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DINOFLAGELLATE CYST STRATIGRAPHY OF THE UPPER CRETACEOUS OF WESTERN BELGIUM

by

Stephen LOUWYE[1]

ABSTRACT

A detailed micropalaeontological analysis with dinoflagellate cysts of the Cretaceous sections intercepted by five wells in western Belgium allows a biostratigraphical correlation and a chronostratigraphical interpretation of the sediments concerned. The transgression of the Cretaceous sediments on the southern part of the Palaeozoic Brabant Massif appears to be strongly diachronous. In the Nieuwkerke and Oostduinkerke wells, situated south of the present day topographic crest of the Brabant Massif (Nieuwpoort - Oudenaarde), the transgression is dated as Late or latest Cenomanian and close to the crest in the Keiem well as Late Turonian. North of the crest, in the De Haan and Knokke wells, it is dated as Late Santonian.
The Late Cenomanian strata are present only in the Nieuwkerke and the Oostduinkerke wells, at some distance south of the crest. Sediments dated as Turonian are found only south of the crest, with a decreasing thickness towards the crest, from the Nieuwkerke to the Keiem well. The Coniacian also occurs only south of the crest, with a similar thickness in the two latter wells. The Santonian has a similar thickness in the same two wells south of the crest and is present only with a reduced thickness of Late Santonian age in the De Haan and Knokke wells. Campanian sediments occur only north of the crest, in both latter wells. Only Lower Campanian is present in the De Haan well, while a more complete Campanian section, followed by Maastrichtian, is observed more to the north, in the Knokke well. A post- Cretaceous erosion is thought to be responsible for the observed thickness variations in the Campanian north of the crest.

RESUME

Une analyse micropaléontologique detaillée à l'aide de kystes de dinoflagellés appliquée aux dépôts crétacés de cinq forages dans l'ouest de la Belgique, permet d'établir des corrélations biostratigraphiques entre ces forages et une interprétation chronostratigraphique de ces sédiments. La transgression du Crétacé sur le socle paléozoique du Massif du Brabant paraît fortement diachronique. Dans les forages de Nieuwkerke et Oostduinkerke, situés au sud de la crête topographique contemporaine du Massif du Brabant (Nieuwpoort - Oudenaarde), la transgression date du Cénomanien supérieur ou tardif et dans le forage de Keiem, situé plus près de la crête topographique, elle date du Turonien supérieur. Au nord de la crête topographique, dans les forages de De Haan et de Knokke, la transgression date du Santonien supérieur. Les dépots cénomaniens sont présents uniquement dans les forages de Nieuwkerke et de Oostduinkerke, situés à quelque distance au sud de la crête topographique. Le Turonien est présent seulement au sud de la crête, avec une épaisseur décroissante vers le nord, de Nieuwkerke à Keiem. Le Coniacien aussi n'est présent qu'au sud de la crête avec une épaisseur comparable dans les deux forages cités. Le Santonien aussi a une épaisseur comparable dans ces mêmes forages. Dans les forages de De Haan et de Knokke, on retrouve du Santonien supérieur avec une épaisseur réduite et du Campanien. Seule une partie du Campanien inférieur est présent dans le forage de De Haan, tandis qu'à Knokke la section campanienne continue jusque dans le Campanien supérieur, qui y serait couvert par le Maastrichtien. Une érosion datant du post Crétacé est tenue responsable pour les variations observées dans le Campanien au nord de la crête.

KEY WORDS

Dinoflagellates, cysts, Cretaceous, Belgium, stratigraphy.

[1] Present adress: Laboratorium voor Fysische Geografie, Universiteit Gent, Krijgslaan 281, 9000 Gent

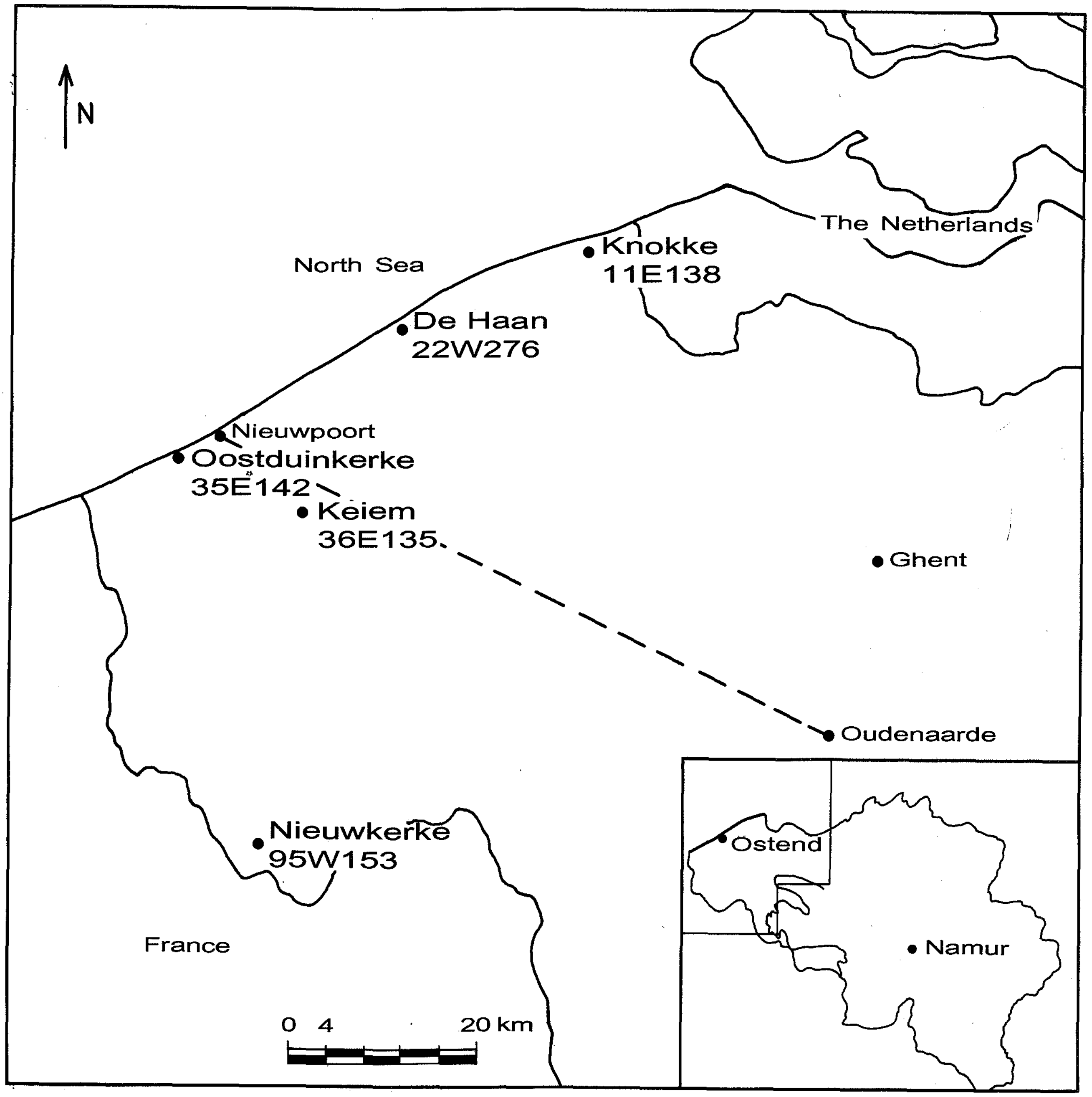

Figure 1. Location of the studied wells. _ _ : present day topographic crest of the Brabant Massif.

1. INTRODUCTION

The aim of this paper is to give a succinct overview of the biostratigraphical correlation and the chronostratigraphical interpretation with the aid of dinoflagellate cysts of the Cretaceous sediments intercepted by five wells in western Belgium (West Flanders) (fig. 1).

Cretaceous sediments cover continuously the Palaeozoic basement (Anglo-Brabant Massif and adjacent basins) in the western, northern and northeastern part of Belgium, with the exception of a central region where a the Cretaceous is eroded and where the Tertiary rests directly upon the basement. The Cretaceous deposits of Belgium were deposited during two different transgressive phases. The sediments covering the southern part of the Brabant Massif were laid down during the Cenomanian-Turonian transgression advancing from the Paris Basin; the Mons Basin was already under a marine influence during the Albian (Marlière, 1954; Colbeaux *et al.*, 1977). The northern limit of the area of the former transgression coincides roughly with the line Oostende-Namur (Legrand, 1968). The Cretaceous sediments resting on the northern part of the Brabant Massif are linked with the transgression advancing from Westphalia and flooding the area during the Santonian. Both areas were separated by a NW-SE oriented "Haut Fond" (Marlière, *ibid.*), here called the crest of the Brabant Massif and corresponding to the "central" part of the "sous-bloc Brabant Nord", according to Colbeaux *et al.* (*ibid.*). The majority of the sediments consists of chalk and other carbonate-rich sediments of Late Cretaceous age. Sediments with a continental character are found in the Mons Basin and in adjacent areas and are of Early Cretaceous age. Freshwater and near-shore marine deposits with a Santonian age are located in northeastern Belgium (Batten *et al.*, 1988). A post Cretaceous general uplift makes that the Tertiary lies unconformably on the Cretaceous in northern and western Belgium, while sedimentation continued in the Mons Basin and northeastern Belgium.

