal grounds by FLETCHER & WOOD (1978).

In conclusion, these four hardgrounds, which occur in widely separated areas in northwest Europe, appear to be coeval on belemnite as well as other faunal evidence. The hardgrounds are situated at the base of the *Belemnitella minor* I Zone and are of earliest late Late Campanian age.

The formation of hardgrounds is generally associated with reduced sedimentation rates or hiatuses (GALE,

1996), and was ascribed by HANCOCK (1993b) to one of three causes: 1) a widespread fall of sea-level, 2) local diapiric uplift, 3) or rejuvenation of uplift along earlier tectonic axis. HANCOCK (1990, 1993a) used hardgrounds and nodular chalks, when he developed a sea-level curve for the Upper Cretaceous of Britain. Each hardground was taken as a marker for the end of a period of relative sea-level fall (bottom of regressive trough), and transgressive peaks were placed midway between two hardgrounds. However, GALE (1996) suggested that hardgrounds represent both regressive and transgressive events and noted that (p. 185): "In sequence stratigraphical terminology, they [hardgrounds] developed both at sequence boundaries, at the maximum rate of sea-level fall, and as parts of the transgressive systems tracts, when current winnowing was dominant." ERNST *et al.* (1996, Fig. 4) independently arrived at the same conclusion.

Thus, the middle Upper Campanian hardgrounds may represent a regional, chronostratigraphical marker horizon, the origin of which is related to a global eustatic sea-level change. In this context, it is worthy of note that NIEBUHR *et al.* (1997) showed that the *Bostrychoceras polyplacum* regression in the Höver-Misburg-Ahlten area at Hannover began in the "vulgaris"/*stolleyi* Zone and the depth of the sea reached a minimum of about 50 m in the *bipunctatum/roemeri* Zone (Fig. 7). It was during the *polyplacum* regression that the so-called Opoka (a spongiferous, spiculitic marl), was deposited at Ahlten (NIEBUHR *et al.*, 1997).

At Lägerdorf in northwest Germany, the calcareous content of the chalk decreased to 93-94% in the *polyplacum* Zone and reached a minimum of 88-90% in the Campanian-Maastrichtian boundary beds (SCHULZ, 1978). This decrease may be linked to the *polyplacum* regression. The Craie de Spiennes is a coarse-grained chalk which becomes calcarenitic at the top. Thus, this formation was deposited during more shallow-water conditions than the underlying Craie de Nouvelles, probably during the *polyplacum* regression. The fauna of the Beeston Chalk of Norfolk is extraordinarily rich both in numbers and diversity at some horizons (WOOD, 1988), and this chalk is most likely a shallow-water chalk. Thus, the Beeston Chalk may have been deposited during the *polyplacum* regression. In the Kristianstad Basin in southern Sweden the upper Upper Campanian is missing (CHRISTENSEN, 1975, 1998b).

It can thus be concluded that the upper Upper Campanian was a period of regression, and the hardgrounds at the base of the *Belemnitella minor* I Zone may have been developed during the maximum rate of sea-level fall.

In contrast, HANCOCK (1990, 1993a) has a transgressive peak low in the *Belemnitella langei* Zone *sensu anglico* (peak no. 3 of HANCOCK, 1993a), being in the middle Beeston Chalk in Norfolk, low in the Portrush Chalk of Northern Ireland, and near the top of the *Bostrychoceras polyplacum* Zone of Lägerdorf in northwest Germany. As mentioned above, the Beeston Chalk and the *polyplacum* Zone chalk of Lägerdorf were probably deposited during

a relative fall of sea-level. Moreover, FLETCHER & WOOD (1978, p. 100) suggested that the Portrush Chalk was laid down in relatively shallow-water. The late Late Campanian transgressive peak of HANCOCK is thus enigmatic.

Systematic Palaeontology

MORPHOLOGY OF THE GUARD AND TERMINOLOGY: The guard is usually the only part of the skeleton which is preserved in the Belemnitellidae, and its external and internal characters are used for taxonomic classification (Fig. 9).

The guard is completely calcified only in the genera *Belemnitella*, *Belemnella* and possibly *Fusiteuthis* KONGIEL, 1962, and these have, therefore, a true alveolus adorally. However, complete guards are extremely rare, because the most adoral part of the guard is usually not preserved due to its fragility.

MEASURED CHARACTERS AND ABBREVIATIONS: A list of measured characters and their abbreviations is given in Figure 9. In addition, the following are in the descriptions: lateral diameter at the protoconch (LDP) and maximum lateral diameter (MLD). It is worthy of note that the fissure angle of SCHULZ (1979, 1982) is defined in another way than by BIRKELUND (1957) and CHRISTENSEN (1975, 1986, 1991, 1995), among others. The fissure angle of SCHULZ is the angle between the longitudinal axis of the guard and the straight line which connects the intersection points of the bottom of the ventral fissure on the wall of the alveolus and the outer margin of the guard. The fissure angle of BIRKELUND and CHRISTENSEN is the

angle between the wall of the alveolus and the straight line connecting the the intersection points of the bottom of the ventral fissure. The difference between the two definitions is that the fissure angle in the first case includes the half of the alveolar angle.

SCHULZ (1979) introduced a set of derived characters in his study of Lower Maastrichtian species of *Belemnella*. These are discussed below.

Linear measurements were made with vernier calipers to an accuracy of 0.1 mm, and angles were measured with a goniometer ocular fitted on a Wild stereomicroscope to an accuracy of 0.5°.

BIOMETRIC METHODS: Species variability is analyzed using univariate and bivariate statistical methods and is summarized by descriptive statistics and scatter diagrams. The statistics were calculated according to standard formulae presented by SIMPSON *et al.* (1960) and SOKAL & ROHLF (1969).

In the univariate analyses estimates of the following statistics were calculated: arithmetical mean value (\bar{X}), standard deviation (SD) and coefficient of variation (CV). In addition, the observed range (OR) is reported and N is the number of specimens.

The regression line is written: $y = a + bx$, and the original measurements were used in the calculations due to the linear trend on ordinary graph paper and the homoscedastic variance around the regression line. Estimates of the following statistical parameters were calculated: the slope (b), the standard deviation of the slope (SD_b), the intercept on the y -axis (a), the standard deviation of the intercept (SD_a), the standard deviation of the regression line (SD_{yx}), and the correlation coefficient.

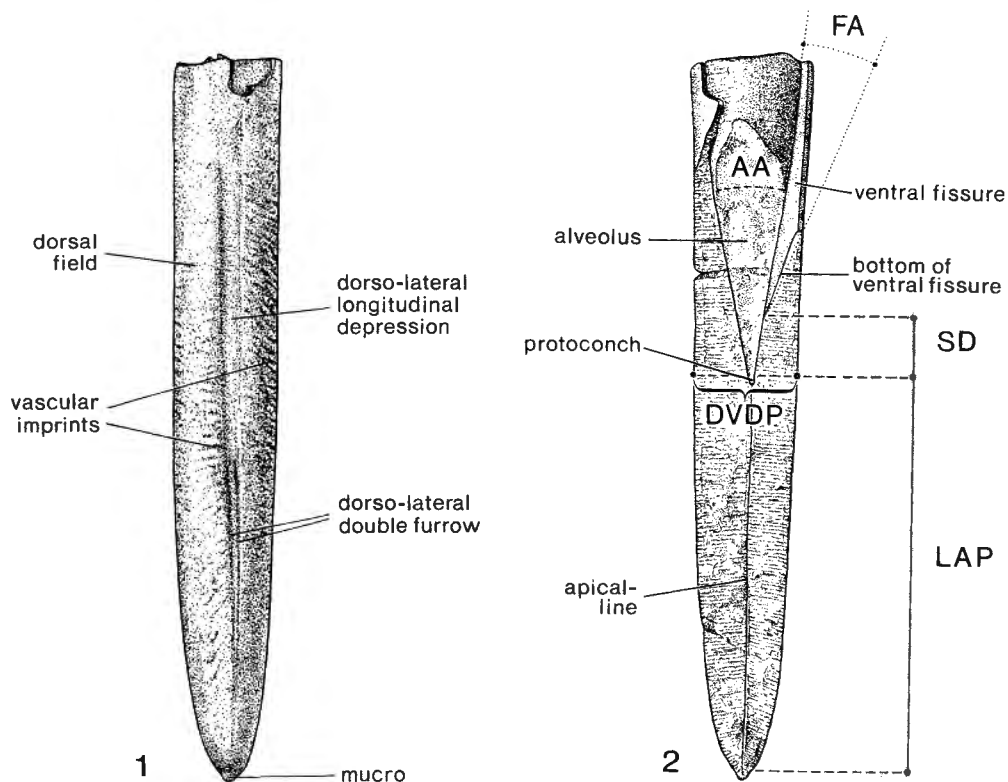


Fig. 9 – Morphological elements of the guard, neotype of *Belemnitella mucronata*. 1, ventro-lateral view; 2, view of the split guard. LAP = length from apex to protoconch; DVDP = dorso-ventral diameter at protoconch; SD = Schatzky distance; AA = alveolar angle; and FA = fissure angle. After CHRISTENSEN (1975).

cient (r). N is the number of specimens. The correlation coefficients were tested for significance using Table Y in ROHLF & SOKAL (1969), and t -tests on the y -intercepts were performed in order to see if the intercept differed significantly from zero. The latter test has significant biological implications since a regression line passing through the origin indicates isometric growth, $y = bx$. In this case the ratio of x divided by y remains constant during growth. The equations $y = a + bx$ and $y = bx^a$ both represent allometric growth. The latter is usually referred to as the equation of simple allometry. In case of allometry, the ratio of x divided by y changes during growth.

Conventional statistical significance levels are as follows:

$0.05 > P > 0.01$; significant*

$0.01 > P > 0.001$; highly significant**

$P < 0.001$; very highly significant***;

P = probability.

Ratios have been widely used in belemnite studies, but these should be used only when growth is isometric or when specimens of nearly the same size of different species are compared (CHRISTENSEN, 1997a).

The relationship of the length from the apex to the protoconch vs the dorso-ventral diameter at the protoconch usually does not differ significantly from isometry in the genus *Belemnitella* (CHRISTENSEN, 1995). In contrast, this relationship is strongly allometric in the genus *Belemnella*. Since the relationship of the two variates usually is isometric in the genus *Belemnitella*, the ratio of these variates, which was named the Birkelund Index by CHRISTENSEN (1995), was calculated for each specimen. The mean value of the Birkelund Index, which has been shown to be of important taxonomic value, is reported in the univariate analyses.

LOCATION OF SPECIMENS: This is indicated by the following abbreviations: (1) BGS GSM, British Geological Survey, Geological Survey Museum. (2) BMNH, Natural History Museum, London. (3) IRSNB, Institut Royal des Sciences Naturelles de Belgique, Bruxelles. (4) MGUH and GM, Geological Museum, University of Copenhagen. Figured specimens are housed in the Type Collection, with prefix MGUH; other specimens carry accession numbers, prefix GM. (5) SGPIH, Geologisch-Paläontologisches Institut der Universität Hamburg.

Class Cephalopoda CUVIER, 1795
Subclass Coleoidea BATHER, 1881
Superorder Belemnoida HYATT, 1884
Order Belemnitida ZITTEL, 1895
Suborder Belemnopseina JELETZKY, 1965
Family Belemnitellidae PAVLOW, 1914
[ICZN 1985, Opinion 1328, name no. 572]

DIAGNOSIS: See CHRISTENSEN (1997a).

REMARKS: CHRISTENSEN (1997a) recognized nine genera and two subgenera of the Belemnitellidae: *Praeactinocamax* NAIDIN, 1964b, *Actinocamax* MILLER, 1823, *Belemnocamax* CRICK, 1910, *Gonioteuthis* BAYLE, 1878, *Belemnelloamax* NAIDIN, 1964b, *Goniocamax* NAIDIN, 1964b, *Belemnitella* d'ORBIGNY, 1840, *Belemnella* (*Belemnella*) NOWAK, 1913, *Belemnella* (*Pachybelemnella*) SCHULZ, 1979, *Belemnella* (*Neobelemnella*) NAIDIN, 1975 and *Fusiteuthis* KONGIEL, 1962. He provided diagnosis of these genera and subgenera and discussed their origin.

DISTRIBUTION: Belemnitellids occur only in the Northern Hemisphere and are recorded from the North European and North American Provinces of the North Temperate Realm, in addition to the northern margin of the Tethyan Realm in Europe (CHRISTENSEN, 1997a, 1997b). The earliest species, *Praeactinocamax primus* (ARKHANGELSKY, 1912), appeared in the Lower Cenomanian, some way above the base of the substage. The belemnitellids became extinct at the Maastrichtian-Danian boundary, as did the ammonites.

Genus *Belemnitella* d'ORBIGNY, 1840
[ICZN 1985, Opinion 1328; name no. 2269]

TYPE SPECIES: *Belemnites mucronatus* SCHLOTHEIM, 1813, p. 111, by subsequent designation of HERRMANNSEN (1846, p. 105); ICZN Opinion 1328 (1985), name no. 2979.

DIAGNOSIS: See CHRISTENSEN (1997a).

