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YPRESIAN CALCAREOUS NANNOPLANKTON BIOSTRATIGRAPHY AND PALAEOGEOGRAPHY OF THE BELGIAN BASIN

by

E. STEURBAUT

(with 5 figures, 5 tables and 5 plates)

ABSTRACT

Re-investigation of the Ypresian calcareous nannoflora of the Belgian Basin has led to the identification of various additional nannoplankton-events, resulting in a refinement of the nanno-zonation of STEURBAUT (1986). This new biostratigraphic information shows that there is a mid-Ypresian hiatus in the northern part of the basin. This hiatus is considered to result from tectonic adjustments of distinct blocks in the Brabant Massif. The hiatus can be recognised in the Kallo and Mol boreholes, which therefore, cannot be taken as reference-sections for the Ypresian.

Some new lithostratigraphic correlations are proposed: the Morlanwelz Argilite Member correlates with the Orchies Clay Member; the "Forest sands" with the upper middle part of the Mons-en-Pévèle Sand Member. The term "Tielt glauconitic bed" is rejected, as it has been used for at least 3 clearly distinct glauconitic beds within the middle of the Ieper Formation.

The Ypresian history of the Belgian Basin is briefly outlined. Distribution charts and correlation schemes of litho- and biostratigraphic units are given. Several new nannofossil taxa are described, including one new genus, *Aubrysphaera*, three new species, *Aubrysphaera deconinckii, Naninfula dupuisii* and *Pontosphaera kingii*, and one new subspecies, *Zygrhablithus bijugatus nolfii.*

Key words: Calcareous nannoplankton biostratigraphy, palaeogeography, new taxa, Ypresian, Belgian Basin.

SAMENVATTING

Aanvullend onderzoek van kalkschalig nannoplankton uit het Ypresien van het Belgisch Bekken laat toe verscheidene nieuwe "nannoplankton-events" te herkennen, die bruikbaar zijn voor de verfijning van de nanno-zonatie van STEURBAUT (1986). Uit deze nieuwe gegevens blijkt dat er, tijdens het Midden-Ypresien, een hiaat voorkomt in het noordelijk deel van het bekken. Een dergelijk hiaat zou wijzen op tektonische aanpassingen van verschillende blokken in het Massief van Brabant. Het werd aangetoond in de boringen van Kallo en Mol, en deze mogen daardoor niet aanzien worden als referentie-sekties voor het Ypresien.

Enkele nieuwe lithostratigrafische korrelaties worden voorgesteld: de "Argiliet van Morlanwelz" is korreleerbaar met de Klei (Lid) van Orchies en de "Zanden van Vorst" met de bovenste lagen uit het midden van de Zanden (Lid) van Mons-en-Pévèle. De term "Glauconietlaag van Tielt" wordt verworpen, gezien hij gebruikt werd voor op zijn minst 3 verschillende glauconietlagen uit het midden van de Formatie van Ieper.

De evolutie van het Belgisch Bekken tijdens het Ypresien wordt summier geschetst. Tabellen en kaarten met de verspreiding van de verschillende soorten, en de korrelaties van litho- en biostratigrafische eenheden worden voorgesteld. Verscheidene nieuwe nannoplankton taxa worden beschreven, waaronder 1 nieuw genus, *Aubrysphaera*, 3 nieuwe soorten, *Aubrysphaera deconinckii, Naninfula dupuisii, Pontosphaera kingii*, en 1 nieuwe subsoort, *Zygrhablithus bijugatus nolfii.*

Sleutelwoorden: Kalkschalig nannoplankton, biostratigrafie, paleogeografie, nieuwe taxa, Ypresien, Belgisch Bekken.

RESUME

De nouvelles recherches sur la nannoflore calcaire de l'Yprésien du Bassin belge nous ont permis d'identifier plusieurs nouveaux événements à nannoplancton, qui ont conduit à une zonation encore plus fine que celle proposée par STEURBAUT en 1986. Ces nouvelles informations biostratigraphiques permettent de mettre en évidence un hiatus d'âge yprésien moyen dans la partie septentrionale du bassin. Le développement d'un tel hiatus nous semble lié à des ajustements tectoniques des différents blocks du Massif du Brabant. Cet hiatus a été reconnu dans les sondages de Kallo et de Mol, et ceux-ci ne peuvent donc pas être désignés comme hypostratotypes de l'Yprésien.

Quelques nouvelles corrélations lithostratigraphiques sont proposées: l'Argilite de Morlanwelz est mise en corrélation avec l'Argile (Membre) d'Orchies et les "Sables de Forest" avec le sommet de la portion moyenne des Sables (Membre) de Mons-en-Pévèle. Le terme "Lit glauconifère de Tielt" est rejeté, puisque celui-ci a été utilisé pour au moins 3 différents lits glauconieux vers le milieu de la Formation d'Ypres.

L'ensemble de l'évolution du Bassin belge durant l'Yprésien est présenté. Des tableaux et cartes précisant la répartition stratigraphique des différentes espèces, ainsi que la corrélation entre les unités litho- et biostratigraphiques sont ajoutés. Plusieurs nouveaux taxa sont décrits, dont un nouveau genre, *Aubrysphaera*, trois nouvelles espèces, *Aubrysphaera deconinckii, Naninfula dupuisii*, et *Pontosphaera kingii*, et une nouvelle sous-espèce, *Zygrhablithus bijugatus nolfii.*

Mots-clés: Nannoplancton calcaire, biostratigraphie, paléogéographie, nouveaux taxa, Yprésien, Bassin belge.

Dr. Sc., Laboratorium voor Paleontologie, Rijksuniversiteit Gent, Geologisch Instituut, Krijgslaan 281/S8, B-9000 Gent, Belgium.

1. INTRODUCTION

Until recently very little was known about the occurrence of calcareous nannofossils in the Ypresian of Belgium and northwestern France. A few samples were examined by HAY and MOHLER (1967), BIGNOT and LEZAUD (1969), MARTINI (1971), KAPELLOS and SCHAUB (1973), MOORKENS and CEPEK (1974), BIGNOT and MOORKENS (1975), MÜLLER and WILLEMS (1981) and BIGG (1982).

The study of the sedimentary sequences and the calcareous nannofossils from 50 outcrop and borehole sections in the Ypresian of the Belgian Basin, recently published by STEURBAUT and NOLF (1986), has led to a major advance in the knowledge of the Ypresian stratigraphy. The results of this investigation are discussed here, including additional information from newly drilled boreholes and from more detailed analyses of previously studied sections.

2. GENERAL COMMENTS ON THE YPRESIAN DEPOSITS

The Ypresian is one of the best studied and internationally accepted stages of the Belgian Tertiary. It was defined by DUMONT in 1849 to comprise the marine deposits between the previously introduced Landenian and Brusselian Stages (DUMONT, 1839), consisting of a lower, thick clayey unit and an uppermost, sandy unit. Shortly afterwards, in 1851, DUMONT established the Paniselian Stage for the clayey-sandy deposits between his formerly defined Ypresian and Brusselian Stages. Since then, two different interpretations of the Ypresian Stage concept have been used:

1. the Ypresian *sensu stricto*, when referring to the two major lithologic units defined by DUMONT in 1849. In this opinion the Paniselian Stage is considered to be valid;
2. the Ypresian *sensu lato*, when referring to boundaries mentioned in DUMONT's original definition. Here, the Ypresian is considered to include all deposits between the top of the Landenian and the base of the Brusselian. Consequently, the Paniselian is rejected, as it falls within the Ypresian.

Recent compilation works on Palaeogene stratigraphy (e.g. BERGGREN *et al.*, 1985 and CAVELIER & POMEROL, 1986) adopt the second version with an "extended" Ypresian. The Ypresian is considered by STEURBAUT and NOLF (1986, fig. 10) as the time-interval during which all the deposits between the base of the Ieper Clay auct. and the top of the Aalterbrugge Lignitic Horizon (*sensu* HACQUAERT, 1939) were deposited. According to CURRY and ODIN (1982) the deposition of this sequence is supposed to have taken place within 6 M.Y., and between 51 and 45 million years ago. BERGGREN *et al.* (1985) give somewhat "older" ages, between 58 and 52 M.Y. respectively, also based on radiometric datings on glauconite. The duration of the Ypresian has been reduced to 5 M.Y. in a recent paper by HAQ, HARDENBOL and VAIL (1987) (interval between 54 and 49 million years).

The Ypresian deposits have an extensive geographic distribution and for centuries have had a considerable economic value. Even today the clays are used for brick and tile manufacture, and the sands for road construction. The Ypresian deposits underlie the whole northern half of Belgium beneath a thin Quaternary cover (see STEURBAUT, 1988b, fig. 3). They generally rest on Palaeocene deposits that are lagoonal in the Northwest and terrestrial in the Northeast and the Southwest. In the centre of the basin, in the triangle Geraardsbergen-Mons-Genappe southwest of Brussels, they rest directly on Palaeozoic deposits.

The thickness of the Ypresian deposits in Belgium increases northward, from a few metres in the extreme South and Southeast to about 150m in the northern part of the basin, with a maximum recorded thickness in the extreme Northwest of the country (Knokke: 182m). The strata dip gently to the North, and are overlain by deposits which become progressively younger northward.

In the Northwest (towards the North Sea Basin centre), the lithological succession consists of a lower clayey sequence (100 to 140m; symbol Yc of the Belgian geological map) overlain by very fine sands (10 to 20m; symbol Yd of the geological map). The top of the Ypresian in that area consists of rather coarse, more or less clayey glauconitic sands with sandstone bands (maximum thickness of about 30m; symbol P1 or "Lower Paniselian" of the Belgian geological map). The boundary between the Yd and P1 deposits is marked by a thin (5 to 10m) stiff clay, the Merelbeke Clay (= P1m of the Belgian geological map), which is an excellent marker in the North of the area, but is absent to the South.

Towards the margin of the basin, in northern France and in southern Belgium, a more or less similar lithological succession was recognised by ORTLIEB and CHELLONNEIX as early as 1870, and by GOSSELET in 1874, before the completion of the legend of the Belgian geological map (1892). In this area, the clayey part (Yc) of the Ypresian consists of a lower stiff clay, the Orchies Clay, and a very silty and fossiliferous upper part, the Roubaix Clay. Further East, the Orchies Clay is covered by sandy deposits, the Mons-en-Pévèle Sands, which were considered by GOSSELET (1874) to represent, at least in part, the lateral equivalent of the Roubaix Clay. Both the Roubaix Clay (in the West) and the Mons-en-Pévèle Sands (in the East) are overlain by the 10m thick Aalbeke Clay, which in turn is covered by "Lower Paniselian" (P1) sands.

On the basis of similarity in the lithological succession (clay/sand or silty clay/ clay/glauconitic sand with sandstones) in both the North and the South of the basin, the correlations, shown by arrows in Fig. 1 were established, resulting in the outline of a legend for the Belgian geological map (1892). These correlations, however, were refuted by STEURBAUT and NOLF (1986). Through detailed lithostratigraphic analysis and calcareous nannoplankton investigation it was demonstrated that the nummulitic sands from the southern part of the basin (= Mons-en-Pévèle Sand Member, e.g. at Mons-en-Pévèle, Forest, Ronse, Mont Panisel...)

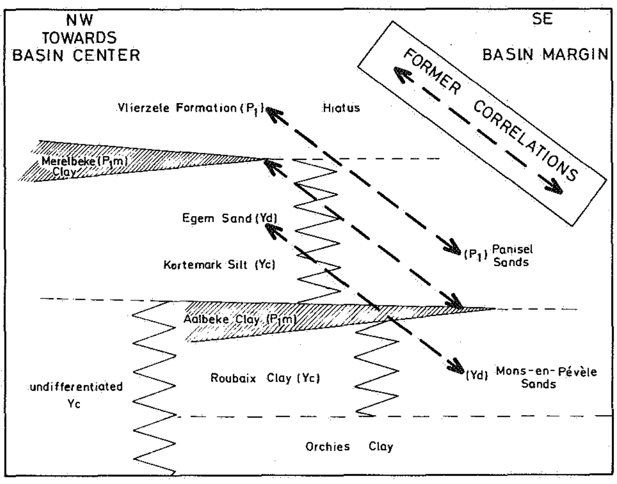


Fig. 1
Simplified correlation scheme for the Belgian Ypresian deposits, compared to the correlation used for the establishment of the Belgian geological map (after STEURBAUT & NOLF, 1986).

and the overlying clay (= Aalbeke Clay Member, e.g. at Aalbeke, Ronse, Marke...) and clayey sand (= Panisel Sand Member, e.g. at Mont Panisel (topmost beds), Moeskroen, Schepdaal...) are older and unconnected with their supposed equivalents from northern Belgium, successively the nummulitic Sand at Egem and around Gent (= Egem Sand Member); the clay at Merelbeke (= Merelbeke Clay Member) and the sandy clay to clayey sand at Pittem and Vlierzele (= Vlierzele Formation) (see Figs. 1 and 5).

Two formations were distinguished by STEURBAUT and NOLF (1986): a lower Ieper Formation and an upper Vlierzele Formation. The Ieper Formation includes a lower clayey sequence (Orchies Clay, Roubaix Clay and Aalbeke Clay Members); a middle silty to sandy part (Kortemark Silt and Egem Sand Members) and an upper stiff clay (Merelbeke Clay Member). Further East, the Roubaix Clay Member is represented by its sandy equivalent, the Mons-en-Pévèle Sand Member, whereas the silty to sandy middle part (Kortemark Silt and Egem Sand Members) is replaced by a heterogeneous sand-clay unit with numerous sandstone bands, the Panisel Sand Member.

The Vlierzele Formation consists of a locally developed lower clayey to silty part, the Pittem Clay Member, and of yellowish-green to grey glauconitic sand with sandstone bands.

3. ALPHABETICAL LIST OF SAMPLE LOCALITIES PREVIOUSLY STUDIED BY STEURBAUT AND NOLF (1986) AND MENTIONED HERE

The localities of the Ypresian exposures and boreholes mentioned in the present paper are listed alphabetically (see Fig. 2 for locations). For more details the reader is referred to STEURBAUT and NOLF (1986, p. 134-150). Each locality name is followed, in parentheses, by one of the abbreviations A. (= Antwerpen), B. (= Brabant), H. (= Hainaut), O.V. (= Oost-Vlaanderen) or W.V. (= West-Vlaanderen), indicating the provinces (see Fig. 2). The abbreviation B.G.D. means that the borehole was drilled on behalf of the Belgische Geologische Dienst (= Belgian Geological Survey).

Egem (W.V.), Ampe clay pit-sand pit; map-sheet 21/1; coordinates: x = 70.150, y = 190.150 (see also STEURBAUT, 1988b, p. 348).
Erpe (Aalst) (O.-V.), B.G.D. borehole 71E-34; map-sheet 22/8, coordinates: x = 123.050, y = 179.700.
Heestert (W.-V.), clay pit in "Kwadestraat"; map-sheet 29/6; coordinates: x = 80.550, y = 165.550.
Kallo (O.-V.), "Fort la Perle": B.G.D. borehole 27E-148; map-sheet 15/2; coordinates: x = 144.860, y = 217.840 (see Tab. 1).
Knokke (W.-V.), "Hazegraspolder": B.G.D. borehole 11E-138; map-sheet 5/6; coordinates: x = 78.776, y = 226.370 (see also STEURBAUT, in press a).
Kortemark (W.-V.), Desimpel clay pit; map-sheet 20/3; coordinates: x = 57.050, y = 190.400 (see also STEURBAUT, 1988b, p. 345).
Kruishoutem (O.-V.), "Gendarmerie": B.G.D. borehole 84E-1362(I); map-sheet 29/4; coordinates: x = 90.600, y = 177.350.
Lauwe (W.-V.), clay pit "Céramiques et Briqueteries du Littoral"; now abandoned and filled in; map-sheet 29/5; coordinates: x = 67.975, y = 165.140.
Maldegem (O.-V.), borehole 39W-213 of the Belgian Geological Survey (also listed TGO 81-9/D4, Geological Institute, Gent); map-sheet 13/7; coordinates: x = 86.860, y = 205.900 (see also DE BREUCK *et al.*, in press).
Marke (W.-V.), Koekelberg clay pit; map-sheet 29/5; coordinates: x = 69.000, y = 166.800 (see also STEURBAUT, 1988b, p. 342).
Mater (O-V.), Hauwaert: B.G.D. borehole 85W-18 (VII); map-sheet 30/1; coordinates: x = 99.950, y = 169.300.
Melle (O.-V.), Zuivelstation: B.G.D. borehole 70E-183; map-sheet 22/6; coordinates: x = 111.125, y = 187.425.
Moen (O.-V.), west bank of the Bossuit Canal; lectostratotype of the Roubaix Clay Member; map-sheet 29/6; coordinates: x = 79.775, y = 164.725 (see Tab. 3).
Moeskroen (H.), "Bois Fichau" clay pit (also known as "Mulier"); map-sheet 29/5; coordinates: x = 68.575, y = 161.850.
Mol (A.), S.C.K.: B.G.D. borehole 31W-237; map-sheet 17/1; coordinates: x = 198.350, y = 211.750 (see Tab. 2).
Mons (H.), Mont-Héribu; map-sheet 45/7; coordinates: x = 119.750, y = 124.150.
Mons-en-Pévèle, France: borehole made by Dr. Geets along the road Mons-en-Pévèle — Bersée, 1 km East of the Mons-en-Pévèle village centre; map-sheet Carvin (1/50.000), XXV-5; coordinates: x = 655.300, y = 309.075.
Oordegem (O.-V.), B.G.D. borehole 71W-33; map-sheet 22/7; coordinates: x = 117.350, y = 182.675.
Orchies, France: "tuilerie de Beuvry-les-Orchies",