Cretaceous sediments are observed in numerous wells in Flanders. Due to the relative lithological uniformity of the chalky sediments and the lack of macrofossils in the wells, it was difficult to compare and correlate them with Cretaceous outcrop areas either in northeastern Belgium and southeastern Netherlands (the Euregio Meuse/Rhine) or the Mons Basin.

Until now, only a few studies dealt with the biostratigraphical analysis with organic-walled microplankton of the Belgian Cretaceous. The first steps in detailed biostratigraphical research with organic-walled phytoplankton of Late Cretaceous sediments in Belgium were made by Wilson (1971, 1974), Foucher & Robaszynski (1977) and Foucher (1985). Lejeune-Carpentier (1937, 1938a, 1938b, 1939, 1940, 1941, 1942, 1943, 1946, 1951) studied the morphology of dinoflagellate cysts from Cretaceous flints of varied localities in Belgium and adjacent areas, but paid little attention to the stratigraphical aspects; her material was restudied by Lejeune-Carpentier & Sarjeant (1981, 1983). The Cretaceous sediments of the Knokke well formed the subject of multidisciplinary investigations (Laga & Vandenberghe, 1990). Biostratigraphical analysis of the Cretaceous, with calcareous nannoplankton and ostracods, was done respectively by Bal & Verbeek (1990) and by Nuyts (1989). Louwye (1990) gives a first correlation of the Cretaceous in the Knokke and the De Haan wells based on dinoflagellate cysts.

2. MATERIAL

The five wells are situated in the province of West Flanders in the western part of Belgium and were all drilled on behalf of the Belgian Geological Survey (fig. 1). The Cretaceous section from the Knokke well is entirely cored. The sections from the Keiem, Nieuwkerke and Oostduinkerke wells are partly cored and partly drilled with the rotary-percussion method. The De Haan well was entirely drilled with the rotary-percussion method. The Cretaceous deposits in all wells rest directly on the Palaeozoic basement and are covered unconformably with Tertiary sediments. The schematic lithological profiles of the Cretaceous sections are given in fig. 10. The lithological descriptions are mainly based on the archives of the Belgian Geological Survey. All depths mentioned in the following lithological descriptions and in the figures are referred to the Belgian altimetric reference level (T.A.W).

2.1. The Knokke well 11E138

\+ 4.9 m - 25.1 m : Quaternary
\- 25.1 m - 306.1 m : Tertiary
\- 306.1 m - 427.1 m : Cretaceous, entirely cored
- 306.1 m - 365.1 m (app.) : friable, fine-grained chalk with between -311 m and -317 m a more coarse-grained section and around -340 m a more indurated interval
- 365.1 m (app.) - 423.1 m : indurated, fine-grained white chalk
- 423.1 m - 427.1 m : glauconitic, sandy chalk with at the base a glauconitic sandstone.
\- 427.1 m: Palaeozoic basement

2.2. The De Haan well 22W276

\+ 5 m - 36.5 m : Quaternary
\- 36.5 m - 221.5 m : Tertiary
\- 221.5 m - 294 m : Cretaceous, entirely drilled with rotary-percussion method
- 221.5 m - 257 m : fine-grained white chalk
- 257 m - 291 m: fine-grained white chalk with glauconite
- 291 m - 294 m: glauconitic chalk
\- 294 m: Palaeozoic basement

2.3. The Keiem well 36E135

\+ 3 m - 9 m : Quaternary
\- 9 m - 170 m : Tertiary
\- 170 m - 181.4 m : Cretaceous, section drilled with the rotary-percussion method
\- 181.4 m - 212.3 m : Cretaceous, cored section
- 181.4 m - 199.85 m : white, sandy and strongly bioturbated chalk with intercalations of pure white chalk
- 199.85 m - 200.4 m : marly chalk with white, bioturbated chalk
- 200.4 m - 211 m : grey, bioturbated chalk with a minor sandy fraction and some intercalations of pure, white chalk. A 40 cm thick marly intercalation at -202.7 m

- *211 m - 212.3 m : grey bioturbated chalk with a downward increase of sand and glauconite*
- 212,3 m: Palaeozoic basement

2.4. The Nieuwkerke well 95W153

+ 32 m + 28 m : Quaternary
+ 28 m - 85 m : Tertiary
- 85 m - 158.78 m : Cretaceous, section drilled with the rotary-percussion method. Alternation of sandy marls, sandy, glauconitic chalk and marly chalk
- 158.78 m - 186.2 m: Cretaceous, cored section
- *158.78 m - 160.23 m : greenish grey, sandy indurated chalk with clayey intercalations*
- *160.23 m - 161.4 m : green, sandy marl*
- *161.4 m - 163.15 m : green, sandy chalk*
- *163.15 m - 163.55 m : marl*
- *163.55 m - 165.55 m : green, strongly bioturbated marly chalk*
- *165.55 m - 171.56 m : silty marl*
- *171.56 m - 172.02 m : marly silt*
- *172.02 m - 173.85 m : indurated chalk*
- *173.85 m - 174.10 m : silty marl*
- *174.10 m - 175.33 m : marly chalk*
- *175.33 m - 176.11 m : silty marl*
- *176.11 m - 177.25 m: marly chalk*
- *177.25 m - 178.25 m: no core*
- *178.25 m - 181.08 m: marly chalk with glauconite*
- *181.08 m - 186.2 m: glauconitic chalk with intercalations of coarse-grained chalk*
- 186.2 m: Palaeozoic basement

2.5. The Oostduinkerke well 35E142

+ 6.5 m - 20.5 m : Quaternary
- 20.5 m - 175.5 m : Tertiary
- 175.5 m - 247.3 m : Cretaceous, section drilled with the rotary-percussion method
- 247.3 m - 257.95 m : Cretaceous, cored section
- *247.3 m - 255.1 m : strongly bioturbated marl*
- *255.1 m - 255.9 m : glauconitic chalk, rich in small pebbles and weathered slate fragments from the basement.*
- *255.9 m - 257.95 m : the glauconitic chalk grades downward into a conglomerate of slate, shell fragments and dolerite.*
- 257.95 m: Palaeozoic basement

3. SAMPLE PREPARATION

All samples were processed following standard palynological preparation techniques for chalk and other carbonate-rich sediments (Wilson, 1970). Each sample weighed 200 gram and was treated with two subsequent acid attacks (HCl and HF). No oxidation nor ultrasonic treatment was applied. The samples were filtrated on a gaze with a 10 µm mesh size. The material was examined under a transmitted light microscope Leitz Ortholux; a total of 300 to 400 cysts were determined and counted in each sample.

4. DINOFLAGELLATE CYST ASSOCIATIONS

A total of 47 samples were examined. Their stratigraphic position is given on figs. 2 - 9. Three samples were barren, all other samples yielded well to excellently preserved and rich dinoflagellate cyst associations. Few acritarchs and pollen and spores were encountered. The only other micropalaeontological analyses of the study material involved investigations with calcareous nannoplankton (Bal & Verbeek, 1990) and ostracods (Nuyts, 1989) from the Knokke well. The ditch samples from the sections drilled with the rotary-percussion method are contaminated with Tertiary palynomorphs and, consequently, only the first downhole occurrence of a species is given for these sections.
We refer to Louwye (*in prep.*) for the description of the new dinoflagellate cyst species. In another paper, a full account of the dinoflagellate cysts associations will be given (Louwye, *in prep.*). There is one remark to be made concerning the taxonomy of some of the dinoflagellate cysts mentioned below. Wilson (1974) made one of the first extensive studies of the Late Campanian-Maastrichtian dinoflagellate cysts within the framework of his PhD thesis. However, this study remains unpublished until now. Nevertheless we used Wilson's (1974) manuscript names for the index species. We retained only three acritarch species in our records. These species could eventually be considered as dinoflagellate cysts but lack the convincing morphological features allowing such an interpretation. The wells are described in a roughly north to south direction.

4.1. The Knokke well

We examined eighteen samples from this well and recorded a total of 139 organic-walled microfossils species: 136 dinoflagellate cysts species and 3 acritarchs species. One sample (-307.0 m) was barren. According to the literature and our own observations, the following species have a stratigraphic significance. Fig. 2 gives the vertical distribution of those selected dinoflagellate cysts species.