REMARKS: CHRISTENSEN (1995) introduced a classification of size ranges of species of *Belemnitella* based on the length from the apex to the protoconch (LAP), which is as follows: 1) guard small, LAP less than 55 mm; 2) guard large, LAP 55-65 mm; and 3) guard very large, LAP larger than 65 mm. He also introduced a classification of the slenderness of the guard based on the mean Birkelund Index (BI), which is as follows: 1) guard stout, mean value of BI less than 4; 2) guard slender, mean value of BI 4 to 5; and 3) guard very slender, mean value of BI larger than 5.

DISTRIBUTION: *Belemnitella* is widely distributed and occurs in the North European and North American Provinces, in addition to the northern part of the Tethyan Realm in Europe. It appears at the base of the Santonian and continues to the top of the Maastrichtian. It is thus a very long-ranging genus, about 21 million years longevity (CHRISTENSEN, 1997a).

Belemnitella mucronata group

This group includes species with small to very large guards, which are stout to slender. The fissure angle is usually small to medium-sized, the bottom of the ventral fissure is usually straight and the Schatzky distance is medium-sized to large (CHRISTENSEN, 1995).

Belemnitella mucronata (SCHLOTHEIM, 1813)
Pl. 1, Figs 1-8; Pl. 2, Figs 1-4

SYNONYMY: See CHRISTENSEN (1995).

NEOTYPE: Specimen no. kca 5/2 in the Collections of the Niedersächsisches Landesamt für Bodenforschung, Hannover (International Commission on Zoological No-

menclature 1985, Opinion 1328). It came from the upper part of the lower Upper Campanian *stobaei/basiplana* Zone of the Germania IV pit at Misburg near Hannover and was described by CHRISTENSEN *et al.* (1975, pl. 1, fig. 1; fig. 9 herein).

MATERIAL: 66 specimens, including MGUH 19569 and 24783, from the top 6 m of the Craie de Trivières; 13 specimens, including MGUH 24787, from the basal 1.2 m of the Craie d'Obourg, CCC pit, Harmignies.

SHORT DESCRIPTION: Guard large and stout; slightly lanceolate to subcylindrical in ventral view and high conical to subcylindrical in lateral view; guard flattened over its entire length; apical end acute or obtuse with well-defined mucro; mean value of Birkelund Index usually about 3.3-3.6; Schatzky distance medium-sized to large (mean values 7-9.5 mm); fissure angle small (mean values 15-25°); alveolar angle large, mean values generally 20-21°; and bottom of ventral fissure usually straight.

BIOMETRY: I have analyzed biometrically two samples: 1) 46 specimens from the top six metres of the Craie de Trivières, CCC pit, Harmignies and 2) eight specimens from the basal 120 cm of the Craie d'Obourg, CCC pit, Harmignies. Univariate analyses were made for both samples; bivariate analysis only for sample 1 due to the small number of specimens in sample 2.

The results of the univariate analyses are shown in Tables 1-2. The scatter plot of the length from the apex to the protoconch vs the dorso-ventral diameter at the protoconch of sample 1 is shown in Figure 10, as is the regression line. The value of the correlation coefficient is very highly significant, ($P < 0.001$, with 41 degrees of freedom). The t -test of the y -intercept gives a value of

Table 1 - Univariate analysis of *Belemnitella mucronata*, topmost 6 m of the Craie de Trivières, CCC pit, Harmignies.

Character	N	\bar{X}	SD	CV	OR
LAP	43	43.1	8.1	18.8	22.7-57.1
DVDP	46	13.2	2.8	21.1	6.7-18.5
LDP	44	13.6	2.8	20.3	8.2-19.4
MLD	36	13.5	2.9	21.1	6.2-19.4
SD	27	9.0	1.9	20.6	5.7-12.7
FA	24	17.8	5.7	31.7	10.0-31.0
AA	22	20.1	0.8	4.0	19.0-22.0
BI	42	3.3	0.3	10.1	2.7- 4.2

Table 2 - Univariate analysis of *Belemnitella mucronata*, basal 120 cm of the Craie d'Obourg, CCC pit, Harmignies.

Character	N	\bar{X}	SD	CV	OR
LAP	8	41.8	8.6	20.5	28.5-56.0
DVDP	8	12.2	3.2	25.8	7.1-16.5
LDP	7	11.5	2.9	25.6	6.6-15.0
MLD	7	12.5	3.1	24.9	6.6-15.1
SD	4	10.4	1.0	9.7	9.5-11.4
FA	4	16.3	6.9	42.2	8.0-24.0
AA	4	20.5	0.4	2.0	20.0-21.0
BI	8	3.5	0.4	12.6	2.7- 4.0

0.2084, which is not significant ($0.90 > P > 0.80$, with 41 degrees of freedom), implying an isometric relationship of the variates.

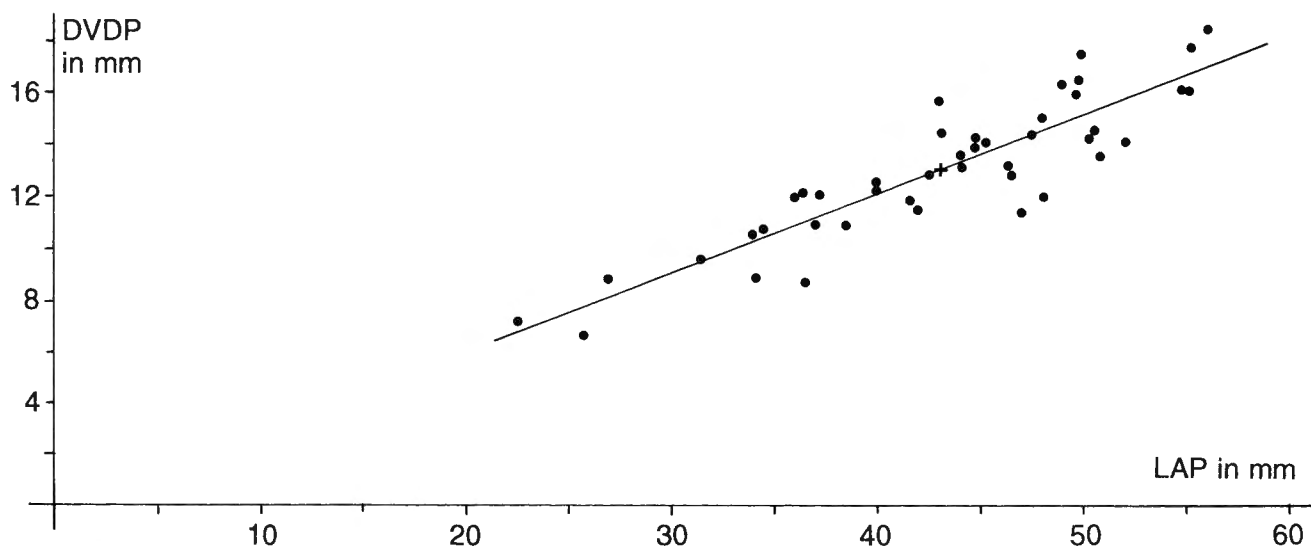


Fig. 10 - Scatter plot and regression line for *Belemnitella mucronata*, top 6 m of the Craie de Trivières, CCC pit, Harmignies. LAP = length from apex to protoconch; DVDP = dorso-ventral diameter at protoconch; + = mean value.

$$DVDP = -0.2203 + 0.3067LAP; N = 43; r = 0.8923***; SD_a = 1.0570; SD_b = 0.0241; SD_{yx} = 1.2656.$$

DISCUSSION: The specimens from the top six metres of the Craie de Trivières and basal 120 cm of the Craie d'Obourg are referred to *B. mucronata*, because they are large and stout, and have well developed vascular markings, a small fissure angle, and the mean value of the alveolar angle is *c.* 20-21°. The mean value of the Schatzky distance of sample 1 is within the known range of this character for *B. mucronata*. In contrast, the mean value of the Schatzky distance of sample 2 is large (\bar{X} = 10.4 mm) and outside the range of this character for *B. mucronata*. However, it is based on only four specimens, which obviously do not exhibit the entire variability.

DISTRIBUTION: *B. mucronata* is widespread in the North European Province and may also occur in the northern part of the Tethyan Realm of Europe. It appears in the uppermost Lower Campanian, *Belemnitella mucronata/Goniot euthis quadrata gracilis* Zone, and continues into the lower Upper Campanian. It has been recorded also from the upper Upper Campanian and Lower Maastrichtian, but CHRISTENSEN (1998b) showed that these records are misconceptions.

Belemnitella woodi CHRISTENSEN, 1995
Pl. 1, Figs 9-20

- 1988 *Belemnitella mucronata* (SCHLOTHEIM); WOOD, p. 34
 1988 *Belemnitella "lanceolata"* SHARPE non SCHLOTHEIM; WOOD, p. 34
 1988 *Belemnitella minor* JELETZKY; WOOD, p. 35
 1989 *Belemnitella cf. mucronata postrema* NAIDIN; CHRISTENSEN in ROBASZYNSKI & CHRISTENSEN, p. 397, pl. 1, fig. 3
 pars 1989 *Belemnitella cf. mucronata mucronata* (SCHLOTHEIM); CHRISTENSEN in ROBASZYNSKI & CHRISTENSEN, p. 397
 1995 *Belemnitella woodi* CHRISTENSEN, p. 50, pl. 3, figs 1-16; figs 12A-G
 1995 *Belemnitella woodi* CHRISTENSEN; KEUTGEN, p. 176
 1997a *Belemnitella woodi* CHRISTENSEN; CHRISTENSEN, p. 74
 1997 *Belemnitella woodi* CHRISTENSEN; NIEBUHR *et al.*, p. 220

HOLOTYPE: By original designation, an unregistered specimen in the Norwich Castle Museum, *ex* P.S. WHITTLESAE Collection; Keswick, Weybourne₁ Chalk, Norfolk (CHRISTENSEN 1995, pl. 3, figs 13-16).

MATERIAL: 19 specimens, including MGUH 19571, 24784-5, from the top 4 m of the Craie de Nouvelles, except the hardground at the top of the formation, CCC pit, Harmignies.

DESCRIPTION: Guard large and stout; generally slightly lanceolate to cylindrical in ventral view and high conical in lateral view; flattened over its entire length; apical end acute or obtuse with mucro, rarely pointed; vascular

Table 3 – Univariate analysis of *Belemnitella woodi*, Craie de Nouvelles, 0-4 m below hardground, CCC pit, Harmignies.

Character	N	\bar{X}	SD	CV	OR
LAP	10	44.2	9.8	22.1	26.4-62.8
DVDP	10	12.5	3.1	24.6	6.9-17.4
LDP	9	12.9	3.6	27.8	6.5-18.2
MLD	10	12.7	3.4	27.0	6.5-18.2
SD	7	8.2	1.0	11.8	7.0- 9.8
FA	6	26.3	12.7	48.2	13.5-45.0
AA	8	19.5	0.7	3.6	18.5-20.5
BI	10	3.6	0.4	9.7	3.1- 4.3

markings usually well developed around the ventral fissure and weakly developed or not present elsewhere.

Schatzky distance large (means 9-11 mm); fissure angle medium-sized (means 25-30°); alveolar angle small (means *c.* 19°); shape of bottom of ventral fissure generally straight; mean Birkelund Index 3.3-3.4 in the early form and 3.6-3.7 in the late form.

BIOMETRY: I have analyzed a small sample, consisting of 10 specimens, from the top 4 m of the Craie de Nouvelles, except the hardground at the top of the formation, CCC pit, Harmignies. Due to the small number of specimens only univariate analysis was performed (Table 3).

DISCUSSION: These specimens are assigned to *B. woodi* on the basis of the size and slenderness of the guard, weakly developed vascular markings, shape of apical end, medium-sized fissure angle and small alveolar angle. CHRISTENSEN (1995) distinguished early and late forms of *B. woodi* on the basis of the slenderness of the guard and Schatzky distance. The mean Birkelund Index is 3.3 to 3.4 and the mean Schatzky distance is about 9 mm in the early form. The mean Birkelund Index is 3.7 to 3.8 and the mean Schatzky distance is 10 to 11 mm in the late form. The sample from the Craie de Nouvelles has a mean Birkelund Index of 3.6, which indicates the late form, whereas the mean Schatzky distance of 8.2 mm indicate the early form. In conclusion, it is not possible on the basis of the small number of specimens from the Craie de Nouvelles to assign these to either the early or late form of *B. woodi*. However, the hardground at the top of the Craie de Nouvelles equates with the main Catton Sponge Bed of Norfolk (see above). Therefore, the specimens from the top 4 m of the Craie de Nouvelles belong to the late form of *B. woodi*.

DISTRIBUTION: CHRISTENSEN (1995) recorded *B. woodi* from the Pre-Weybourne₅ Chalk and Weybourne₁₋₃ Chalk, except the Catton Sponge Beds, of Norfolk, *i.e.* the upper part of the lower Upper Campanian (Fig. 7). It is here recorded from the top 4 m of the Craie de Nouvelles, except the hardground at the top of the formation.

KEUTGEN (1995) recorded this species from the Zeven Wegen Member of the Gulpen Formation, 10-28 m above the base, of the CPL quarry, northeast Belgium (Fig. 7). NIEBUHR *et al.* (1997) recorded *B. woodi* from the "vulgaris"/*stolleyi* Zone and *B. cf. woodi* from the *minor/polyplacum* and *bipunctatum/roemeri* Zones of the Misburg-Höver-Ahlten area, northwest Germany (Fig. 7).