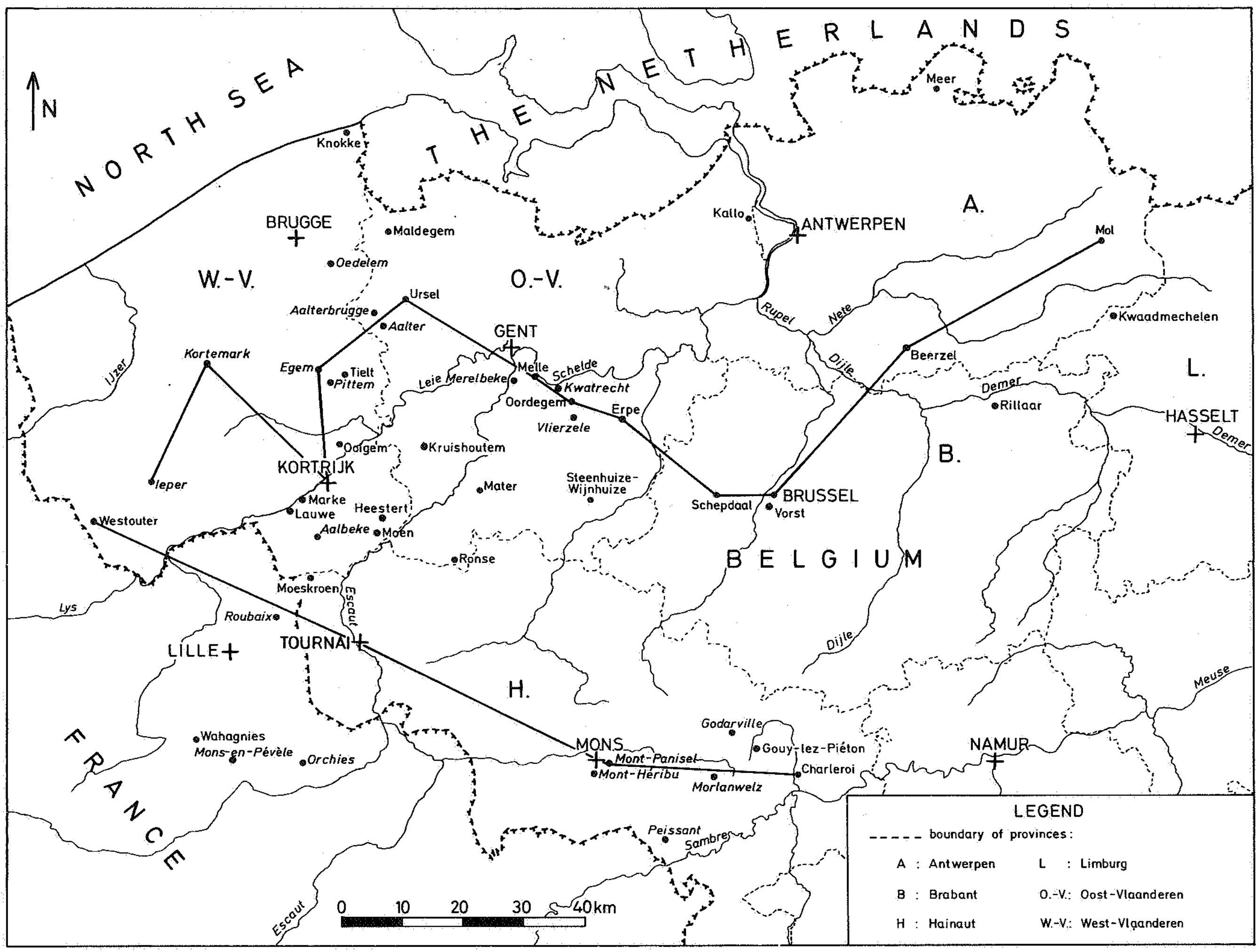


Fig. 2

Location of sampled sites and of type localities of lithostratigraphic units (in italics) discussed in the present paper. The thick lines refer to cross-sections shown in Fig. 5.

2 km South of the Orchies village centre; now abandoned and filled in; map-sheet St. Amand-les-Eaux (1/50.000), XXVI-5; coordinates: x = 664.950, y = 306.800.

Ronse (O.-V.), "Waaienberge": old railway cutting; map-sheet 30/5; coordinates: x = 98.525, y = 159.000.

Schepdaal (B.), "Het Koeiken": B.G.D. boreholes 87E-2 and 87E-5; map-sheet 31/2; coordinates: x = 139.025, y = 169.550 (87E-2); x = 139.100, y = 169.500 (87E-5).

Steenhuize-Wijnhuize, Herzele (O.-V.): Den Hoek, B.G.D. borehole 86W-142(VII, C); map-sheet 30/3; coordinates: x = 114.700; y = 169.675.

Tielt (W.-V.), "Lanno": B.G.D. borehole 68E-169; map-sheet 21/6; coordinates: x = 76.425, y = 187.550 (see Tab. 5).

Ursel (O.-V.), Drongengoed: borehole 39W-212 of the Belgian Geological Survey (also listed TGO 81-9/B5, Geological Institute, Gent); map-sheet 13/7; B5-I: 0.00-26.00 m, coordinates: x = 87.900, y = 204.220; B5-II: 26.00-59.50 m, coordinates: x = 87.880, y = 204.160; B5-III: 57.00-82.00 m, coordinates: x = 87.910, y = 204.260 (see also DE BREUCK *et al.*, in press).

Wahagnies, "Briqueteries de Libercourt" (northwestern France); map-sheet Carvin (1/50.000), XXV-5; coordinates: x = 649.250, y = 310.600.

Westouter (W.-V.), Rodeberg: B.G.D. borehole 95W-150; map-sheet 28/5; coordinates: x = 36.325, y = 165.000.

4. ADDITIONAL SAMPLE LOCALITIES NOT STUDIED BY STEURBAUT & NOLF (1986)

The localities are also listed alphabetically. Abbreviations as in section 3 (see Fig. 2 for locations). Borehole data is taken from the files of the Belgian Geological Survey.

Gouy-lez-Piéton (H.), motorway cutting at junction E42-R3: temporary outcrop sampled by Mr. C. KING (Watford) in 1982; map-sheet 46/2; coordinates: x = 146.000, y = 129.700.

General comments: a 9 m thick sequence was exposed, showing the contact between the Brussel Formation and the Ieper Formation. The Brussel Formation consists of an upper, 4 m thick, glauconitic sand with irregularly-shaped sandstone concretions ("grès fistuleux"), a thin siliceous sandstone and a lowermost 0.75 m thick fine glauconitic sand with clay bands and interbedded oyster debris, and which occasionally contains pebbles at the base. The Ieper Formation is represented by a 4m thick, glauconitic sandy clayey silt, overlain by a 60cm thick, glauconitic, heavily bioturbated, semi-indurated sandstone. This silty sequence, of which the lowermost 2m is calcareous and rich in molluscs, seems to be attributable to the Morlanwelz Argilite Member (sensu MOURLON, 1873).

Provenance of samples: one sample from the lowermost fossiliferous Ypresian bed was examined.

Calcareous nannoplankton: poorly preserved, fairly rich assemblage (20 species), assignable to the uppermost part of nanno-unit I, which corresponds to the middle part of NP11 (presence of *Discoaster multiradiatus, Chiasmolithus consuetus, Chiasmolithus solitus* and *Toweius pertusus*; absence of *Rhabdosphaera sola, Pontosphaera pectinata* and *Chiasmolithus eograndis*). This sample can be correlated with the Kallo borehole sequence between 337.00 and 331.50m depth (see Tab. 1).

Stratigraphy: Morlanwelz Argilite Member, Ypresian.

Kwaadmechelen (L.), B.G.D. borehole 46E-179; map-sheet 17/6; coordinates: x=204.525, y=198.700.

General comments: this 1.138,75m deep borehole was terminated in Upper Carboniferous shales. The Ieper Formation is recorded from 282.75 to 218.50m and consists of a lowermost sandy clay, the Orchies Clay Member (282.75-265.60m) and an uppermost fine sand which corresponds to the Mons-en-Pévèle Sand Member. The upper unit can be subdivided in a lower well stratified silty sand (265.60-238.85m) and an upper poorly sorted fine sand (238.85-218.50m) with coarse glauconite grains and very thin interbedded clay bands. At the top is a thin non-silicified nummulite bed (between 219.70 and 219m depth).

Provenance of samples: two samples from the uppermost part of the Ypresian sequence were examined, taken immediately above (interval 219-218.50m) and below (interval 224-219.80m) the nummulite bed.

Calcareous nannoplankton: both samples contain similar nanno-associations: moderately well-preserved, fairly diverse assemblages (23 species) assignable to the here introduced nanno-unit IIIb2 (presence of *Aubrysphaera deconinckii, Rhabdosphaera truncata, Pontosphaera exilis* and *Micrantholithus mirabilis*) which corresponds to the lower part of NP12 (see Fig. 3).

Stratigraphy: Mons-en-Pévèle Sand Member, Ypresian.

Mont Panisel (H.), Mons: B.G.D. borehole 151E-340; map-sheet 45/8; coordinates: x=122.265, y=125.372; type locality of the Panisel Sand Member.

General comments: the 65.60m deep borehole was drilled into the Ieper Formation, penetrating some 18m of completely oxidized and decalcified slightly clayey, glauconitic fine sand with very thin clay bands towards the base and 3.50m of highly glauconitic medium sand, both representing the Panisel Sand Member; some 43m of very fine sands representing the Mons-en-Pévèle Sand Member, oxidized at the top and completely decalcified to the depth of 31.30m, and finally a lowermost 0.70m thick alternation of grey sandy clay and grey-green very fine sand, which may be attributable to the Orchies Clay Member (*sensu* STEURBAUT & NOLF, 1986).

Provenance of samples: 23 samples were examined; the uppermost (down to 35m depth) and the lowermost ones (from 60 to 65.50m) were decalcified (see STEURBAUT, in press b).

Calcareous nannoplankton: some well-preserved, highly diverse assemblages (30 species) were found between 42 and 37m depth. Sample 41.75m is attributable to nanno-unit IIb (presence of *Zygrhablithus bijugatus nolfii, Rhabdosphaera sola* and *Cyclolithus bramlettei*; absence of *Rhabdosphaera truncata* and *Chiphragmalithus calathus*); samples 39.85 and 37.65m are assignable to zone IIIa1 (presence of *Z. bijugatus nolfii, R. truncata, R. sola* and *C. calathus*), which corresponds to the upper part of NP11.

Stratigraphy: see general comments.

Ooigem (W.-V.), Keihoek: B.G.D. borehole 83E-407; map-sheet 29/2; coordinates: x=76.050, y=177.200.

General comments: this 185m deep borehole was terminated in Silurian shales (145.50 to 185m), penetrating 92.20m of Ypresian clays (1.80-94m), 33.50m of Landenian sands and clays (94-127.50m) and 18m of Cretaceous marls and sandstones (127.50-145.50m). The Ypresian is represented by (descending): 2m of silty clay, the Kortemark Silt Member (1.80-3.80m); a 5m thick stiff clay, the Aalbeke Clay Member (3.80-8.80m); a 41.20m thick heterogeneous silty clay with several shell-layers and glauconite levels, less silty towards the base, representing the Roubaix Clay Member (8.80-50m) and a 44m thick stiff clay, slightly sandy in the basal 3m, the Orchies Clay Member (*sensu* STEURBAUT & NOLF, 1986) (50-94m). The uppermost 1.80m was not recovered.

Provenance of samples, calcareous nannoplankton and stratigraphy: see Tab. 4.

Rillaar (B.), B.G.D. borehole 75E-317; map-sheet 24/8; coordinates: x=187.300, y=184.925.

General comments: this 370m deep borehole was terminated in Carboniferous limestones (367-370m), penetrating 1.50m of Pleistocene loam, 60.50m of green, rather coarse, glauconitic Miocene sand (1.50-62.00m), 38m of glauconitic Middle Eocene sand (62-100m), 48m of Ypresian sands and clays (100-148m), 80m of Landenian sands, silts and clays (148-228m) and 139m of Upper Cretaceous chalk (228-367m). The Ypresian is represented by an upper, very fine sand with a few sandstone layers, the Mons-en-Pévèle Sand Member, which at 126m depth rests on a lower silty clay with a slightly sandy base, the Orchies Clay Member.

Provenance of samples: 10 samples from the Ypresian sequence were examined, of which the uppermost (104 m, beds b and c) and lowermost (137.20 m) were devoid of nannofossils; the remainder presented rather rich but entirely allochthonous associations, at depths of 108, 114, 120, 125 and 134 m (contamination from higher levels); in situ, non-contaminated associations were recorded from 127 and 128 m depth.

Calcareous nannoplankton: the non-contaminated samples contain poorly preserved, low-diversity assemblages, which seem to be attributable to nanno-zone IIIa or the top of NP11.

Stratigraphy: see general comments.

Vorst, Rue de Bourgogne: temporary outcrop between point II and III of CASIER (1946, p. 22, fig. 6), now inaccessible; map-sheet 31/7; coordinates: in the vicinity of x = 147.000, y = 167.000; type locality of the "Forest sands" *sensu* FEUGUEUR (1951).

General comments: according to CASIER (1946, p. 24) the following succession was visible in the "Rue de Bourgogne": 2.50 m of nummulitic fine sand with sandstones (named "Forest sands" by FEUGUEUR, 1951) overlain by a 4 m thick alternation of Ypresian sands and clays and a thin Quaternary cover (0.40 m).

Provenance of samples: one sample from the collections of the "Koninklijk Belgisch Instituut voor Natuurwetenschappen, Brussel" was examined; it was taken in a temporary outcrop in the "Rue de Bourgogne" and consists of a thin, compact, non-silicified nummulite bed; its exact stratigraphic position within the "Forest sand" sequence is unknown.

Calcareous nannoplankton: poorly preserved, low-diversity assemblage, assignable to unit IIIb3 (presence of *Aubrysphaera deconinckii, Pontosphaera exilis, Rhabdosphaera sola*; absence of *Rhabdosphaera truncata, Chiasmolithus consuetus* and *Cyclolithus bramlettei*).

Stratigraphy: Mons-en-Pévèle Sand Member *sensu* STEURBAUT & NOLF (1986); Ypresian.

Vorst, "Fabrique de thermogène": B.G.D. borehole 88W-557; map-sheet 31/7; coordinates: x = 146.800, y = 166.500.

General comments: this 21 m deep borehole penetrated 4 m of Brusselian sand, 12 m of yellowish fine sand (= "Forest Sands" *sensu* FEUGUEUR) and 5 m of sandy clays with sand intercalations, representing the Ieper Formation.

Provenance of samples and stratigraphy: one sample from 11 m depth was examined; Mons-en-Pévèle Sand Member (*sensu* STEURBAUT & NOLF, 1986), Ypresian.

Calcareous nannoplankton: rich nanno-association, with *Pontosphaera exilis, Ericsonia eopelagica* and *Toweius pertusus* as most dominant forms. The co-occurrence of *Rhabdosphaera sola, Rhabdosphaera truncata* and *Cruciplacolithus cribellus* and the absence of *Discoaster lodoensis, Aubrysphaera deconinckii, Naninfula dupuisii* and *Zygrhablithus bijugatus nolfii* indicate nanno-unit IIIa2, or the top of NP11.

5. CALCAREOUS NANNOPLANKTON BIOSTRATIGRAPHY

The majority of the studied Ypresian outcrop and borehole sections contain poorly to moderately preserved, low-diversity assemblages with 15 to 20 species (see STEURBAUT & NOLF, 1986; STEURBAUT, in press a). However, a few associations with more than 30 autochthonous forms were recorded, up to a maximum of 44 in the Mol borehole at 394.70 m depth. There was almost no reworking of Cretaceous and Palaeocene taxa, except for the Mons-en-Pévèle stratotype association and in the lower part of the Kallo and Mol boreholes.

The Ypresian is generally assumed to include MARTINI's standard nannoplankton zones NP10, NP11, NP12, NP13 and the base of NP14 (see BERGRREN *et al.*, 1985; see MARTINI & MÜLLER, 1986 for more details on MARTINI's nanno-zonation). MARTINI's NP10, however, could not be identified in the Belgian Basin, whereas NP11, NP12, NP13 and NP14 could be further subdivided in several units. Eleven biostratigraphic units were recognised by STEURBAUT in STEURBAUT & NOLF (1986): units I, II and IIIa were correlated with MARTINI's NP11, units IIIb, IV, V, VI, VII and VIII with NP12, units IX and X with NP13, and unit XI with the basal part of NP14. The Kallo well section was chosen as a reference-section because it reveals one of the thickest, the least decalcified and almost completely recovered Ypresian sequences of Belgium (see Table 1). However, more detailed biostratigraphic investigation, recently carried out by the author, has shown that there is an important hiatus in the Kallo and Mol wells and that these, therefore cannot be taken as reference-sections (see next chapters). Nanno-unit IIIb2 which is well-developed in the southern part of the basin, in the area between Kortrijk and Brussel seems to be missing in the Kallo and Mol wells (see Fig. 4 and Tabs. 1 and 2).

The nanno-zonation proposed here differs from the previous one published by STEURBAUT & NOLF (1986), and commented on in STEURBAUT (1988a) and in VERBEEK, STEURBAUT and MOORKENS (1988), by the further subdivision of units II, IIIa, IIIb and VI. The boundaries of STEURBAUT's biostratigraphic units are based on first or last occurrences of one or more species, or coincide with the concurrent part of the ranges of two or more species. Most of these occurrences seem to have worldwide significance as they have also been recognised in the Californian Lodo Formation (see STEURBAUT, 1988a). The most important Ypresian calcareous nannoplankton events are summarised in Fig. 3.

