

The upper Campanian-Lower Maastrichtian chalks of the Mons basin, Belgium: a preliminary study of belemnites and foraminifera in the Harmignies and Cibly areas

Francis Robaszynski¹ & Walter Kegel Christensen²

¹ *Faculté Polytechnique, 9 rue de Houdain, 7000 Mons, Belgium;* ² *Geological Museum, Øster Voldgade 5–7, 1350 Copenhagen, Denmark*

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Abstract

The Upper Campanian-Lower Maastrichtian chalks of the Mons Basin in Belgium, in ascending order, Craie de Trivières, Craie d'Obourg, Craie de Nouvelles, Craie de Spiennes, and Craie Phosphatée de Cibly, are tentatively placed in the international stratigraphic framework on the basis of preliminary studies of belemnites and foraminifera, as well as some other macrofossils.

The top of the Craie de Trivières, the Craie d'Obourg, the Craie de Nouvelles are from the lower part of the Upper Campanian, and the basal 10–12 m of the Craie de Spiennes from the upper part of the Upper Campanian. The Craie Phosphatée is regarded to be from the upper part of the lower Lower Maastrichtian.

Résumé. Le Campanien supérieur-Maastrichtien inférieur du Bassin de Mons est constitué du bas vers le haut des Craies de Trivières, d'Obourg, de Nouvelles, de Spiennes et de Cibly. Ces différents niveaux de craie qui ont valeur de formations sont replacés dans le cadre stratigraphique international sur la base d'études préliminaires des bélemnites, de quelques autres groupes de macrofossiles et des foraminifères.

Le sommet de la Craie de Trivières, la Craie d'Obourg et la Craie de Nouvelles sont attribués à la partie inférieure du Campanien supérieur et les 10 à 12 m de base de la Craie de Spiennes à la partie supérieure du Campanien supérieur. La Craie Phosphatée de Cibly est considérée comme appartenant à la partie supérieure du Maastrichtien inférieur, partie inférieure.

Introduction: the succession of Mons basin chalks

The stratigraphy and geology of the Upper Cretaceous of the Mons Basin was reviewed by Marlière in 1954 in the 'Prodrome d'une Géologie de la Belgique' (see also Marlière, 1957 and Marlière & Robaszynski, 1975). The Campanian-Maastrich-

tian chalks exposed at the borders of the basin have been subdivided into several 'formations' listed below (top to bottom):

Tuffeau de Saint-Symphorien (Rutot & Van den Broeck, 1885): a yellowish, loose, calcarenite with several flint bands. A phosphatic conglomerate is present at the base and a hardground at the top.

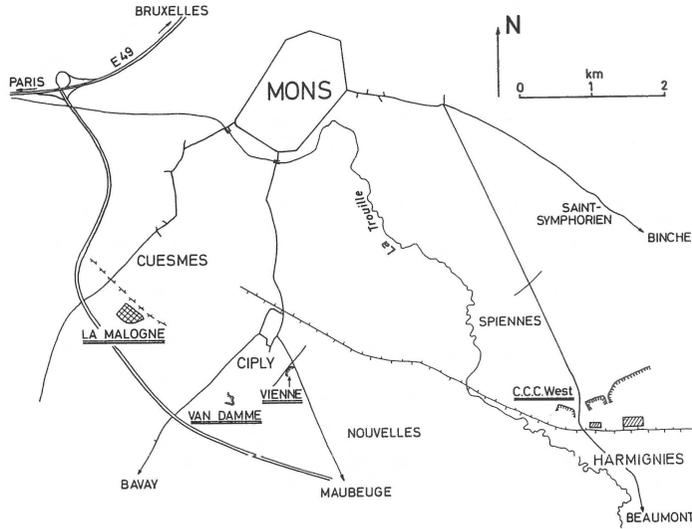


Fig. 1. Map showing the outcrops in the Mons Basin.

The inarticulate brachiopod *Thecidea papillata* is common. The Tuffeau de Saint-Symphorien is not present in the section studied.

Craie Phosphatée de Ciplly ('craie grise' = grey

chalk of Cornet & Briart, 1866 or 'craie brune' = brownish chalk of Cornet & Briart, 1874): a grey to brownish calcarenite consisting of many phosphatic grains in a chalky matrix and generally with flint

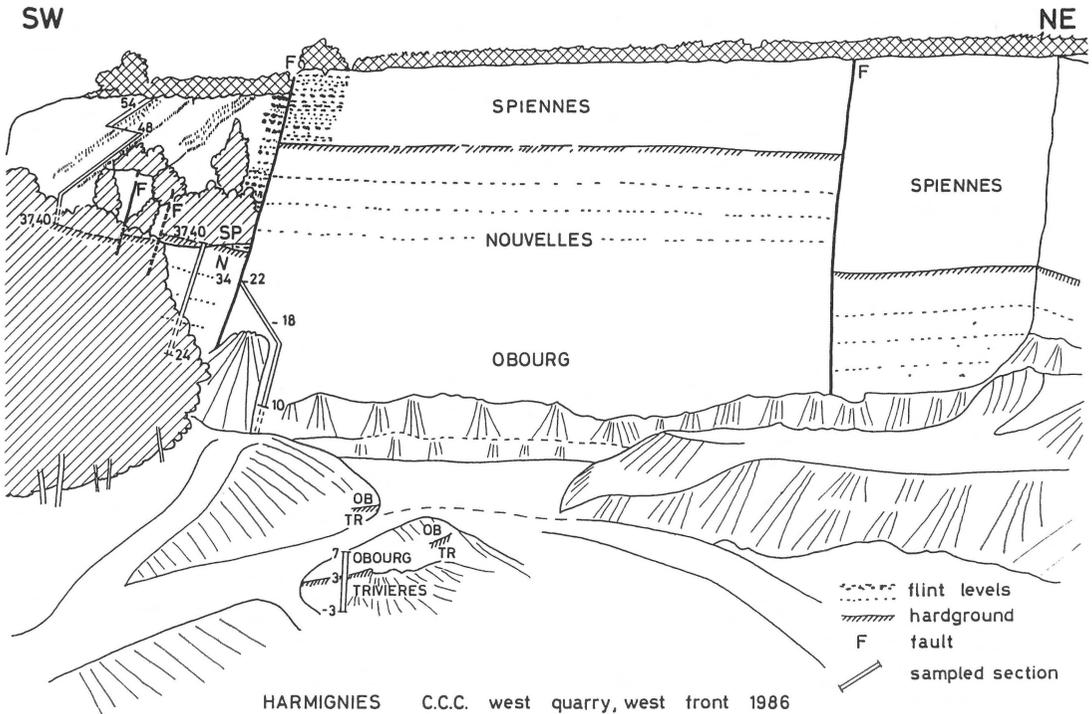


Fig. 2. View of the western face of the C.C.C. quarry at Harmignies.

bands. On the southern border of the basin the Conglomérat de Cuesmes (Briart & Cornet, 1880) forms the base of the 'formation'. The top is capped by a prominent hardground, which is about one metre thick.

Craie de Spiennes (Cornet & Briart, 1870): a white, rather coarse-grained, chalk which becomes calcarenitic towards the top. It has many thick black flint bands which were used by neolithic man to produce tools. There may be a thin layer of phosphatized pebbles at the base and a burrowed level at the top.

Craie de Nouvelles (Cornet & Briart, 1870): a pure, massive, fine-grained, white chalk without flints except for three thin bands at the top. At the border of the basin, a prominent hardground is present in the topmost part of the 'formation'. There is a gradual transition to the subjacent Craie d'Obourg. The brachiopod *Magas chitoniformis* (= *Magas pumilus* of authors) occurs commonly.