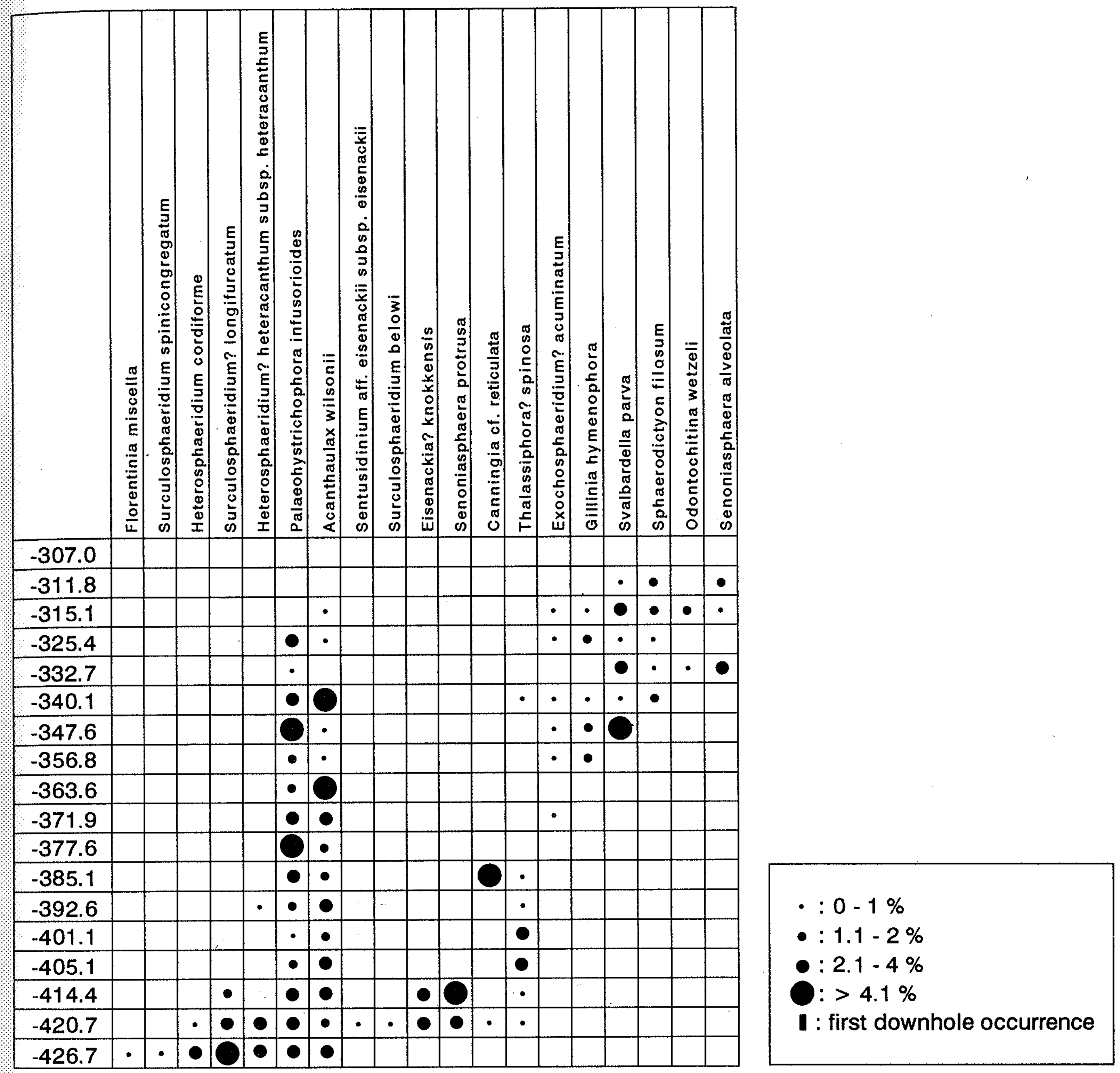

Figure 2. Vertical distribution of selected dinoflagellate cysts in the Knokke well 11E138.

* *Florentinia miscella* Yun, 1981, *Heterosphaeridium cordiforme* Yun, 1981 and *Surculosphaeridium spinicongregatum* Yun, 1981 occur in sample -426.7 m. *H. cordiforme* is also present in sample -420.7 m. The three species are found in the Lower Santonian of the Münster Basin (Yun, 1981). *F. miscella* occurs also in the Upper Turonian of northwest Germany (Prössl, 1990). *H. cordiforme* occurs in southern Germany in the Lower Santonian - Campanian (Kirsch, 1991).
* *Heterosphaeridium*? *heteracanthum* (Deflandre & Cookson, 1955) subsp. *heteracanthum* is present in samples in -426.7 m and -420.7 m and probably reworked in sample -392.6 m (only one badly preserved specimen was found). This species is reported from various localities and has a wide compiled stratigraphical range: it occurs in the Hauterivian of Morocco (Below, 1982) and disappears in the very base of the basal Campanian in the Paris Basin (Foucher, 1979). It has also been reported from the Middle Albian till the Lower Campanian of Australia (Helby, Morgan & Partridge, 1987). Foucher (1985) found this species in the top of the Lower Campanian, the Upper Campanian and the Lower Maastrichtian of the Euregio Meuse/Rhine but suspects reworking of this species in the latter region. Archangelsky (1969) and Chateauneuf (1980) found *H.*? *heteracanthum* subsp. *heteracanthum* in respectively the Eocene of Argentina and the Upper Eocene - Lower Oligocene of northern France.
* *Surculosphaeridium*? *longifurcatum* (Firtion, 1952) is encountered in the three basal samples: -426.7 m, -420.7 m and -414.4 m. This species has

a wide compiled stratigraphical range: from the Early Hauterivian (Williams, 1975) into the Campanian (Aurisano 1989; Tocher, 1987) and the Santonian - Campanian (Ioannides, 1986). *S.? longifurcatum* disappears at the top of the base of the Lower Campanian in the Paris Basin (Foucher, 1979) and in the Upper Maastrichtian in the Euregio Meuse/Rhine (Foucher, 1985).

* *Sentusidinium* aff. *eisenackii* (Boltenhagen, 1977) subsp. *eisenackii* occurs in sample -420.7 m.

* *Surculosphaeridium belowi* Yun, 1981 is encountered in sample -420.7 m. It was encountered in the Lower Santonian of the Münster Basin by Yun (1981) and in the Lower Santonian and Lower Campanian of southern Germany by Kirsch (1991).

* *Eisenackia*? *knokkensis* n.sp. Louwye, *in prep.* is restricted to samples -420.7 m and -414.4 m with respectively 2.5 % and 3.9 %.

* *Senoniasphaera protrusa* Clarke & Verdier, 1967 occurs in samples -420.7 m and -414.4 m. The oldest record of this species is from the Cenomanian, offshore northwestern Africa (Williams, 1978). It has been found in the Lower and Upper Campanian of the Euregio Meuse/Rhine (Foucher, 1985). Hultberg (1985) records *S. protrusa* also from the Upper Maastrichtian in Southern Sweden and in the Upper Maastrichtian of Denmark (Wilson, 1974), but here we may refer to the remark by Neumann & Platel (1985, p.54) on this occurrence: "On peut se demander s'il s'agit bien des mêmes espèces?". According to Foucher (1979), this species occurs from the middle Santonian and disappears at the top of the base of the Lower Campanian in the Paris Basin.

* The last and abundant presence of *Canningia* cf. *reticulata* Cookson & Eisenack, 1960b in sample -385.1 m (7 %).

* The last appearance of *Thalassiphora*? *spinosa* (Clarke & Verdier, 1967) in sample -340.1 m. Foucher (1979) recorded this species in the Coniacian - base Upper Campanian of the Paris Basin. In the Euregio Meuse/Rhine, Foucher (1985) found *T.*? *spinosa* in the Lower Campanian and in the base of the Upper Campanian, while Wilson (1974) also found it in the very base of the Upper Campanian.

* *Exochosphaeridium*? *acuminatum in* Wilson, 1974 is recorded from level -371.9 m till -315.1 m and has been found by Wilson (1974) and Foucher (1985) to be restricted to the lower part of the Upper Campanian in the Euregio Meuse/Rhine.

* The first appearance of *Gillinia hymenophora* Cookson & Eisenack, 1960a in sample -356.8 m. *G. hymenophora* is recorded in the Upper Campanian and in the Lower Maastrichtian of the Euregio Meuse/Rhine by Foucher (1985) and in the Lower Santonian - Upper Maastrichtian of Australia (Helby, Morgan & Partridge, 1987).

* *Svalbardella parva in* Wilson, 1974 occurs distinctively in the interval from -347.6 m till -311.8 m. This species has been recorded by Wilson (1974) in the Upper Campanian of Denmark.

* *Sphaerodictyon filosum in* Wilson, 1974 occurs from samples -340.1 m till sample -311.8 m. It occurs sporadically in the Upper Campanian and in the Lower Maastrichtian of the Euregio Meuse/-Rhine (Wilson, 1974).

* The first appearances of *Odontochitina wetzeli in* Wilson, 1974 and *Senoniasphaera alveolata in* Wilson, 1974 in sample -332.7 m and the last appearance of *Palaeohystrichophora infusorioides* Deflandre, 1935 in level -325.4 m. In the Euregio Meuse/Rhine, *Odontochitina wetzeli* was recorded by Wilson (1974) in the Upper Campanian, while Foucher (1985) found this species in the Upper Campanian and in the Lower Maastrichtian of the Euregio Meuse/Rhine. *Senoniasphaera alveolata* is recorded by Wilson (1974) in the lower part of the Upper Campanian in the Euregio Meuse/Rhine. It has furthermore been recorded in the same area by Foucher (1985) in the base of the Upper Campanian. The oldest record of *Palaeohystrichophora infusorioides* is in the Middle Albian of the Blake-Bahama Plateau by Habib & Drugg (1983). In the Euregio Meuse/Rhine, this species is recorded in the Lower Campanian by Foucher (1985) and in the lower part of the Upper Campanian by Wilson (1974). *P. infusorioides* disappears in the base of the Upper Campanian in the Paris Basin (Foucher 1979). There are several post-Campanian records for this species, i.e. by Aurisano (1989) in the Atlantic Coastal Plain and by McMinn (1988) in NW Australia.

* The last appearance of *Acanthaulax wilsonii* Yun, 1981 in sample -315.1 m. Marshall & Batten (1988) found this species in the Upper Cenomanian - Lower Turonian of northwestern Germany. Yun (1981) recorded it from the Lower Santonian of the Münster Basin. *A. wilsonii* seems to disappear in the base of the Upper Campanian in the Euregio Meuse/Rhine (Foucher, 1985, Wilson, 1974).