***Belemnitella minor* JELETZKY, 1951a**

REMARKS: CHRISTENSEN (1995) recognized three chronological subspecies of *B. minor*, which were considered to form an evolutionary lineage. *B. minor* subspecies I JELETZKY, 1951a from the lower part of the upper Upper Campanian, *B. minor* subspecies II CHRISTENSEN, 1995 from the upper part of the upper Upper Campanian, and the lower Lower Maastrichtian *B. minor* subspecies III CHRISTENSEN, 1995. However, the latter is placed in synonymy with *B. minor* II herein (see later discussion).

***Belemnitella minor* I JELETZKY, 1951a**
Pl. 2, Figs 5-27

- 1853 *Belemnitella mucronata* (SCHLOTHEIM); SHARPE, p. 6, pl. 1, fig. 2, non figs 1, 3
 1951a *Belemnitella mucronata* mut. *minor* JELETZKY, p. 203
 1951b *Belemnitella mucronata* mut. *minor* JELETZKY; JELETZKY, p. 87, pl. 1, fig. 3
 1964 *Belemnitella mucronata mucronata* (LINK); JELETZKY, p. 280, pl. 1, figs 1, 3-4; non fig. 2
 non 1975 *Belemnitella minor* JELETZKY; CHRISTENSEN, p. 56, pl. 11, figs 4-5 (= *B. carlsbergensis* CHRISTENSEN 1998b)
 1987 *Belemnitella mucronata* (SCHLOTHEIM); DOYLE, pl. 40, figs 1-4
 1988 *Belemnitella mucronata sensu* JELETZKY; WOOD, p. 37
 1988 *Belemnitella minor* JELETZKY; WOOD, p. 37
 1988 *Belemnitella americana* (MORTON)?; WOOD, p. 72
 pars 1989 *Belemnitella cf. mucronata mucronata* (SCHLOTHEIM); CHRISTENSEN in ROBASZYNSKI & CHRISTENSEN, p. 398
 1989 *Belemnitella cf. "minor"* JELETZKY; CHRISTENSEN in ROBASZYNSKI & CHRISTENSEN, p. 398
 1995 *Belemnitella minor* I JELETZKY; CHRISTENSEN, p. 55, pl. 1, figs 4-7; pl. 4, figs 5-15; pl. 5, figs 9-16; pl. 6, figs 11-17
 1997a *Belemnitella minor* I JELETZKY; CHRISTENSEN, p. 74
 1997b *Belemnitella minor* I JELETZKY; CHRISTENSEN, p. 474
 1998 *Belemnitella minor* I JELETZKY; CHRISTENSEN, p. 15

HOLOTYPE: By original designation, the original of Sharpe (1853, pl. 1, fig. 2), BGS GSM 7747, from the Upper Chalk, near Norwich, Norfolk. It was refigured by JELETZKY (1951a, pl. 1, fig. 3) and CHRISTENSEN (1995, pl. 1, figs 4-7; pl. 4, fig. 5).

MATERIAL: Five specimens, including MGUH 24788, from the hardground at the top of the Craie de Nouvelles; 69 specimens, including MGUH 24789-95, from the basal 10 m of the Craie de Spiennes, all from the CCC pit, Harmignies.

DESCRIPTION: Guard very large (LAP slightly above 70 mm) and slender; generally cylindrical or subcylindrical in ventral view and high conical in lateral view; guard flattened over its entire length; apical end acute or obtuse with mucro; relationship of length from apex to protoconch and dorso-ventral diameter at protoconch isometric; mean value of Birkelund Index about 4; Birkelund Index of individual specimens from 3.2 to 4.9.

Schatzky distance large (mean value *c.* 9 mm); fissure angle medium-sized (mean values 25-30°); alveolar angle small (mean value *c.* 19°); and bottom of ventral fissure usually straight.

Vascular markings, dorso-lateral depressions and dorso-lateral double furrows well-developed; vascular markings most prominent on ventral and lateral side of guard; some specimens with pseudogranulation on ventral side and longitudinal striae on posterior dorsal side.

BIOMETRY: Two samples from the CCC pit, Harmignies, were analyzed: 1) 23 specimens from the basal 4 m of the

Table 4 – Univariate analysis of *Belemnitella minor* I, basal 4 m of the Craie de Spiennes, CCC pit, Harmignies.

Character	N	\bar{X}	SD	CV	OR
LAP	23	48.4	7.0	14.5	32.0-62.0
DVDP	23	12.2	1.6	12.9	8.5-15.0
LDP	22	12.6	1.9	14.9	8.5-16.0
MLD	20	12.5	1.9	15.0	8.5-16.0
SD	15	9.4	2.2	23.3	6.0-13.5
FA	14	32.3	11.2	34.6	14.0-55.0
AA	13	19.0	0.7	3.5	18.0-20.0
BI	23	4.0	0.3	8.5	3.4- 4.8

Table 5 – Univariate analysis of *Belemnitella minor* I, 7-10 m above the base of the Craie de Spiennes, CCC pit, Harmignies. * = estimated.

Character	N	\bar{X}	SD	CV	OR
LAP	9	50.1	5.1	10.1	46* -57*
DVDP	12	13.4	3.0	22.4	8.4-18.8
LDP	12	13.4	3.4	25.0	8.1-19.8
MLD	10	13.6	2.6	19.3	10.5-19.8
SD	6	9.5	2.1	21.6	7.7-13.5
FA	6	27.5	7.9	28.8	15.0-35.0
AA	7	18.9	0.8	4.2	18.0-20.0
BI	9	3.9	0.2	6.0	3.5- 4.3

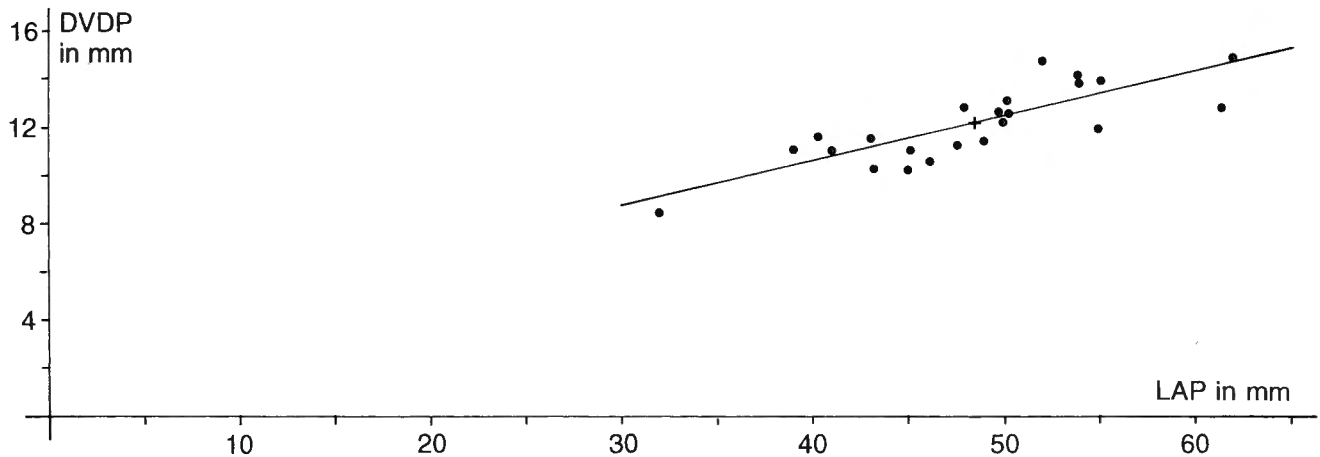


Fig. 11 – Scatter plot and regression line for *Belemnitella minor* I, basal 4 m of the Craie de Spiennes, CCC pit, Harmignies. LAP = length from apex to protoconch; DVDP = dorso-ventral diameter at protoconch, + = mean value. $DVDP = 3.4175 + 0.1814LAP$; $N = 23$; $r = 0.8121^{***}$; $SD_a = 1.4106$, $SD_b = 0.0289$; $SD_{yx} = 0.9519$.

Craie de Spiennes and 2) 12 specimens from 7-10 m above the base of the Craie de Spiennes. Univariate and bivariate analyses were made for sample 1, whereas only univariate analysis was performed for sample 2 due to the small number of specimens in this sample.

The results of the univariate analyses are shown in Tables 4-5. The scatter plots of the length from the apex to the protoconch vs the dorso-ventral diameter at the protoconch is shown in Figure 11, as is the regression line. The value of the correlation coefficient is very highly significant ($P < 0.001$, with 21 degrees of freedom). The t -test on y -intercept gives a value of 2.4227, which is significant ($0.025 > P > 0.02$, with 21 degrees of freedom), implying an slightly allometric relationship of the variates. If the correlation is perfect the Birkelund Index will vary with the length from the apex to the protoconch as shown in Table 6. Adult specimens are thus more slender than juvenile specimens. Due to individual variation the Birkelund Index varies from 3.4 in an adolescent specimen to 4.8 in an adult specimen. Since the relationship of the variates is allometric it is not legal to calculate the mean Birkelund Index of this sample. Nevertheless, I have calculated the mean of this index

Table 6 – Tabulation of the Birkelund Index (BI) with increasing length from the apex to the protoconch (LAP) in *Belemnitella minor* I from the basal 4 m of the Craie de Spiennes, CCC pit, Harmignies.

LAP (mm)	BI
30	3.4
40	3.7
50	4.0
60	4.2

(Table 4), because the relationship of the variates is only slightly allometric.

DISCUSSION: CHRISTENSEN (1995, pp. 56-60) analyzed biometrically six samples of *B. minor* I from the Catton Sponge Bed, Beeston Chalk and the basal part of the Paramoudra₁ Chalk of Norfolk. The weighted grand means of these samples are as follows: $\bar{X}_{SD} = c. 9$ mm; $\bar{X}_{FA} = c. 30^\circ$; $\bar{X}_{AA} = c. 19^\circ$; and $\bar{X}_{BI} = c. 4$. The two samples of *B. minor* I from the Craie de Spiennes differ in no significant respect from the samples from Norfolk.

Two specimens from 7-10 m above the base of the Craie de Spiennes are slightly lanceolate in ventral view (pl. 2, figs 17-20). I consider these as extreme variants. The length from the apex to the protoconch of the incomplete specimen figured on pl. 2, figs 19-20 is estimated to be larger than 65 mm.

DISTRIBUTION: CHRISTENSEN (1995) recorded *B. minor* I from the Catton Sponge Bed, Beeston Chalk and basal Paramoudra₁ Chalk of Norfolk, *i.e.* the lower part of the upper Upper Campanian. It predominates in the Beeston Chalk and constitutes about 60% of the belemnite fauna. It is here recorded from the hardground at the top of the Craie de Nouvelles and the basal 10 m of the Craie de Spiennes of the CCC pit. It has also been recorded from the Maastricht-Aachen-Liège district.

***Belemnitella minor* II CHRISTENSEN, 1995**
Pl. 3, Figs 1-19; Pl. 4, Figs 1-7

- ? 1878 *Belemnites paxillosus* LAMARCK; BAYLE, pl. 23, figs 1-2
1967 *Belemnitella langei* JELETZKY *sensu* KONGIEL; WOOD, p. 278
1967 *Belemnitella* aff. *junior* NOWAK; WOOD, p. 278

- pars 1988 *Belemnitella* "posterior" KONGIEL; WOOD, pl. 75
 1989 *Belemnitella* aff. *mucronata* SCHLOTHEIM; CHRISTENSEN in ROBASYNSKI & CHRISTENSEN, p. 403, pl. 1, fig. 2
 1989 *Belemnitella* aff. *mucronata* (SCHLOTHEIM)/*posterior* KONGIEL; CHRISTENSEN in ROBASYNSKI & CHRISTENSEN, p. 405, pl. 1, fig. 6
 ? 1990 *Belemnitella* ex gr. *mucronata* (SCHLOTHEIM); KEUTGEN & VAN DER TUUK, p. 13, pl. 1, figs 1-2
 1995 *Belemnitella minor* II CHRISTENSEN, p. 64, pl. 7, figs 3-10; figs 20A-D
 1995 *Belemnitella minor* III CHRISTENSEN, p. 69, pl. 8, figs 1-9
 1997a *Belemnitella minor* II CHRISTENSEN, p. 71, pl. 2, figs 3-5
 1997b *Belemnitella minor* II CHRISTENSEN; CHRISTENSEN, p. 474
 1998a *Belemnitella minor* II CHRISTENSEN; CHRISTENSEN, p. 15

HOLOTYPE: By original designation, BMNH C43553, Whitlingham, Paramoudra₁ Chalk; ex A.W. Rowe Collection (CHRISTENSEN 1995, pl. 7, figs 3-6).

MATERIAL: 15 specimens, including MGUH 19570, 24796-7, from the top 1 m of the Craie de Spiennes, La Malogne at Cuesmes; eight specimens, including MGUH 24799, from the topmost Craie de Spiennes, André et Fils pit no. 6, Cibly, ex F. Schmid Collection; 73 specimens from the Poudingue de Cuesmes, Cibly, André et Fils pit no. 6, Cibly, ex F. Schmid Collection; 47 specimens, including MGUH 24798, from the Craie Phosphatée de Cibly, André et Fils pit no. 6, Cibly, ex F. Schmid Collection; 10 specimens, including MGUH 19574, from the Craie Phosphatée de Cibly, La Malogne at Cuesmes; and six specimens, including IRSNB AD 85-4 and AD 85-70 from the Craie Phosphatée de Cibly, André et Fils pit, Cibly.