Craie d'Obourg (Cornet & Briart, 1870): a fine-grained white chalk, which is slightly more grey than the Craie de Nouvelles. In the southern part of the basin flint bands are not present. A phosphatic conglomerate occurs at the base.

Craie de Trivières (Briart & Cornet, 1880): a white to greyish chalk without flint-layers. There is a phosphatic conglomerate with sponges at the base and a hardground at the top. In the eastern part of the Mons Basin several hardgrounds are distributed through the 'formation'.

The Craie de Trivières overlies the Craie de Saint-Vaast succeeding the Craie de Maisières. The latter 'formations' are also from the Upper Cretaceous, but are not considered in the present paper.

According to Leriche (1929), a profound change in the fossil fish faunas took place at the boundary between the Craie de Nouvelles and the Craie de Spiennes, and he therefore placed the Craie de Nouvelles in the Campanian and the Craie de Spiennes in the Maastrichtian. This point of view was followed by subsequent authors, including Jeletzky (1951a, b), Marlière (1954) and Hofker (1959, 1961). Peake & Hancock (1961, 1970), however, suggested that the Craie de Spiennes is from the Upper Campanian ('Upper Senonian') and Lower Maastrichtian,

but their interpretation seemed to be supported only by the presence of *Echinocorys belgica* which 'is said to appear in the upper part of the Craie de Spiennes'.

On the basis of recent studies of belemnites and other macrofossils, presented and discussed during the 'Cretaceous Stage Boundaries Symposium' held in Copenhagen in 1983, a standard zonation has been established for NW Germany which can be extended to the whole of NW Europe (Schulz et al., 1984). Moreover, biostratigraphy based on the belemnites (Schulz et al., 1984; Christensen, 1986) and foraminifera (Hofker, 1966; Koch, 1977; Villain, 1977; Meessen et al., 1978; Hart et al., 1981; Robaszynski et al., 1985) from the Campanian-Maastrichtian has been greatly improved. The purpose of the present paper is to place the Upper Campanian-Lower Maastrichtian chalks of the Mons Basin in the NW European stratigraphic framework on the basis of belemnites (W.K. Christensen), of some other macrofossils and of foraminifera (F. Robaszynski).

The Belemnites

Belemnites have been shown to be of fundamental importance in biostratigraphy and correlation in the Upper Cretaceous of Europe, especially during the Coniacian through Maastrichtian Stages. This study is based on belemnites collected recently, in addition to material collected earlier and housed in the collections of the Institut Royal des Sciences Naturelles de Belgique, Brussel, and the Faculté Polytechnique, Mons. Moreover, belemnites collected by Dr J.M. Hancock, London, have also been studied. The belemnites collected recently and those in the Hancock Collection are very accurately located with reference to lithological marker beds. The belemnites of the Brussel and Mons collections are generally only labelled with the name of the outcrop and the 'formation', e.g. Craie de Nouvelles, Harmignies.

Various belemnite species have been recorded from the Mons Basin by earlier authors, including Jeletzky (1951a, b) and Marlière (1972), but according to our knowledge, no belemnites have

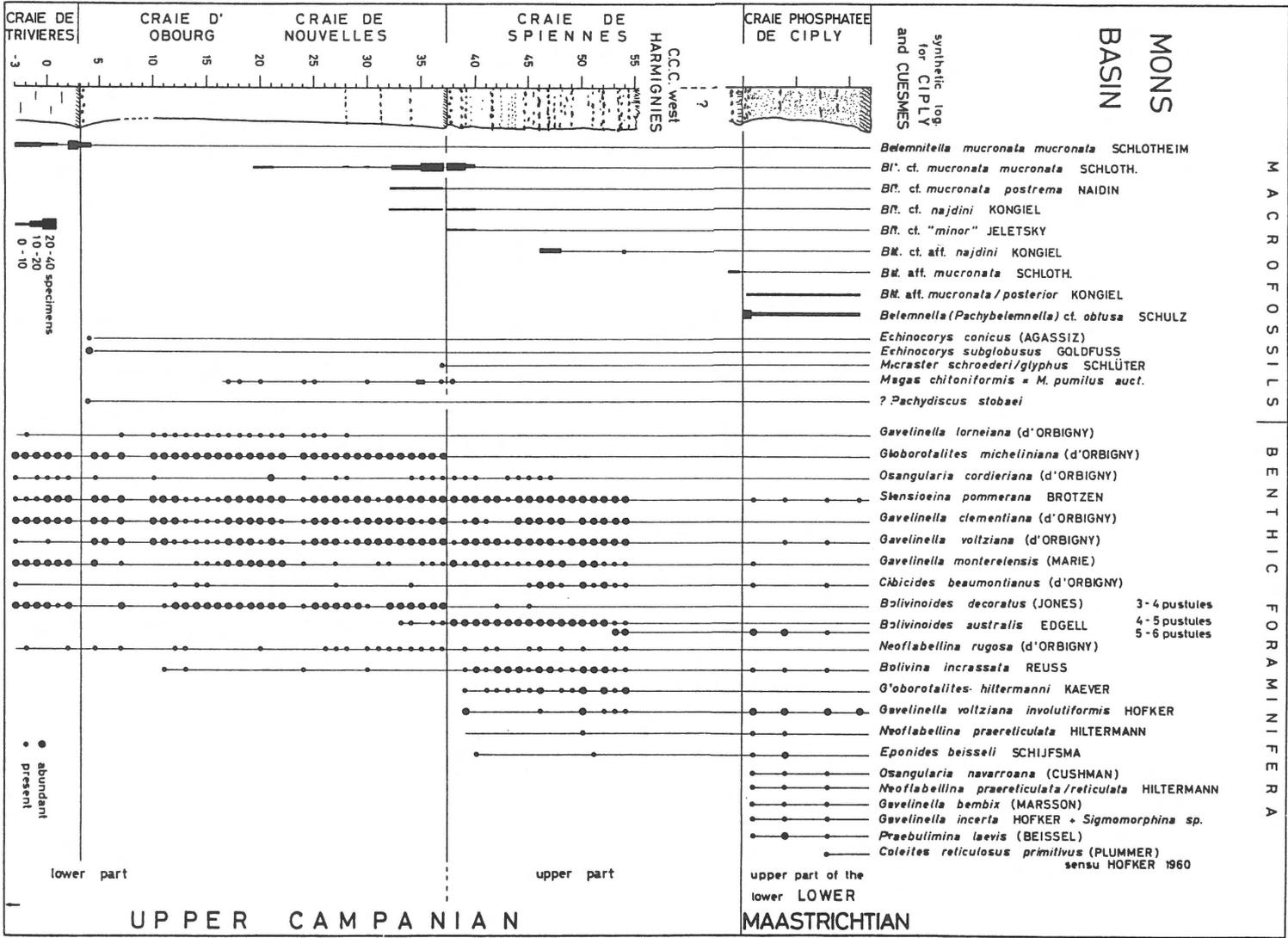


Fig. 3. Diagram showing the lithological logs of the chalks of Harmignies and Ciplly-Cuesmes, in addition to the vertical distribution of macrofossils and benthic foraminifera (thicknesses in metres).

been described or figured. Jeletzky (1951b, table 1) recorded '*Belemnitella* ex gr. *mucronata*, *Belemnitella junior* (?) and *Belemnella lanceolata*' from the Craie de Spiennes, and '*B. lanceolata*, *B. junior*, and *B. ex gr. mucronata*' from the Craie de Ciply. The study of Jeletzky was based on material housed in various museums in NW Europe and on the literature. Some of the museum material may have been mixed or incorrectly labelled. The *Belemnitella* specimens, some of which are *junior*-like, from the Craie de Spiennes and the Craie de Ciply are here assigned to *B. cf./aff. najdini*, *B. aff. mucronata*, and *B. aff. mucronata/posterior* (see below). *Belemnella lanceolata* has not been recognized from the Craie de Spiennes.