Unit I

This unit is characterised by the co-occurrence of *Discoaster multiradiatus* and *D. diastypus*. Its upper limit is defined by the first occurrence of *Rhabdosphaera sola*. Only low-diversity assemblages are recorded, up to 15 species, with

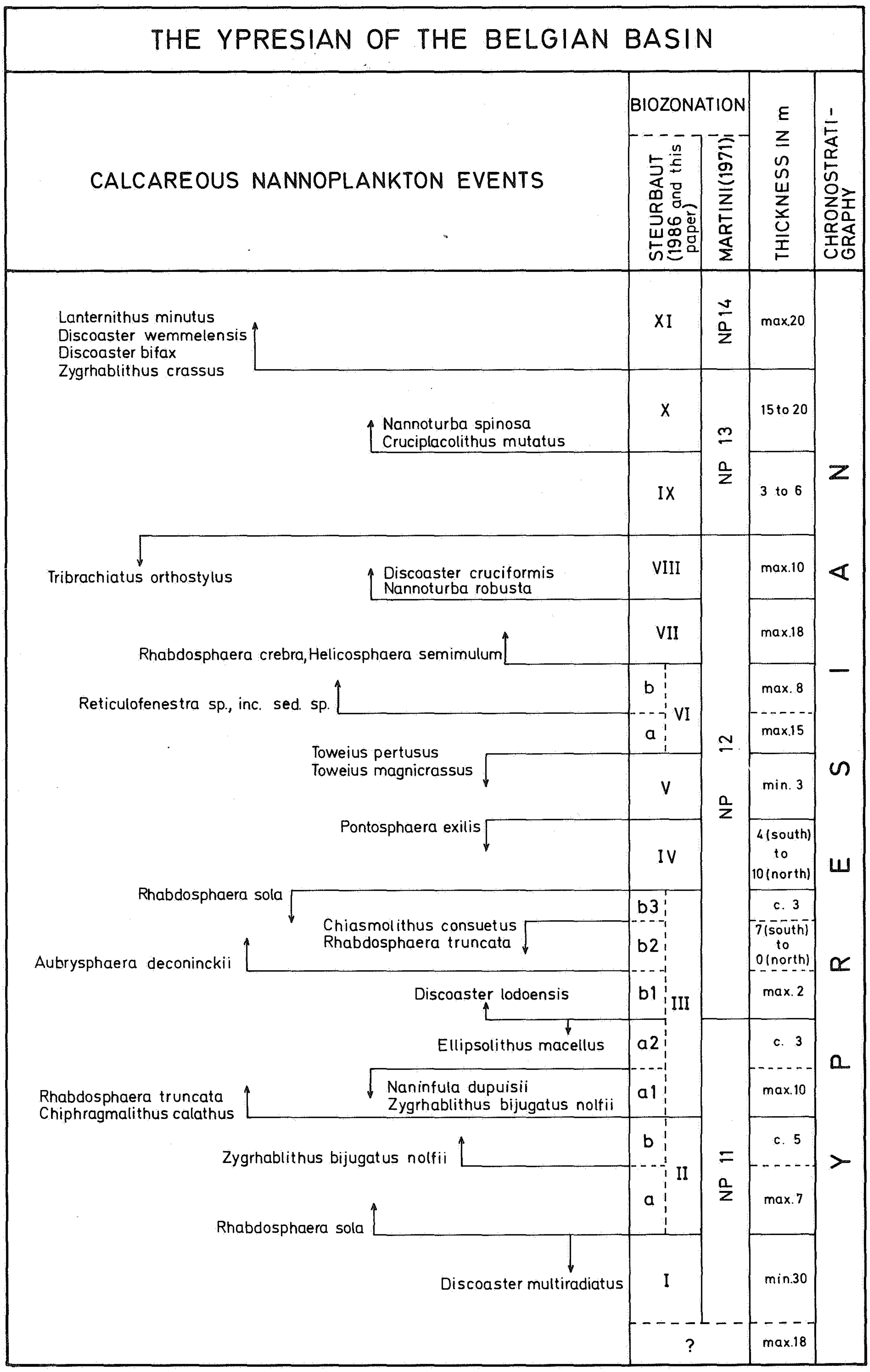


Fig. 3

Calcareous nannoplankton events in the Ypresian of the Belgian Basin.

Tribrachiatus orthostylus and *Toweius occultatus* being the dominant forms.

Unit I was encountered in the Kallo and Mol wells (see Tabs. 1 and 2) and in a motorway cutting near Charleroi. Its lower limit is uncertain as it overlies a totally barren non-calcareous interval. Unit I corresponds to the lower part of MARTINI's NP11 (presence of *T. orthostylus,* absence of *Discoaster lodoensis*).

Unit II

Unit II comprises moderately diversified assemblages (25 to 30 species) fairly rich in *Pontosphaera exilis, Toweius pertusus* and *Toweius magnicrassus*. Its lower limit is defined by the first occurrence of *Rhabdosphaera sola*, its upper limit by the first occurrence of *Rhabdosphaera truncata* and *Chiphragmalithus calathus*. Unit II can be subdivided into 2 subunits, IIa and IIb, by the first occurrence of *Zygrhablithus bijugatus nolfii*. Both subunits have been recognised in the Kallo well (see Tab. 1), the Mont Panisel (STEURBAUT, in press b) and the Ooigem boreholes (see Tab. 4). Unit II is also known from several other boreholes and many outcrops in the Belgian Basin (see STEURBAUT & NOLF, 1986). It corresponds to the middle part of MARTINI's *Discoaster binodosus* zone or NP11.

Unit III

Unit III comprises the richest and best preserved assemblages of the Belgian Ypresian (30 to 35 species). Many first occurrences are recorded, e.g. *Rhabdosphaera truncata* and *Chiphragmalithus calathus*, which are used to define the lower limit of the unit. Its upper limit is placed at the last occurrence of *Rhabdosphaera sola*. Other forms which are restricted to unit III are: *Cruciplacolithus delus, Cruciplacolithus cribellus* and *Naninfula dupuisii.*

Unit III can be subdivided into 2 subunits, IIIa and IIIb, by the first occurrence of *Discoaster lodoensis*. The base of subunit IIIb therefore corresponds to the base of MARTINI's NP12. An additional distinctive feature is the occurrence of *Ellipsolithus macellus* (only present in units I, II and IIIa). *D. lodoensis* and other marker species are rather rare in the lowermost part of NP12 and, as the associations are quite similar, the subdivision into IIIa and IIIb was thought to be difficult to establish. The present study, however, has demonstrated that several additional calcareous nannoplankton events can be identified within subzones IIIa and IIIb, resulting in a refinement of these units. The subdivision in IIIa$_1$ and IIIa$_2$ is based on the last occurrence of *Naninfula dupuisii* and *Zygrhablithus bijugatus nolfii*, which seem to be contemporaneous in the studied sequence. The limit between IIIb$_1$ and IIIb$_2$ is defined by the first appearance of *Aubrysphaera deconinckii*; the limit between IIIb$_2$ and IIIb$_3$ by the last occurrence of *Rhabdosphaera truncata* and *Chiasmolithus consuetus*. Additional forms with stratigraphic importance are: *Pontosphaera kingii* and *Zygodiscus plectopons* (restricted to IIIa), *Micrantholithus mirabilis* (first appearance in IIIb$_2$) and *Pontosphaera excelsa* (restricted to IIIb$_3$).

The most diverse associations are found in subunit IIIa. Less rich and less well preserved associations are present in subdivisions IIIb$_1$ and IIIb$_2$. The base of IIIb$_3$ is marked by an abrupt decrease in nannofossils.

Subdivisions IIIa$_1$, IIIa$_2$, IIIb$_1$ and IIIb$_3$ have been recognised in most outcrop and borehole sections. Subdivision IIIb$_2$ is well developed in the southern part of the basin, in the area between Kortrijk and Brussel, but seems to be missing in the North (Kallo and Mol wells) (see Fig. 4; see chapter 6).

Unit IV

The associations of unit IV are less diverse (maximum of 20 species). The base of unit IV is defined by the last occurrence of *Rhabdosphaera sola* and its upper limit by the last occurrence of *Pontosphaera exilis.* Several other forms, known from the underlying units, are no longer present; including *Cruciplacolithus delus, Chiasmolithus eograndis, Lophodolithus nascens* and *Neochiastozygus concinnus.*

Unit IV is known from several borehole sections and from many outcrops south of Kortrijk (see STEURBAUT & NOLF, 1986, fig. 3). It is also present in the Kallo and Mol wells (see Tabs. 1 and 2). Unit IV corresponds to the lower part of MARTINI's NP12.

Unit V

Unit V comprises moderately diverse assemblages (c. 15 species). The base of unit V is defined by the last occurrence of *Pontosphaera exilis*, and the top by the last occurrence of *Toweius pertusus* and *T. magnicrassus*. This unit is further characterised by the dominance of *Toweius pertusus* and *Discoaster kuepperi*, and by the last occurrence of *Aubrysphaera deconinckii, Micrantholithus mirabilis* and *Pontosphaera* sp.. *Chiasmolithus* aff. *expansus* seems to appear within this zone.

Unit V has been encountered in some borehole sections (see Tabs. 1 and 2), and is known from outcrops South of Kortrijk (see STEURBAUT & NOLF, 1986, fig. 3). It can be correlated with the lower middle part of NP12.

Unit VI

Unit VI is defined as the interval between the last occurrence of *Toweius pertusus* and the first occurrence of *Rhabdosphaera crebra* and *Helicosphaera seminulum*. It consists of rather poor assemblages (generally less than 10 species, up to 20 species in the uppermost part) and contains the "last" *Chiasmolithus* aff. *expansus*, and a few *Lophodolithus reniformis*. Furthermore, it is characterised by the first appearance of *Discoaster mirus* and *D. tanii* that enter just above the base. Unit VI can be subdivided into VIa and VIb by the first occurrence of *Reticulofenestra* sp. and inc. sed. sp. (see Tabs. 1 and 2).

Unit VI is known from the claypit Desimpel at Kortemark, from the Kallo and Mol boreholes and from a few outcrops around Tielt (see STEURBAUT & NOLF, 1986, fig. 5). It corresponds to the middle part of MARTINI's NP12.

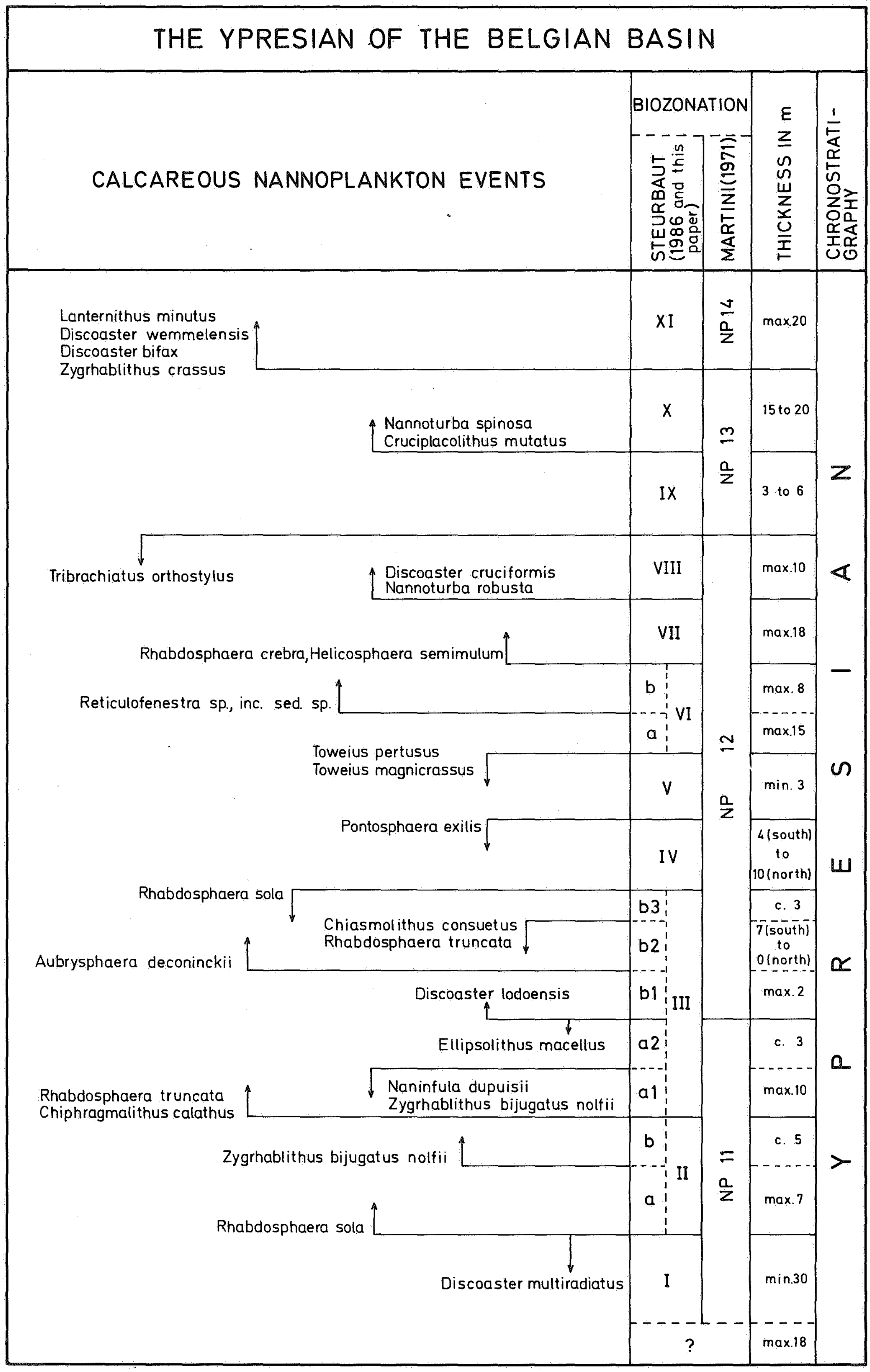


Fig. 3

Calcareous nannoplankton events in the Ypresian of the Belgian Basin.

Tribrachiatus orthostylus and *Toweius occultatus* being the dominant forms.

Unit I was encountered in the Kallo and Mol wells (see Tabs. 1 and 2) and in a motorway cutting near Charleroi. Its lower limit is uncertain as it overlies a totally barren non-calcareous interval. Unit I corresponds to the lower part of MARTINI's NP11 (presence of *T. orthostylus*, absence of *Discoaster lodoensis*).

Unit II

Unit II comprises moderately diversified assemblages (25 to 30 species) fairly rich in *Pontosphaera exilis*, *Toweius pertusus* and *Toweius magnicrassus*. Its lower limit is defined by the first occurrence of *Rhabdosphaera sola*, its upper limit by the first occurrence of *Rhabdosphaera truncata* and *Chiphragmalithus calathus*. Unit II can be subdivided into 2 subunits, IIa and IIb, by the first occurrence of *Zygrhablithus bijugatus nolfii*. Both subunits have been recognised in the Kallo well (see Tab. 1), the Mont Panisel (STEURBAUT, in press b) and the Ooigem boreholes (see Tab. 4). Unit II is also known from several other boreholes and many outcrops in the Belgian Basin (see STEURBAUT & NOLF, 1986). It corresponds to the middle part of MARTINI's *Discoaster binodosus* zone or NP11.

Unit III

Unit III comprises the richest and best preserved assemblages of the Belgian Ypresian (30 to 35 species). Many first occurrences are recorded, e.g. *Rhabdosphaera truncata* and *Chiphragmalithus calathus*, which are used to define the lower limit of the unit. Its upper limit is placed at the last occurrence of *Rhabdosphaera sola*. Other forms which are restricted to unit III are: *Cruciplacolithus delus*, *Cruciplacolithus cribellus* and *Naninfula dupuisii*.

Unit III can be subdivided into 2 subunits, IIIa and IIIb, by the first occurrence of *Discoaster lodoensis*. The base of subunit IIIb therefore corresponds to the base of MARTINI's NP12. An additional distinctive feature is the occurrence of *Ellipsolithus macellus* (only present in units I, II and IIIa). *D. lodoensis* and other marker species are rather rare in the lowermost part of NP12 and, as the associations are quite similar, the subdivision into IIIa and IIIb was thought to be difficult to establish. The present study, however, has demonstrated that several additional calcareous nannoplankton events can be identified within subzones IIIa and IIIb, resulting in a refinement of these units. The subdivision in $IIIa_1$ and $IIIa_2$ is based on the last occurrence of *Naninfula dupuisii* and *Zygrhablithus bijugatus nolfii*, which seem to be contemporaneous in the studied sequence. The limit between $IIIb_1$ and $IIIb_2$ is defined by the first appearance of *Aubrysphaera deconinckii*; the limit between $IIIb_2$ and $IIIb_3$ by the last occurrence of *Rhabdosphaera truncata* and *Chiasmolithus consuetus*. Additional forms with stratigraphic importance are: *Pontosphaera kingii* and *Zygodiscus plectopons* (restricted to IIIa), *Micrantholithus mirabilis* (first appearance in $IIIb_2$) and *Pontosphaera excelsa* (restricted to $IIIb_3$).

The most diverse associations are found in subunit IIIa. Less rich and less well preserved associations are present in subdivisions $IIIb_1$ and $IIIb_2$. The base of $IIIb_3$ is marked by an abrupt decrease in nannofossils.

Subdivisions $IIIa_1$, $IIIa_2$, $IIIb_1$ and $IIIb_3$ have been recognised in most outcrop and borehole sections. Subdivision $IIIb_2$ is well developed in the southern part of the basin, in the area between Kortrijk and Brussel, but seems to be missing in the North (Kallo and Mol wells) (see Fig. 4; see chapter 6).

Unit IV

The associations of unit IV are less diverse (maximum of 20 species). The base of unit IV is defined by the last occurrence of *Rhabdosphaera sola* and its upper limit by the last occurrence of *Pontosphaera exilis*. Several other forms, known from the underlying units, are no longer present; including *Cruciplacolithus delus*, *Chiasmolithus eograndis*, *Lophodolithus nascens* and *Neochiastozygus concinnus*.