Two series of characteristic successions of first downhole occurrences or first appearances are notable:

* The first downhole occurrences in the basal levels: *Eisenackia*? *knokkensis* Louwye, *in prep.*, *Senoniasphaera protrusa* Clarke & Verdier, 1967 and *Surculosphaeridium? longifurcatum* (Firtion, 1952) in sample -414.4 m; *Heterosphaeridium cordiforme* Yun, 1981, *H.? heteracanthum* (Deflandre & Cookson, 1955) subsp. *heteracanthum* and *Surculosphaeridium belowi* in sample -420.7 m; *Florentinia miscella* Yun, 1981 and *Surculosphaeridium spinicongregatum* Yun, 1981 in sample -426.7 m.

	Acanthaulax wilsonii	Palaeohystrichophora infusorioides	Canningia cf. reticulata	Senoniasphaera protrusa	Heterosphaeridium? heteracanthum subsp. heteracanthum	Surculosphaeridium? longifurcatum	Sentusidinium aff. eisenackii subsp. eisenackii	Surculosphaeridium spinicongregatum
-222.0	▮	▮						
-229.0			▮					
-237.0								
-245.0								
-253.0								
-261.0				▮				
-273.0					▮	▮		
-281.0								
-289.0							▮	
-293.0								▮

Figure 3. First downhole occurrence of selected dinoflagellate cysts in the De Haan well 22W276.

* The first appearances of *Gillinia hymenophora* Cookson & Eisenack, 1960a in sample -356.8 m, *Svalbardella parva in* Wilson, 1974 in sample -347.6 m, *Sphaerodictyon filosum in* Wilson, 1974 in sample -340.1 m, *Odontochitina wetzeli in* Wilson, 1974 and *Senoniasphaera alveolata in* Wilson, 1974 in sample -332.7 m.

4.2. The De Haan well

Ten samples from this well were examined (fig. 3). As this well was entirely drilled with the rotary-percussion method, only the first downhole occurrence of a species is mentioned. One sample, -253.0 m, was completely barren. A total of 74 dinoflagellate cyst species and 1 acritarch, *Nummus similis*? (Cookson & Eisenack, 1960b), with a known occurrence in the Cretaceous, were recorded. After comparison with the vertical distribution of some species in the Knokke well and the known distribution in the literature, the following first downhole occurrences are considered relevant for stratigraphical correlation: *Canningia* cf. *reticulata* Cookson & Eisenack, 1960b (-229.0 m), *Senoniasphaera protrusa* Clarke & Verdier, 1967 (-261.0 m), *Heterosphaeridium*? *heteracanthum* (Deflandre & Cookson, 1955) subsp. *heteracanthum* and *Surculosphaeridium*? *longifurcatum* (Firtion, 1952) (-273.0 m), *Sentusidinium* aff. *eisenackii* (Boltenhagen, 1977) subsp. *eisenackii* (-289.0 m) and *Surculosphaeridium spinicongregatum* Yun, 1981 (-293.0 m). *Acanthaulax wilsonii* Yun, 1981 and *Palaeohystrichophora infusorioides* Deflandre, 1935 occur in the topmost sample, their youngest appearance is probably not situated in that level, but their presence can be significant.

4.3. The Keiem well

We recorded three acritarch species and 116 dinoflagellate cyst species in six cored samples from this well. According to the literature and own observations, the following species are considered to have a stratigraphic importance, either by their presence or last occurrence (fig. 4).

* *Microdinium*? *crinitum* Davey, 1969 and *Cyclonephelium chabaca* Below, 1981 occur in sample -211.6 m. *M.*? *crinitum* has not been found in northern European deposits younger than Turonian (Foucher, 1979, 1981, 1983) and *C. chabaca* is normally restricted to ante-Turonian deposits (Below, 1981, 1984; Masure, 1988). Davey (1978) found "*Canningia*" cf. *scabrosa* Cookson & Eisenack, 1970, considered as a synonym of *Cyclonephelium chabaca* by Below (1981), in the Turonian offshore southwestern Africa.

* *Litosphaeridium siphoniphorum* (Cookson & Eisenack, 1958) subsp. *siphoniphorum* occurs in level -211.6 m with a relative frequency of <1 %. This species is frequent in the Cenomanian and rare in the Turonian (Williams & Bujak, 1985; Lucas-Clark; 1984, Foucher, 1979, 1980, 1981, 1982, 1983; Marshall & Batten, 1988).

* *Chatangiella victoriensis* (Cookson & Manum, 1964) and *Palaeotetradinium silicorum* Deflandre, 1936 occur respectively in sample -211.6 m and in samples -211.6 m and -196.3 m. *C. victoriensis* has been found from the Middle Turonian till the basal Santonian in the Paris Basin by Foucher (1979) and from the Coniacian till the base of the Maastrichtian by Williams & Bujak (1985). *P. silicorum* occurs in the Paris Basin from the Upper Turonian till the base of the Upper Campanian (Foucher, 1979) and, according to Williams & Bujak (1985), from the Turonian into the Campanian.

* *Florentinia radiculata* (Davey & Williams, 1966) occurs in samples -211.6 m to -204.0 m. This species disappears in the lowermost Santonian of the Paris Basin (Foucher, 1979).

* The last occurrence of *Cleistosphaeridium ancoriferum* (Cookson & Eisenack, 1960a), *Kleithriasphaeridium readei* (Davey & Williams, 1966) and *Florentinia tenera* (Davey & Verdier, 1976) in sample -199.6 m. According to the literature, they

	Chatangiella victoriensis	Cyclonephelium chabaca	Litosphaeridium siphoniphorum subsp. siphoniphorum	Microdinium? crinitum	Florentinia radiculata	Cleistosphaeridium ancoriferum	Florentinia tenera	Kleithriasphaeridium readei	Canningia keiemensis	Endoscrinium campanula subsp. campanula	Palaeotetradinium silicorum	Ellipsodinium rugulosum	Canningia sp. A	Surculosphaeridium belowi	Florentinia miscella	Senoniasphaera protrusa	Surculosphaeridium spinicongregatum
-184.7												•		•		•	•
-196.3									•	•	•	•		•			
-199.6						•	•	●					⬤	•	•		
-204.0					•			•	●			•	•				
-208.3					•		•	•				•	•				
-211.6	•	•	•	•	•	●	●	•	⬤	•	•	•					

Figure 4. Vertical distribution of selected dinoflagellate cysts in the Keiem well 36E135.

disappear respectively in the Coniacian, at the top of the Coniacian and in the lowermost Santonian (Foucher, 1979; Williams & Bujak, 1985).

* *Canningia* sp. A occurs in samples -208.3 m, -204.0 m and -199.6 m with respectively <1 %, <1 % and 4.8 %.

* *Florentinia miscella* Yun, 1981 occurs in level -199.6 m. This species has been found in the Lower Santonian of the Münster Basin by Yun (1981) and in the Upper Turonian of northwestern Germany by Prössl (1990).

* *Surculosphaeridium belowi* Yun, 1981 occurs in levels -199.6 m, -196.3 m and -184.7 m. This species has been recorded from Lower Santonian deposits in the Münster Basin (Yun, 1981) and in Lower Santonian - Lower Campanian deposits of southwestern Germany by Kirsch (1991).

* *Endoscrinium campanula* (Gocht, 1959) subsp. *campanula* and *Canningia keiemensis* n.sp. Louwye, *in prep.* have in the Keiem well their highest occurrence in sample -196.3 m. The first mentioned species has its top range in the basal Santonian of the Paris Basin (Foucher, 1979) and occurs in the Lower Santonian of the Münster Basin (Yun, 1981).

* *Senoniasphaera protrusa* Clarke & Verdier, 1967 and *Surculosphaeridium spinicongregatum* Yun, 1981 occur in sample -184.7 m (see 4.1.).

* *Ellipsodinium rugulosum* Clarke & Verdier, 1967 occurs in samples -211.6 m to -184.7 m and has its youngest occurrence in the middle Santonian (Foucher, 1979; Williams & Bujak, 1985).

Following occurrences are notable:

* The joint first downhole occurrence of *Litosphaeridium siphoniphorum* (Cookson & Eisenack, 1958) subsp. *siphoniphorum* and *Microdinium? crinitum* Davey, 1969 in the basal part of the section (sample -211.6 m).

* The first downhole occurrence of *Endoscrinium campanula* (Gocht, 1959) subsp. *campanula* (sample -196.3 m) just above the last appearances in sample -199.6 m of *Canningia* sp. A, *Cleistosphaeridium ancoriferum* (Cookson & Eisenack, 1960a), *Florentinia tenera* (Davey & Verdier, 1967) and *Kleithriasphaeridium readei* (Davey & Williams, 1966).

* The joint occurrence of *Ellipsodinium rugulosum* Clarke & Verdier, 1967, *Senoniasphaera protrusa* Clarke & Verdier, 1967 and *Surculosphaeridium spinicongregatum* Yun, 1981 in sample -184.7 m.

4.4. The Nieuwkerke well

Eight ditch samples and three cored samples were examined from this well (fig. 5). A total of 132 organic-walled microfossil species are recorded: 108 are found in the ditch samples, 105 in the cored samples of which 24 occur only in the cored samples.