EMENDED DIAGNOSIS: Guard very large and stout; Schatzky distance very large; fissure angle medium-sized; alveolar angle small; and mean Birkelund Index *c.* 3.5-3.6.

DESCRIPTION: Guard very large (LAP slightly above 70 mm) and stout; generally cylindrical in ventral view and high conical in lateral view; guard flattened over its entire length; apical end acute or obtuse with mucro; relationship of length from apex to protoconch and dorso-ventral diameter at protoconch isometric; mean Birkelund Index generally 3.5-3.6; Birkelund Index of individual specimens from 2.8 to 4.3.

Schatzky distance large (mean values 11-12 mm); fissure angle medium-sized (mean values 25-30°; weighted grand mean of seven samples 28°); alveolar angle small (mean value *c.* 19°); and bottom of ventral fissure generally straight.

Vascular markings well-developed ventrally and laterally; dorso-lateral depressions and dorso-lateral longitudinal double furrows prominent; some specimens with

pseudogranulation ventrally and longitudinal striae on posterior dorsal side.

BIOMETRY: Five samples were analyzed: 1) 10 specimens from the top 1 m of the Craie de Spiennes, La Malogne at Cuesmes; 2) 25 specimens from the Poudingue de Cuesmes, André et Fils pit no. 6, Cibly, ex F. Schmid Collection; 3) 23 specimens from the Craie Phosphatée de Cibly, André et Fils pit no. 6, Cibly, ex F. Schmid Collection; 4) 10 specimens from the Craie Phosphatée de Cibly, La Malogne at Cuesmes; and 5) six specimens

Table 7 – Univariate analysis of *Belemnitella minor* II, top 1 m of the Craie de Spiennes, La Malogne at Cuesmes.

Character	N	\bar{X}	SD	CV	OR
LAP	9	45.1	6.3	13.9	36.0-54.5
DVDP	10	13.6	2.5	18.4	10.2-18.0
LDP	10	13.4	2.8	20.8	9.9-19.1
MLD	10	13.4	2.8	20.8	9.9-19.1
SD	8	12.3	2.7	21.8	9.0-16.1
FA	9	28.4	10.9	38.2	18.0-54.0
AA	8	19.3	0.8	4.1	18.0-20.0
BI	9	3.5	0.3	7.5	3.0- 3.7

Table 8 – Univariate analysis of *Belemnitella minor* II, Poudingue de Cuesmes, André et Fils pit no. 6; ex F. Schmid Collection. * = estimated.

Character	N	\bar{X}	SD	CV	OR
LAP	22	50.1	8.4	16.8	37.2-66*
DVDP	25	14.2	2.4	16.7	10.3-19.2
LDP	25	14.2	2.5	17.8	10.1-19.7
MLD	22	14.2	2.6	18.3	10.2-19.7
SD	22	11.4	2.0	17.6	7.7-16.4
FA	20	23.0	8.4	36.4	12.5-35.0
AA	19	19.2	0.7	3.4	18.0-20.0
BI	22	3.6	0.3	9.4	3.0- 4.2

Table 9 – Univariate analysis of *Belemnitella minor* II, Craie Phosphatée de Cibly, André et Fils pit no. 6, Cibly; ex F. Schmid Collection. * = estimated.

Character	N	\bar{X}	SD	CV	OR
LAP	17	46.1	6.0	13.1	34.0-58*
DVDP	23	13.4	2.1	15.8	10.2-18.1
LDP	23	13.4	2.1	15.9	10.4-17.6
MLD	17	13.2	2.0	15.4	10.4-17.0
SD	13	11.7	2.0	16.8	9.0-14.9
FA	9	26.4	5.1	19.3	21.5-36.6
AA	11	19.1	0.7	3.8	18.0-20.0
BI	17	3.5	0.4	10.4	2.8- 4.3

Table 10 – Univariate analysis of *Belemnitella minor* II, Craie Phosphatée de Ciplly, La Malogne, Cuesmes. * = estimated.

Character	N	\bar{X}	SD	CV	OR
LAP	7	50.4	7.4	14.7	41.0-60*
DVDP	10	13.8	2.7	19.7	9.6-17.5
LDP	9	13.9	3.1	22.5	8.9-17.6
MLD	7	13.5	3.2	23.9	8.9-16.8
SD	8	11.6	2.0	17.0	8.3-14.1
FA	7	41.2	17.7	42.9	25.0-77.0
AA	6	19.1	0.6	3.1	18.5-20.0
BI	7	3.8	0.4	9.5	3.4- 4.3

Table 11 – Univariate analysis of *Belemnitella minor* II, Craie Phosphatée de Ciplly, André et Fils pit, Ciplly; ex IRSNB Collection. * = estimated.

Character	N	\bar{X}	SD	CV	OR
LAP	6	55.8	7.4	13.3	44.2-66*
DVDP	6	16.9	2.4	14.2	13.1-19.9
LDP	6	17.0	2.3	13.5	13.2-19.6
MLD	6	17.0	2.3	13.5	13.2-19.6
SD	6	12.1	1.9	15.4	9.8-14.5
FA	5	30.0	8.3	27.7	20.0-40.0
AA	4	19.1	0.5	2.5	18.5-19.5
BI	5	3.3	0.2	7.0	3.0- 3.6

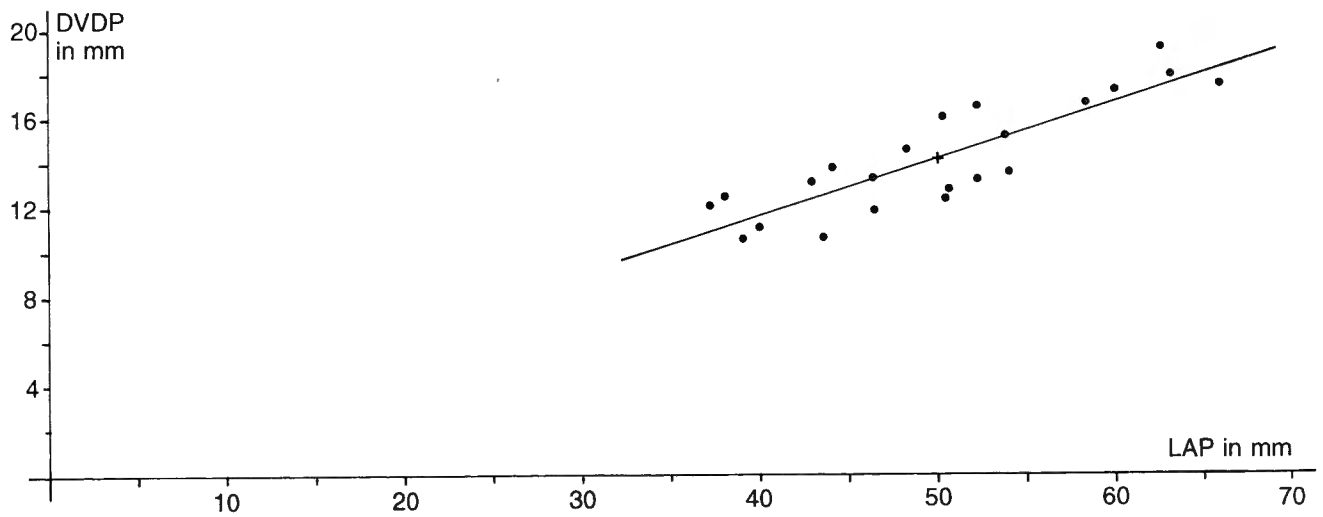


Fig. 12 – Scatter plot and regression line for *Belemnitella minor* II, Poudingue de Cuesmes, André et Fils pit no. 6, Ciplly. LAP = length from apex to protoconch; DVDP = dorso-ventral diameter at protoconch, + = mean value. $DVDP = 1.3849 + 0.2540LAP$; $N = 22$; $r = 0.8698^{***}$; $SD_a = 1.6453$; $SD_b = 0.0324$; $SD_{yx} = 1.2505$.

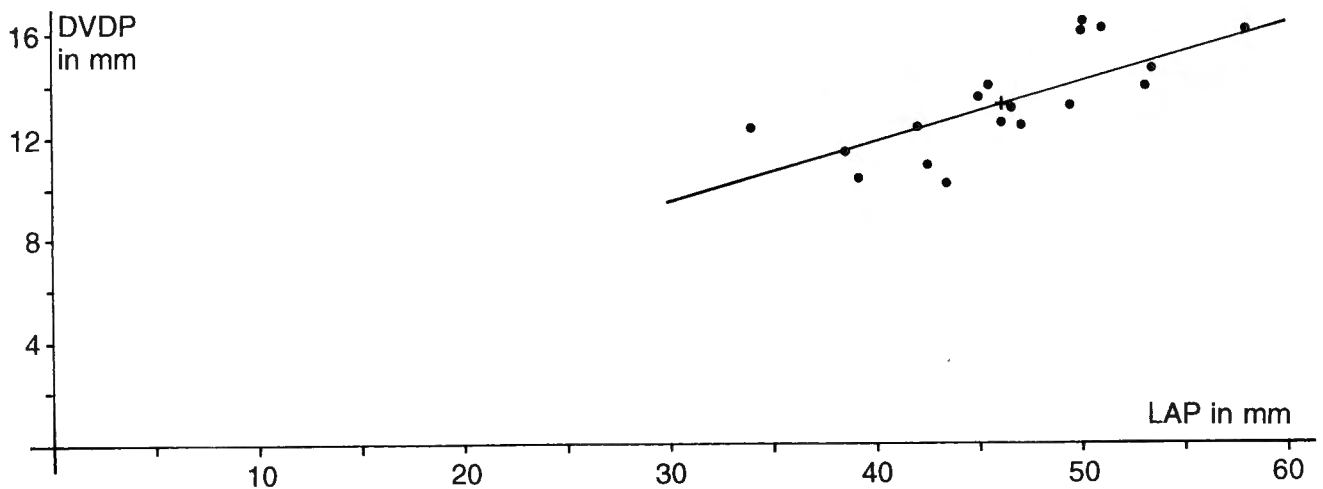


Fig. 13 – Scatter plot and regression line for *Belemnitella minor* II, Craie Phosphatée de Ciplly, André et Fils pit no. 6, Ciplly. LAP = length from apex to protoconch; DVDP = dorso-ventral diameter at protoconch; + = mean value. $DVDP = 2.2642 + 0.2361LAP$; $N = 17$; $r = 0.7426^{***}$; $SD_a = 2.5103$; $SD_b = 0.0540$; $SD_{yx} = 1.3029$.

from the Craie Phosphatée de Ciplly, André et Fils pit, *ex* IRSNB Collection, Bruxelles.

Univariate analyses were made for all samples and the results are shown in Tables 7-11. The mean value of the fissure angle of sample 4, from the Craie Phosphatée de Ciplly, La Malogne at Cuesmes (Table 10), is rather large ($\bar{X} = 41.2^\circ$) owing to an extreme variant with a fissure angle of 77.0° . This clearly shows how an extreme variant can affect the mean value in sample consisting of a small number of specimens.

Bivariate analyses were made for samples 2 and 3. The scatter plots of the length from the apex to the protoconch *vs* the dorso-ventral diameter at the protoconch of these samples are shown in Figures 12-13, as are the regression lines. The values of the correlation coefficients are very highly significant ($P < 0.001$, with $N - 2$ degrees of freedom). The *t*-tests on the *y*-intercepts show that they do not differ significantly from zero at the 5% level, implying an isometric relationship of the variates (sample 2: $t_a = 0.8417$, $0.50 > P > 0.40$, with 20 degrees of freedom; sample 3: $t_a = 0.9020$, $0.40 > P > 0.30$, with 15 degrees of freedom).

DISCUSSION: CHRISTENSEN (1995, pp. 67, 69) analyzed biometrically two small samples of *B. minor* II from the Paramoudra₁ and Paramoudra₂ Chalks and one small sample of *B. minor* III from the pre-*Porosphaera* and *Porosphaera* Beds of Norfolk. He distinguished *B. minor* III from *B. minor* II only by its smaller guard, because the mean values of the Schatzky distance, fissure angle, alveolar angle and Birkelund Index are very closely similar (cf. CHRISTENSEN 1995, tables on pp. 67 and 69). This supposed dissimilarity is now known to be incorrect, because the lower Lower Maastrichtian *B. minor* from the Mons Basin attains a length from the apex to the protoconch, which is larger than 65 mm (see Tables 8, 11). The lower Lower Maastrichtian *B. minor* is thus a very large species, as is *B. minor* II. The mean values of the Birkelund Index, Schatzky distance, fissure angle and alveolar angle of the upper Upper Campanian *B. minor* II and the lower Lower Maastrichtian *B. minor* are very closely similar (cf. Tables 4-5, 7-11), as are the surface markings and the shape of the guard. The weighted grand means of four samples of the lower Lower Maastrichtian *B. minor* II from the Mons Basin are as follows: $\bar{X}_{SD} = c. 12$ mm; $\bar{X}_{FA} = c. 28^\circ$; $\bar{X}_{AA} = c. 19^\circ$; and $\bar{X}_{BI} = 3.6$. Therefore, the lower Lower Maastrichtian *B. minor* III cannot be distinguished from uppermost Campanian *B. minor* II and is consequently placed in synonymy with *B. minor* II.