Unit IV is known from several borehole sections and from many outcrops south of Kortrijk (see STEURBAUT & NOLF, 1986, fig. 3). It is also present in the Kallo and Mol wells (see Tabs. 1 and 2). Unit IV corresponds to the lower part of MARTINI's NP12.

Unit V

Unit V comprises moderately diverse assemblages (c. 15 species). The base of unit V is defined by the last occurrence of *Pontosphaera exilis*, and the top by the last occurrence of *Toweius pertusus* and *T. magnicrassus*. This unit is further characterised by the dominance of *Toweius pertusus* and *Discoaster kuepperi*, and by the last occurrence of *Aubrysphaera deconinckii*, *Micrantholithus mirabilis* and *Pontosphaera* sp.. *Chiasmolithus* aff. *expansus* seems to appear within this zone.

Unit V has been encountered in some borehole sections (see Tabs. 1 and 2), and is known from outcrops South of Kortrijk (see STEURBAUT & NOLF, 1986, fig. 3). It can be correlated with the lower middle part of NP12.

Unit VI

Unit VI is defined as the interval between the last occurrence of *Toweius pertusus* and the first occurrence of *Rhabdosphaera crebra* and *Helicosphaera seminulum*. It consists of rather poor assemblages (generally less than 10 species, up to 20 species in the uppermost part) and contains the "last" *Chiasmolithus* aff. *expansus*, and a few *Lophodolithus reniformis*. Furthermore, it is characterised by the first appearance of *Discoaster mirus* and *D. tanii* that enter just above the base. Unit VI can be subdivided into VIa and VIb by the first occurrence of *Reticulofenestra* sp. and inc. sed. sp. (see Tabs. 1 and 2).

Unit VI is known from the claypit Desimpel at Kortemark, from the Kallo and Mol boreholes and from a few outcrops around Tielt (see STEURBAUT & NOLF, 1986, fig. 5). It corresponds to the middle part of MARTINI's NP12.

Unit VII

Unit VII is defined as the interval between the first occurrence of *Rhabdosphaera crebra* and *Helicosphaera seminulum* and the first occurrence of *Discoaster cruciformis* and *Nannoturba robusta*, which seem to be almost contemporaneous in the Belgian Basin. It comprises fairly rich assemblages (up to 30 species) with *Discoaster kuepperi*, inc. sed. sp., and *Zygrhablithus bijugatus* s.l. as the most dominant forms. Unit VII is also characterised by some first appearances (*Discoaster crassus* and *Rhabdosphaera* sp.), the "last" *Sphenolithus radians*, and by *Trochoaster operosus* which seems to be rather frequent in this unit.

Unit VII is encountered in borehole sections and outcrops of the northern part of West- and Oost-Vlaanderen (see STEURBAUT & NOLF, 1986, figs. 5, 7 and 8). It seems to be missing in the Mol borehole (see Tab. 2). Unit VII is assignable to the upper part of NP12.

Unit VIII

Unit VIII is defined as the interval between the first occurrences of *Discoaster cruciformis* and *Nannoturba robusta* and the last occurrence of *Tribrachiatus orthostylus*. It comprises fairly rich assemblages (up to 25 species). *Chiphragmalithus armatus, Rhabdosphaera crebra* and *Sphenolithus radians* seem to disappear at the top of this unit.

Unit VIII is recognised in several borehole sections and outcrops in the northern part of West- and Oost-Vlaanderen (see STEURBAUT & NOLF, 1986, figs. 5, 7 and 8). It was encountered in the Kallo and Mol boreholes. Unit VIII represents the uppermost part of MARTINI's NP12.

Unit IX

Unit IX contains less diverse assemblages, with *Discoaster kuepperi, Pontosphaera pulchra* and inc. sed. sp. as dominant forms. Its base is defined by the last occurrence of *Tribrachiatus orthostylus*, its upper limit by the first occurrence of *Nannoturba spinosa* and *Cruciplacolithus mutatus*. This unit is known from the Kallo borehole only (see Tab. 1). Its lower limit lies between 242 and 240 m depth; its upper limit could not be established because nannofossils are absent in the interval between 239 and 234.50 m. It corresponds to the basal part of nannozone NP13.

Unit X

Unit X is defined as the interval between the first occurrence of *Nannoturba spinosa* and *Cruciplacolithus mutatus* and the first occurrence of *Lanternithus minutus, Discoaster bifax, Discoaster wemmelensis* and *Zygrhablithus crassus*, which seem to be contemporaneous in the Belgian Basin. It comprises low-diversity assemblages (maximum of 10 species), which are further characterised by the presence of *Discoaster crassus* and *Imperiaster* sp. and by the disappearance of *Discoaster cruciformis, Cyclolithus bramlettei* and inc. sed. sp.

This unit is known only from borehole sections in northwestern Belgium. It is well developed in the Ursel borehole (see STEURBAUT & NOLF, 1986, fig. 8; DE BREUCK *et al.*, 1989, p. 11) and in de Oedelem borehole (STEURBAUT, unpublished data). It is also recognised in the Kallo borehole, although its limits could not be established, because no cores were recovered in the interval from 234.00 to 208.90 m (see Tab. 1). Unit X corresponds to the upper part of NP13.

Unit XI

Unit XI is known from the Ursel borehole only, where it covers the interval from 61.20 to 43.70 m (see STEURBAUT & NOLF, 1986, fig. 8). It is characterised by fairly rich assemblages (c. 25 species). Its lower limit is defined by the first occurrences of *Lanternithus minutus, Zygrhablithus crassus, Discoaster bifax* and *D. wemmelensis*, which are thought to have appeared within MARTINI's NP14. These occurrences seem to be contemporaneous in the studied sequence, although they may be the result of contamination, partly or wholly, during coring of the Ursel borehole. Detailed investigation of selected carefully cored boreholes in Northwest Belgium (such as the recent Oedelem borehole no. 23E-88, unpublished data) will lead to better understanding and resolution of the problem.

Unit XI corresponds to the lower part of MARTINI's NP14, if the above mentioned species are found to be *in situ*. The marker species *Discoaster sublodoensis* BRAMLETTE & SULLIVAN, 1961, could not be identified. The upper limit of unit XI is characterised by the appearance of *Birkelundia arenosa, Cruciplacolithus staurion, Discoaster saipanensis* and *Pentaster lisbonensis*.

6. NEW LITHOSTRATIGRAPHIC ASPECTS AND CORRELATIONS

Morlanwelz Argilite Member

The term "Argilite de Morlanwelz" was introduced by MOURLON in 1873 (p. 68, 69 and 99) to describe the sand and clay beds with interbedded highly glauconitic claystones, including an uppermost clayey sand with thin nummulitic stone-bed, outcropping between Mons and Charleroi. The topmost part of this sequence was sampled by C. KING: a sandy clayey silt from a temporary outcrop near Charleroi, some 3 m below a glauconitic semi-indurated sandstone. The nannofossils were studied by the present author. A fairly rich association was identified, assignable to the upper part of nanno-unit I or the middle part of NP11. The nannoflora suggests correlation with the interval 337-331.50 m of the Kallo borehole, and with strata around 418 m depth in the Mol borehole (Tabs. 1 & 2). It is concluded that the Morlanwelz Argilite Member represents a lateral, southeastern facies of the Orchies Clay Member (*sensu* STEURBAUT & NOLF, 1986).

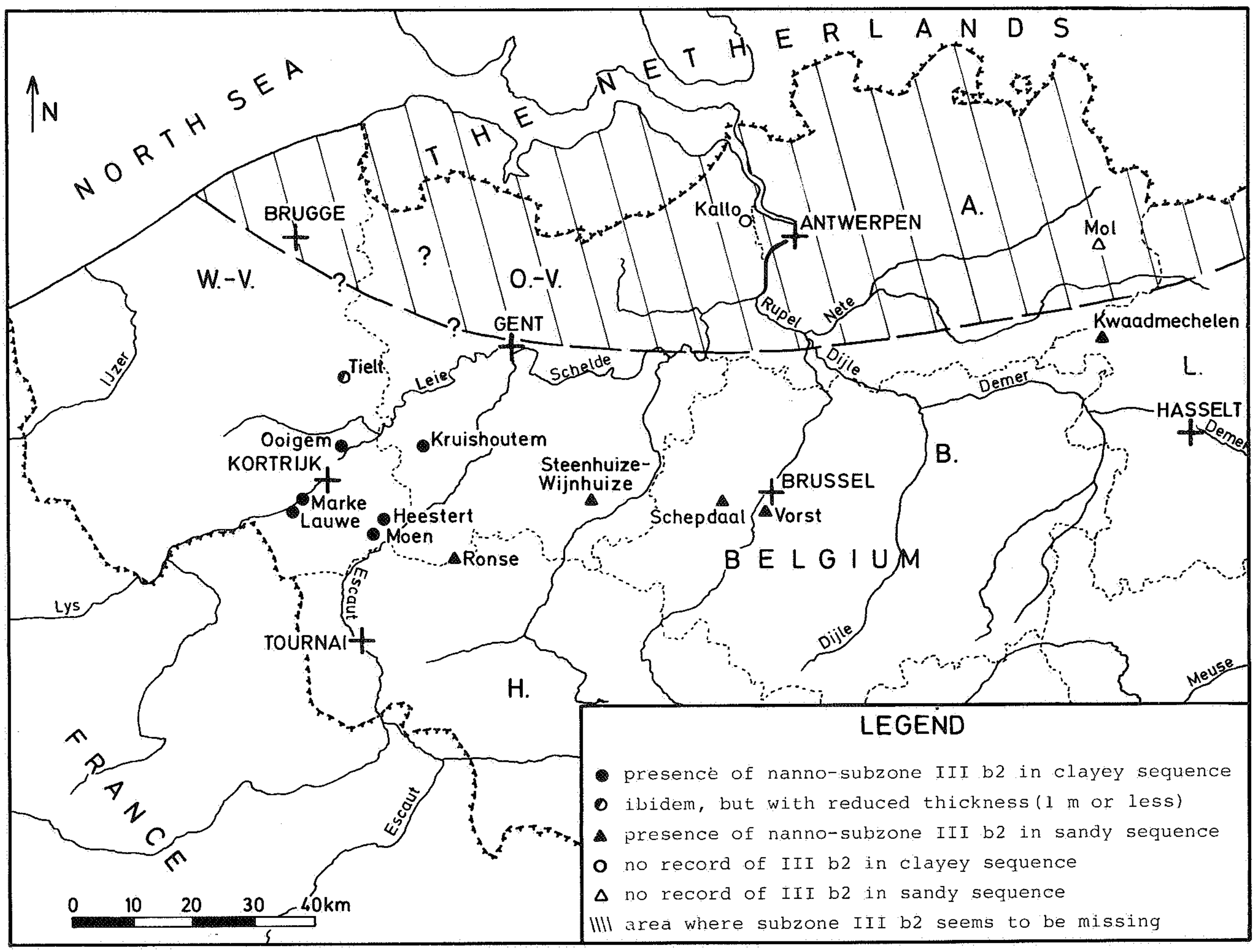
"Forest Sands"

The term "Sables de Forest" or "Forest Sands" was erroneously attributed to LYELL (1852) by de HEINZELIN & GLIBERT (1957) and to CASIER (1946) by WILLEMS, BIGNOT & MOORKENS (1981). Both LYELL and CASIER used the term "Sands with (Sables à) *Nummulites planulatus*" when referring to the outcrop at Forest (Vorst), South of Brussels. The term "Sables de Forest" was introduced by FEUGUEUR (1951, p. 237) as a correlative of the Mons-en-Pévèle sands, and is used as such by STEURBAUT and NOLF (1986). According to CASIER (1946, p. 23-25) it consists of very fine calcareous sands with sandstone intercalations, nummulite beds and occasional shell beds. Several samples, collected by T. MOORKENS, J. HERMAN and from the collections from the "Koninklijk Belgisch Instituut voor Natuurwetenschappen" and the Geological Survey were studied. Most of these are poor in nannofossils and could not be dated accurately. A nummulitic sand from a temporary outcrop in the "Rue de Bourgogne" contained a rather rich nanno-assemblage, assignable to subunit IIIb3 (see chapter 4). A sample from a borehole some 300 m southwest of the "Rue de Bourgogne" showed a quite distinct association. It was taken at 11 m below surface, and was attribuable to subunit IIIa2 or the top of NP11. This indicates that the fossiliferous sands in and around Forest, or Vorst, known as the "Forest Sands", belong to nanno-units IIIa and IIIb, and that the uppermost, exposed part, which is nummulitic and contains sandstone beds, corresponds to subunits IIIb2 and IIIb3. The presence of these nanno-zones implies correlation of the "Forest Sands" with the upper middle part of the Mons-en-Pévèle Sand Member.

"Tielt Glauconitic bed"

Glauconite is a common, often abundant, component of marine non-argillaceous shelf sediments. This is also true for the Ypresian deposits of the Belgian Basin, where it is common in the upper, sandy part of the Ieper Formation (Egem Sand and Panisel Sand Members) and in the Vlierzele Formation. The underlying clayey part of the Ieper Formation shows no significant glauconite concentrations, except for a single level in the middle of the Roubaix Clay Member. This glauconitic bed, called "Lit glauconifère de Tielt" by DE CONINCK (1973), was encountered in several boreholes in northwestern Belgium (Kallo, Tielt, Ooigem, etc.) and was thought to be an important marker horizon throughout the Belgian Basin. From the present study, however, it is clear that there is more than one glauconitic bed.

Fig. 4
Distribution of nanno-subunit IIIb2 in the Ypresian of the Belgian Basin.



The "Tielt Glauconitic bed" from the Tielt borehole (Tab. 5) does not correlate with the main glauconite level in the Kallo and Ooigem boreholes (Tabs. 1 and 4). In the Tielt borehole it occurs at 101.50m depth, within nanno-unit IIIa1. Some 3m above this level is a second, less conspicuous bed which falls within unit IIIa2. The main glauconite level from the Kallo and Ooigem boreholes, situated at respectively 306.80m and 30.70m depth, coincides with the base of unit IIIb1 or with the NP11/NP12 boundary. These data also correspond with the observations of KING (personal communication, see also the present volume). According to this author at least 5 such, thin, glauconite levels can be identified within the middle of the Ieper Formation. They are suggested to be valuable marker horizons for local and regional correlation.

A Mid-Ypresian hiatus in the northern part of the basin

The Kallo borehole section has been chosen as a framework for stratigraphic analysis in nearly all recent work on the Ypresian (DE CONINCK, 1976; WILLEMS, 1982; STEURBAUT & NOLF, 1986). It was thought to represent one of the thickest, most complete, least decalcified and best recovered Ypresian sequences of Belgium. Very detailed nannofossil analysis, however, has shown that nanno-subunit IIIb2 is missing, or is extremely thin, in the Kallo and Mol boreholes (Tabs. 1 and 2). This subunit is very well represented in the southern part of the basin, where it spans a 7m thick interval in the area between Marke and Brussel (see Fig. 4). This interval thins towards the North, from about 5m north of Kortrijk to about 1m around Tielt. It has not been encountered further northward.

At first it was assumed that the occurrence of subunit IIIb2 was merely related to lithofacies and consequently to water depth. However, as it has been identified in the entire southern part of the basin, within the western clayey sequences as well as within the more eastern, shallower, sandy sequences, its lithofacies-controlled origin has to be rejected. Secondly, its presence was thought to be related to specific characteristics of the surface waters or to oceanic currents. The co-occurrence of *Aubrysphaera deconinckii, Rhabdosphaera truncata, Chiasmolithus consuetus* and *Discoaster lodoensis*, by which subunit IIIb2 is defined, may be due to specific physico-chemical parameters of the surface waters (temperature, salinity, acidity, nutrients, etc.) or to oceanic surface currents. This implies the existence of two distinct water masses at that particular time, a northern and a southern, with somewhat different nanno-associations. However, this would be exceptional, as nearly all other Ypresian calcareous nannoplankton events, and consequently the different subzones, could be identified throughout the entire Belgian Basin. Finally the non-occurrence of subunit IIIb2 in the Kallo and Mol wells (or its very condensed aspect) could also be the result of a sedimentary, or less probably, an erosional discontinuity. In his original description of the Kallo borehole GULINCK (unpublished data) mentioned a sharp junction with burrows and fossil wood-fragments at 305m depth, whereas strong bioturbation was recorded at 384.50m depth in the Mol borehole (GULINCK & LAGA, unpublished data). Both events indicate phases of non-deposition or very slow sedimentation. Both levels also coincide with important changes in nannofossil associations (absence of [or extremely thin] unit IIIb2 in the Kallo borehole and of IIIb1 and b2 in the Mol borehole). Thus, there is substantial biostratigraphic and sedimentological evidence for a significant mid-Ypresian discontinuity in the northern part of the basin, and this may be the result from tectonic adjustments within the Brabant Massif.

7. RELATION BETWEEN LITHOSTRATIGRAPHIC UNITS AND BIOZONES

The relationship between the lithostratigraphic units and the biozones (MARTINI, 1971; STEURBAUT in STEURBAUT & NOLF, 1986; slightly modified here) is summarised in Fig. 5.

Orchies Clay Member

The first appearance of calcareous nannofossils is at about 17m above the base of the Ieper Formation, within the Orchies Clay Member. The lowermost 30m of this member is devoid of nannofossils except for one level in the Kallo borehole (−360.00m depth) and a few in the Mol borehole (see Tab. 2). These levels reveal poorly preserved, low-diversity assemblages assignable to the lower part of MARTINI's NP11 and to STEURBAUT's unit I. Higher up in the Orchies Clay Member, nanno-associations become progressively richer, indicating that the top of this unit is slightly diachronous, attributable to unit I in the Kallo borehole, but belonging to unit II in the Mol borehole.