Marlière (1972) listed '*B. junior*' from the Craie de Spiennes, and '*B. lanceolata* and *B. casimirovensis*' from the Craie de Ciply. In the opinion of W.K. C. these taxa were incorrectly identified. The specimens of *Belemnella* from the Craie de Ciply, referred to as *B. lanceolata* by Jeletzky and Marlière, are here assigned to *B. obtusa* (see below), following the work by Schulz (1979). In this paper, belemnites will be discussed briefly only.

More than a score of species, subspecies and varieties of *Belemnitella* from the uppermost Lower Campanian-Lower Maastrichtian have been erected and the majority of these taxa were established by east-European workers. The systematics of many of these taxa are in a state of disorder and they are poorly understood. *B. mucronata* Schlothheim, *B. senior* Nowak, *B. minor* Jeletzky and *B. langei* Jeletzky are used as index species in the uppermost Lower Campanian-Upper Campanian. *B. mucronata* is interpreted with respect to the neotype and type-series (ICZN Opinion 1328, 1985, name no. 2979; Christensen et al., 1975, Pl 1:1).

B. senior, *B. minor* and *B. langei* were discussed by Christensen et al. (1975), Schulz (1978) and Christensen (1986). *B. senior* was considered a junior synonym of *B. mucronata* by Christensen (1986). The holotype of *B. minor* falls within the variation of the 'type-population' of *B. mucronata* from the basal Upper Campanian (Christensen et al., 1975). With respect to *B. langei*, Christensen et

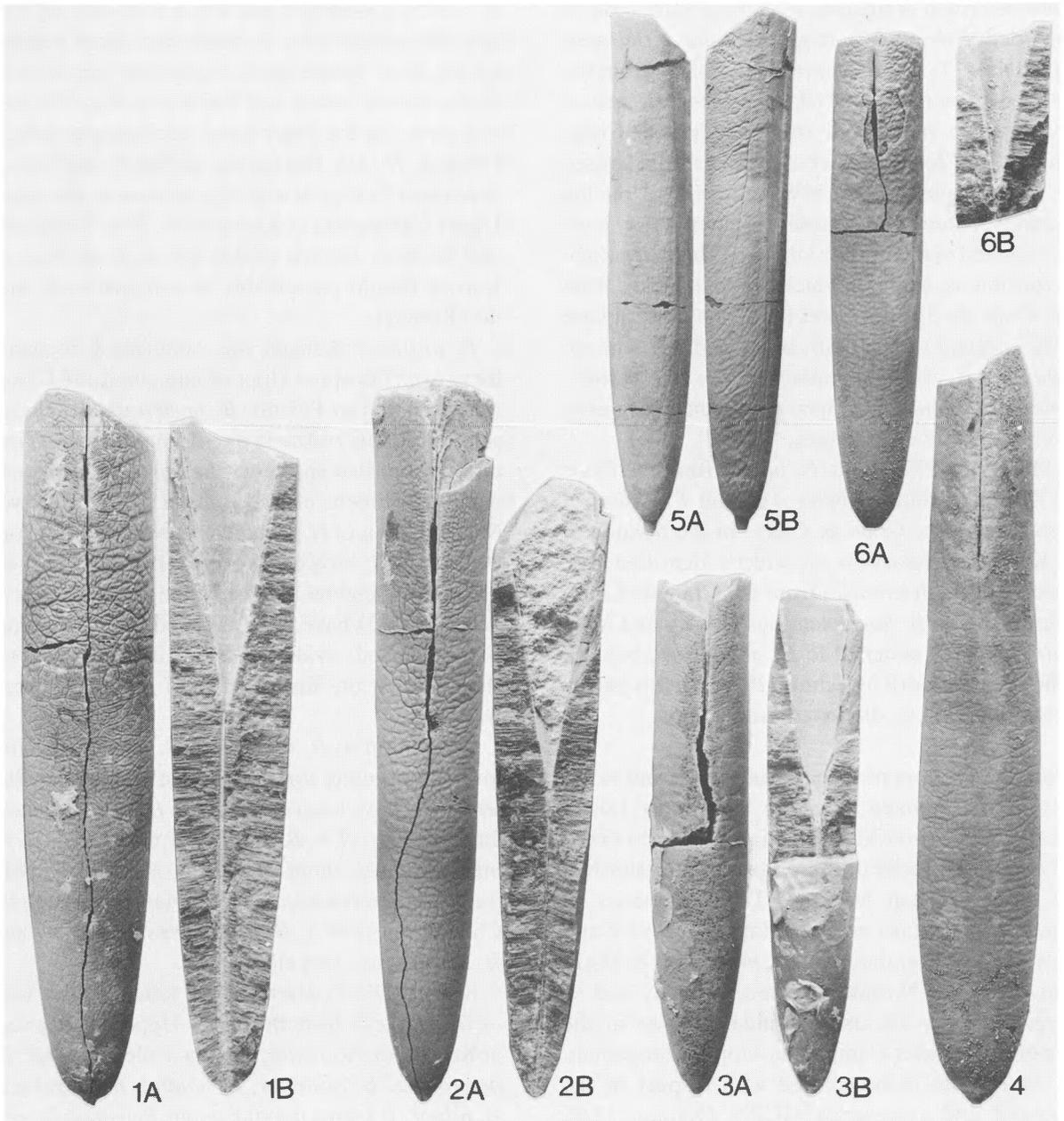
al. (1975) considered that it is a well-defined species characterized by its small size, large relative length, large fissure angle, complexly bent bottom of the ventral fissure and lanceolate shape in ventral view. On the other hand, according to Schulz (1978: p. 78, 81), this species probably only occurs in western Europe at a specific horizon in the upper Upper Campanian at Krons Moor, West Germany, and all other records of this species from western Europe should presumably be assigned to *B. najdini* Kongiel.

B. posterior Kongiel was established on specimens from the upper Upper Campanian and Lower Maastrichtian of Poland. *B. posterior* strongly resembles *B. mucronata* in its external characters but differs from that species by having a larger fissure angle. Specimens of *Belemnitella* from the Lower Maastrichtian of N. Ireland and Norfolk, England (Wood, 1967; Fletcher & Wood, 1978), north-west Germany, Belgium and the Netherlands (Schulz & Schmid, 1983) have been assigned to *B. posterior*. No published evidence is available, however, showing that the fissure angle of these specimens was studied.

In addition to *B. langei* and *B. najdini*, the following lanceolate forms of Upper Campanian *Belemnitella* have been established: *B. pseudolanceolata* Jeletzky (? = *B. lundgreni* de Morgan), *B. mucronata* var. *mobergi* Nikitin, *B. gorkiana* Nikitin, *B. mucrolanceolata* Nikitin (see discussion by Christensen, 1986), *B. langei* sensu Kongiel, and *B. langei* sensu Birkelund.

Kongiel (1962) described the following five taxa of *Belemnitella* from the upper Upper Campanian horizon 't' of Piotrawin, Vistula Valley, Poland: *B. mucronata*, *B. posterior*, *B. najdini*, *B. langei* and *B. minor*. It seems that the genus *Belemnitella* was the subject of excessive subdivision by Kongiel.

In the present paper the lower to upper Upper Campanian *Belemnitella* specimens are left in open nomenclature, because it seems unwise to refer them to poorly understood species.



The white chalks of Harmignies (C.C.C. West quarry)

The two C.C.C. working pits (Crayères, Cimenteries et Chaux) are situated on the south flank of the eastern part of the Mons Basin, on both sides of the road from Mons to Beaumont (Fig. 1). They are cut in a small cuesta exposing the flint-bearing Craie de

Spiennes. The western quarry shows the uppermost part of the Craie de Trivières, the Craie d'Obourg, the Craie de Nouvelles, and the lower part of the Craie de Spiennes.