I have compared statistically the mean values of the Schatzky distance and Birkelund Index of *B. minor* I from the basal 4 m of the Craie de Spiennes, CCC pit, and *B. minor* II from the Poudingue de Cuesmes, André et Fils pit no. 6 with the following results. The *F*-tests show that the variances of the Schatzky distance and Birkelund Index do not differ significantly ($P > 0.20$, with $N - 2$ degrees of freedom). The *t*-test of the means of the

Schatzky distance gives a value of 2.8687, which is highly significant ($0.01 > P > 0.005$, with 35 degrees of freedom). The *t*-test of the means of the Birkelund Index gives a value of 4.4743, which is very highly significant ($P < 0.001$, with 43 degrees of freedom). Thus, *B. minor* II is more stout and has a larger Schatzky distance than *B. minor* I.

CHRISTENSEN (1995) suggested that *B. minor* III (= *B. minor* II herein) may be conspecific with the lowermost Maastrichtian *B. langei sensu* BIRKELUND, 1957 from Denmark. This suggestion is now known to be incorrect, because *B. langei sensu* BIRKELUND is smaller and has a smaller Schatzky distance, a larger fissure angle and a larger alveolar angle than *B. minor* II.

KEUTGEN & VANDER TUUK (1990) suggested that *B. ex gr. mucronata*, from the lower Lower Maastrichtian *B. obtusa* Zone of the Maastricht-Aachen-Liège district, may be conspecific with *B. aff. mucronata/posterior* of CHRISTENSEN *in* ROBASZYNSKI & CHRISTENSEN (1989), which is here placed in synonymy with *B. minor* II. CHRISTENSEN (1995, p. 72) noted that the sample of *B. ex gr. mucronata* may be heterogeneous, because it included very slender specimens (the observed range of the Birkelund Index is from 3.2 to 5.4). *B. ex gr. mucronata* is therefore placed in synonymy with *B. minor* II with a query.

B. minor II differs from *B. cf. najdini sensu* SCHULZ, 1979 by its larger and stouter guard, larger Schatzky distance and smaller fissure angle (cf. univariate analysis of *B. cf. najdini* by CHRISTENSEN, 1995, p. 72).

B. minor II differs from *B. carlsbergensis* CHRISTENSEN, 1998b, from the basal Maastrichtian of Scania in southern Sweden, by its stouter guard, larger Schatzky distance and smaller alveolar angle.

DISTRIBUTION: CHRISTENSEN (1995) recorded *B. minor* II from the Paramoudra Chalk and *B. minor* III (= *B. minor* II herein) from the pre-*Porosphaera* and *Porosphaera* Beds of Norfolk (Figs 7-8). The Paramoudra Chalk is of latest Campanian age and equates probably with the upper part of the *langei* Zone and the overlying *grimmsis/granulosus* Zone of northwest Germany, as well as the upper part of the *Didymoceras donezianum* Zone and *Nostoceras hyatti* Zone of central Poland (CHRISTENSEN, 1995, fig. 1). The pre-*Porosphaera* and *Porosphaera* Beds are early Early Maastrichtian in age and equate with the upper part of the *Belemnella lanceolata* Zone, the *B. pseudobtusa* Zone and the lower part of the *B. obtusa* Zone (CHRISTENSEN, 1995, fig. 3). *B. minor* II predominates in the uppermost Campanian and is rare in the lower Lower Maastrichtian. It is here recorded from the top one metres of the Craie de Spiennes, the Poudingue de Cuesmes and the Craie Phosphatée de Ciplly. It occurs together with *Belemnella obtusa* in the Poudingue de Cuesmes and Craie Phosphatée de Ciplly. *B. minor* II is thus latest Campanian and early Early Maastrichtian in age. *B. minor* II occurs in the uppermost Upper Campanian and lower Lower Maastrichtian in the Maastricht-Aachen-Liège district (KEUTGEN, 1995, 1996; KEUTGEN

& JAGT, in press). CHRISTENSEN (1998b) suggested that four specimens referred to as *B. mucronata* by KONGIEL (1962), from the upper part of the *Didymoceras donezianum* Zone and the *Nostoceras hyatti* Zone of Poland, most likely are *B. minor* II. It may also occur in the Craie Blanche at Meudon in the Paris Basin (CHRISTENSEN, 1995).

Belemnitella sp. 1
Pl. 4, Figs 11-14

pars 1989 *Belemnitella mucronata mucronata* (SCHLOTHEIM); CHRISTENSEN in ROBASZYNSKI & CHRISTENSEN, p. 398

MATERIAL: MGUH 24801 and GM 1998.30 from 1.8 m above the base of the Craie de Spiennes, CCC pit, Harmignies.

DIMENSIONS: Measurements of critical characters are shown in Table 12.

REMARKS: These specimens are stout and vascularized. GM 1998.30 has an acute apical end. MGUH 24801 has a large Schatzky distance, a medium-sized fissure angle and a large alveolar angle. They occur together with *B. minor* I in the basal part of the Craie de Spiennes, but differ from this subspecies by their more stout guard. They may be either *B. mucronata* or *B. woodi*, but a specific determination is not possible due to small number of specimens. They are therefore referred to as *Belemnitella* sp. 1.

Belemnitella langei group

REMARKS: CHRISTENSEN (1995) included three species in this group, the upper Upper Campanian *B. langei* JELETZKY, 1948 and *B. najdini* KONGIEL, 1962, in addition to the Lower Maastrichtian *B. pulchra* SCHULZ, 1982. These are

small and slender to very slender, with a small Schatzky distance and a large fissure angle. Moreover, the bottom of the ventral fissure is irregular.

Belemnitella pulchra SCHULZ, 1982
Pl. 4, Figs 19-25

- 1982 *Belemnitella pulchra* SCHULZ, p. 284, pl. 1, figs 1-14
1983a *Belemnitella pulchra* SCHULZ; SCHULZ & SCHMID, p. 656, pl. 1, fig. 12
1990 *Belemnitella pulchra* SCHULZ; KEUTGEN & VAN DER TUUK, p. 14, pl. 2, fig. 2
1995 *Belemnitella pulchra* SCHULZ; KEUTGEN in JAGT *et al.*, p. 9
1996 *Belemnitella pulchra* SCHULZ; KEUTGEN, p. 62

HOLOTYPE: By original designation, the original of Schulz (1982, pl. 1, figs 1-3); SGPIH 2551; middle part of the upper Lower Maastrichtian *Belemnella sumensis* Zone, Krons Moor, northwest Germany, 0.3 m below marl bed 628.

MATERIAL: MGUH 24804, *ex* F. Schmid Collection, Poudingue de Cuesmes, André et Fils pit no. 6, Cipl. MGUH 24803, *ex* Ph. Hoogstoel Collection, from the Craie Phosphatée de Cipl. of the Vienne pit, Cipl.

DIMENSIONS: Measurements of the critical characters are shown in Table 13.

DESCRIPTION: Guard small, very slender and mucronated; slightly lanceolate in ventral view and cylindrical in lateral view; Schatzky distance small (5-7.5 mm, mean value *c.* 6 mm); fissure angle highly variable (28-125°); alveolar angle 17-22°, mean value *c.* 20°; bottom of ventral fissure irregular; Birkelund Index usually 5-7, mean value *c.* 6.

Vascular markings well-developed ventrally; dorso-lateral depressions and double furrows prominent; pro-

Table 12 – Measurements of critical characters of *Belemnitella* sp. 1, 1.8 m above the base of the Craie de Spiennes, CCC pit, Harmignies. * = estimated.

Specimen	LAP	DVDP	LDP	MLD	SD	FA	AA	BI
GM 1998.30	44.5	15.5	16.0	16.0	–	–	–	2.9
MGUH 24801	55*	17.2	17.9	17.9	9.2	39.0	20.0	3.2

Table 13 – Measurements of critical characters of *Belemnitella pulchra* from the Mons Basin.

Specimen	LAP	DVDP	LDP	MLD	SD	FA	AA	BI
MGUH 24804	41.0	9.2	9.1	9.2	7.4	74.0	21.0	4.5
MGUH 24803	43.0	8.3	7.7	8.3	–	–	18.5	5.2

nounced longitudinal striae on posterior part of guard; pseudogranulation present on ventral side of guard below ventral fissure.

DISCUSSION: MGUH 24804 differs in no significant respect from *B. pulchra*. MGUH 24803 differs in no significant respect from *B. pulchra*, except being slightly more stout than the specimens recorded previously. It is regarded as an extreme variant of *B. pulchra*.

DISTRIBUTION: *B. pulchra* occurs from the Lower, but not lowest, Maastrichtian to the lower Upper Maastrichtian, that is from the upper part of the *Belemnella lanceolata* Zone to the top of the *Belemnella sumensis* Zone (SCHULZ, 1982; KEUTGEN & VAN DER TUUK, 1990; KEUTGEN, 1996). It is recorded from the Kronsmoor pit in northwest Germany and central Poland (SCHULZ, 1982), the Ultrahelvetic of southern Germany, which is situated on the northern margin of the Tethyan Realm (SCHULZ & SCHMID, 1983a), the Maastricht-Aachen-Liège district (KEUTGEN & VAN DER TUUK, 1990; KEUTGEN *in JAGT et al.*, 1995; KEUTGEN, 1996). It is here recorded from the Mons Basin.

Belemnitella sp. 2

Pl. 4, Figs 8-10, 15-18

1989 *Belemnitella* cf. *najdini* KONGIEL; CHRISTENSEN *in* ROBASZYNSKI & CHRISTENSEN, p. 397

MATERIAL: MGUH 24800 and 24802, in addition to GM 1998.31-32, from the Craie de Nouvelles, 80-300 cm below the top of the formation, CCC pit, Harmignies.

DIMENSIONS: Measurements of critical characters are listed in Table 14.

DESCRIPTION: Guard small and slender, slightly lanceolate in ventral view and subcylindrical in lateral view, and only slightly flattened ventrally. Apical end obtuse, with a mucro. Mean value of Birkelund Index 4.5, with an observed range of 4.2-4.9.

Vascular markings well-developed ventrally, weakly developed elsewhere; dorso-lateral depressions and double furrows present; longitudinal striae may be present ventrally.

DISCUSSION: The internal characters are known only in MGUH 24802 (see Table 14). This specimen has a large Schatzky distance, a large fissure angle, a large alveolar angle, and the bottom of the ventral fissure is convexly curved.

B. sp. 2 probably belongs to the *B. langei* group owing to the size, shape and slenderness of the guard, in addition to the large fissure angle. It differs from this group, however, in its large Schatzky distance and shape of the bottom of the ventral fissure.

It differs from most species of the *B. mucronata* group in its slender guard. Very few species of this group have a mean value of the Birkelund Index between 4.5-5.0, and these are *B. aff. langei* from the middle Upper Campanian of Scania (CHRISTENSEN, 1975, 1986), *B. hoeferi* (SCHLOENBACH, 1867) from the upper Upper Campanian of Austria (CHRISTENSEN, 1998a) and the Upper Maastrichtian *B. junior* NOWAK, 1913. *B. sp. 2* is markedly smaller than *B. junior* and smaller than *B. aff. langei* and *B. hoeferi*. Consequently, the specimens are referred to as *B. sp. 2*.

DISTRIBUTION: *B. sp. 2* is recorded only from the Mons Basin, where it occurs in the top part of the Craie de Nouvelles, 80-300 cm below the top of the formation.

Genus *Belemnella* NOWAK, 1913

[ICZN 1985, Opinion 1328; name no. 2270]

TYPE SPECIES: *Belemnites lanceolatus* SCHLOTHEIM, 1813, p. 111, by subsequent designation by VON BÜLOW-TRÜMMER (1920, p. 195); ICZN Opinion 1328 (1985); name no. 2980.

DIAGNOSIS: See SCHULZ (1979) and CHRISTENSEN (1997).

DISCUSSION: The genus comprises three subgenera, the Lower Maastrichtian *Belemnella* (*Belemnella*), the Lower and lower Upper Maastrichtian *Belemnella* (*Pachybelemnella*) SCHULZ, 1979, and the Upper Maastrichtian *Belemnella* (*Neobelemnella*) NAIDIN, 1975. These subgenera include only large species in contrast to the genus *Belemnitella*. According to SCHULZ (1979) subgenus *B. (Pachybelemnella)* differs from the nominotypical subgenus by being more stout.

Table 14 – Measurements of critical characters of *Belemnitella* sp. 2, Craie de Nouvelles, 80-300 cm below the top of the formation, CCC pit, Harmignies. * = estimated.