The following occurrences are considered to be stratigraphically relevant:

	Ellipsodinium rugulosum	Endoscrinium campanula subsp. campanula	Canningia keiemensis	Florentinia tenera	Canningia sp. A	Cyclonephelium chabaca	Kleithriasphaeridium readei	Cleistosphaeridium ancoriferum	Microdinium? crinitum	Maghrebinia breviornata	Florentinia? torulosa	Carpodinium obliquicostatum	Litosphaeridium siphoniphorum subsp. siphoniphorum	Pervosphaeridium cenomaniense	Florentinia resex	Kiokansium polypes subsp. polypes
-91.0	▮	▮														
-103.0			▮	▮												
-111.0					▮	▮	▮									
-120.0								▮	▮							
-126.0																
-137.0										▮						
-144.0											▮					
-153.0																
-159.0	•	•		•			●							•		●
-172.3	•	●				●	•	•						●	•	
-183.3	●	●					•	⬤	●			•	●	●		

Figure 5. First downhole occurrence (-91.10 m - -153.0 m) and vertical distribution (-159.0 m - -183.3 m) of selected dinoflagellate cysts in the Nieuwkerke well 95W153.

* *Ellipsodinium rugulosum* Clarke & Verdier, 1967 and *Endoscrinium campanula* (Gocht, 1959) subsp. *campanula* occur together in the topmost ditch sample -91.0 m. Maybe their last appearance is not situated in that level, but their presence can be stratigraphically significant (see 4.3.).

* *Canningia keiemensis* n.sp. Louwye, *in prep.* and *Florentinia tenera* (Davey & Verdier, 1976) have their first downhole occurrence in level -103.0 m (see 4.3.).

* The first downhole occurrence of *Canningia* sp. A, *Cyclonephelium chabaca* Below, 1981 and *Kleithriasphaeridium readei* (Davey & Williams, 1966) is in level -111.0 m (see 4.3.).

* *Cleistosphaeridium ancoriferum* (Cookson & Eisenack, 1960a) and *Microdinium? crinitum* Davey, 1969 have their first downhole occurrence in sample -120.0 m (see 4.3.).

* *Maghrebinia breviornata* Masure, 1988 is present in -137.0 m. This species was encountered by Masure (1988) in the Upper Albian - Middle Cenomanian of the Bahamas. ?*Maduradinium* sp. A in Davey (1978) is considered by Masure (1988) to be a synonym of the aforementioned species and was found in the Turonian, offshore SW Africa.

* *Florentinia? torulosa* (Davey & Verdier, 1976) is present only in level -144.0 m. According to Foucher (1979, 1983), it has its earliest appearance in the Middle Turonian and disappears at the end of the Coniacian in the Paris Basin.

* *Kiokansium polypes* (Cookson & Eisenack, 1962) subsp. *polypes* is present in cored sample -159.0 m and has, according to Foucher (1981), its top range in the Lower Turonian of the northern European realm. *Florentinia resex* (Davey & Verdier, 1976) occurs only in cored sample -172.3 m, a species with its top range in the Turonian of northern France (Davey & Verdier, 1976) and in the Turonian offshore southwestern Africa (Davey, 1978). *Pervosphaeridium cenomaniense* (Norvick, 1976) is present in the three basal cored samples. This species was found by Norvick (1976) in the Cenomanian and Lower Turonian of Australia.

* *Litosphaeridium siphoniphorum* (Cookson & Eisenack, 1958) subsp. *siphoniphorum* is relatively abundant in the lowermost level -183.3 m (see 4.3)

together with *Carpodinium obliquicostatum* Cookson & Hughes, 1964, a species with its youngest occurrence in the Upper Cenomanian of northwestern Europe (Foucher, 1981).

The following first downhole occurrences are notable:
* *Kiokansium polypes* (Cookson & Eisenack, 1962) subsp. *polypes* and *Pervosphaeridium cenomaniense* Norvick, 1976 in sample -159.0 m.
* *Florentinia resex* (Davey & Verdier, 1976) in sample -172.3 m.
* *Carpodinium obliquicostatum* Cookson & Hughes, 1964 and *Litosphaeridium siphoniphorum* (Cookson & Eisenack, 1958) subsp. *siphoniphorum* in sample -183.3 m.

	Carpodinium obliquicostatum	Gonyaulacysta cassidata	Litosphaeridium siphoniphorum subsp. siphoniphorum	Pervosphaeridium cenomaniense
-254.5	•	•	●	•

Figure 6. Vertical distribution of selected dinoflagellate cysts in the Oostduinkerke well 35E142.

4.5. The Oostduinkerke well

Only two samples from the cored section from this borehole were investigated (fig. 6). Sample -256.5 m was barren, sample -254.5 m yielded 69 dinoflagellate cyst species. After comparison with own observations and the literature, the presence of following species in level -254.5 m can be considered meaningful: *Carpodinium obliquicostatum* Cookson & Hughes, 1964, *Litosphaeridium siphoniphorum* (Cookson & Eisenack, 1958) subsp. *siphoniphorum, Pervosphaeridium cenomaniense* (Norvick, 1976) (see 6.3. and 4.4) and *Gonyaulacysta cassidata* (Eisenack & Cookson, 1960), a species with its youngest abundant occurrence in the Cenomanian and only a few post-Cenomanian records (Cookson & Eisenack, 1962; Yun, 1981).

5. CORRELATIONS BETWEEN THE FIVE WELLS AND WITH NE BELGIUM

5.1. Knokke - De Haan

The correlation between the Cretaceous sections in the Knokke well and in the De Haan well is given on fig. 7. The correlation is mainly based on *Canningia* cf. *reticulata* Cookson & Eisenack, 1960b, *Senoniasphaera protrusa* Clarke & Verdier, 1967, *Surculosphaeridium*? *longifurcatum* (Firtion, 1952), *Heterosphaeridium*? *heteracanthum* (Deflandre & Cookson, 1955) subsp. *heteracanthum, Sentusidinium* aff. *eisenackii* (Boltenhagen, 1977) subsp. *eisenackii* and *Surculosphaeridium spinicongregatum* Yun, 1981. The section in the De Haan well below approximatively -225 m can be correlated with the basal part below approximatively -381 m in the Knokke well.
The absence of *Odontochitina wetzeli in* Wilson, 1974, *Sphaerodictyon filosum in* Wilson, 1974 and *Senoniasphaera alveolata in* Wilson,1974 in the De Haan well indirectly confirms the correlation with the basal part of the Knokke well.

5.2. Knokke - northeastern Belgium

The hiatus between the Lower and Upper Campanian in northeastern Belgium is located between the Vaals Formation and the lowest member of the above lying Gulpen Formation, *viz.* the Zeven Wegen Member. This hiatus is present in the CPL Quarry at Hallembaye near Liège. The dinoflagellate cyst associations of this quarry have been investigated by Foucher (1985) and by Wilson (1974).
According to the vertical distribution of dinoflagellate cysts given by the latter authors, the hiatus can be correlated with the section between approximatively -375 m and -340 m in the Knokke well (fig. 8). The correlation is based on the vertical distribution of *Thalassiphora*? *spinosa* Clarke & Verdier, 1967, *Exochosphaeridium*? *acuminatum in* Wilson, 1974, *Gillinia hymenophora* Cookson & Eisenack, 1960a, *Sphaerodictyon filosum in* Wilson, 1974, *Odontochitina wetzeli in* Wilson, 1974 and *Senoniasphaera alveolata in* Wilson, 1974.

5.3. Keiem - Nieuwkerke

Fig. 9 gives the correlation between these two wells. It is based on the vertical distribution of *Ellipsodinium rugulosum* Clarke & Verdier, 1967, *Canningia keiemensis* n.sp. Louwye, *in prep.*, *Endoscrinium campanula* (Gocht, 1959) subsp.