All these chalks are worked for industrial purposes. There are several faults in the pit, but samples and macrofossils have been collected with reference to lithological marker beds. The sedimen-

(Facing page) Plate 1: Belemnites

Figs. 1–6 – Selected belemnites from the Upper Campanian-Lower Maastrichtian of the Mons Basin. Photographed specimens are coated with ammonium chloride, and all figures are of natural size. The specimens are housed in the Geological Museum of the University of Copenhagen with prefix MGUH.

Fig. 1 – A typical specimen of *Belemnitella mucronata mucronata* (Schlotheim), c. 350 cm below the top of the Craie de Trivières, C.C.C. west quarry at Harmignies. A: Ventral view, B: View of the split guard showing the internal characters.

Fig. 2 – *Belemnitella* aff. *mucronata* (Schlotheim), uppermost 1 m of the Craie de Spiennes, La Malogne at Cuesmes. A: Ventral view, B: View of the split guard showing internal characters. The Schatzky distance is 14.8 mm and the fissure angle is 21°.

Fig. 3 – *Belemnitella* cf. *mucronata postrema* Naidin, 150 cm below the top of the Craie de Nouvelles, C.C.C. quarry at Harmignies. A: Ventral view, B: View of the split guard showing internal characters. The specimen has a pointed apical end, is almost smooth, and the fissure angle is c. 40°.

Fig. 4 – A large specimen of *Belemnella* cf. *obtusa* Schulz with vascular markings, Craie phosphatée de Cibly, top of lower phosphatic unit, La Malogne. Ventral view.

Fig. 5 – *Belemnitella* cf./aff. *najdini* Kongiel, Craie de Spiennes, 8–10 m above the base, C.C.C. west quarry at Harmignies. A: Dorsal view, B: Lateral view. This specimen has a whitish surface and is pseudogranulate.

Fig. 6 – *Belemnitella* aff. *mucronata* (Schlotheim)/*posterior* Kongiel, Craie phosphatée de Cibly, Cuesmes. A: Ventral view, B: View of the anterior end showing the internal characters. The Schatzky distance is 12 mm, and the fissure angle is c. 45°. Moreover, the specimen is pseudogranulate.

tary sequency was measured in the western and southern faces of the pit (Fig. 2), and the lithological log is shown in Fig. 3.

Belemnites (pl. 1)

The chalks of the C.C.C. quarry have only yielded the genus *Belemnitella*, apart from a single find of a specimen of *Gonioteuthis* sp. with an oyster attached to the guard. This specimen came from the top of Craie de Trivières 40 cm beneath the base of the Craie d'Obourg. The oyster and belemnite may have been redeposited and the entire sequence is regarded to be from the Upper Campanian.

The belemnites from the top 5 m of the Craie de Trivières, the hardground at the top of the Craie de Trivières, and the basal 120 cm of the Craie d'Obourg are typical *B. mucronata mucronata*. They are large and stout, strongly vascularized and have a well-defined mucro. The ratio of length from apex to protoconch and dorso-ventral diameter at the protoconch varies from 2.7 to 3.9, with a mean value of 3.3. The fissure angle is small (mean value: 18°) and the bottom of the ventral fissure is generally straight. Belemnites occur commonly in the top

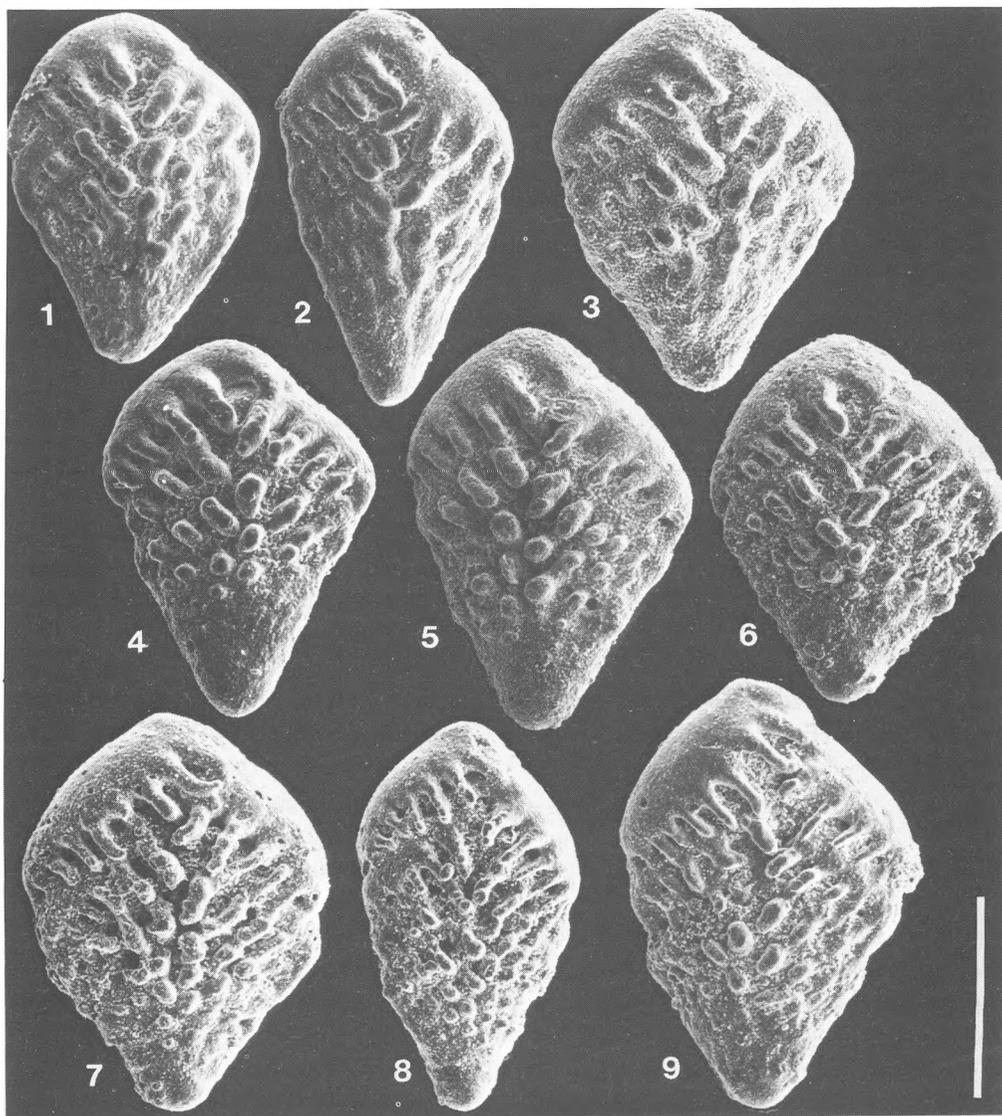
of the Craie de Trivières, whereas they are more rare in the basal part of the Craie d'Obourg.

On the basis of the belemnites, this part of the sequence is judged to be from the lower part of the Upper Campanian.

The *Belemnitella* specimens from the top 5–6 m of the Craie de Nouvelles are generally smaller than the specimens below, although large specimens very closely comparable to *B. mucronata* do occur at this level. The top of the Craie de Nouvelles has also yielded specimens of *Belemnitella*, which are slightly lanceolate in ventral view, almost smooth, and have a pointed apical end rather than a distinct mucro. The fissure angle of these specimens is about 30°–40°. They are referred to as *B. cf. mucronata postrema* Naidin (? : *B. lanceolata* Sharpe non Schlotheim). In addition, small, slender, strongly vascularized, slightly lanceolate specimens with a large fissure angle (40°–50°) do also occur in the top of the Craie de Nouvelles. They are referred to as *B. cf. najdini*.