Specimen	LAP	DVDP	LDP	MLD	SD	FA	AA	BI
GM 1998.31	43*	8.8	8.6	8.8	–	–	–	4.9
GM 1998.32	32.0	7.0	6.9	6.9	–	–	–	4.6
MGUH 24800	48.5	11.0	10.9	11.3	–	–	–	4.4
MGUH 24802	42.0	10.1	10.2	10.5	10.0	51.0	20.0	4.2

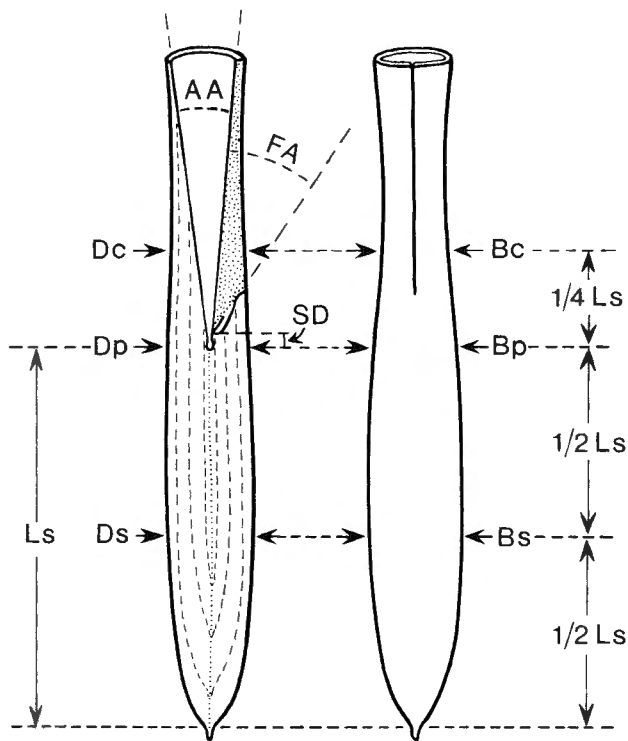


Fig. 14 – Schematized drawing, showing morphological elements of the guard in the genus *Belemnella*. D = dorso-ventral diameter; B = lateral diameter. Modified from SCHULZ (1979).

SCHULZ (1979) studied the subgenera *B. (Belemnella)* and *B. (Pachybelemnella)* in great detail and stressed the importance of the shape of the guard in ventral view compared to the length from the apex to the protoconch (= rostrum solidum (Ls) of SCHULZ). Since growth is strongly allometric in *Belemnella*, he introduced the derived variable “standardized length from the apex to the protoconch” (Lsn) in order to compare specimens of different size. The equation of this derived variable is given below. The shape of the guard in ventral view was defined by an index, AV (“Ventralaspekt” of Schulz), which is defined below. The late ontogenetic growth quotient, WQs (= Wachstumquotient of rostrum solidum) is calculated on the basis of measurements obtained from successive growth stages of individual specimens (see definition below).

The derived variables are defined in the following way (Fig. 14):

- (1) $WQs = Ls_2 - Ls_1 / Dp_2 - Dp_1$; ($Dp_2 > Dp_1 > 6$ mm);
- (2) $Lsn = Ls + WQs(13.5 - Dp)$ mm;
- (3) $AV = (Bs - Bc)100/Bp$ %;

SCHULZ (1979, fig. 53) also provided a graphic key for species of the two subgenera, which is based on the mean values of AV and Lsn; this is used herein. The graphic key is valid only for samples of *Belemnella*, and does not permit identification of individual specimens with certainty.

Subgenus *Belemnella (Pachybelemnella)*
SCHULZ, 1979

TYPE SPECIES: By original designation *B. (P.) obtusa* SCHULZ (1979, p. 106, pl. 9, figs 1-8; pl. 12, fig. 9).

DIAGNOSIS: See SCHULZ (1979).

DISTRIBUTION: *Belemnella (Pachybelemnella)* is distributed essentially in the Lower Maastrichtian. Two specimens of *B. (P.) cf. cimbrica* BIRKELUND, 1957 were recorded from the lower Upper Maastrichtian of Denmark (SCHULZ & SCHMID, 1983). The subgenus occurs in the North European Province and the northern part of the Tethyan Realm in Europe.

Belemnella (Pachybelemnella) obtusa SCHULZ, 1979
Pl. 4, Figs 26-32

- 1913 *Belemnella (Belemnella) lanceolata* (SCHLOTHEIM) mut. *junior* NOWAK, p. 407, pl. 42, fig. 19 (non 24)
- 1951 *Belemnella lanceolata* (SCHLOTHEIM); JELETZKY, p. 112, pl. 3, fig. 5
- 1957 *Belemnella aff. lanceolata* (SCHLOTHEIM); BIRKELUND, p. 40, pl. 3, fig. 5 (non 4)
- 1957 *Belemnella occidentalis occidentalis* BIRKELUND, p. 42, pl. 6, fig. 2 (non 1)
- 1958 *Belemnella junior* NOWAK s. str.; JELETZKY, pp. 58-59
- 1979 *Belemnella (Pachybelemnella) obtusa* SCHULZ, p. 114, pl. 9, figs 1-8; pl. 12, fig. 9; fig. 62
- 1980 *Belemnella occidentalis* BIRKELUND; VAN DER TUUK & BOR, p. 127, fig. 7
- 1985 *Belemnella lanceolata inflata* (ARKHANGELSKY); VAN DER TUUK in ROBASYNSKI *et al.*, p. 18, pl. 2, fig. 3
- 1985 *Belemnella "occidentalis"* BIRKELUND; VAN DER TUUK in ROBASYNSKI *et al.*, p. 18, pl. 3, fig. 1
- 1989 *Belemnella cf. obtusa* SCHULZ; CHRISTENSEN in ROBASYNSKI & CHRISTENSEN, p. 405, pl. 1, fig. 4
- 1990 *Belemnella (Pachybelemnella) obtusa* SCHULZ; KEUTGEN & VAN DER TUUK, p. 18, pl. 3, figs 3-5

HOLOTYPE: By original designation, the original of SCHULZ (1979, pl. 9, figs 3-4; pl. 12, fig. 9; fig. 62d); SGPIH 2123; lower Lower Maastrichtian, *Belemnella obtusa* Zone, 24.4 m above the base of the Maastrichtian, “Saturn” pit, Krons Moor, northwest Germany.

MATERIAL: Several hundreds of specimens from the Poudingue de Cuesmes and Craie Phosphatée de Ciplu of La Malogne, André et Fils pits and Vienne pit, including MGUH 24805-6.

DESCRIPTION: Guard short and very stout (Lsn commonly 40-60 mm), cylindrical to slightly lanceolate in ventral view (AV 0-20%) and cylindrical to cone-shaped in lateral view; alveolar angle large (generally 14-17°);

Table 15 – Univariate analysis of *Belemnella (Pachybelemnella) obtusa* from the Craie Phosphatée de Ciplly, La Malogne at Cuesmes.

Character	N	\bar{X}	SD	CV	OR
LAP	20	56.3	8.6	15.2	43.0-69.0
DVDP	20	15.2	2.3	14.9	10.9-18.4
LDP	20	15.2	2.2	14.2	11.0-18.8
SD	18	2.2	0.8	37.7	1.0- 4.1
FA	18	22.8	8.1	35.6	12.0-49.0
AA	18	16.7	1.1	6.3	14.5-18.0
WQs	7	1.6	0.2	10.2	1.5- 1.9
Lsn	20	53.7	6.0	11.1	43.3-68.6
AV	20	10.8	5.2	47.8	1.9-19.6

Schatzky distance large (1.5-4 mm); cross-section of guard at protoconch circular in adult specimens and compressed elliptical in juvenile specimens; apical end very obtuse with a well-defined mucro; late ontogenetic growth-quotient small (mean value 1.5-2.0); surface of guard generally smooth or with weakly developed vascular markings, but very rarely with well-developed vascular markings.

BIOMETRY: I have analyzed a sample, consisting of 20 specimens, from La Malogne at Cuesmes. The result of the univariate analysis is shown in Table 15.

The late ontogenetic growth quotient, WQs, was measured in seven specimens, and the mean value is 1.6, with

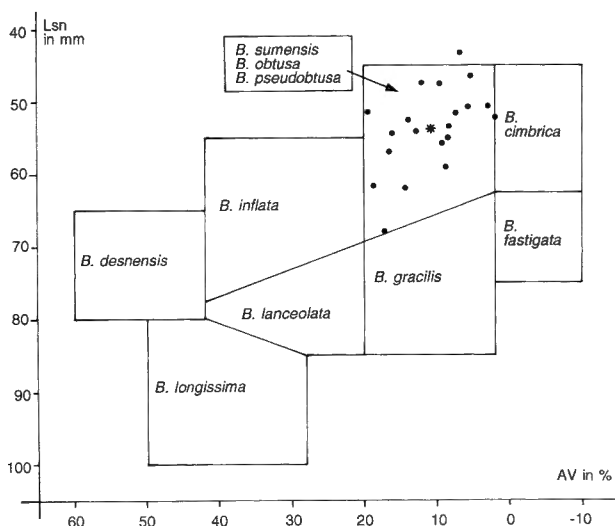


Fig. 15 – Graphic key for Lower Maastrichtian species of *Belemnella* (after SCHULZ, 1979), showing the plot of the specimens of *Belemnella (Pachybelemnella) obtusa* from the Craie Phosphatée de Ciplly, La Malogne at Cuesmes (dots) and the mean values of Lsn and AV (asterisk).

an observed range of 1.5-1.9 (Table 15). The standardized length from the apex to the protoconch was calculated for each specimen using this mean value. The mean value of the standardized length from the apex to the protoconch is 53.7 mm and the mean value of AV is 10.8% (Table 15).

The standardized length from the apex to the protoconch and the shape of the guard in ventral view (AV) of the specimens are plotted in Figure 15, as are the mean values of these variables.

DISCUSSION: The majority of the specimens plot in the area for *B. (P.) pseudobtusa* SCHULZ, 1979, *B. (P.) obtusa* and *B. (P.) sumensis* JELETZKY, 1949, as do the mean values of Lsn and AV (Fig. 15).

B. (P.) obtusa differs from *B. (P.) sumensis* by its smaller late ontogenetic growth quotient; the mean value of this variate is 1.5-2.0 in *obtusa* and 2.2-2.6 in *sumensis* (SCHULZ, 1979). Moreover, the apical end of large specimens is more obtuse in *B. (P.) obtusa* than in *B. (P.) sumensis*.

B. (P.) pseudobtusa and *B. (P.) obtusa* are very closely similar. The late form of *pseudobtusa* has, however, a larger Schatzky distance. Moreover, the mean value of the late ontogenetic growth quotient is 1.9 in *B. (P.) pseudobtusa*.

The specimens from the Craie Phosphatée de Ciplly are assigned to *B. (P.) obtusa* on the basis of the small late ontogenetic growth quotient, small Schatzky distance and very obtuse apical end.

SCHULZ (1979, tables 2, 5) distinguished three stratigraphical forms of *B. (P.) obtusa* on the basis of the mean values of the Lns, AV and WQs: forma anterior, forma media and forma posterior (Table 16). The sample of *B. (P.) obtusa* from the Craie Phosphatée de Ciplly may be assigned to forma media, because the mean value of Lns is small, the mean value of AV is medium-sized, and the mean value of WQs is small.

DISTRIBUTION: *B. (P.) obtusa* has been recorded from Krons Moor, Zeltberg at Lüneburg and Rügen in north Germany, Hvide Klint and Møns Klint in Denmark, Norfolk in England and Limburg in the Netherlands. It is here reported from the Mons Basin.

B. (P.) obtusa occurs only in the *B. obtusa* Zone, which is from the upper part of the lower Lower Maastrichtian.

Table 16 – Measurements of critical characters of three stratigraphical forms of *Belemnella (Pachybelemnella) obtusa*. After SCHULZ (1979, Tables 2 and 5).

Form	\bar{X}_{Lsn} (mm)	\bar{X}_{AV} (percent)	\bar{X}_{WQs}
posterior	54-57	5- 8	1.9
media	50-54	5-10	1.5
anterior	55-59	10-20	1.8

At Kronsnoor, *B. (P.) obtusa* forma media is distributed in the interval 21-25 m above the base of the Maastrichtian (SCHULZ, 1979).

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Captions to Plates

PLATE 1

- Figs 1-4 – *Belemnitella mucronata* (SCHLOTHEIM), MGUH 24783, CCC pit, Harmignies, Craie de Trivières, 3 m below the top of the formation; 1, dorsal view; 2, lateral view; 3, ventral view; 4, view of the split anterior end. Birkelund Index, 3.7.
- Figs 5-8 – *Belemnitella mucronata* (SCHLOTHEIM), MGUH 19569, CCC pit, Harmignies, Craie de Trivières, c. 3.5 m below the top of the formation; 5, dorsal view; 6, lateral view; 7, ventral view; 8, view of the split anterior end. Schatzky distance, 7 mm; fissure angle, 13.0°; alveolar angle, 21.0°; Birkelund Index, 3.1. Figured as *B. mucronata mucronata* by ROBASYNSKI & CHRISTENSEN (1989, pl. 1, fig. 1).
- Figs 9-12 – *Belemnitella woodi* CHRISTENSEN, MGUH 19571; CCC pit, Harmignies, Craie de Nouvelles, 150 cm below the top of the formation; 9, dorsal view; 10, lateral view; 11, ventral view; 12, view of split anterior end. Schatzky distance, 9.8 mm; fissure angle, 45.0°; alveolar angle, 19.0°; Birkelund Index, 3.1. Figured as *B. cf. mucronata postrema* NAIDIN by ROBASYNSKI & CHRISTENSEN (1989, pl. 1, fig. 3).
- Figs 13-16 – *Belemnitella woodi* CHRISTENSEN, MGUH 24784, CCC pit, Harmignies, Craie de Nouvelles, 80 cm beneath the top of the formation; 13, dorsal view; 14, lateral view; 15, ventral view; 16, view of the split anterior end. Schatzky distance, 8.8 mm; fissure angle, 22.0°; alveolar angle, 20.0°; Birkelund Index, 3.4.
- Figs 17-20 – *Belemnitella woodi* CHRISTENSEN, MGUH 24785, CCC pit, Harmignies, Craie de Nouvelles, immediately below the hardground at the top of the formation; 17, dorsal view; 18, lateral view; 19, ventral view; 20, view of the split anterior end. Schatzky distance, 7.7 mm; fissure angle, 13.5°; alveolar angle, 19.0°; Birkelund Index, 3.6.
- Figs 21-23 – *Belemnitella mucronata* (SCHLOTHEIM) or *B. woodi* CHRISTENSEN, MGUH 24786, CCC pit, Harmignies, Craie de Nouvelles, 5-11 m above the base of the formation; 21, lateral view; 22, ventral view; 23, view of the split anterior end. Schatzky distance, 11.4 mm; fissure angle, 23.0°; alveolar angle, 19.0°; Birkelund Index, 2.7.