Morlanwelz Argilite Member

Only the topmost part of this member has been examined (see chapters 4 and 6). A poorly preserved, moderately diverse assemblage was identified, assignable to the upper part of nanno-unit I and the middle part of NP11. The Morlanwelz Argilite Member is a lateral equivalent of the Orchies Clay Member.

Roubaix Clay Member

This member was sampled at various exposures and in borehole sections. Its lower part, a fossiliferous silty clay with many thin silt or sand layers, contains relatively diverse assemblages attributable to the here proposed units I, II and IIIa1 and to MARTINI's NP11 (presence of *Tribachiatus orthostylus*, absence of *Discoaster lodoensis*). Higher up is a more clay-rich part with somewhat less diverse assemblages, representing the top of NP11 (unit IIIa2). The middle part, well exposed in the lectostratotype, is less clayey and contains a few basal glauconitic horizons and several shell beds. It corresponds to subunit IIIb. The upper part, containing more clay, comprises

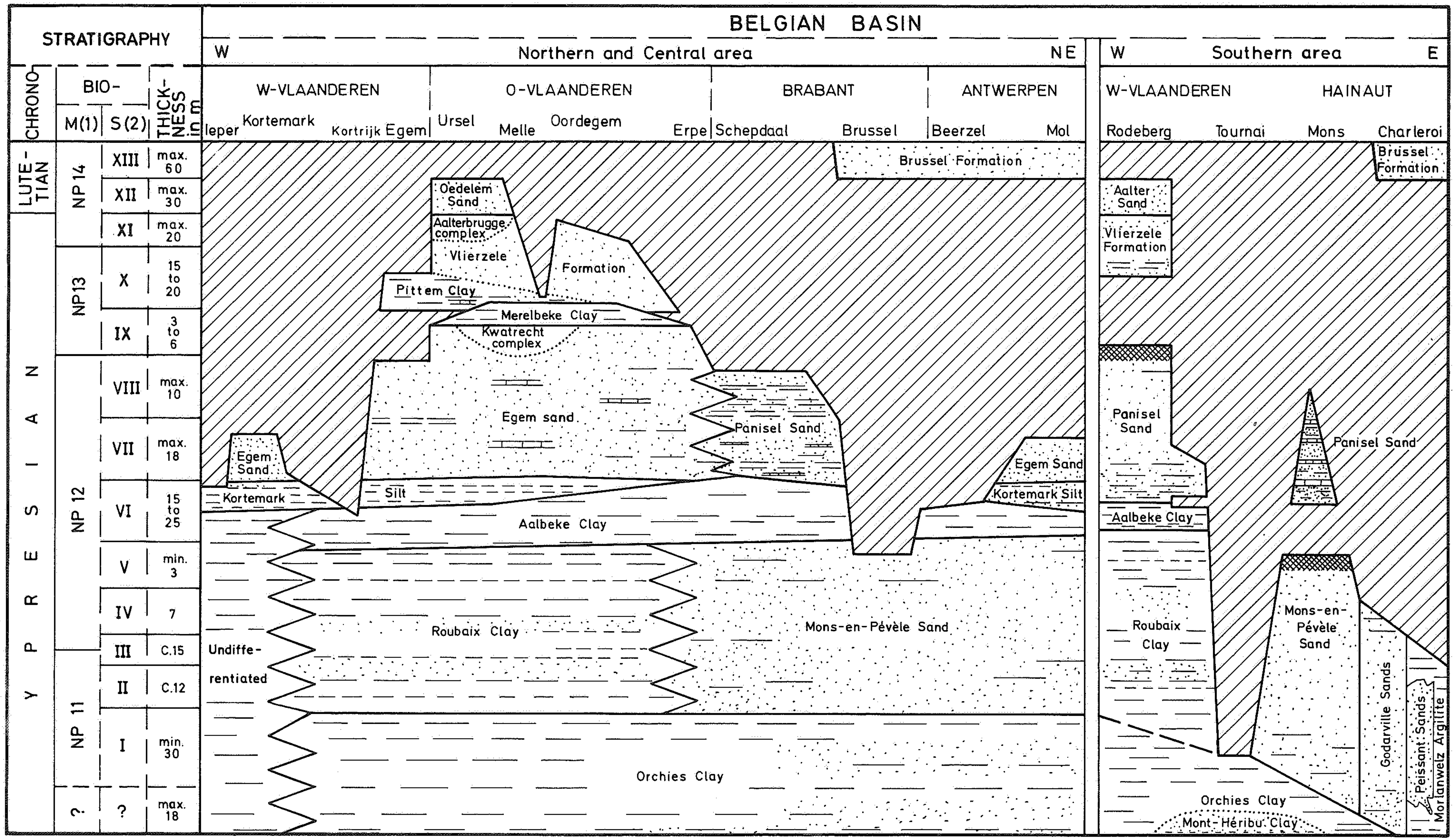


Fig. 5

Correlation of the litho- and biostratigraphic subdivisions of the Ypresian in the Belgian Basin (see Fig. 2 for the lines of cross-sections; (1) = MARTINI, 1971; (2)-STEURBAUT in STEURBAUT & NOLF, 1986).

units IV and V, and represents the lower part of MARTINI's NP12. The Roubaix Clay Member passes eastwards and southwards into the Mons-en-Pévèle Sand Member.

Mons-en-Pévèle Sand Member

The Mons-en-Pévèle Sand Member contains some high-diversity assemblages (44 species at a depth of 394.70 m in the Mol borehole; 35 species in the stratotype and in the Ronse sequences). Units II, III, IV and V are easily distinguishable. The subdivision into IIa and IIb, however, is often difficult to establish. Subdivision IIIb2 is very well represented in the southern part of the basin, between Ronse and Kwaadmechelen, but seems to be missing in the Mol borehole (Fig. 4, Tab. 2). The Mons-en-Pévèle Sand Member is a lateral equivalent of the Roubaix Clay Member.

Aalbeke Clay Member

No nannofossils are recorded from the Aalbeke Clay Member, except for one level in the Mol borehole sequence, somewhere in the middle part of the unit. A poorly preserved, low-diversity assemblage is encountered, attributable to STEURBAUT's subunit VIa, which corresponds to the middle part of MARTINI's NP12.

Kortemark Silt Member

The lowermost part of this member contains low-diversity assemblages, assignable to nanno-subzone VIa. The topmost 5 m are more diversified and belong to subzone VIb. The stratotype sequence is difficult to evaluate, because of almost complete decalcification. Only one level, some 8 m below the top of the unit, contains nannofossils, attributable to subunit VIa, and to the middle part of NP12.

Egem Sand Member

The topmost 3 m of the Egem Sand Member, encountered only in the Kallo borehole, belong to MARTINI's NP13 and to STEURBAUT's unit IX. The remainder is attributable to the upper part of MARTINI's NP12 and can be subdivided into units VII and VIII. The base of the Egem Sand Member seems to be slightly diachronous, being somewhat younger in the East (Mol borehole, nanno-unit VIII).

Panisel Sand Member

The stratotype section is completely decalcified and oxidized and devoid of nannofossils. Only a few interpretable nannofossil associations have been recorded from this member. The base is slightly diachronous, attributable to unit VII in the western area (Steenhuize-Wijnhuize), but belonging to unit VIII, somewhat more to the East (Schepdaal). The middle part is also calcareous and assignable to unit VIII. Consequently, the Panisel Sand Member is a lateral equivalent of the Egem Sand Member.

Merelbeke Clay Member

Not a single calcareous nannofossil has been recorded from this unit. The nannofossils from the underlying and overlying strata, however, indidate MARTINI's NP13.

Vlierzele Formation

Its lower part, the Pittem Clay Member, and the lowermost part of the overlying sands are attributable to nanno-unit X, which corresponds to the upper part of NP13. The upper part of the Vlierzele Formation, encountered only in the Ursel borehole, presents richer assemblages, which, if not contaminated, are assignable to MARTINI's NP14 and to the author's unit XI.

8. PALAEOGEOGRAPHY OF THE BELGIAN BASIN DURING YPRESIAN TIMES

In the Belgian Basin the Ypresian transgression advanced rapidly from Northwest to Southeast over an almost completely emerged and eroded "late Landenian" land area. Lagoonal sedimentation with organic-rich black clays and intercalated oyster and *Corbicula* beds (Oostende-ter-Streep Member) had continued only in the extreme North (Knokke, Kallo). These beds are correlated by DUPUIS, DE CONINCK and ROCHE (1984) with the basal beds of the London Clay Formation. The basal Ypresian transgressive event seems to correspond to important eustatic variations (see VAIL & HARDENBOL, 1979). Local tectonics may also have been involved (see DUPUIS *et al.*, 1984), the base of the Ypresian being diachronous, somewhat older in the North (Kallo) than in the more central and southern areas (see DUPUIS *et al.*, 1984; DE CONINCK, 1986).

The Ypresian sea reached its maximum extent in early Ypresian times, with a clayey depositional regime throughout the basin. Later on, probably due to a combination of local tectonic activity and minor sea-level changes, it was replaced, at least in the southeastern part of the basin, by sandy deposition (Mons-en-Pévèle Sand Member). Evidence for local tectonic activity is demonstrated in the Mons-en-Pévèle stratotype. Erosion of pre-Eocene deposits in the southern hinterland must have taken place because Cretaceous and Palaeocene nannofossils are abundant in the Mons-en-Pévèle nanno-associations. Additional evidence for tectonic activity is found in the northern part of the basin. The absence of nanno-subunit IIIb2 in that part of the basin seems to be due to a widespread sedimentary or erosional hiatus, probably resulting from tectonic adjustments of distinct blocks in the Brabant Massif. Evidence for sea-level lowering and possible emergence is found in the extreme southern part of the basin. In the Mont Panisel Hill sequence the upper part of the Mons-en-Pévèle Sand Member is absent (STEURBAUT, in press b). This regressive tendency is also reflected in the

Northwest (Kortrijk-area) through the appearance of high-energy deposits (sand layers) within the clayey sequence. In the extreme West, however, beyond the line Diksmuide-Brugge (see Fig. 2), depositional conditions remained almost unchanged and led to the deposition of a nearly uniform clayey sequence.

The base of the Aalbeke Clay Member is considered to represent the start of a second rather discontinuous transgressive event, because the Aalbeke Clay Member is absent in the southern Mont Panisel stratotype (due to non-deposition). This event is probably related to a minor sea-level rise. In the central part of the Belgian Basin, approximately North of the Westouter-Kortrijk-Mater-Beersel line (see Fig. 2), deposition between the base of the Aalbeke Clay Member and the upper part of the Egem Sand Member is nearly uninterrupted, although its rate was sometimes very slow or occasionally discontinued by local submarine erosion (presence of erosive channels). Further South, a major phase of very slow deposition with erosional intervals occurs at the top of the Aalbeke Clay Member (Moeskroen clay pit, Steenhuize-Wijnhuize borehole, etc.).

The basal, somewhat clayey beds of the Panisel Sand Member represent the maximum extension of the second transgressive event. They unconformably overlie the Aalbeke Clay Member (from Westouter to Schepdaal), or, in the extreme South (Mont Panisel), the Mons-en-Pévèle Sand Member. They seem, however, not to have crossed the line of the present River Dyle. The middle part of the Panisel Sand Member is highly glauconitic, indicating low sedimentation rates, and contains dark, organic-rich, lagoonal clays (e.g. at Schepdaal). These reflect a regressive tendency, which is also detectable in the western part of the basin. Evidence for the withdrawal of the sea is found in the Rodeberg borehole sequence (Westouter) where the uppermost beds of the Panisel Sand Member (present in the hills of southern West-Vlaanderen only) are oxidized, and are considered to correspond to a truncated palaeosol. It is also reflected in the more northern areas (Tielt, Egem), where the upper part of the Egem Sand Member and the entire Merelbeke Clay Member are absent. Obviously, the top of the Ieper Formation corresponds to a major hiatus, which occurs over most of the Belgian Basin. Only in the extreme North (Ursel-Kallo) did sedimentation continue. This major hiatus at the top of the Egem Sand Member was previously recognised by ISLAM (1983) and AUBRY (1985) and was correlated by them with erosional surfaces in the Paris and Hampshire-London Basins. It was thought to correspond to a major sea-level lowering (AUBRY, 1985:200). In the Belgian Basin it encompasses the top of NP12 and the base of NP13, and, consequently, falls within the Ypresian. It only spans a small interval and seems not to have had the same proportions as in the adjacent basins. It certainly does not correspond to the Early Eocene/Middle Eocene boundary (see STEURBAUT, 1988a).

The Ieper Formation-Vlierzele Formation boundary unconformity is followed by a third transgressive cycle that deposited the Vlierzele Formation. The sediments of the Vlierzele Formation must have covered large parts of the Belgian Basin, as they are present in the Rodeberg borehole sequence where they overlie the purple oxidation horizon on top of the Panisel Sand Member. Unfortunately, the Vlierzele Formation was eroded over most of the basin, and its previous extent thus cannot be established. However, it is preserved in the northern part of Oost-Vlaanderen, where it is bounded by various lignitic lenses known as the Aalterbrugge Lignitic Horizon. An important break in sedimentation between this horizon and the overlying Aalter Sand Member can be seen in the vicinity of Gent (DE CONINCK, 1976). To the Northwest (Ursel borehole) sedimentation continued somewhat longer, the hiatus being less important. The Aalterbrugge Lignitic Horizon, which seems to represent an important regressive phase, ends the Ypresian history of the Belgian Basin. Most evidence, however, especially in the eastern part of the basin, was obliterated by the Brusselian transgression, during which the Ypresian deposits were deeply eroded by strong tidal currents of the Brusselian sea (see HOUTHUYS & GULLENTOPS, 1985:16).

9. ALPHABETICAL LIST OF SPECIES AND REMARKS ON THEIR DISTRIBUTION

The Ypresian calcareous nannoflora of the Belgian Basin consists of 116 species, of which 12 have not been recorded previously by STEURBAUT & NOLF (1986, p. 165). All species are listed in alphabetical order according to the generic name now considered as correct (previous names used in STEURBAUT & NOLF (1986) are given in parentheses). The distribution of each species within MARTINI's standard nannoplankton zonation (1971: NP-zones) and within STEURBAUT's updated biostratigraphic scale (this paper: units I to XI) is given. The following notations are used: P.Y. (post-Ypresian) indicates that the species is also known from younger, post-Ypresian strata; I.... etc. to V.... etc. indicate that the species has been found in the interval from I.,... to, inclusive V.... etc. References to the illustrations in this paper (plates 1 to 5) are also added.

Aubrysphaera deconickii n. sp. (*Dactylethra* sp.): NP12 - IIIb2 to V (Pl. 1, Figs 16-24; Pl. 4, Figs 13-15.
Birkelunda sp.: NP12-VII, VIII.
Braarudosphaera bigelowii (Gran & Braarud, 1935): NP11, 12, 13, 14 - II, III, IV, VIII, X, XI — P.Y.
Braarudosphaera discula Bramlette & Riedel, 1954: NP13, 14 - X, XI — P.Y.
Calcidiscus aff. *protoannulus* (Gartner, 1971): NP11 - IIIa (Pl. 4, Fig. 8).
Cepekiella lumina (Sullivan, 1964): NP11, 12, 13, 14 — to IV, VI, VII, VIII, X, XI — P.Y.
Chiasmolithus consuetus (Bramlette & Sullivan, 1961): NP11, 12 — I to IIIb2 (Pl. 1, Figs 7, 12; Pl. 2, Figs 11-12).