On belemnite evidence, the top of the Craie de Nouvelles is tentatively regarded to be from the top of the lower part of the Upper Campanian.

Belemnites occur more commonly in the Craie de Spiennes than in the top of the Craie de Nouvelles and the belemnites from the basal 2–3 m of



the Craie de Spiennes are generally larger than the specimens from the top of the Craie de Nouvelles. The basal part of the Craie de Spiennes has yielded large, stout, strongly vascularized specimens, which may be referred to *B. mucronata*. This level has also yielded medium-sized, strongly vascularized, slender specimens with large fissure angles (25° – 50° , generally above 30°). These specimens are referred to as *B. 'minor'*. Specimens showing resemblance to *B. najdini* do also occur at this level.

The specimens from 8–10 m above the base of the

Craie de Spiennes are generally small and slender, slightly lanceolate in ventral view, and they have a well-defined mucro. They are strongly vascularized and have also a marked longitudinal striation, which together produce a wrinkled appearance. Moreover, some of the specimens have a whitish surface. The fissure angle seems to be small and the bottom of the ventral fissure to be straight. The wrinkled surface (pseudogranulation) and whitish surface are often also seen in the Upper Maastrichtian *B. junior* Nowak. The specimens from the

(Facing page) Plate 2: Benthic foraminifera

All specimens of benthic foraminifera presented in plates 2, 3 and 4 come from the Upper Campanian chalks exposed at the C.C.C. west quarry of Harmignies. They are housed in the Mons Polytechnic with prefix HRM followed by a number referring to the log of Fig. 3. Genus *Bolivinoidea*.

Fig. 1 – *Bolivinoidea decorata* (Jones), sample HRM-3, Craie de Trivières; with 3 pustules on the last chamber.

Fig. 2 – *B. decorata*, sample HRM-7, base of the Craie d'Obourg; with 4 pustules.

Fig. 3 – *B. decorata*, sample HRM-18, between Craie d'Obourg and Craie de Nouvelles; with 4 pustules and a small one.

Fig. 4 – *Bolivinoidea australis* Edgell, sample HRM-41, base of the Craie de Spiennes; with 5 pustules. If one follows Hofker's opinion, a mean number of 5 pustules indicates a Lower Maastrichtian age. As *Belemnitella mucronata* occurs in the Craie de Spiennes and gives an Upper Campanian age to the formation, *Bolivinoidea australis* cannot be a marker for the Lower Maastrichtian, in the Mons Basin at least.

Fig. 5 – *B. australis*, sample HRM-50. Craie de Spiennes; with 5 pustules.

Figs. 6, 7, 8 – *B. australis*, sample HRM-53, Craie de Spiennes; with 6 to 7 pustules.

The bar represents 300 micrometres excepted Fig. 8 where it represents 360 micrometres.

Craie de Spiennes from 8–10 m above the base are referred to as *B. cf./aff. najdini*.

The Craie de Spiennes as exposed in the C.C.C. quarry is regarded to be from the upper part of the Upper Campanian.

broken, about 40 cm in diameter and not easy to identify. As written by W.J. Kennedy (in litteris, 23-11-87): 'The inner whorls seem to be smooth, but the outer whorl recalls *Pachydiscus stobaei*. . . Alternatively it might be a large *Parapuzosia*'.

Other macrofossils**a. Echinoids.**

Echinocorys gr. *conica* and *E. gr. subglobosus* occur 120 cm above the base of the Craie d'Obourg. In northwest Germany, *E. conica* starts in the upper Lower Campanian *conica/gracilis* Zone and continues to the top of the *conica/mucronata* Zone (Schulz et al., 1984). *E. subglobosus* has a relatively large vertical range (upper Lower Campanian to lower *roemeri* Zone). It should be noted, however, that its frequency maximum in northwest German sections falls in most cases in the *basiplana/spiniger* Zone (Khosrovschahian, 1972).

Micraster gr. *schroederi/glyphus*, probably *M. glyphus*, occurs at the top of the Craie de Nouvelles. According to Ernst (1970) *M. glyphus* continues into the basal part of the upper Upper Campanian.

b. Ammonite

One specimen of ammonite was found at about one metre from the base of the Craie d'Obourg. It was

Mesofossils

Micromorphic brachiopods were obtained from three samples: one sample from the Craie de Nouvelles, 2 m below its upper boundary; one sample from the Craie de Spiennes, 0.2 m above its base; and one sample from the Craie de Spiennes, 0.7–0.8 m above its base. The micromorphic brachiopods of the Coniacian-Maastrichtian chalks of northwest Europe have been shown to be of great importance in biostratigraphy and correlation (Surlyk, 1982, 1984; Johansen, 1987, in press, among others). Specimens from the C.C.C. quarry were kindly identified by Dr M.B. Johansen, Copenhagen (pers. comm. 21-11-1987). 'The brachiopods of the three samples belong to following genera: *Cretirhynchia*, *Terebratulina*, *Rugia*, *Argyrotheca*, and *Magas*. The same species are apparently present in all three samples. *Magas chitoniformis* (= *Magas pumilus* of authors) is common. On the basis of various species of *Terebratulina* and *Rugia*, the top of the Craie de Nouvelles and the base of the Craie de Spiennes are regarded to be

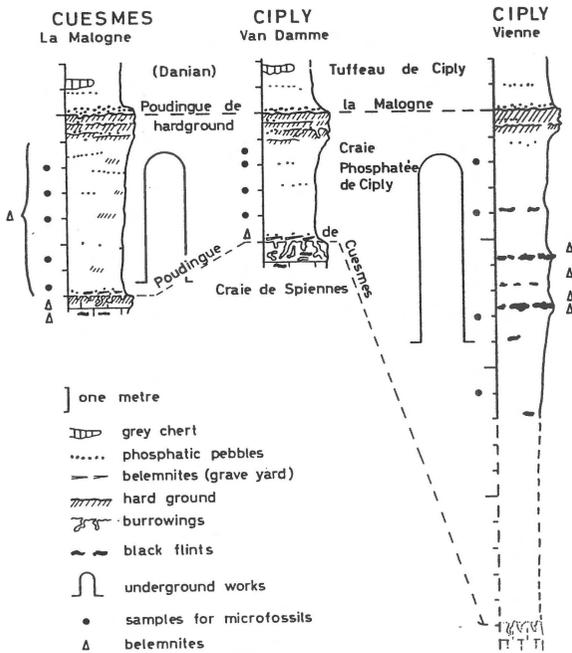


Fig. 4. Sections of the Craie Phosphatée de Ciplly at La Malogne/Cuesmes, and the Van Damme and Vienne pits at Ciplly.

Upper Campanian. The maximum range of this micromorphic brachiopod fauna within the Upper Campanian is from the top of the *basiplanaspinger* Zone to the *langei* Zone, but the ranges of belemnites discussed elsewhere probably restrict this possible age range.'

Foraminifera

Previous work. In 1956, Marie described several new species of foraminifera from the Upper Cretaceous of Belgium. He unfortunately misinterpreted the concept of the Craie de Spiennes, because he also included the hardground at the top of the Craie de Nouvelles and the top 13 m of the Craie de Nouvelles in the Craie de Spiennes. According to Marie, the presence of '*Eponides beisseli*' (very probably *Globorotalites hiltermanni* Kaever, 1961) and '*Neoflabellina praereticulata*' should indicate that the Craie de Spiennes is Lower Maastrichtian. We know now that *Globorotalites hiltermanni* is restricted to the uppermost Campanian (Kaever, 1961; Swiecicki, 1980) and the latter species begins

in Upper Campanian (it continues in the Lower Maastrichtian). Note that the 'true' *Eponides beisseli* ranges from the Upper Campanian through the Maastrichtian.