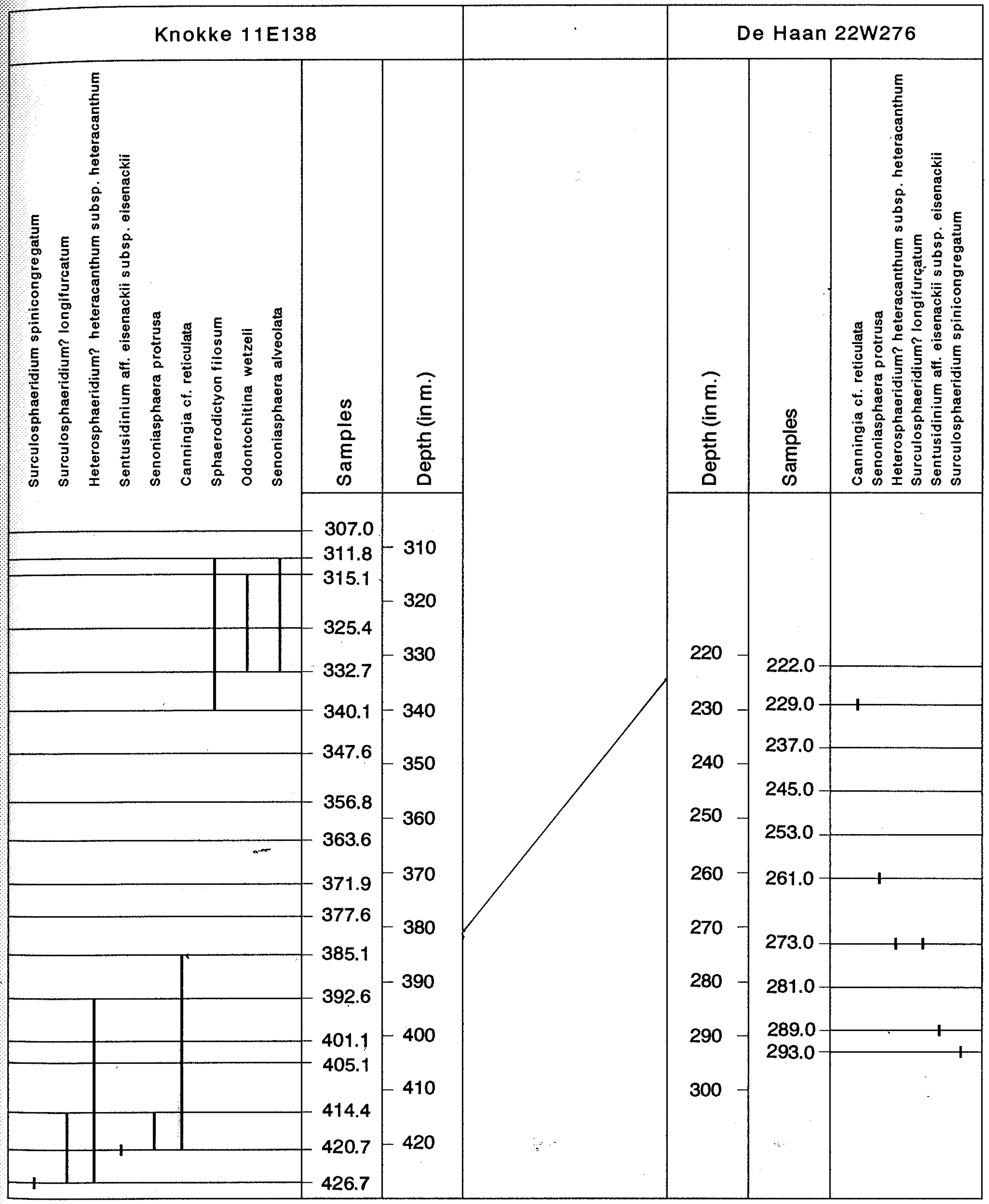

Figure 7. Correlation between the Knokke well 11E138 and the De Haan well 22W276.

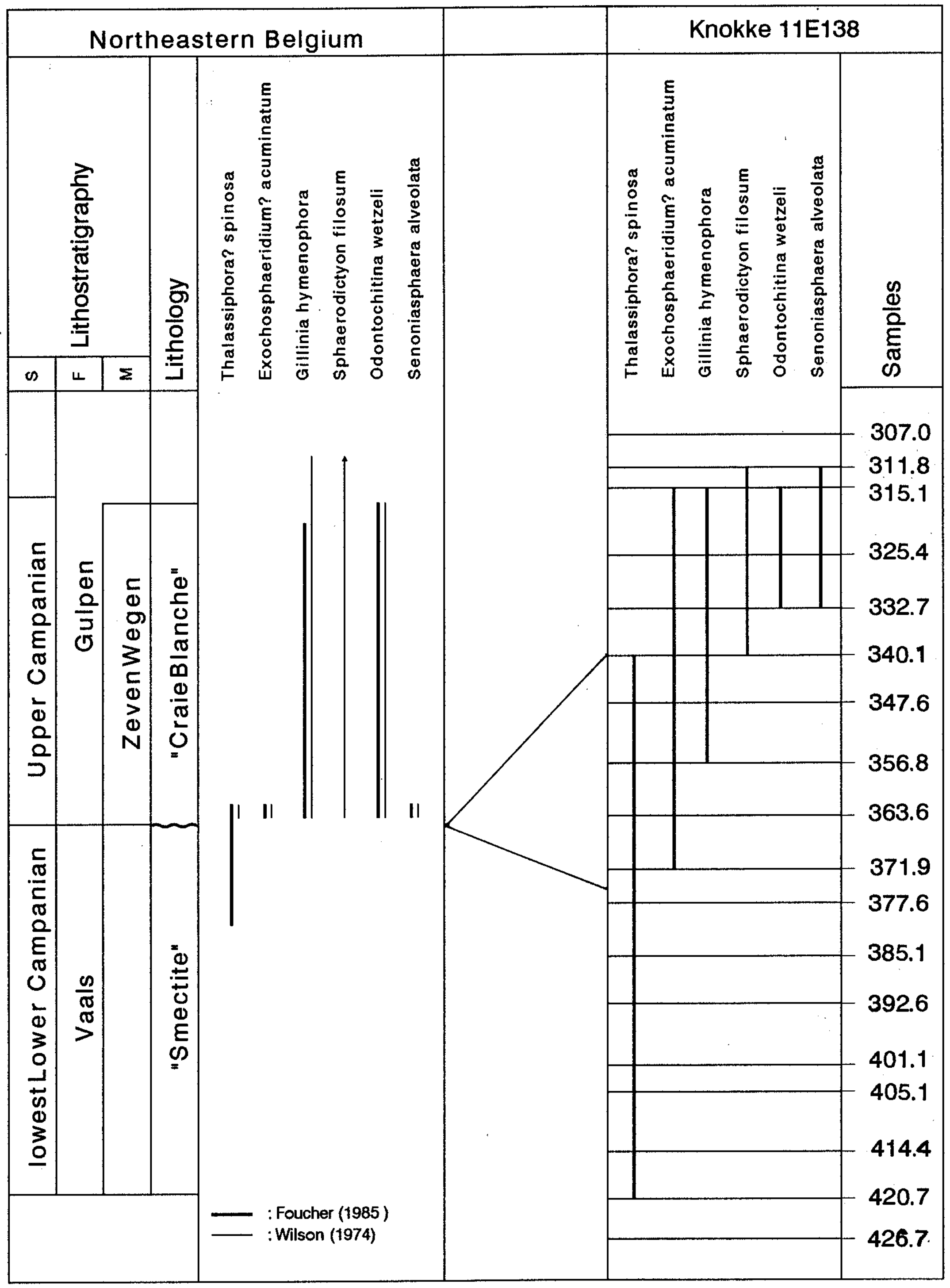

Figure 8. Correlation between the Knokke well 11E318 and the Campanian in the Halembaye Quarry (northeastern Belgium).

campanula, *Canningia* sp.A, *Florentinia tenera* (Davey & Verdier, 1976), *Kleithriasphaeridium readei* (Davey & Williams, 1966) and *Microdinium*? *crinitum* Davey, 1969. These species have approximately the same stratigraphical succession and occurrence in both wells. It can be concluded that the section between approximatively -115 m up till approximatively -91.0 m in the Nieuwkerke well can be correlated with the section between approximatively -210 m up till approximatively -190 m in the Keiem well. The associations in the deeper parts of the Nieuwkerke well were not found in the Keiem well. The association with *Senoniasphaera protrusa* Clarke & Verdier, 1967, *Surculosphaeridium spinicongregatum* Yun, 1981 and *S. belowi* Yun, 1981 from the top of the Keiem well are absent in the topmost part of the Nieuwkerke well.

5.4. Oostduinkerke - Nieuwkerke

Fig. 10 gives the correlation between the Oostduinkerke and Nieuwkerke wells. *Carpodinium obliqui*

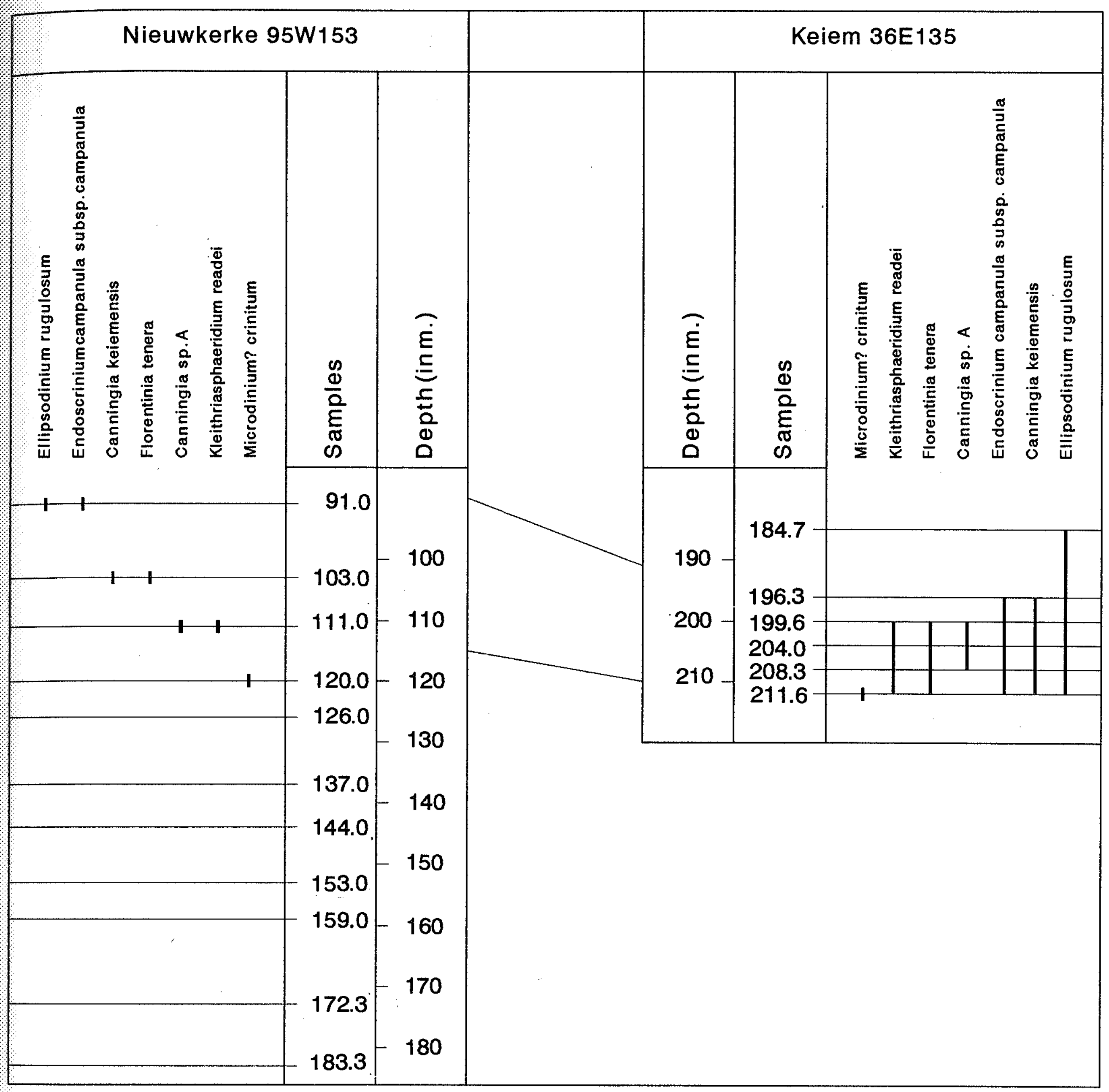

Figure 9. Correlation between the Nieuwkerke well 95W153 and the Keiem well 36E135.