Chiasmolithus eograndis Perch-Nielsen, 1971: NP11, 12 — I (top), II, IIIa, IIIb (Pl. 2, Fig. 5; Pl. 3, Fig. 9).
Chiasmolithus aff. *expansus* (Bramlette & Sullivan, 1961): NP12 — V, VI (Pl. 3, Fig. 4).
Chiasmolithus grandis Bramlette & Riedel, 1954: NP12 — VIII (Pl. 5, Fig. 17).
Chiasmolithus solitus (Bramlette & Sullivan, 1961): NP11, 12, 13, 14 — I to IIIa, V, VI, VII, X, XI — P.Y.
Chiasmolithus sp.: NP11 — IIIa1.
Chiphragmalithus armatus Perch-Nielsen, 1971: NP12 — VII, VIII (Pl. 5, Fig. 16).
Chiphragmalithus calathus Bramlette & Sullivan, 1961: NP11, 12 — IIa, IIIb, IV, V (Pl. 2, Fig. 23; Pl. 3, Fig. 5; Pl. 4, Fig. 18).
Cruciplacolithus cribellus Bramlette & Sullivan, 1961: NP11, 12, 13, 14 — IIIa, IIIb, XI (Pl. 2, Fig. 22).
Cruciplacolithus delus Bramlette & Sullivan, 1961: NP11, 12, 14 — IIIa, IIIb1, XI — P.Y.
Cruciplacolithus mutatus Perch-Nielsen, 1971: NP13, 14 — X, XI — P.Y. (Pl. 5, Fig. 29).
Cruciplacolithus sp.: NP11, 12, 13, 14 — IIIa, IIIb, IV, VII, X, XI — P.Y.
Cyclolithus bramlettei Hay & Towe, 1962: NP11, 12, 13 — IIb, III, IV, VII to X.
Discoaster barbadiensis Tan Sin Hok, 1927: NP11, 12, 14 — II, IIIa, IIIb, XI — P.Y. (Pl. 4, Fig. 21).
Discoaster bifax Bukry, 1971: NP14 — XI — P.Y.
Discoaster binodosus Martini, 1958: NP11, 12, 13 — I to IV, VI to VIII, X — P.Y. (Pl. 3, Fig. 10).
Discoaster crassus Martini, 1958: NP12, 13 — VII, X.
Discoaster cruciformis Martini, 1958: NP12, 13 — VIII, IX.
Discoaster deflandrei Bramlette & Riedel, 1954: NP14 — XI — P.Y.
Discoaster diastypus Bramlette & Sullivan, 1961: NP11 — I, II, IIIa1 (Pl. 1, Fig. 4).
Discoaster distinctus Martini, 1958: NP12, 13 — VI, VII, VIII, X — P.Y.
Discoaster elegans Bramlette & Sullivan, 1961: NP11, 12 — I (top) to VII — P.Y. (Pl. 5, Fig. 10).
Discoaster gemmifer Stradner, 1961: NP12, 13 — IIIb, IV, VII, VIII, X.
Discoaster gemmeus Stradner, 1959: NP11 — II, IIIa.
Discoaster kuepperi Stradner, 1959: NP11, 12, 13, 14 — I to XI — P.Y.
Discoaster lodoensis Bramlette & Riedel, 1954: NP12, 13, 14 — IIIb1 to XI — P.Y. (Pl. 2, Fig. 8; Pl. 4, Fig. 19; Pl. 5, Figs 4, 5, 9).
Discoaster minimus Sullivan, 1964: NP12 — VI.
Discoaster mirus (Deflandre in Grassé, 1952): NP12, 13 — VI, X (Pl. 5, Fig. 12).
Discoaster multiradiatus Bramlette & Riedel, 1954: NP11 — I (Pl. 1, Fig. 1).
Discoaster nonaradiatus Klumpp, 1953: NP13 — X — P.Y.
Discoaster ornatus Stradner, 1958: NP11, 12 — IIIa, VIII.
Discoaster robustus Haq, 1969: NP11 — II.
Discoaster stradneri Martini, 1961: NP14 — XI — P.Y.
Discoaster tanii Bramlette & Riedel, 1954: NP12 — VIb to VIII — P.Y.
Discoaster wemmelensis Achutan & Stradner, 1967: NP14 — XI — P.Y.
Discoaster sp.: NP11 — II.
Ellipsolithus macellus (Bramlette & Sullivan, 1961): NP11 — I, II, IIIa (Pl. 2, Fig. 6-7; Pl. 3, Fig. 8; Pl. 4, Fig. 12).
Ericsonia eopelagia (Bramlette & Riedel, 1954): NP11, 12, 13, 14 — I to XI — P.Y.
Ericsonia fenestrata (Deflandre & Fert, 1954): NP14 — XI — P.Y.
Ericsonia formosa (Kamptner, 1963): NP11, 12, 13, 14 — IIIa, VIb to IX, XI — P.Y.
Hayella sp. *(Cyclococcolithus* sp.): NP12 — IIIb2, VII (Pl. 2, Figs 24-25).
Helicosphaera seminulum Bramlette & Sullivan, 1961: NP12 — VII, VIII, IX — P.Y.
Holodiscolithus sp.: NP11 — IIIa1 (Pl. 1, Fig. 15).
Imperiaster obscurus (Martini, 1958): NP11, 12, 13 — I to IX.
Imperiaster sp.: NP13 — X.
Inc. sed. sp.: NP12, 13 — VIb to IX (Pl. 5, Fig. 11).
Lanternithus minutus Stradner, 1962: NP14 — XI — P.Y.
Lophodolithus nascens Bramlette & Sullivan, 1961: NP11, 12 — IIb to IIIb2 (Pl. 2, Fig. 4).
Lophodolithus reniformis Bramlette & Sullivan, 1961: NP12 — VIb.
Markalius inversus (Deflandre in Deflandre & Fert, 1954): NP11, 12, 13, 14 — I to XI — P.Y.
Micrantholithus aequalis Sullivan, 1964: NP11, 12 — II, III, IV, VII.
Micrantholithus flos Deflandre in Deflandre & Fert, 1954: NP12, 13, 14 — VII, X, XI — P.V.
Micrantholithus inaequalis Martini, 1961: NP11, 12, 13, 14 — II, VIII, X, XI (Pl. 5, Fig. 25).
Micrantholithus mirabilis Locker, 1965: NP12 — IIIb2 to V, VII (Pl. 2, Fig. 13; Pl. 3, Figs 1-3).
Micrantholithus cf. *pinguis* Bramlette & Sullivan, 1961: NP12 — IV, VII.
Micrantholithus vesper Deflandre, 1954: NP12, 13, 14 — IV, V, VII, VIII, X, XI — P.Y.
Naninfula dupuisii n. sp.: NP11 — IIIa1 (Pl. 2, Figs 1-3; Pl. 4, Figs 1-4).
Naninfula sp.: NP11 — IIIa1 (Pl. 3, Fig. 22).
Nannoturba robusta Müller, 1979: NP12, 13, 14 — VIII to XI — P.Y. (Pl. 5, Fig. 27).
Nannoturba spinosa Müller, 1979: NP13 — X (Pl. 5, Fig. 28).
Neochiastozygus concinnus (Martini, 1961): NP11, 12 — II, IIIa, IIIb (Pl. 3, Fig. 11).
Neochiastozygus distentus (Bramlette & Sullivan, 1961): NP11 — IIIa.
Neochiastozygus junctus (Bramlette & Sullivan, 1961): NP11 — IIIa1 (Pl. 4, Fig. 7).
Neochiastozygus perfectus Perch-Nielsen, 1971: NP12 — IIIb.
Neococcolithes dubius (Deflandre, 1954): NP11, 12, 13, 14 — I to VIII, X, XI — P.Y.
Neococcolithes protenus (Bramlette & Sullivan, 1961): NP11, 12, 13 — I to IV, VI, VIII, X — P.Y.
Pemma sp.: NP14 — XI — P.Y.
Pentaster sp.: NP11, 12 — II to IV (base) (Pl. 4, Fig. 22).
Pontosphaera excelsa (Perch-Nielsen, 1971): NP12 — IIIb3 (Pl. 4, Fig. 20).

Pontosphaera exilis (Bramlette & Sullivan, 1961): NP11, 12 — I to IV (Pl. 4, Figs 5-6).
Pontosphaera fimbriata (Bramlette & Sullivan, 1961): NP11, 12, 13, 14 — I to VIII, IX, X, XI — P.Y. (Pl. 1, Figs. 2, 5; Pl. 2, Figs 9-10; Pl. 5, Fig. 20).
Pontosphaera kingii n. sp.: NP11 — IIIa1, IIIa2 (Pl. 3, Fig. 19).
Pontosphaera multipora (Kamptner, 1948): NP 13, 14 — X, XI — P.Y.
Pontosphaera obliquipons (Deflandre in Deflandre & Fert, 1954): NP13, 14 — X, XI — P.Y.
Pontosphaera ocellata (Bramlette & Sullivan, 1961): NP11, 13 — IIIa2, X — P.Y.
Pontosphaera pectinata (Bramlette & Sullivan, 1961): NP11, 12, 13, 14 — I (top) to IIIb3, X, XI — P.Y.
Pontosphaera plana (Bramlette & Sullivan, 1961): NP11 — II, IIIa1.
Pontosphaera pulchra (Deflandre in Deflandre & Fert, 1954): NP11, 12, 13, 14 — II (top) to XI — P.Y. (Pl. 2, Fig. 19).
Pontosphaera punctosa (Bramlette & Sullivan, 1961): NP11, 12, 13 — IIIa, IIIb, IV, V, VIII, X.
Pontosphaera scissura (Perch-Nielsen, 1971): NP11, 12 — IIIa, IIIb.
Pontosphaera versa (Bramlette & Sullivan, 1961): NP11 — II, IIIa.
Pontosphaera sp.: NP11, 12 — II to V.
Reticulofenestra callida (Perch-Nielsen, 1971): NP14 — XI — P.Y.
Reticulofenestra umbilica (Levin, 1965): NP14 — XI — P.Y.
Reticulofenestra sp.: NP12, 13, 14 — VIb to XI (Pl. 5, Fig. 21).
Rhabdosphaera crebra Deflandre in Deflandre & Fert, 1954: NP12, 14 — VII, XI — P.Y. (Pl. 5, Fig. 24).
Rhabdosphaera morionum (Deflandre in Deflandre & Fert, 1954): NP11, 12 — IIIa, IIIb.
Rhabdosphaera sola Perch-Nielsen, 1971: NP11, 12 — II to IIIb3 (Pl. 1, Figs. 10-11; Pl. 3, Figs 20-21).
Rhabdosphaera truncata Bramlette & Sullivan, 1961: NP11, 12 — IIIa1, IIIa2, IIIb2 (Pl. 2, Figs 14-16; Pl. 4, Figs 9-11).
Rhabdosphaera vitrea Deflandre in Deflandre & Fert, 1954: NP11, 12 — II, IIIa, IIIb, IV, VI to VIII — P.Y.
Rhadosphaera sp.: NP11, 12 — IIIa, V, VII, VIII.
Scapholithus apertus Hay & Mohler, 1967: NP12 — VII.
Semihololithus kerabyi Perch-Nielsen, 1971: NP11, 12 — II, IIIa, IIIb, IV (Pl. 1, Fig. 9; Pl. 3, Fig. 7).
Sphenolithus anarrhopus Bukry & Bramlette, 1969: NP11, 12 — I to IV.
Sphenolithus editus Perch-Nielsen, 1978: NP11, 12 — II, IIIa, IV.
Sphenolithus moriformis (Brönnimann & Stradner, 1960): NP11, 12 — II to V, VII, VIII — P.Y.
Sphenolithus radians Deflandre, 1952: NP11, 12, 13, 14 — I to VII, X, XI.
Sphenolithus spiniger Bukry, 1971: NP14 — XI — P.Y.
Toweius gammation (Bramlette & Sullivan, 1961): NP13, 14 — X, XI.
Toweius magnicrassus (Bukry, 1971): NP 11, 12 — I to V (Pl. 1, Fig. 8; Pl. 2, Fig. 20; Pl. 4, Figs 16-17).
Toweius occultatus (Locker, 1967): NP11, 12, 13, 14 — I to XI (Pl. 5, Fig. 13).
Toweius pertusus (Sullivan, 1965): NP11, 12 — I to V (Pl. 3, Fig. 23).
Toweius sp.: NP11, 12, 13 — II, III, IV, V, X (Pl. 2, Figs 17-18).
Tribrachiatus orthostylus Shamrai, 1963: NP11, 12 — I to VIII (Pl. 1, Figs 3, 6; Pl. 5, Fig. 23).
Trochoaster operosus (Deflandre, 1954) (*Lithostromation operosum*): NP 12, 13, 14 — VII, X, XI — P.Y.
Zygrhablithus bijugatus s. 1 (Deflandre, 1959): NP 11, 12, 13, 14 — II to VIII, X, XI — P.Y. (Pl. 2, Fig. 21; Pl. 3, Fig. 6; Pl. 5, Figs 1-3, 6, 7, 8, 14, 15, 18, 19, 22, 26).
Zygrhablithus bijugatus subsp. *nolfii* n. subsp.: NP 11 — IIb2, IIIa1 (Pl. 1, Figs 13-14; Pl. 3, Figs 14-18).
Zyghrablithus crassus Locker, 1967: NP14 — XI — P.Y.
Zygodiscus adamas Bramlette & Sullivan, 1961: NP11 — IIIa (Pl. 3, Fig. 13).
Zygodiscus plectopons Bramlette & Sullivan, 1961: NP11 — IIIa (Pl. 3, Fig. 12).

10. DESCRIPTION OF NEW TAXA

Genus: *Aubrysphaera* n. gen.

Type-species: *Aubrysphaera deconinckii* n. sp.

Derivatio nominis. — In honour of Dr. M.-P. AUBRY (Lyon, France), author of the "Handbook of Cenozoic Calcareous Nannoplankton".

Diagnosis. — This genus is introduced for dome-shaped, porous nannoliths, consisting of a hollow construction of bifurcating ribs, which in certain orientations show high birefringence in cross-polarised light.

Remarks. — *Aubrysphaera* differs from other holococcolithid genera by its typical dome-shaped outline and by its hollow construction, which, in certain orientations, show high birefringence under crossed nicols. There is a certain similarity of shape and construction between this genus and *Trochoaster* KLUMPP, 1953. The latter, however never exhibits birefringence under crossed nicols (see AUBRY, 1988, p. IV). This difference in optical behaviour cannot be due to secondary calcification because representatives of *Trochoaster* which show no birefringence (e.g. *T. operosus*) are also found in the same samples and slides. *Aubrysphaera* also seems to be related to the genus *Dactylethra* GARTNER, 1969. The type species of this monospecific genus *D. punctulata* GARTNER, 1969, however, has a solid construction with a completely enclosed centre which is filled with calcite (see GARTNER & BUKRY, 1969, p. 1219). It also seems to be formed of several crystals of calcite, which act differently in cross-polarised light, some of them showing maximum and others minimum birefringence.

Only one species is known, the type species *Aubrysphaera deconinckii*. It is recorded from various exposures and boreholes in the Ypresian of the Belgian Basin.

Aubrysphaera deconinckii n. sp.
(Pl. 1, Figs. 16-24; Pl. 4, Figs 13-15)

1986 *Dactylethra* sp. — STEURBAUT & NOLF, p. 165.

Holotype. — Pl. 1, Fig. 22 (negatives Laboratorium voor Paleontologie, R.U. Gent, Belgium).

Locus typicus. — Kruishoutem borehole (84E-1362/I), Belgium (x = 90.600; y = 177.350); 41.50m depth.

Stratum typicum. — Ieper Formation, Roubaix Clay Member; nanno-zone IIIb2, lower part NP12.

Age. — Ypresian.

Paratypes. — Pl. 1, Figs 16-21, 23-24; Pl. 4, Figs 13-15 (negatives Lab. voor Paleontologie, R.U. Gent, Belgium).

Derivatio nominis. — In honour of my friend and colleague Dr. J. DE CONINCK (Gent), author of a very detailed dinoflagellate-zonation of the Belgian Ypresian.

Diagnosis. — Dome-shaped, porous, bilateral symmetric body, consisting of a rather flat basal face with single large opening and a hollow construction of robust bifurcating ribs.

Description. — *Aubrysphaera deconinckii* is a dome-shaped nannolith, with somewhat variable outline, ranging from perfectly round to more rectangular forms. It consists of a flat basal face with single large opening (see Pl. 1, Figs 16a, 17b, 19 and 22c) and a hollow construction of robust ribs. These ribs form a central bridge on top of the uppermost face, which encloses two small circular openings on top and two larger elliptical depressions laterally (see Pl. 1, Figs 22b, 23, 24; Pl. 4, Fig. 13). In this view, the nannolith resembles an owl's face, with two protruding heavy eyesockets (Pl. 4, Figs 13 and 15). The lateral depressions are best observed in lateral view, in planes perpendicular to the axis of symmetry of the nannolith, which is vertical in standard orientation (Pl. 1, Fig. 20). In cross-polarised light the specimens act as single crystals, showing maximum birefringence viewed at 45° and nearly no or extremely low birefringence parallel to the polarisation directions.

Dimensions. — Length: 9 to 10μm, width: 8 to 10μm and heighth: 8μm (Holotype: L = 10μm; W = 10μm; H = 8μm).

Remarks. — This species was originally listed by STEURBAUT & NOLF (1986, p. 165) as *Dactylethra* sp., because it most closely resembles *Dactylethra punctulata* GARTNER, 1969. There are, however, some important structural differences between both species (see description of *Aubrysphaera*), which actually seem to exclude a close relationship. *A. deconinckii* is also rather similar to *Trochoaster operosus* (DEFLANDRE, 1954), especially in shape and construction, but differs fundamentally in optical behaviour.

Distribution. — Up to now this species has only been recorded from the Ypresian of the Belgian Basin, where it seems to be restricted to the lower part of NP12. It defines the base of subzone IIIb2, in which it is also fairly well represented; rare in subzones IIIb3; IV and V.

Genus: _Naninfula_ PERCH-NIELSEN, 1968

Type species: *Naninfula deflandrei* PERCH-NIELSEN, 1968.

Remarks. — The genus *Naninfula* was redefined by PERCH-NIELSEN in 1971 (p. 50) to include small hat-shaped nannoliths with a single basal plate. Some 5 species, of which several are new, are known from the Belgian Eocene (STEURBAUT, in prep.).

Naninfula dupuisii n. sp.
(Pl. 2, Figs 1-3; Pl. 4, Figs 1-4)

Holotype. — Pl. 4, Fig. 3 (negatives, Lab. voor Paleontologie, R.U. Gent, Belgium).

Locus typicus. — Mol borehole (31W-237), Belgium (x = 198.350, y = 211.750); 388.50m depth.

Stratum typicum. — Ieper Formation, Mons-en-Pévèle Sand Member; nanno-zone IIIa1, upper part NP11.

Age. — Ypresian.

Paratypes. — Pl. 2, Figs 1-3; Pl. 4, Figs 1, 2 and 4 (negatives, Lab. voor Paleontologie, R.U. Gent, Belgium).

Derivatio nominis. — In honour of Dr. C. DUPUIS (Mons, Belgium), co-editor of the special volume on the Ypresian of the Belgian Basin.

Diagnosis. — Small, hat-shaped, gently tapering nannolith consisting of a single basal plate, a rather high collar and a conical process composed of helicoidally arranged, lath-like elements.

Description. — *Naninfula dupuisii* is a rather small, hat-shaped, gently tapering nannolith. The single basal plate is rather wide, subcircular and may consist of more than one cycle of elements (difficult to evaluate with Light Microscope techniques!). The central process has a conical outline and seems to be composed of helicoidally arranged lath-like elements, which in cross-polarised light form a tapering helicoidal structure (see Pl. 2, Figs 2 and 3). Central process and base are connected through a rather high, distinct collar, which seems to consist of two concentric cycles of elements (see Pl. 2, Fig. 3 and Pl. 4, Fig. 3). Viewed in cross-polarised light with a gypsum plate inserted in the light-beam (1 λ), these forms show typical coloured sectors, which can best be observed in non-standard orientation (= central axis of nannolith making an angle with the polarisation directions). In these orientations the central process shows an uniform colour (bleu or yellow, depending on the orientation) whereas the collar and the external part of the basal plate have the same colour, opposite to that of the central process.