All specimens are coated with ammonium choride, except figs 4, 8, 12, 16, 20, 23, and are natural size.

PLATE 2

- Figs 1-4 – *Belemnitella mucronata* (SCHLOTHEIM), MGUH 24787, CCC pit, Harmignies, Craie d'Obourg, 80 cm above the base of the formation; 1, dorsal view, 2, lateral view; 3, ventral view; 4, view of the split anterior end. Schatzky distance, 9.5 mm; fissure angle, 19.0°; alveolar angle, 20.5°; Birkelund Index, 3.6.
- Figs 5-7 – *Belemnitella minor* I JELETZKY, MGUH 24788, CCC pit, Harmignies, hardground at the top of the Craie de Nouvelles; 5, dorsal view; 6, lateral view; 7, ventral view. Birkelund Index, 4.7. Medium-sized, slender specimen with pseudogranulation.
- Figs 8-11 – *Belemnitella minor* I JELETZKY, MGUH 24789, CCC pit, Harmignies, Craie de Spiennes, 70 cm above the base of the formation; 8, dorsal view; 9, lateral view; 10, lateral view; 11, view of the split anterior end. Schatzky distance, 13.5 mm; fissure angle, 37.0°; alveolar angle, 19.5°; Birkelund Index, 3.9.
- Figs 12-13 – *Belemnitella minor* I JELETZKY, MGUH 24790, CCC pit, Harmignies, Craie de Spiennes, loose, but probably from 8 m ± 1 m above the base of the formation; 12, ventral view; 13, view of the split anterior end. Schatzky distance, 8.7 mm; fissure angle, 24.0°; alveolar angle, 19.5°; alveolar fragment of a large specimen.
- Figs 14-16 – *Belemnitella minor* I JELETZKY, MGUH 24791, CCC pit, Harmignies, Craie de Spiennes, c. 1 m above the base of the formation; 14, dorsal view; 15, lateral view; 16, ventral view. Schatzky distance, 10 mm; fissure angle, 55.0°; alveolar angle, 18.5°; Birkelund Index 4.1.
- Figs 17-18 – *Belemnitella minor* I JELETZKY, MGUH 24792, CCC pit, Harmignies, Craie de Spiennes, 8-10 m above the base of the formation; 17, dorsal view; 18, lateral view. Birkelund Index, 4.0; slightly lanceolate specimen. Figured as *B. cf./aff. najdini* KONGIEL by ROBASYNSKI & CHRISTENSEN (1989, pl. 1, fig. 5).
- Figs 19-20 – *Belemnitella minor* I JELETZKY, MGUH 24793, CCC pit, Harmignies, Craie de Spiennes, 8-10 m above the base of the formation; 19, lateral view; 20, ventral view; large pseudogranulated specimen, which is slightly lanceolate in ventral view.
- Figs 21-23 – *Belemnitella minor* I JELETZKY, MGUH 24794, CCC pit, Harmignies, Craie de Spiennes, c. 10 m above the base of the formation; 21, lateral view; 22, ventral view; 23, view of the split anterior end. Schatzky distance, 9.4 mm; fissure angle, 15.0°; alveolar angle, 18.5°; Birkelund Index, 3.8.
- Figs 24-27 – *Belemnitella minor* I JELETZKY, MGUH 24795, CCC pit, Harmignies, Craie de Spiennes, 100 cm above the base of the formation; 24, dorsal view; 25, lateral view; 26, ventral view; 27, view of the split anterior end. Schatzky distance, 9.1 mm; fissure angle, 33.0°; alveolar angle, 19.5°; Birkelund Index, 4.8; slender specimen.

All specimens are coated with ammonium chloride, except figs 4, 11, 13, 23 and 27, and are natural size.

PLATE 3

- Figs 1-2 – *Belemnitella minor* II CHRISTENSEN, MGUH 24796, La Malogne at Cuesmes, Craie de Spiennes, immediately below the top of the formation; 1, ventral view, showing pseudogranulation; 2, view of the split anterior end. Schatzky distance, 14.5 mm; fissure angle, 22.0°; alveolar angle, 18.0°; Birkelund Index, 3.6-3.7 (estimated).
- Figs 3-6 – *Belemnitella minor* II CHRISTENSEN, MGUH 24797, La Malogne at Cuesmes, Craie de Spiennes, top 1 m of the formation; 3, dorsal view; 4, lateral view; 5, ventral view; 6, view of split anterior end. Schatzky distance, 16.1 mm; fissure angle, 24.0°; alveolar angle, 19.0°; Birkelund Index, 3.7.
- Figs 7-10 – *Belemnitella minor* II CHRISTENSEN, MGUH 19570, La Malogne at Cuesmes, Craie de Spiennes, immediately below the top of the formation; 7, dorsal view; 8, lateral view; 9, ventral view; 10, view of the split anterior end. Schatzky distance, 14.8 mm; fissure angle, 21.0°; alveolar angle, 20.0°; Birkelund Index, 2.9. A stout specimen. Figured as *B. aff. mucronata* (SCHLOTHEIM) by ROBASZYNSKI & CHRISTENSEN (1989, pl. 1, fig. 2).
- Figs 11-12 – *Belemnitella minor* II CHRISTENSEN, IRSNB AD 85-4, André et Fils pit, Cibly, Craie Phosphatée de Cibly; 11, ventral view; 12, view of split anterior end. Schatzky distance, 11.0 mm; fissure angle, 40.0°; alveolar angle, 18.5°; Birkelund Index, 3.0. A large, stout specimen.
- Figs 13-16 – *Belemnitella minor* II CHRISTENSEN, IRSNB AD 85-70, André et Fils pit, Cibly, Craie Phosphatée de Cibly; 13, dorsal view; 14, lateral view; 15, ventral view; 16, view of split anterior end. Schatzky distance, 9.8 mm; fissure angle, 32.5°; alveolar angle, 19.0°; Birkelund Index, 3.6.
- Figs 17-19 – *Belemnitella minor* II CHRISTENSEN, MGUH 24798, ex F. Schmid Collection, André et Fils pit no. 6, Craie Phosphatée de Cibly, 3 m above the base of the formation; 17, lateral view; 18, ventral view; 19, view of split anterior end. Schatzky distance, 11.9 mm; fissure angle 12.5°; alveolar angle, 18.0°; Birkelund Index, 3.5.

All specimens are coated with ammonium chloride, except figs 2, 6, 10, 12, 16 and 19, and are natural size.

PLATE 4

- Figs 1-3 – *Belemnitella minor* II CHRISTENSEN, MGUH 19574, La Malogne at Cuesmes, Craie Phosphatée de Cibly; 1, lateral view; 2, ventral view; 3, view of split anterior end. Schatzky distance, 11.6 mm; fissure angle, 49.0°; alveolar angle, 20.0°; Birkelund Index, 3.6. Figured as *B. aff. mucronata* (SCHLOTHEIM) by ROBASZYNSKI & CHRISTENSEN (1989, pl. 1, fig. 6).
- Figs 4-7 – *Belemnitella minor* II CHRISTENSEN, MGUH 24799, ex F. Schmid Collection, André et Fils pit no. 6, Cibly, top Craie de Spiennes; 4, dorsal view; 5, lateral view; 6, ventral view; 7, view of split anterior end. Schatzky distance, 16.7 mm; fissure angle, 14.0°; alveolar angle, 20.0°; Birkelund Index, 3.3.
- Figs 8-10 – *Belemnitella* sp. 2, MGUH 24800, CCC pit, Harmignies, Craie de Nouvelles, 80 cm below the top of the formation; 8, dorsal view; 9, lateral view; 10, ventral view. Birkelund Index, 4.4.
- Figs 11-14 – *Belemnitella* sp. 1, MGUH 24801, CCC pit, Harmignies, Craie de Spiennes, 180 cm above the base of the formation; 11, dorsal view; 12, lateral view; 13, ventral view; 14, view of split anterior end. Schatzky distance, 9.2 mm; fissure angle, 39.0°; alveolar angle, 20.0°; Birkelund Index, 3.2.
- Figs 15-18 – *Belemnitella* sp. 2, MGUH 24802, CCC pit, Harmignies, Craie de Nouvelles, 280-300 cm below the top of the formation; 15, dorsal view; 16, lateral view; 17, ventral view; 18, view of split anterior end. Schatzky distance, 10.0 mm; fissure angle, 51.0°; alveolar angle, 20.0°; Birkelund Index, 4.2.
- Figs 19-21 – *Belemnitella pulchra* SCHULZ, MGUH 24803, ex Ph. Hoegstoel Collection, Vienne pit, Cibly, Craie Phosphatée de Cibly; 19, dorsal view; 20, lateral view; 21, ventral view. Birkelund Index, 5.2.
- Figs 22-25 – *Belemnitella pulchra* SCHULZ, MGUH 24804, ex F. Schmid Collection, André et Fils pit no. 6, Cibly, Poudingue de Cuesmes at the base of the Craie Phosphatée de Cibly; 22, dorsal view; 23, lateral view; 24, ventral view; 25, view of split anterior end, 1.5. Schatzky distance, 7.4 mm; fissure angle, 74.0°; alveolar angle, 21.0°; Birkelund Index, 4.5.
- Figs 26-28 – *Belemnella (Pachybelemnella) obtusa* SCHULZ, MGUH 24805, La Malogne at Cuesmes, Craie Phosphatée de Cibly; 26, lateral view; 27, ventral view; 28, view of split anterior end; large specimen with weakly developed vascular markings.
- Figs 29-32 – *Belemnella (Pachybelemnella) obtusa* SCHULZ, MGUH 24806, La Malogne at Cuesmes, Craie Phosphatée de Cibly; 29, dorsal view; 30, lateral view; 31, ventral view; 31, view of split anterior end; medium-sized specimen with vascular markings around ventral fissure.

Specimens are coated with ammonium chloride, except figs 3, 7, 14, 18, 22, 28 and 31, and are natural size unless otherwise stated.