Hofker (1956, 1958a) in a first approach only recorded some species from the Mons Basin ('Hainaut', 'Harmignies' and 'Pourbaix'). Then Hofker (1959) showed the vertical range of about thirty species from the upper part of the Craie de Nouvelles and the lower part of the Craie de Spiennes, exposed in the 'carrière C.B.R.' (= C.C.C. West in the present paper). He correctly disputed the interpretation of the Craie de Spiennes given by Marie. However, Hofker considered this 'formation' to be Early Maastrichtian age (we suggest that it is from the uppermost Campanian), particularly on the basis of the presence of *Bolivinoidea australis* with 4-5 pustules on the last forme chamber.

Benthic foraminifera (pl. 2-3-4). The vertical distribution of main forms isolated from samples collected at each metre in the section is shown in Fig. 3.

Globorotalites micheliniana is present in the Craies de Trivières, Obourg and Nouvelles but it does not occur in the Craie de Spiennes. *Gavelinella monterelensis* (? = *Gavelinopsis menneri* and probably *Gavelinopsis plana* of Hofker) is found throughout the section as are *Stensioeina pommerana* (? = *Stensioeina altissima* of Hofker), *Gavelinopsis voltziana* and *Gavelinella clementiana*. *Bolivina incrassata* is rare in the Craie de Nouvelles but is present in almost all samples from the Craie de Spiennes.

Gavelinopsis involutiformis, a more globose form than *Gavelinopsis voltziana* appears only at the base of the Craie de Spiennes.

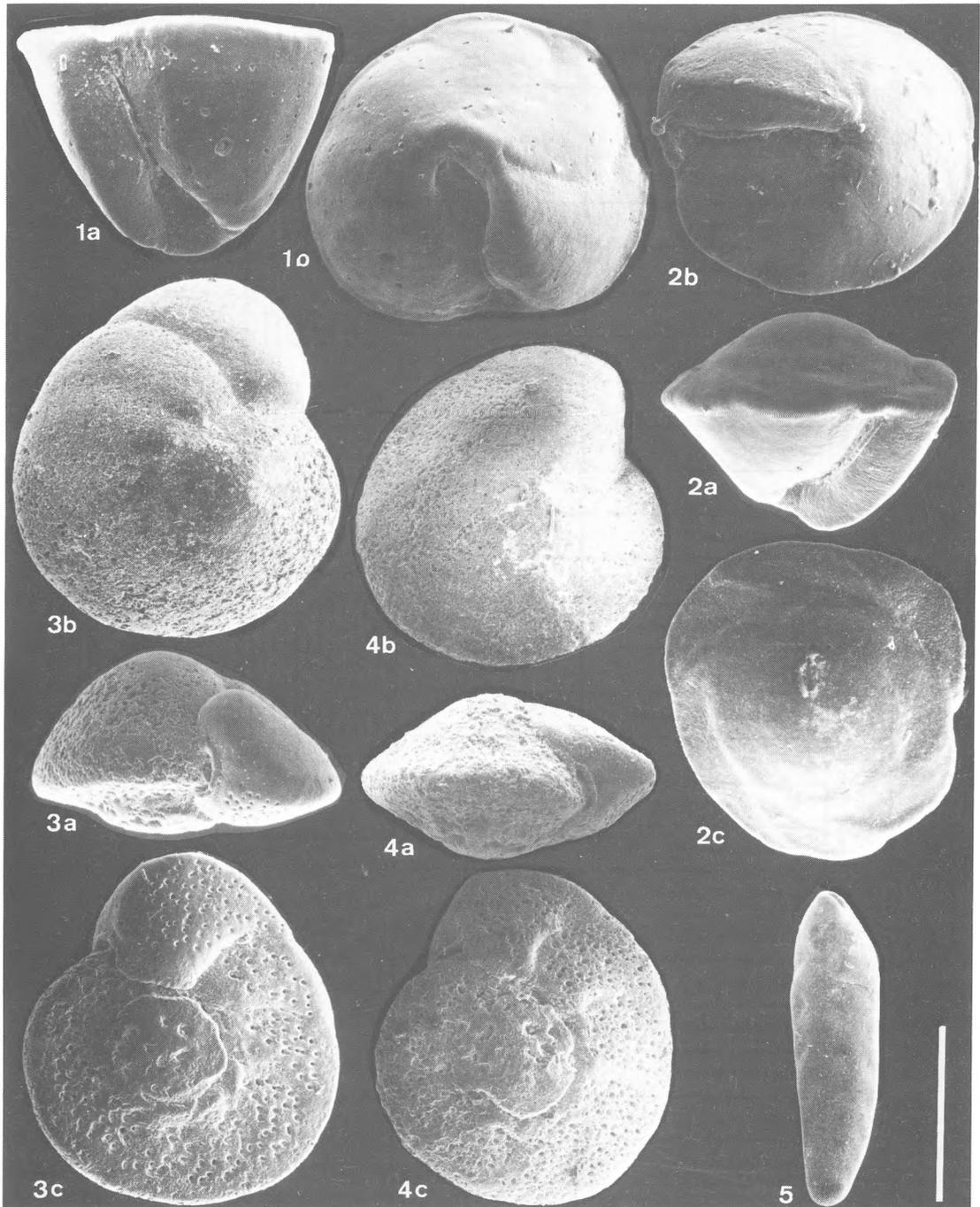
Globorotalites hiltermanni (probably *Eponides beisseli primitiva* of Hofker) is restricted to the Craie de Spiennes where it is sometimes abundant.

Genus *Bolivinoidea*. Several morphotypes are distinguished using the average number of pustules present on the last formed chamber:

Craie d'Obourg : *B. decorata* (3 to 3.5 pustules).
 Craie de Nouvelles: *B. decorata* (3.5 to 4 pustules).
 Craie de Spiennes: *B. australis* (4 to 5 pustules).
 These results are in agreement with those published by Hofker (1958a, 1959).

Sub-stages	Zones in NW Germany	Standard belemnite zones, NW Europe	Mons Basin (Jeletzky, 1951)	Mons Basin Harmignies & Ciplly (This paper)
UPPER MAASTRICHTIAN	upper part	<i>Belemnella casimirovensis</i> (* <i>B. junior</i>)		
		<i>baltica/danica</i>		
	lower part	<i>danica/argenta</i>	Craie de Saint-Symphorien	
		<i>argenta/junior</i> <i>tegulatus/junior</i>	<i>Belemnitella junior</i>	
LOWER MAASTRICHTIAN	upper part	<i>Belemnella fastigata</i>	hiatus	
		<i>Belemnella cimbrica</i>		
		<i>Belemnella sumensis</i>	Craie de Ciplly	hiatus
	lower part	<i>Belemnella obtusa</i>		Craie de Ciplly
		<i>Belemnella pseudobtusa</i>	Craie de Spiennes	hiatus
		<i>Belemnella lanceolata</i>		
UPPER CAMPANIAN	upper part	<i>Belemnitella "langei"</i>	hiatus	Craie de Spiennes
		<i>Belemnitella "minor"</i>		hiatus
	lower part	<i>Belemnitella mucronata</i>	Craie de Nouvelles	Craie de Nouvelles
			Craie d'Obourg	Craie d'Obourg
LOWER CAMPANIAN	upper part	<i>G. q. gracilis / B. mucronata</i>		Craie de Trivières
		<i>G. quadr. gracilis</i>		
	lower part	<i>Goniot euthis quadrata quadrata</i>		
		<i>Goniot euthis granulataquadrata</i>		Craie de Trivières

Fig. 5. Diagram showing the zonation of the Campanian-Maastrichtian of NW Germany, belemnite zones, and the biostratigraphical ages of the 'formations' of the Mons Basin according to the present study. Sources: Column 1 is based on Schulz (1979), Schulz & Schmid (1983), and Schulz et al. (1984); column 2 on Christensen (1986); and column 3 on Jeletzky (1951b).