Dimensions. — Height: 6 to 7 μm; width: 4 to 4.50μm (holotype: H = 7 μm; W = 4.50 μm).

Remarks. — *Naninfula dupuisii* differs from the type species *Naninfula deflandrei* by its more elongated outline. A more detailed comparative analysis cannot be given as no S.E.M. micrographs of *N. dupuisii* are available at the moment. *N. dupuisii* can be distinguished from the other Ypresian form *Naninfula* sp. (Pl. 3, Fig. 22) by its more elongated outline.

Distribution. — Only known from outcrops (Bossuit Canal Section, Mons-en-Pévèle stratotype) and boreholes (see Tables 1, 2, 4 and 5) in the Ypresian of the Belgian Basin; restricted to nannozone IIIa1, upper part of NP11.

Genus: *Pontosphaera* LOHMANN, 1902

Type species: *Pontosphaera syracusana* LOHMANN, 1902.
Remarks. — The genus *Pontosphaera* is used for elliptical plate - like nannoliths, including forms with large central openings (previously grouped in the genus *Transversopontis*), with distinct distal flange (*Koczyia*) and flat forms with small openings or slits (*Discolithina*).

Pontosphaera kingii n. sp.
(Pl. 3, Fig. 19)

Holotype. — Pl. 3, Fig. 19 (negatives, Lab. voor Paleontologie, R.U. Gent, Belgium).
Locus typicus. — Mol borehole (31W-237), Belgium (x = 198.350, y = 211.750); 386.80 m depth.
Stratum typicum. — Ieper Formation, Mons-en-Pévèle Sand Member; nanno-zone IIIa2, top of NP11.
Age. — Ypresian.
Paratypes. — A few eroded non-figured specimens.
Derivatio nominis. — In honour of Dr. C. KING (Watford, England) who contributed much to our knowledge of the Ypresian in the North Sea Basin.
Diagnosis. — Small plate-like nannolith, with raised margin supported by 18 to 22 rather slender struts and two somewhat oblique slits in the foci of the ellipse.
Description. — This species is characterised by its raised margin, 18 to 22 well-developed struts and by two slits almost in the foci of the ellipse. The slits are somewhat oblique compared to the central axis of the plates and both show, at the end which is pointed to the centre, a small incurvation towards the margin. In cross-polarised light the extinction lines present a V-shaped pattern and are laevogyre when viewed at 45° to the polarisation directions (Pl. 3, Fig. 19d). Viewed at 90° (Pl. 3, Fig. 19c) the extinction bands follow the axes of the ellipse, as a broad rather diffuse band along the small axis and a much thinner, sharp band along the long axis.
Dimensions. — Length: 9 to 10μm (holotype: 10μ).
Remarks. — This species is somewhat similar to *Pontosphaera pectinata* (BRAMLETTE & SULLIVAN, 1961) as far as the general shape and construction of the struts is concerned. However, *P. pectinata* does not have slits, but shows a pair of small elliptical openings at the foci of the ellipse (see BRAMLETTE & SULLIVAN, 1961, p. 142, pl. 3, figs 4 & 5).
Distribution. — Only known from nanno-zones IIIa1 and IIIa2 (= topmost part of NP11) of the Ypresian of the Belgian Basin.

Genus: *Zygrhablithus* DEFLANDRE, 1959

Type species: *Zygrhablithus bijugatus* (DEFLANDRE, 1954).
Remarks. — See AUBRY (1988, p. 199) for descriptions, taxonomic analysis and illustrations of this genus.

Zygrhablithus bijugatus subsp. *nolfii* n. subsp.
(Pl. 1, Figs 13-14; Pl. 3, Figs 14-18)

Holotype. — Pl. 3, Fig. 14 (negative Lab. voor Paleontologie, R.U. Gent, Belgium).
Locus typicus. — Mol borehole (31W-237), Belgium (x = 198.350, y = 211.750); 394.70 m depth.
Stratum typicum. — Ieper Formation, Mons-en-Pévèle Sand Member; nanno-zone IIIa1, upper part NP11.
Age. — Ypresian.
Paratypes. — Pl. 1, Figs. 13-14; Pl. 3, Figs 15-18 (negatives Lab. voor Paleontologie, R.U. Gent, Belgium).
Derivatio nominis. — In honour of my friend and colleague Dr. D. NOLF (Brussel) to commemorate the decennial of our fruitful scientific collaboration.
Diagnosis. — Cubical, somewhat truncated nannoliths with a conspicuous notch in the raised side of the cube and a medial groove.
Description. — *Z. bijugatus nolfii* is characterised by its robust, somewhat truncated, cubical outline and by the presence of a rather wide medial groove. Almost in the middle of the raised sides of the cube is a conspicuous notch. This new subspecies also shows birefringence between crossed nicols. Several distinct areas with similarly oriented crystals can be distinguished, which optically react as single crystals. Some of them show maximum birefringence, whereas others minimum birefringence, depending on the orientation of the nannolith.
Dimensions. — Width: 5 to 7μm; Height: 4 to 6μm (holotype: W = 6μm; H = 7μm).
Remarks. — *Z. bijugatus nolfii* is separated from *Z. bijugatus* on the basis of its cubical, truncated shape and the presence of a rather wide medial groove. The publication of the name of the subspecies *Z. bijugatus nolfii* automatically establishes the name of another subspecies *Z. bijugatus bijugatus*, according to article 26.2 of the International Code of Botanical Nomenclature (1978, p. 25-26). However, from our personal observations it can be concluded that *Zygrhablithus bijugatus* is composed of more than two subspecies but, as its taxonomy is not completely worked out yet, we retain the term "*Zygrhablithus bijugatus* s.l." for all subspecies of *Z. bijugatus*, except *Z. bijugatus nolfii*.
Distribution. — Only known from the Ypresian of the Belgian Basin: restricted to nanno-zones IIb2 and IIIa1, of which it respectively defines the base and the top; upper part of NP11.

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TABLE 1

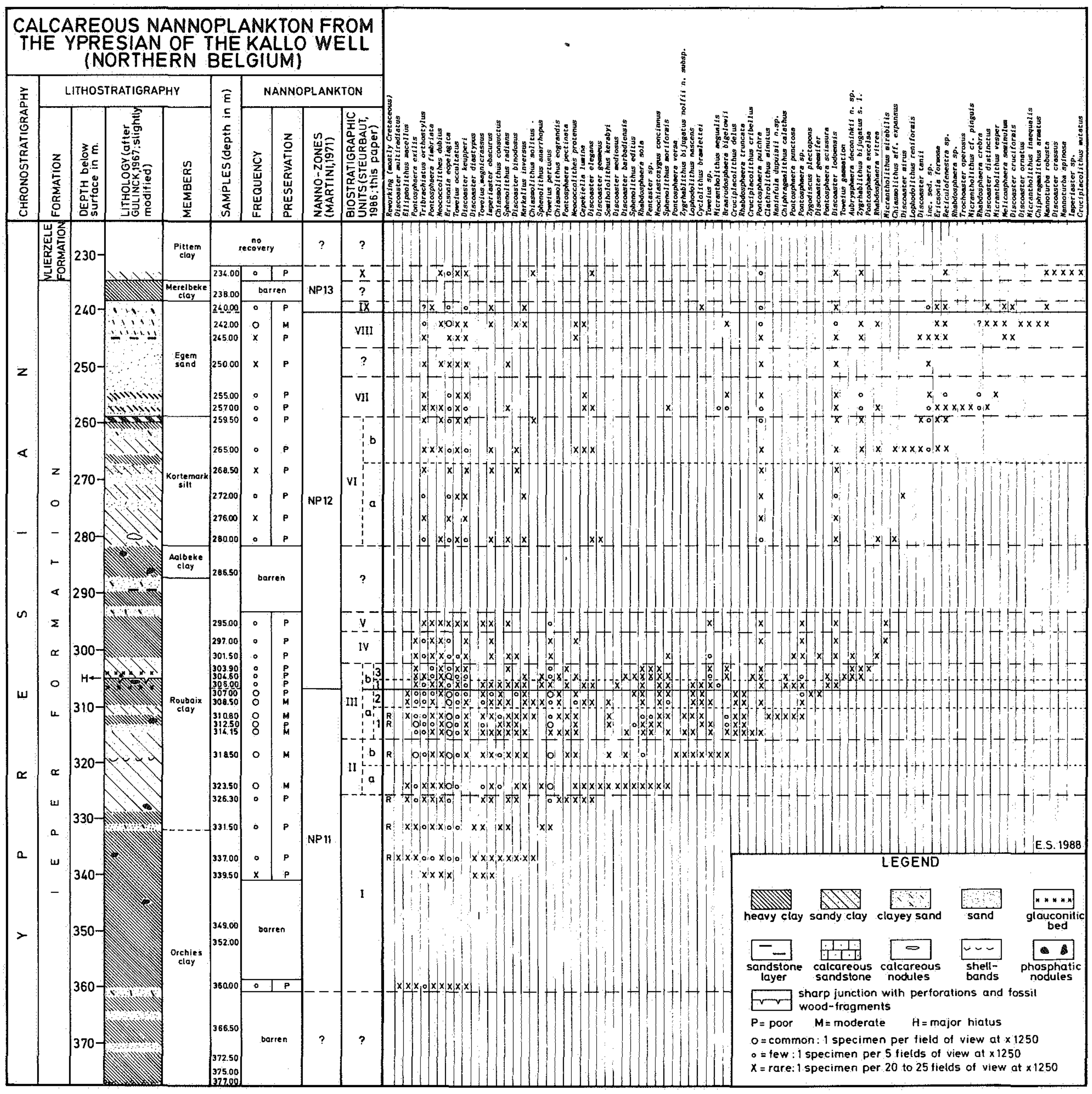

CALCAREOUS NANNOPLANKTON FROM THE YPRESIAN OF THE KALLO WELL (NORTHERN BELGIUM)
CHRONOSTRATIGRAPHY
LITHOSTRATIGRAPHY
FORMATION
DEPTH below surface in m.
LITHOLOGY (after GULINCK, 1967; slightly modified)
MEMBERS
SAMPLES (depth in m)
NANNOPLANKTON
FREQUENCY
PRESERVATION
NANNO-ZONES (MARTINI, 1971)
BIOSTRATIGRAPHIC UNITS (STEURBAUT, 1986; this paper)
YPRESIAN
VLIERZELE FORMATION
IEPER FORMATION
Pittem clay
Merelbeke clay
Egem sand
Kortemark silt
Aalbeke clay
Roubaix clay
Orchies clay
no recovery
barren
NP13
NP12
NP11
E.S. 1988
LEGEND
heavy clay
sandy clay
clayey sand
sand
glauconitic bed
sandstone layer
calcareous sandstone
calcareous nodules
shell-bands
phosphatic nodules
sharp junction with perforations and fossil wood-fragments
P= poor
M= moderate
H= major hiatus
O= common: 1 specimen per field of view at x1250
o = few: 1 specimen per 5 fields of view at x1250
X= rare: 1 specimen per 20 to 25 fields of view at x1250

TABLE 2

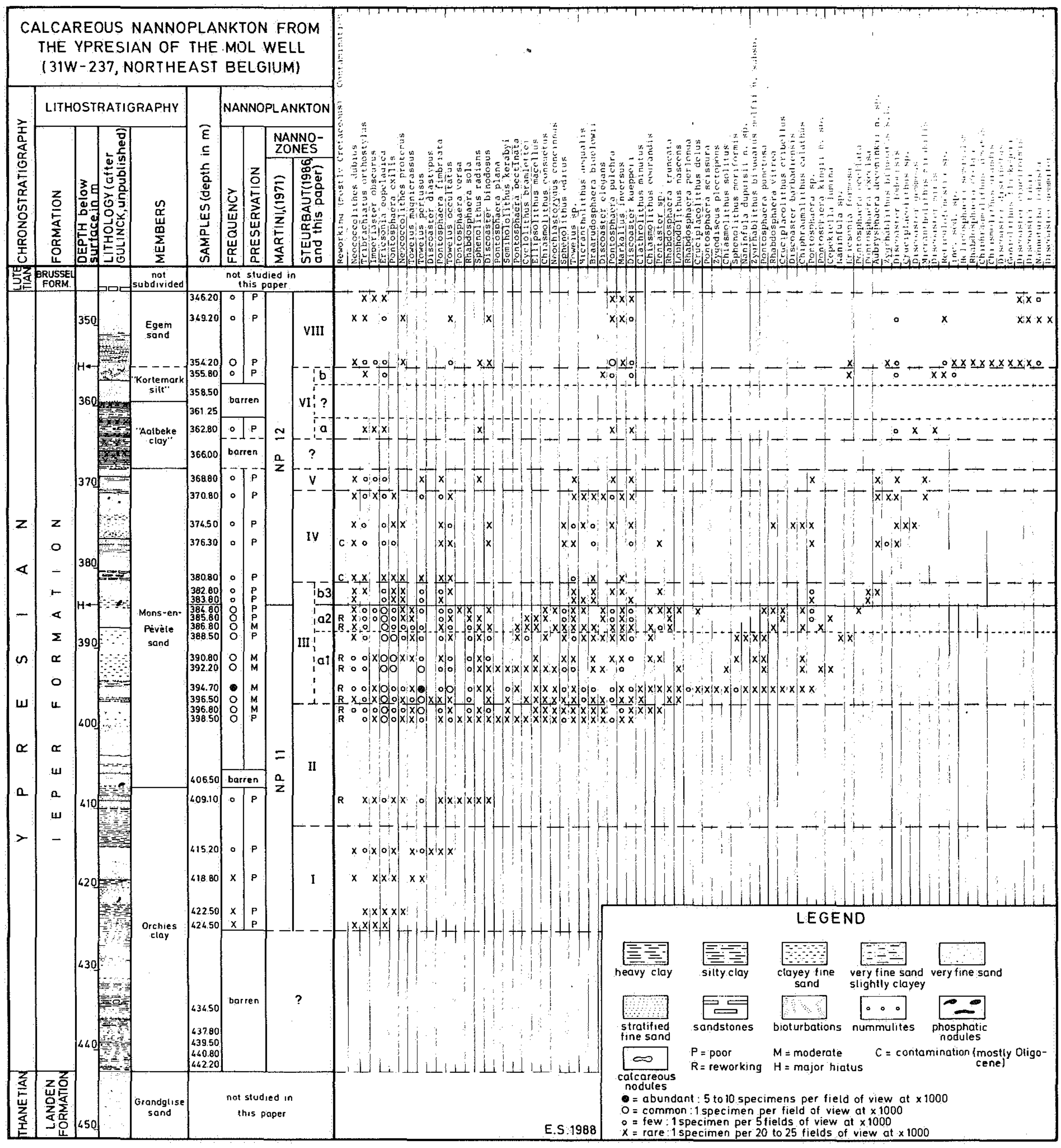

CALCAREOUS NANNOPLANKTON FROM THE YPRESIAN OF THE MOL WELL (31W-237, NORTHEAST BELGIUM)
CHRONOSTRATIGRAPHY
LITHOSTRATIGRAPHY
FORMATION
DEPTH below surface in m
LITHOLOGY (after GULINCK, unpublished)
MEMBERS
SAMPLES (depth in m)
NANNOPLANKTON
FREQUENCY
PRESERVATION
NANNO-ZONES
MARTINI (1971)
STEURBAUT (1986 and this paper)
LUTETIAN
BRUSSEL FORM.
not subdivided
not studied in this paper
YPRESIAN
IEPER FORMATION
Egem sand
"Kortemark silt"
"Aalbeke clay"
Mons-en-Pévèle sand
Orchies clay
barren
NP 12
NP 11
VIII
VI
V
IV
III
II
I
THANETIAN
LANDEN FORMATION
Grandglise sand
E.S.1988
LEGEND
heavy clay
silty clay
clayey fine sand
very fine sand slightly clayey
very fine sand
stratified fine sand
sandstones
bioturbations
nummulites
phosphatic nodules
calcareous nodules
P = poor
M = moderate
C = contamination (mostly Oligocene)
R = reworking
H = major hiatus
● = abundant : 5 to 10 specimens per field of view at x1000
O = common : 1 specimen per field of view at x1000
o = few : 1 specimen per 5 fields of view at x1000
X = rare : 1 specimen per 20 to 25 fields of view at x1000

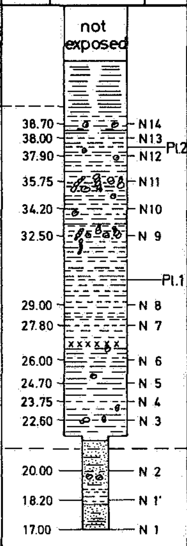
TABLE 3

CALCAREOUS NANNOFOSSILS FROM THE BOSSUIT CANAL SECTION, LECTOSTRATOTYPE OF THE ROUBAIX CLAY MEMBER MOEN, W.-FLANDERS BELGIUM.