costatum Cookson & Hughes, 1964 and *Litosphaeridium siphoniphorum* (Cookson & Eisenack, 1958) subsp. *siphoniphorum*, which forms 2% of the assemblage in sample -254.5 m in the Oostduinkerke well, allow a correlation with the basal sample -183.3 m from the Nieuwkerke well. *Pervosphaeridium cenomaniense* (Norvick, 1976) is found in sample -254.5 m in the Oostduinkerke well and in the cored samples -159.0 m, -172.3 m and -183.3 m of the Nieuwkerke well and may confirm the proposed correlation.

6. CHRONOSTRATIGRAPHICAL INTERPRETATIONS

The chronostratigraphical interpretations are mainly based on the vertical ranges of selected species as mentioned in the literature. Criteria for selection included easy identification of a species and a well delimitated occurrence in outcrops or wells where macrofossils or other microfossil groups provided calibration (e.g. Foucher, 1985; Wilson, 1974). A comparison of these data resulted in what is believed to be the true stratigraphical range of a species (see 4).

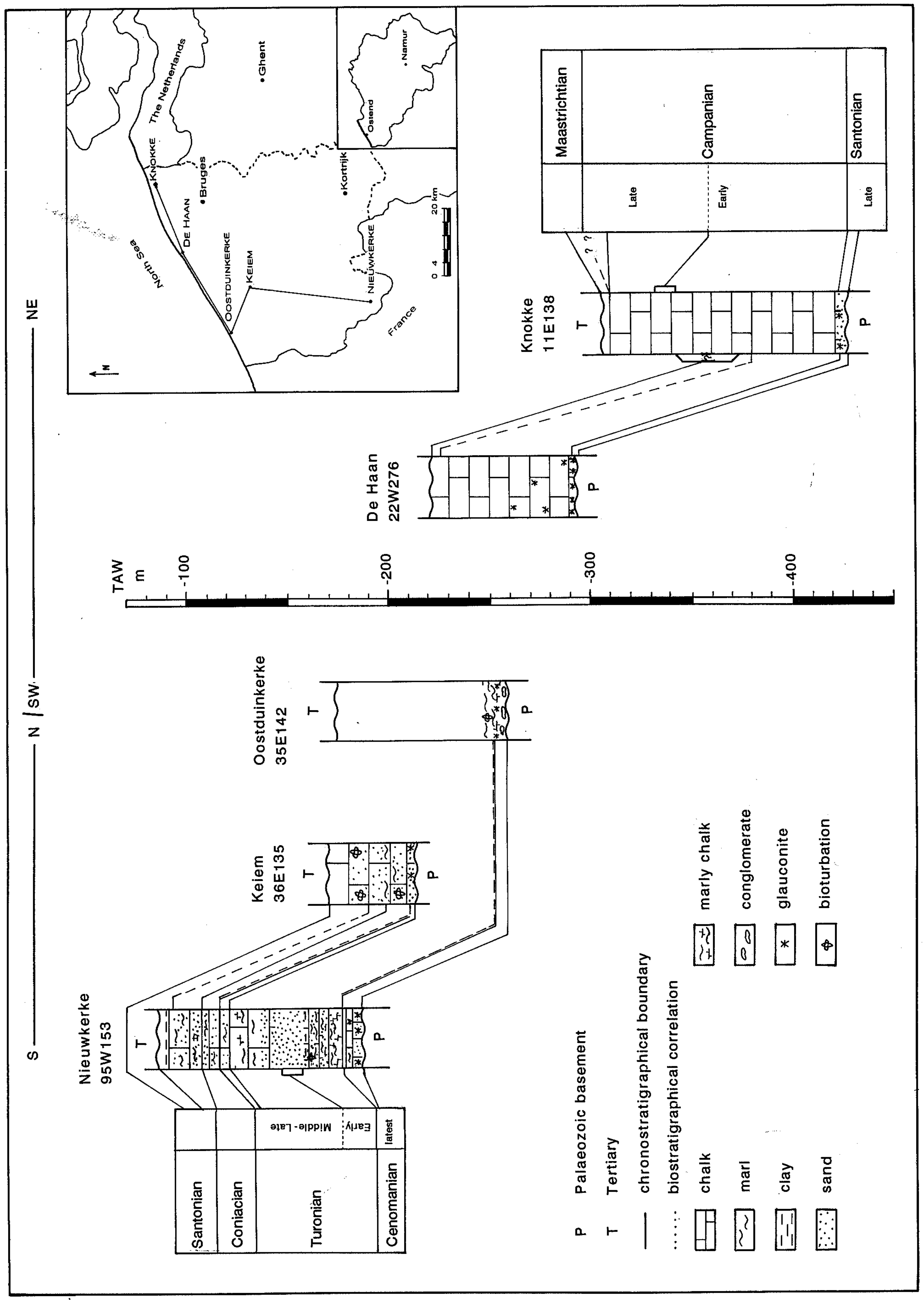

Figure 10. Correlation of the Cretaceous sections intercepted by five wells in western Belgium (West Fanders).

6.1. The Knokke well

The presence of *Florentinia miscella* Yun, 1981 and *Surculosphaeridium spinicongregatum* Yun, 1981 in sample -426.7 m and their absence in level -420.7 m (fig. 2) suggests that the limit between the Santonian and the Campanian in this well can be placed between these two levels. This is furthermore corroborated by the presence of *Heterosphaeridium cordiforme* Yun, 1981 only in samples -426.7 m (3.8 %) and -420.7 m (<1%).

The presence of *Heterosphaeridium*? *heteracanthum* (Deflandre & Cookson, 1955) subsp. *heteracanthum*, *Surculosphaeridium*? *longifurcatum* (Firtion, 1952) and that of *Senoniasphaera protrusa* Clarke & Verdier, 1967 with a certain reservation, allows to attribute a basal Early Campanian age to levels -420.7 m and -414.4 m.

According to the distribution of *Odontochitina wetzeli in* Wilson, 1974 and *Senoniasphaera alveolata in* Wilson, 1974, significant species according to Foucher (1985) and Wilson (1974), it is possible to situate the limit between the Lower and Upper Campanian immediately below level -332.7 m. The last appearance of *Palaeohystrichophora infusorioides* (-325.4 m) in the base of the Upper Campanian corroborates the foregoing (Foucher, 1979; Wilson 1974). The last occurrence of *Thalassiphora*? *spinosa* (Clarke & Verdier, 1967) in level -340.1 m lowers the limit to just below this level.

The genera *Areoligera* and *Cladopyxidium* appear, according to Foucher (1985), in the upper part of the Upper Campanian in northeastern Belgium. We did not find these genera in the uppermost level -311.8 m. However, it is not excluded that the uppermost part of the Cretaceous section of the Knokke well, where we had a sterile sample (-307.0 m), has a terminal Campanian or Maastrichtian age. The chronostratigraphical interpretations of the Cretaceous sequence of the Knokke well by Bal and Verbeek (1990) differ only slightly from ours. On the basis of calcareous nannoplankton, these authors attribute a Santonian age to the basal part of the Cretaceous below -423.6 m and place the limit between the Lower and Upper Campanian between -335.6 m and -351.6 m. The section between -319.6 m and the top has an Early Maastrichtian age (Bal & Verbeek, 1990), while according to the results with dinoflagellate cysts this can only be found above -311.8 m.

6.2. The De Haan well

We can attribute an Early Campanian age to the Cretaceous sequence intercepted by the De Haan well (fig. 3), this on the basis of species in common with the basal part of the Knokke well. The presence of *Acanthaulax wilsonii* Yun, 1981 and *Palaeohystrichophora infusorioides* Deflandre, 1935 in level -222.0 m, just below the Tertiary, can be indicative of an age older than the basal Late Campanian. The absence of *Odontochitina wetzeli in* Wilson, 1974, *Senoniasphaera alveolata in* Wilson, 1974 and *Gillinia hymenophora* Cookson & Eisenack, 1960a confirms the absence of Late Campanian or Maastrichtian sediments. The presence of *Surculosphaeridium spinicongregatum* Yun, 1981 allows to attribute a Santonian age to the section below -289.0 m.