Remarks

The Lower Maastrichtian of the Limburg area is characterized by *Bolivinoides australis* with a mean number of pustules between 4 to 6 (Hofker 1958a,

b; see also Meessen *in* Robaszynski et al., 1985). Hofker (1959), on the basis of *B. australis* with 4 to 5 pustules, referred the Craie de Spiennes to the Lower Maastrichtian. The Craie de Spiennes (at least the lower part which is exposed in the C.C.C.

(Facing page) Plate 3: Benthic foraminifera

a: lateral view; b: spiral side; c: umbilical side. The bar represents 300 micrometres in Figs. 1, 2, 3; 360 micrometres in Fig. 4 and 550 micrometres in Fig. 5.

Fig. 1 – *Globorotalites michelinianus* (d'Orbigny), sample HRM-18, between Craie d'Obourg and Craie de Nouvelles. Note the flat spiral side.

Fig. 2 – *Globorotalites hiltermanni* Kaever, sample HRM-41, Craie de Spiennes. Note the lateral view biconvex. This species is typically of the upper Upper Campanian (cf. Hart *et al.*, 1981, pl. 7–13).

Fig. 3 – *Gavelinopsis voltziana* (d'Orbigny), sample HRM-18. Note the umbilical side flat.

Fig. 4 – *Gavelinopsis voltziana involutiformis* Hofker, sample HRM-52, Craie de Spiennes. Note the lateral view biconvex.

Fig. 5 – *Bolivina incrassata* Reuss, sample HRM-42, Craie de Spiennes.

quarry) has yielded upper Upper Campanian species of *Belemnitella*. *B. australis* with 4 to 5 pustules, therefore, occurs as early as the Upper Campanian in the Mons Basin.

When the vertical distributions of benthic foraminifera from the Mons Basin are compared with those of England (Swiecicki, 1980; Hart *et al.*, 1981) or Germany (Kaever, 1961; Koch, 1977), it is evident that *Globorotalites micheliniana* disappears before the end of the Campanian, that *Bolivina incrassata* appears in the uppermost Campanian and that *Globorotalites hiltermanni* is restricted to the uppermost Campanian.

The Craie de Spiennes can thus be assigned to the upper Upper Campanian on belemnite and foraminiferal evidence. This is in contrast to Leriche (1929), who referred this 'formation' to the Lower Maastrichtian (see above: Introduction).

The phosphatic chalk of the Ciplly area

Three localities where the phosphatic chalk is still exposed were examined: the abandoned quarry Van Damme at Ciplly, the abandoned underground quarries of La Malogne at Cuesmes and the abandoned quarry Vienne at Ciplly (Fig. 1). In these three localities the succession is rather similar and shows from bottom to top (Fig. 4):

- the Craie de Spiennes, the top of which is marked by an erosion surface and burrows filled with overlying phosphatic chalk;
- the Craie Phosphatée de Ciplly which starts with the Cuesmes Conglomerate composed of phos-

phatic pebbles and sponges generally accompanied by a belemnite graveyard, and capped by a complex hardground, about 1 m thick, forming a resistant roof in the underground mines;

- the Tuffeau de Ciplly, a calcarenite of Danian age.

(Note that the Tuffeau de Saint-Symphorien, normally placed between the Craie Phosphatée de Ciplly and the Tuffeau de Ciplly, is locally missing from this part of the Mons Basin).

Belemnites (pl. 1)

Belemnites have been collected from the uppermost 1 m of the Craie de Spiennes and the Craie de Ciplly in the underground mines of La Malogne at Cuesmes. Moreover, specimens from the Van Damme and Vienne pits, obtained on loan, have also been studied.

Craie de Spiennes The topmost Craie de Spiennes has yielded *Belemnitella* aff. *mucronata*. This taxon is closely comparable to *B. mucronata* with respect to size and shape, surface markings and shape of the bottom of the ventral fissure. It differs, however, from *B. mucronata* by its large Schatzky distance (observed range: 10.0–14.5 mm; mean value about 13) and large fissure angle (observed range: 21°–54°; mean value about 30°). *B. aff. mucronata* differs from *B. posterior* by its larger Schatzky distance and smaller fissure angle. The biostratigra-

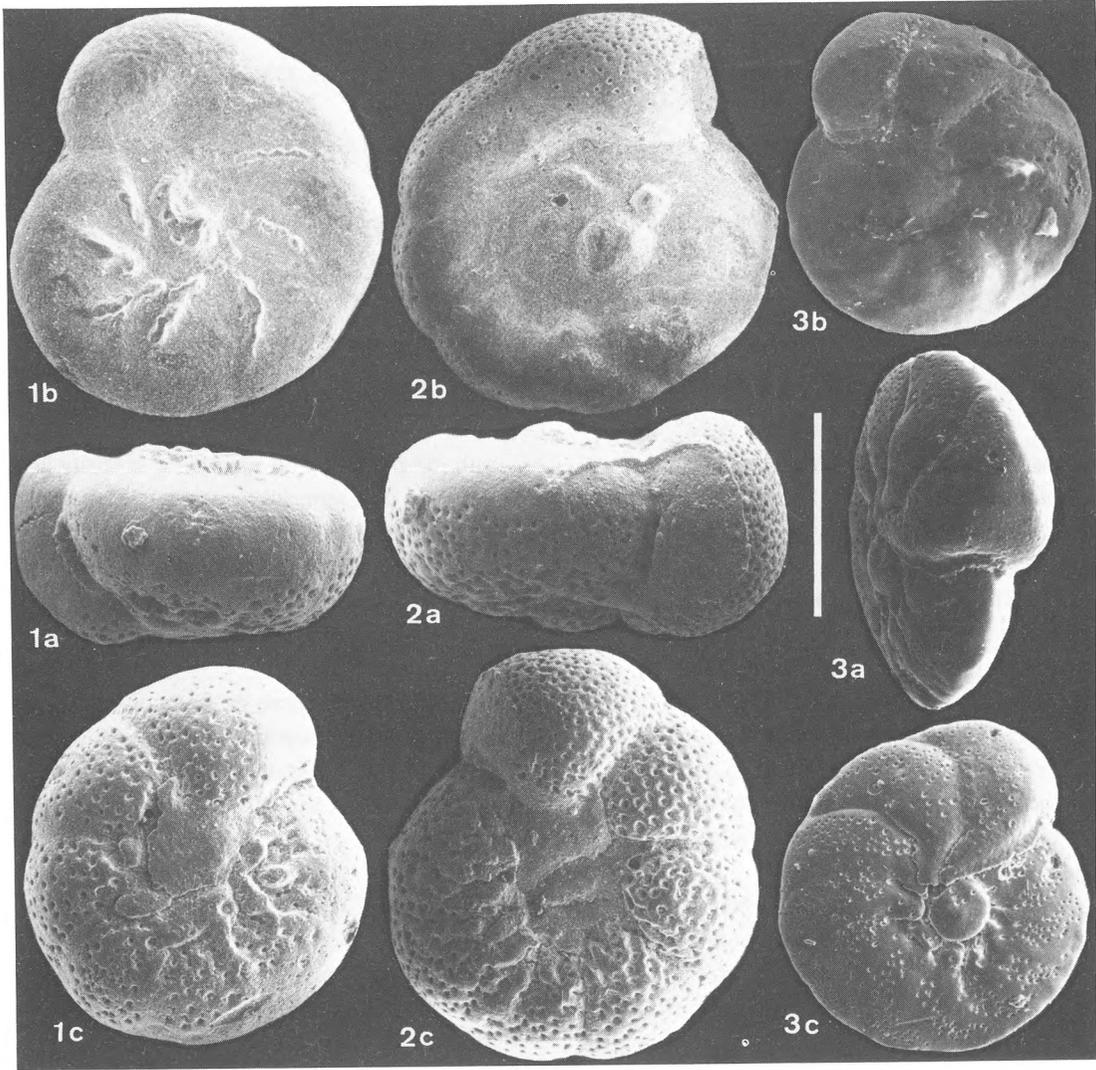


Plate 4: Benthic foraminifera

a: lateral view; b: spiral side; c: umbilical side. The bar represents 300 micrometres in Fig. 1 and 360 micrometres in Figs. 2 and 3.