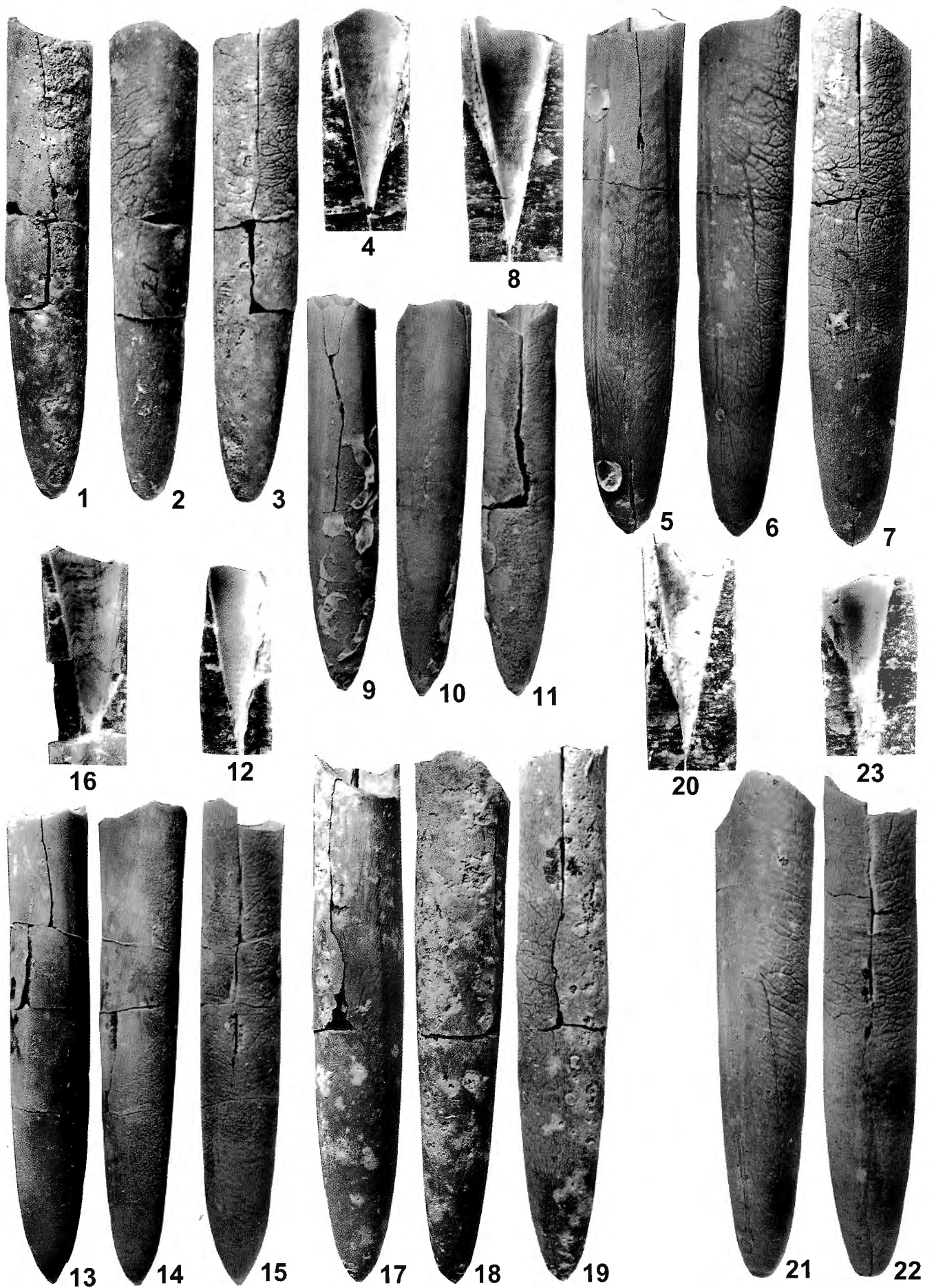


PLATE 1

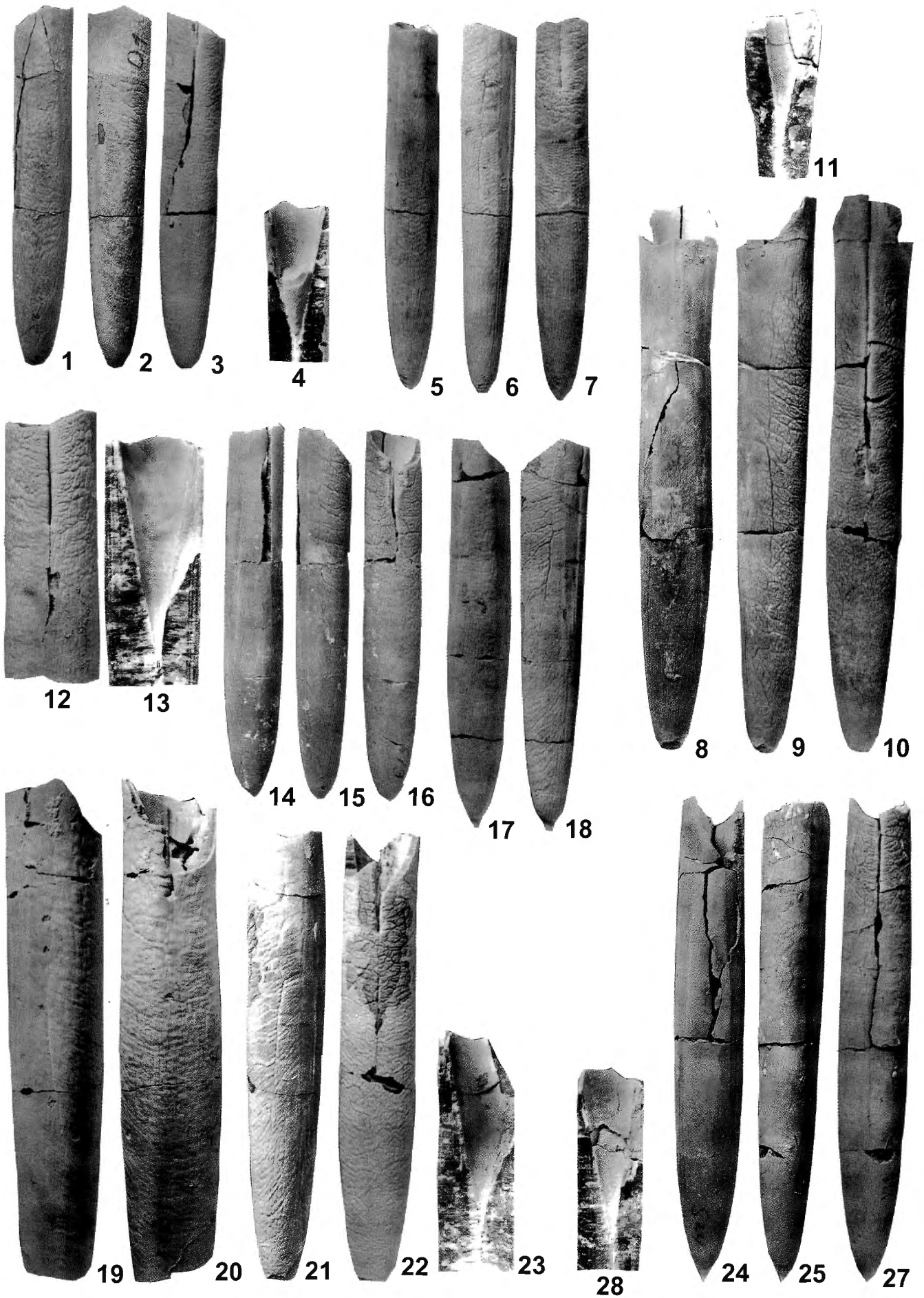


PLATE 2

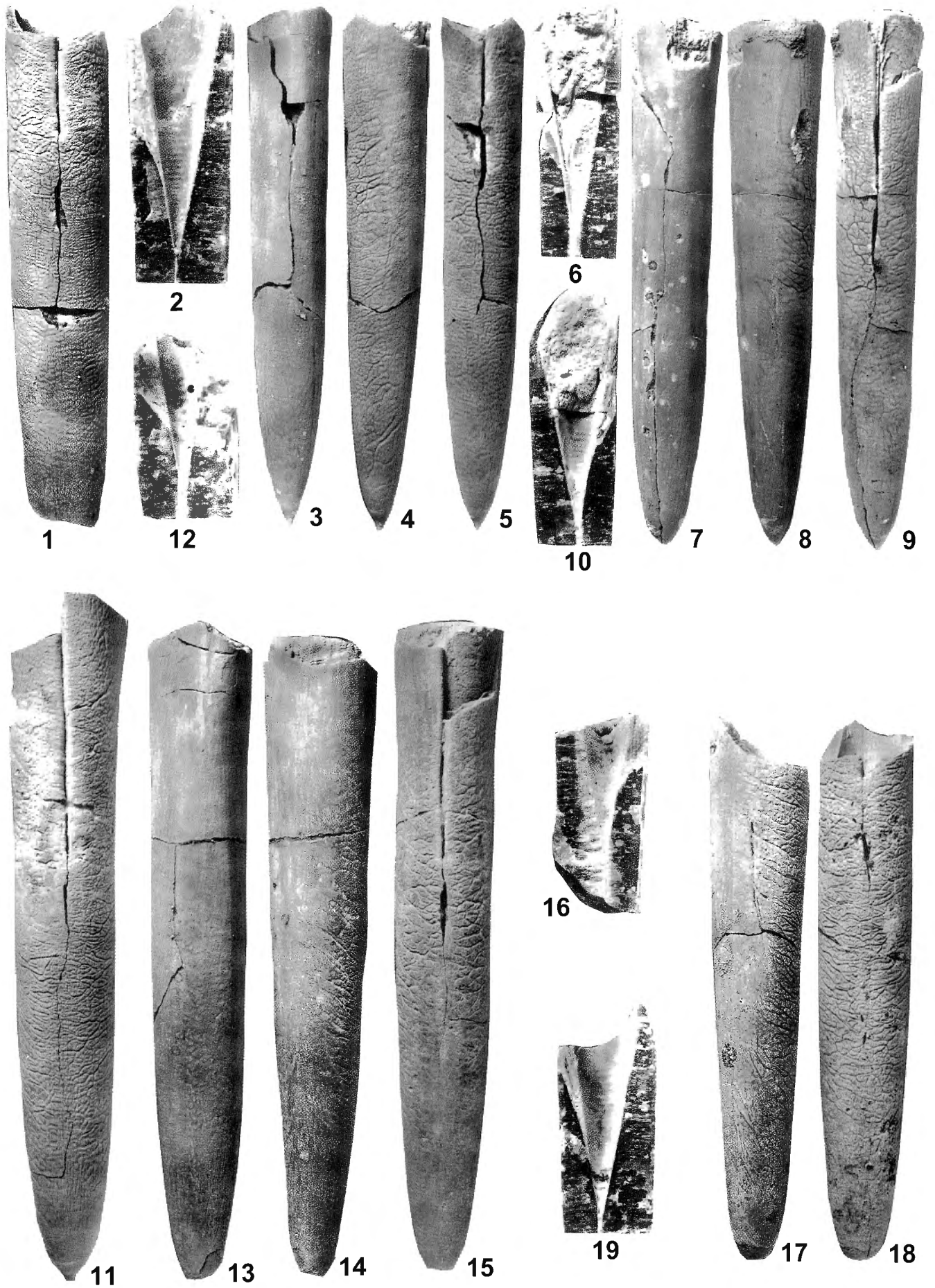


PLATE 3

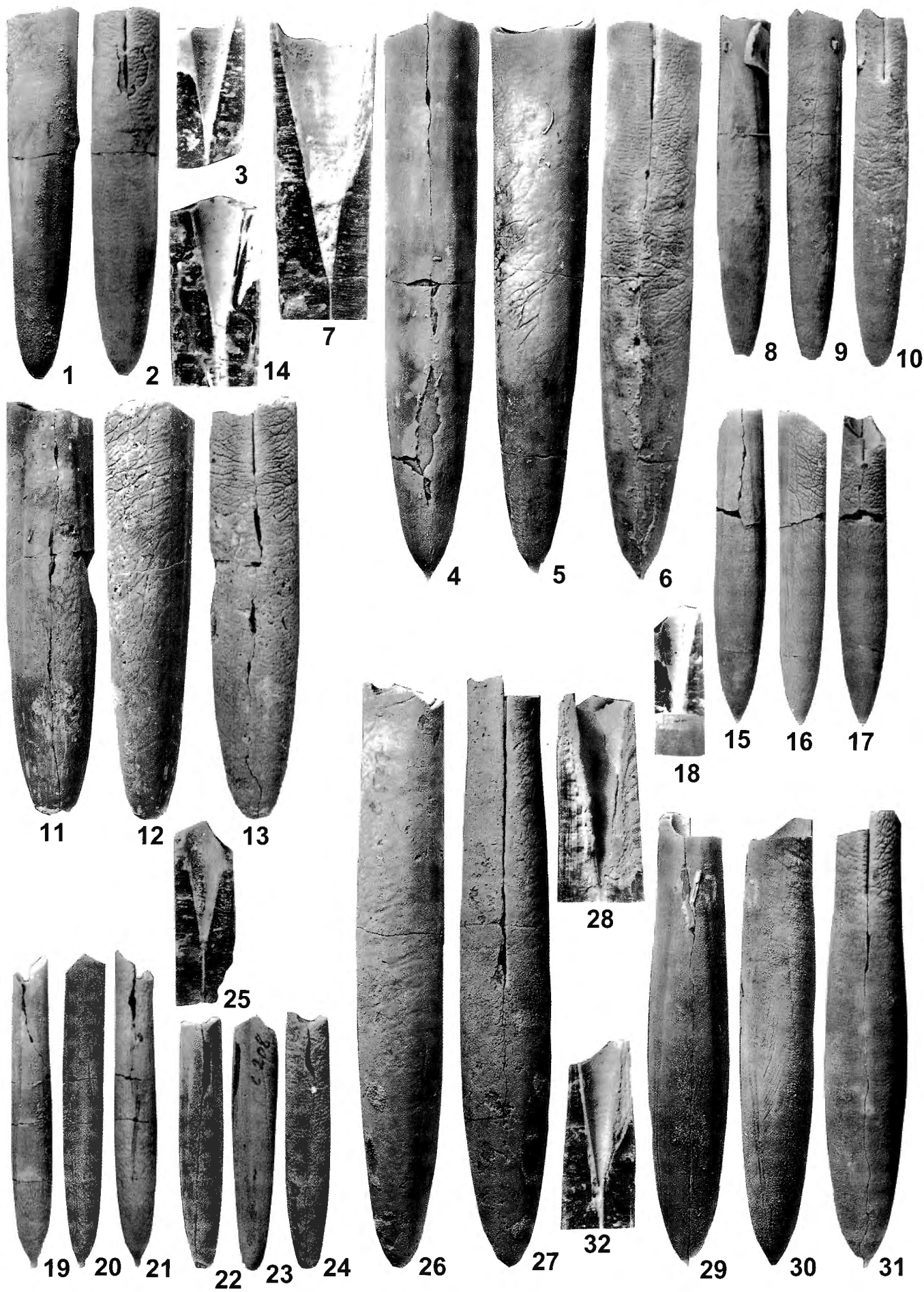


PLATE 4