6.3. The Keiem well

The presence of *Microdinium*? *crinitum* Davey, 1969, restricted to sample -211.6 m (fig. 4), allows to place the limit between the Turonian and the Coniacian between samples -211.6 m and -208.3 m. This is confirmed by the occurrence of *Litosphaeridium siphoniphorum* (Cookson & Eisenack, 1958) subsp. *siphoniphorum* in level -211.6 m (Williams & Bujak, 1985; Lucas-Clark; 1984, Foucher, 1979, 1980, 1981, 1982, 1983; Marshall & Batten, 1988) (see 4.3.). The occurrences of *Chatangiella victoriensis* (Cookson & Manum, 1964) and *Palaeotetradinium silicorum* Deflandre, 1936 in level -211.6 m prove that the basal part is not older than Late Turonian (Foucher, 1979, Williams & Bujak, 1985).

The limit between the Coniacian and the Santonian can nearly certainly be situated between samples -199.6 m and -196.3 m, because of the last occurrence of *Florentinia tenera* (Davey & Verdier, 1976) and *Kleithriasphaeridium readei* (Davey & Williams, 1966) in level -199.6 m (Foucher, 1979, Williams & Bujak, 1985). The last occurrence of *Cleistosphaeridium ancoriferum* (Cookson & Eisenack, 1960a) in sample -199.6 m corroborates the foregoing (Foucher, 1979; Williams & Bujak, 1985). *Florentinia radiculata* (Davey & Williams, 1966) occurs in samples -211.6 m to -204.0 m and confirms the Coniacian age.

The occurrence of *Ellipsodinium rugulosum* Clarke & Verdier, 1967 in level -184.7 m demonstrates that the cored section is older than the Late Santonian (Foucher, 1979; Williams & Bujak, 1985). This is confirmed by the occurrences of *Senoniasphaera protrusa* Clarke & Verdier, 1967 and *Surculosphaeridium spinicongregatum* Yun, 1981 in level -184.7

m (Foucher, 1979, 1980; Williams & Bujak, 1985; Yun, 1981) and *Endoscrinium campanula* (Gocht, 1959) subsp. *campanula* in -196.3 m.

6.4. The Nieuwkerke well

The occurrence of *Ellipsodinium rugulosum* Clarke & Verdier, 1967 and *Endoscrinium campanula* (Gocht, 1959) subsp. *campanula* in level -91.0 m (fig. 5) indicates that the top of the section with ditch samples has an Early Santonian age (Foucher, 1979; Williams & Bujak, 1985; Yun, 1981). On the one hand, the absence of *Senoniasphaera protrusa* Clarke & Verdier, 1967 and *Surculosphaeridium spinicongregatum* Yun, 1981 (Foucher, 1979; Yun, 1981) and on the other hand the joint occurrence of *Ellipsodinium rugulosum* Clarke & Verdier, 1967 and *Endoscrinium campanula* (Gocht, 1959) subsp. *campanula* (Foucher, 1979; Yun, 1981) in the highest sample -91.0 m, indicate that the top of the Cretaceous section is of earlier Santonian age than in the Keiem well.

The first downhole occurrence of *Florentinia tenera* (Davey & Verdier, 1976) and of *Kleithriasphaeridium readei* (Davey & Williams, 1966) in respectively samples -103.0 m and -111.0 m allows to place the limit between the Santonian and the Coniacian between these two levels (Foucher, 1979, Williams & Bujak, 1985). The first downhole occurrence of *Cyclonephelium chabaca* Below, 1981 in level -111.0 m enlarges its vertical range from the Aptian into the Coniacian.

Cleistosphaeridium ancoriferum (Cookson & Eisenack, 1960a) and *Microdinium*? *crinitum* Davey, 1969 are found together in level -120.0 m. The latter species is also present in levels -126.0 m, -137.0 m and -153.0 m. The last occurrence of this species is probably situated in level -120.0 m, which also would determine the limit between the Coniacian and the Turonian. The occurrence of *Maghrebinia breviornata* Masure, 1988 in level -137.0 m confirms the Turonian age.

The last occurrence of *Florentinia*? *torulosa* (Davey & Verdier, 1976) in level -144.0 m and the absence of this species in the lower levels allows to place, with a certain reservation, the limit between the Early and Middle Turonian between levels -144.0 m and -159.0 m (Davey & Verdier, 1976; Foucher, 1979, 1983). The presence of *Florentinia resex* Davey & Verdier, 1976, *Pervosphaeridium cenomaniense* Norvick, 1976 and *Kiokansium polypes* (Cookson & Eisenack, 1962) subsp. *polypes* in the two topmost cored levels (-159.0 m and -172.3 m) confirms their Early Turonian age (Davey & Verdier, 1976; Davey, 1978; Norvick, 1976; Foucher, 1981). The occurrence of *Litosphaeridium siphoniphorum* (Cookson & Eisenack, 1958) subsp. *siphoniphorum* in level -183.3 m, with a relative frequency of 3.7 %, suggests a Cenomanian age for the lowermost sample (see 4.3.). Also limited to the Cenomanian is *Carpodinium obliquicostatum* Cookson & Hughes, 1964 (<1% relative frequency in level -183.3 m) (Foucher, 1980, 1981; Williams & Bujak, 1985; Marshall & Batten, 1988). Nevertheless, some characteristic Cenomanian species are absent in that sample: *Epelidosphaeridia spinosa* (Cookson & Hughes, 1964), *Apteodinium granulatum* Eisenack, 1958 and *Cauca parva* (Alberti, 1961); their absence could point to a terminal Cenomanian age for level -183.3 m, the lowermost sample.

6.5. The Oostduinkerke well

Litosphaeridium siphoniphorum (Cookson & Eisenack, 1958) subsp. *siphoniphorum* occurs with a 2 % relative frequency in the only studied sample -254.5 m, together with *Carpodinium obliquicostatum* Cookson & Hughes, 1964 and *Gonyaulacysta cassidata* (Eisenack & Cookson, 1960). These species point to a terminal Cenomanian age for this level (Foucher, 1979, 1980, 1981, 1982; Lucas-Clark, 1984; Williams & Bujak, 1985; Marshall & Batten, 1988) (see 4.4. and 6.3.).

7. CONCLUSIONS

The Cenomanian-Turonian transgression, advancing from the Paris Basin, deposited sediments in southern West Flanders on the southern part of the Brabant Massif and on the northwestern extension of the Namur Synclinorium. The sediments in the base of the Cretaceous sections of the Nieuwkerke and Oostduinkerke wells consist of chalky marls and glauconitic chalk with pebbles, with a conglomerate in the very base of the latter well. The dinoflagellate cyst associations found in the basal parts of the Nieuwkerke and Oostduinkerke wells strongly suggest a Late or terminal Cenomanian age for these sediments, which have approximate thicknesses of respectively 8.4 m and minimal 3.4 m. Further research can establish how much farther north of the line Oostduinkerke - Nieuwkerke the Cenomanian deposits transgress. Whether Cenomanian sediments occur as isolated erosional patches or form a continuous cover remains unsolved.

In the Keiem well, closer to the present day topographic crest of the Brabant Massif, about 2.3 m Late Turonian sediments cover the basement, followed by 12 m Coniacian and minimal 13.2 m Santonian. The Turonian, about 62.3 m thick in the Nieuwkerke well, is covered by 8.5 m of Coniacian and minimal 16 m of Santonian. From the data of these two wells, one may conclude tentatively that the Turonian is reduced in thickness in a northward direction towards the topographically elevated crest of the Brabant Massif, roughly coinciding with the line Nieuwpoort - Oudenaarde (Legrand, 1968), while the thicknesses of the Coniacian and the Santonian remain in the same order of magnitude in both wells. We can add that the top of the Santonian in the Keiem well is younger than in the Nieuwkerke well. The Campanian is definitely lacking in the Nieuwkerke well. Its presence in the Keiem well cannot be excluded in its topmost but not examined part. From these results it is clear that the transgression is strongly diachronous on the southern part of the Brabant Massif.

The northern part of the Brabant Massif in the Knokke and the De Haan wells are covered by glauconitic sandy sediments of Late Santonian age with respective thicknesses of 3.4 m and 3 m. In the Knokke well, the Santonian is followed by pure white chalks with an Early and Late Campanian age. The Campanian in the Knokke well has a minimal thickness of 114.3 m, but it has been impossible to confirm or reject, with the aid of dinoflagellate cysts, that some Maastrichtian sediments are present in the topmost part of the Cretaceous section. However, according to Bal & Verbeek (1990), Early Maastrichtian sediments can be found in the very top of the Cretaceous section in which we had a barren sample. In the De Haan well, only 69.5 m of white chalk of Early Campanian age are found. It can be concluded that along the present day coastline, a thin cover of Late Santonian sediments covers the northern part of the Brabant Massif, followed by Campanian sediments diminishing in thickness in a southern direction, with the younger sediments lacking. It is thought that this observed variation in thickness of the Cretaceous deposits in western Belgium is the result of an important erosional phase, caused by an asymmetric uplift of the Brabant Massif, stronger in the south than in the north. This erosion is corroborated by the abundant presence of reworked Late Cretaceous dinoflagellate cyst and calcareous nannoplankton assemblages in the Heers Formation (Orp Sand and Gelinden Marl Members) with an early Late Palaeocene age (Schumacker-Lambry, 1978, Verbeek *et al.*, 1988, Vlerick, 1987). With the present knowledge, the age of that erosional phase can only be situated between the end of the Cretaceous sedimentation in the study area (post-Early Maastrichtian in the Knokke area) and not later than the early Late Palaeocene.

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