Fig. 1 – *Gavelinella clementiana* (d’Orbigny), sample HRM-27, Craie de Nouvelles. Note the presence of small ribs on the spiral side.

Fig. 2 – *Gavelinella clementiana* (d’Orbigny), sample HRM-52, Craie de Spiennes. The lack of ribs on the spiral side indicates a high level in the Upper Campanian.

Fig. 3 – *Gavelinella monterelensis* (Marie), sample HRM-53, Craie de Spiennes.

phy of this taxon cannot be evaluated since other occurrences are not known.

Craie de Phosphatée de Ciplly. Two genera occur

together in this ‘formation’: *Belemnella* (common) and *Belemnitella* (rare).

Schulz (1979) introduced a set of parameters for determining species of *Belemnella* from the Lower Maastrichtian and this method is used herein. The

specimens are tentatively assigned to *Belemnella* (*Pachybelemnella*) *obtusa* Schulz; this species only occurs in the upper part of the lower Lower Maastrichtian *obtusa* Zone.

The *Belemnitella* specimens are referred to as *B. aff. mucronata/posterior*. This taxon is closely comparable to *B. mucronata* with regard to size and surface markings. It differs from *B. mucronata*, however, by being slightly more slender, by having a larger Schatzky distance and a large fissure angle (observed range: 28°–80°). Moreover, some specimens are pseudogranulate and have an undulating bottom of the ventral fissure. *B. aff. mucronata/posterior* differs from *B. posterior* by its larger Schatzky distance and smaller fissure angle. It differs from *B. aff. mucronata* from the top of the Craie de Spiennes by being slightly more slender and having a smaller Schatzky distance and larger fissure angle.

B. aff. mucronata/posterior is very similar to and may be conspecific with the form occurring in the upper Lower Lower Maastrichtian pre-*Porosphaera* and *Porosphaera* beds of Sidstrand, Norfolk, referred to as *B. posterior* by Fletcher & Wood (1978). *B. aff. mucronata/posterior* may be regarded as an ancestor of the Upper Maastrichtian *B. junior*.

Foraminifera

Several samples were collected from the three localities. The foraminiferal populations are rather similar in all samples and are composed of the following important taxa: *Bolivinooides australis* (with a mean number of 5 to 6 pustules on the last formed chamber, pustules being elongated), *Osangularia navarroana*, *Praebulimina laevis*, *Neoflabellina* cf. *praereticulata/reticulata* (very rare), *Reussella cimbrica*, *Gavelinopsis bembix*, *Gavelinella incerta*, *Gavelinella monterelensis* (rare), *Coleites reticulosus primitivus* (very rare), *Orbignyna equigranensis*, *Gavelinopsis involutiformis*, *Cibicides beaumontianus*, *Guttulina* sp., *Eponides beisseli*, *Stensioeina pommerana*, *Nonionella troostae*, *Archaeoglobigerina cretacea*, and *Bolivina incrassata*.

Remarks

Hofker (1960) studied several samples from the phosphatic chalk of Ciplly and concluded that this 'formation' was from the Upper Maastrichtian. This conclusion was based on the presence of *Bolivinooides australis* with 5 to 6 pustules on the last formed chamber. Similar forms also occur in the Upper Maastrichtian Zone F in the Limburg area. The Craie de Ciplly has yielded the Lower Maastrichtian belemnite species, *Belemnella obtusa* and *Belemnitella* aff. *mucronata/posterior*. Therefore, in the Mons Basin, *Bolivinooides australis* with 5 to 6 pustules, as well as the other benthic foraminifera accompanying *B. australis*, are from the Lower Maastrichtian.

Conclusions

Belemnites

The top 5 m of the Craie de Trivières and the basal 120 cm of the Craie d'Obourg yielded *B. mucronata mucronata* and is from the lower part of the Upper Campanian.

The hardground between the Craie de Trivières and Craie d'Obourg was earlier taken as the boundary between the Lower and Upper Campanian. Since the top of the Craie de Trivières has only yielded *B. mucronata mucronata*, apart from the single specimen of *Goniotheuthis* sp., which may have been redeposited (see above), the top of the Craie de Trivières is placed in the lower part of the Upper Campanian in the present paper.

The belemnite assemblage from the top of the Craie de Nouvelles consisting of three forms of *Belemnitella*, suggests a top lower part of Upper Campanian age. The basal 10–12 m of the Craie de Spiennes is from the upper part of the Upper Campanian on present belemnite evidence.

The topmost Craie de Spiennes yielded *Belemnitella* aff. *mucronata*, the biostratigraphical age of which is unknown.

The Craie Phosphatée de Ciplly yielded abundant *Belemnella* (*Pachybelemnella*) cf. *obtusa* with subordinate *Belemnitella* aff. *mucronata/posterior*.

This assemblage is regarded to be from the upper part of the lower Lower Maastrichtian, Zone of *B. obtusa*.

Foraminifera

Since the chalks of the C.C.C. quarry at Harmignies are from the Upper Campanian (the top of the Craie de Trivières, Craie d'Obourg, Craie de Nouvelles, and the lower part of the Craie de Spiennes) on belemnite evidence it is worthy of note that:

- *Gavelinella monterelensis*, *G. clementiana*, *Gavelinopsis voltziana*, and *Stensioeina pommerana* are present in the entire section;
- *Globorotalites micheliniana* does not extend higher than the Craie de Nouvelles;
- *Bolivina incrassata* appears in the Craie de Spiennes and *Globorotalites hiltermanni* is restricted to the Craie de Spiennes.
- *Bolivinoidea australis* with 4 to 5 pustules on the last formed chamber is well represented in the Craie de Spiennes, whereas *B. decoratus* with 3 to 4 pustules is present below;
- *Neoflabellina rugosa* is present in the Craie de Nouvelles and the Craie de Spiennes, but it is not common.

Since all the outcrops of the Craie Phosphatée de Cibly studied in the present paper are from the Lower Maastrichtian, it is worthy of note that:

- *Gavelinopsis voltziana*, *G. involutiformis*, *Stensioeina pommerana*, *Bolivina incrassata* and *Eponides beisseli*, all known from the Campanian, are well represented;
- *Gavelinella monterelensis*, although rare, is present in the Lower Maastrichtian;
- several species which do not occur in the Craie de Spiennes at Harmignies are present in the Craie Phosphatée. These species are *Praebulimina laevis*, *Bolivinoidea australis* with 5 to 6 pustules, which are elongated, *Osangularia navarroana*, *Neoflabellina praeoreticulata/reticulata*, and *Gavelinella incerta*.

Stratigraphy

In Fig. 5 the Upper Cretaceous 'formations' of the Mons Basin, studied in the present paper, are tentatively placed in the NW European stratigraphic framework. It should be stressed that several non-sequences are present at the border of the basin. These non-sequences are probably of a smaller magnitude and/or may even disappear in the centre of the basin where subsidence was more or less continuous.

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