CHRONOSTRATIGRAPHY: Y P R E S I A N

LITHOSTRATIGRAPHY: I E P E R F O R M A T I O N — Roubaix Clay Member; Aalbeke Clay Member (not exposed)

SECTION STUDIED IN STEURBAUT & NOLF, 1986

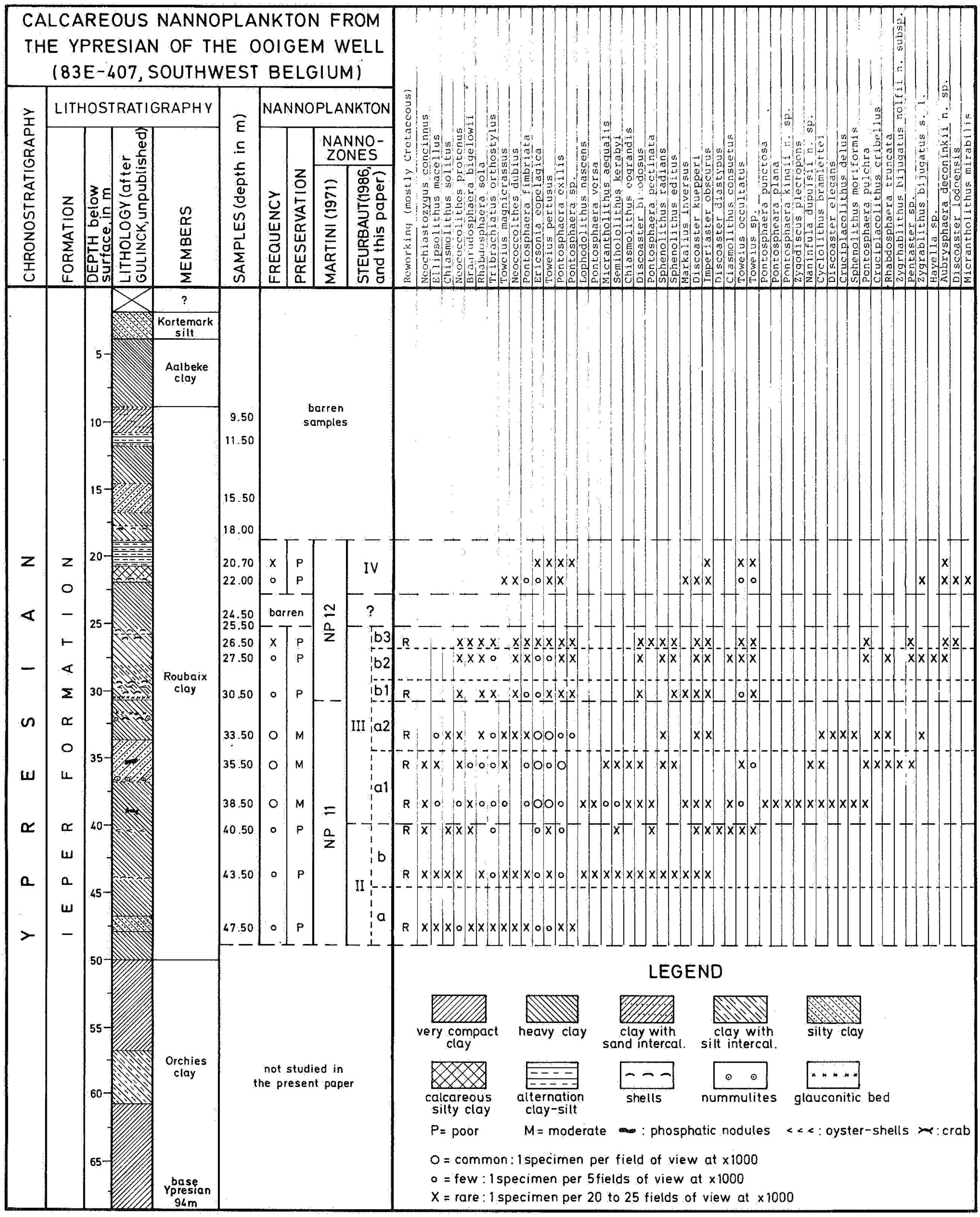


SAMPLES	HEIGHT in m.	LITHOSTRATIGRAPHY	NANNOPLANKTON ZONES: MARTINI (1971)	STEURBAUT (this paper)	PRESERVATION	ABUNDANCE
N14	38.70	Roubaix Clay Member		barren		
N13	38.00	Roubaix Clay Member		barren		
N12	37.90	Roubaix Clay Member		barren		
N11	35.75	Roubaix Clay Member	NP 12	IIIb 3	P	X
N10	34.20	Roubaix Clay Member	NP 12	IIIb 2	P	o
N 9	32.50	Roubaix Clay Member	NP 12	IIIb 2	P	o
N 8	29.00	Roubaix Clay Member	NP 12	IIIb 1	P	O
N 7	27.80	Roubaix Clay Member	NP 12	IIIb 1	P	o
N 6	26.00	Roubaix Clay Member	NP 11	IIIa 2	P	o
N 5	24.70	Roubaix Clay Member	NP 11	IIIa 2	P	o
N 4	23.75	Roubaix Clay Member	NP 11	IIIa 2	P	o
N 3	22.60	Roubaix Clay Member	NP 11	IIIa 2	M	O
N 2	20.00	Roubaix Clay Member	NP 11	IIIa 1	P	o
N 1'	18.20	Roubaix Clay Member	NP 11	IIIa 1	M	O
N 1	17.00	Roubaix Clay Member	NP 11	II b	P	o

Species	N1	N1'	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11
Discoaster diastypus	X											
Discoaster robustus	X											
Micrantholithus inaequalis	X											
Discoaster elegans	X			X	X			X				
Neochiastozygus concinnus	X		X				X	X				
Toweius magnicrassus	X	X	X	o	X	X			X	X		
Chiasmolithus consuetus	X	X		X		X		X	X	X	X	
Semihololithus kerabyi	X			X		X			X		X	
Ericsonia eopelagica	o	O	o	O	o	o	o	o	O	o	o	X
Tribrachiatus orthostylus	o	X	X	o	X	X	X	o	O	X	o	X
Toweius occultatus	o	X	X	O	X	X	X	X	o	X	X	X
Toweius pertusus	o	o	o	O	X	o	o	X	o	o	o	X
Pontosphaera exilis	X	O	o	O	o	X	X		X	X	X	X
Pontosphaera fimbriata	X	o	X	o	X	X	X	X	o	X	X	X
Rhabdosphaera sola	o	o	X	o	X	X	X	X	X	X	X	X
Discoaster binodosus	X	X	X	X	X	X	X	X	X			X
Neococcolithes dubius	X		X	X				X	X	X	X	X
Markalius inversus	X	X	X	X			X	X	X	X	X	X
Discoaster kuepperi	X	o		X		X	X	o	o	X	o	X
Imperiaster obscurus	X			X		X	X	X	X		X	X
Naninfula dupuisii n. sp.		X										
Discoaster barbadiensis		o										
Zygrhablithus bijugatus nolfii n. sp.		X		X								
Zygodiscus plectopons		X		X								
Sphenolithus editus		X		o		X		X				
Pontosphaera punctosa		X	X						X			
Micrantholithus aequalis		o	X	X						X		
Pentaster sp.		X	X							X		
Braarudosphaera bigelowii		X	X	X						o	X	
Rhabdosphaera truncata		X		X	X		X			X	X	
Cyclolithus bramlettei		X	X	X	X	X	X	X	X		X	
Chiphragmalithus calathus		X		X							X	
Neococcolthes protenus		X		X	X	X	X		X	X	X	X
Pontosphaera pulchra		X	X	X			X			X		X
Sphenolithus radians		X	X	X			X		X	X	X	X
Toweius sp.		X	X		X		X	X		X	X	X
Chiasmolithus solitus			X									
Sphenolithus anarrhopus			X	X	X	X	X					
Sphenolithus moriformis			X		X		X	X	X			
Rhabdosphaera perlonga				X								
Holodiscolithus sp.				X								
Zygodiscus adamas				X								
Pontosphaera pectinata				X		X						
Ellipsolithus macellus				X		X	X					
Chiasmolithus eograndis				X		X		X	X			
Cruciplacolithus delus				X				X	X			
Lophodolithus nascens				X			X	X	X		X	
Cruciplacolithus cribellus				X			X	X			X	
Pontosphaera sp.				X	X	X	X	X	X	X	X	X
Cruciplacolithus sp.					X					X		
Neochiastozygus distentus						X						
Pontosphaera kingii n. sp.						X						
Neochiastozygus perfectus								X				
Discoaster lodoensis								X	X	X	X	X
Hayella sp.										X	X	
Rhabdosphaera vitrea										X	X	
Zygrhablithus bijugatus s.l.										X	X	X
Aubrysphaera deconinkii n. sp.										X	X	X
Micrantholithus cf. pinguis											X	
Ericsonia formosa												X

LEGEND: clayey sand; silt; silty clay; clay; coquina; shells. Pl : platform; xxx : glauconitic bed

TABLE 4



CALCAREOUS NANNOPLANKTON FROM THE YPRESIAN OF THE OOIGEM WELL (83E-407, SOUTHWEST BELGIUM)
CHRONOSTRATIGRAPHY
LITHOSTRATIGRAPHY
FORMATION
DEPTH below surface in m
LITHOLOGY (after GULINCK, unpublished)
MEMBERS
SAMPLES (depth in m)
NANNOPLANKTON
FREQUENCY
PRESERVATION
NANNO-ZONES
MARTINI (1971)
STEURBAUT (1986, and this paper)
Reworking (mostly Cretaceous)
Neochiastozygus concinnus
Ellipsolithus macellus
Chiasmolithus solitus
Neococcolithes protenus
Braarudosphaera bigelowii
Rhabdosphaera sola
Tribrachiatus orthostylus
Toweius magnicrassus
Neococcolithes dubius
Pontosphaera fimbriata
Ericsonia eopelagica
Toweius pertusus
Pontosphaera exilis
Pontosphaera sp.
Lophodolithus nascens
Pontosphaera versa
Micrantholithus aequalis
Semihololithus kerabyi
Chiasmolithus eograndis
Discoaster binodosus
Pontosphaera pectinata
Sphenolithus radians
Sphenolithus editus
Markalius inversus
Discoaster kuepperi
Imperiaster obscurus
Discoaster diastypus
Ciasmolithus consuetus
Toweius occultatus
Toweius sp.
Pontosphaera punctosa
Pontosphaera plana
Pontosphaera kingii n. sp.
Zygodiscus plectopons
Naninfula dupuisii n. sp.
Cyclolithus bramlettei
Discoaster elegans
Cruciplacolithus delus
Sphenolithus moriformis
Pontosphaera pulchra
Cruciplacolithus cribellus
Rhabdosphaera truncata
Zygrhablithus bijugatus nolfii n. subsp.
Pentaster sp.
Zygrablithus bijugatus s. l.
Hayella sp.
Aubrysphaera deconinkii n. sp.
Discoaster lodoensis
Micrantholithus mirabilis
Y P R E S I A N
I E P E R F O R M A T I O N
5
10
15
20
25
30
35
40
45
50
55
60
65
?
Kortemark silt
Aalbeke clay
Roubaix clay
Orchies clay
base Ypresian 94m
9.50
11.50
15.50
18.00
20.70
22.00
24.50
25.50
26.50
27.50
30.50
33.50
35.50
38.50
40.50
43.50
47.50
barren samples
barren
not studied in the present paper
NP 12
NP 11
IV
?
III
II
b3
b2
b1
a2
a1
b
a
LEGEND
very compact clay
heavy clay
clay with sand intercal.
clay with silt intercal.
silty clay
calcareous silty clay
alternation clay-silt
shells
nummulites
glauconitic bed
P= poor
M= moderate
: phosphatic nodules
< < < : oyster-shells
: crab
O = common: 1 specimen per field of view at x1000
o = few: 1 specimen per 5 fields of view at x1000
X = rare: 1 specimen per 20 to 25 fields of view at x1000

TABLE 5

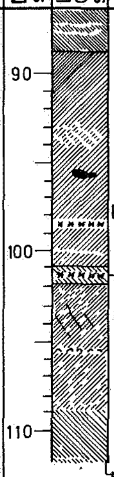
CALCAREOUS NANNOPLANKTON FROM THE YPRESIAN OF THE TIELT WELL (68E-169, WESTERN BELGIUM)

CHRONOSTRATIGRAPHY: Y P R E S I A N

LITHOSTRATIGRAPHY — FORMATION: I E P E R F O R M A T I O N

DEPTH below surface, in m.: 90 – 100 – 110

LITHOLOGY (after GULINCK, unpublished, slightly modified)



MEMBERS: Roubaix Clay Member; Tielt glauconitic bed; base Ypresian 153.80m

SAMPLES (depth in m)	FREQUENCY	PRESERVATION	ZONES: MARTINI (1971)	ZONES: STEURBAUT (1986, and this paper)
not studied in the present paper				
90.50	X	P	NP12	?b3
92.50	o	P	NP12	b2
93.60	X	P	NP12	?b1
95.50	O	M	NP11	III a2
98.50	O	P	NP11	III a2
100.50	O	P	NP11	III a1
102.50	O	M	NP11	III a1
not studied in the present paper				

NANNOPLANKTON	90.50	92.50	93.60	95.50	98.50	100.50	102.50
Reworking (mostly Cretaceous)				R		R	R
Braarudosphaera bigelowii							X
Cepekiella lumina							X
Chiasmolithus sp.							X
Lophodolithus nascens						X	X
Pentaster sp.						X	X
Pontosphaera pectinata						X	X
Markalius inversus						X	o
Ellipsolithus macellus					X	X	o
Chiasmolithus eograndis					X	X	X
Semihololithus kerabyi					X	X	X
Discoaster elegans		X			X		X
Cruciplacolithus delus					X		X
Neochiastozygus concinnus					X		X
Chiasmolithus consuetus				X	o	X	o
Cyclolithus bramlettei				X	X	X	X
Toweius magnicrassus				X	X	X	o
Sphenolithus editus				X	X	o	X
Discoaster kuepperi				X		X	X
Pontosphaera exilis		X	X	X	o	o	o
Tribrachiatus orthostylus		X	X	o	o	o	o
Rhabdosphaera sola		X		X	X	o	X
Discoaster binodosus		X		X	X	X	o
Neococcolithes protenus		X		X	X	X	X
Neococcolithes dubius		X		X		X	X
Toweius occultatus		X		o	X	o	o
Pontosphaera pulchra		X			X	X	X
Sphenolithus radians		X			X	X	X
Toweius sp.		X		o	X		X
Rhabdosphaera truncata		X		X			X
Imperiaster obscurus	X	X	X	X	X	X	X
Ericsonia eopelagica	X	o	X	O	O	O	O
Pontosphaera fimbriata	X	X	X	o	o	o	X
Pontosphaera sp.	X	X	X	O	X	X	X
Toweius pertusus	X	X		O	O	O	O
Naninfula dupuisii n. sp.						X	
Chiphragmalithus calathus					X	X	
Chiasmolithus solitus					X		
Pontosphaera kingii n. sp.					X		
Rhabdosphaera sp.					X		
Discoaster lodoensis		X					
Micrantholithus mirabilis		X					
Aubrysphaera deconinkii n. sp.		X					
Pontosphaera punctosa		X					

LEGEND

very heavy clay; heavy clay; slightly silty clay; silty clay; glauconitic bed; shell debris; phosphatic nodule; slickenside

E.S.1988

EXPLANATION OF THE PLATES

Plates, and figures within each plate, are ordered by first occurrence of species in the different lithostratigraphic units recognised. Sample locality, level or depth (see Fig. 2 for locations and STEURBAUT & NOLF, 1986 for sample descriptions) and biostratigraphic indications (nanno-zonation of STEURBAUT, 1986; refined in this paper) are given for each species. Dark-coloured figures are illustrated by cross-polarised light, others by transmitted light. Scale bar represents 5 μm. Slides and negatives of micrographs are stored in the Laboratorium voor Paleontologie, Krijgslaan 281/S8, B-9000 Gent.

PLATE 1

Morlanwelz Argilite Member; Gouy-lez-Piéton, motorway cutting at junction E42-R3; top of nanno-zone I, NP11.

Fig. 1 : *Discoaster multiradiatus* BRAMLETTE & RIEDEL, 1954
distal view.

Fig. 2 : *Pontosphaera fimbriata* (BRAMLETTE & SULLIVAN, 1961)
proximal view.

Fig. 3 : *Tribrachiatus orthostylus* SHAMRAI, 1963
plane view.

Fig. 7 : *Chiasmolithus consuetus* (BRAMLETTE & SULLIVAN, 1961)
proximal view.

Orchies Clay Member; Kallo borehole (27E-148); top nanno-zone I, NP11.

Fig. 4 : *Discoaster diastypus* BRAMLETTE & SULLIVAN, 1961
337 m depth; side view.

Fig. 5 : *Pontosphaera fimbriata* (BRAMLETTE & SULLIVAN, 1961)
337 m depth; proximal view.

Fig. 6 : *Tribrachiatus orthostylus* SHAMRAI, 1963
360 m depth; plane view.

Fig. 8 : *Toweius magnicrassus* (BUKRY, 1971)
337 m depth; distal view.

Roubaix Clay Member, nanno-zones II and III.

Fig. 9 : *Semihololithus kerabyi* PERCH-NIELSEN, 1971
Kallo borehole (27E-148), 318. 50 m depth; nanno-zone IIb, NP11; side view.

Fig. 10-11 : *Rhabdosphaera sola* PERCH-NIELSEN, 1971
10. Bossuit Canal section, Moen, sample N3; nanno-zone IIIa1, upper part NP11; side view.
11. Kallo borehole (27E-148), 318. 50 m depth; nanno-zone IIb, NP11; side view.

Fig. 12 : *Chiasmolithus consuetus* (BRAMLETTE & SULLIVAN, 1961)
Kallo borehole (27E-148), 314.15 m depth; nanno-zone IIIa1, NP11; distal view.

Fig. 13-14 : *Zygrhablithus bijugatus* subsp. *nolfii* n. subsp.
Kallo borehole (27E-148); side view.
13. 314.15 m depth; nanno-zone IIIa1, NP11; paratype.
14. 318.50 m depth; nanno-zone IIb, NP11; paratype.

Fig. 15 : *Holodiscolithus* sp.
Bossuit Canal Section, Moen, Sample N3; nanno-zone IIIa1, NP11; proximal view.

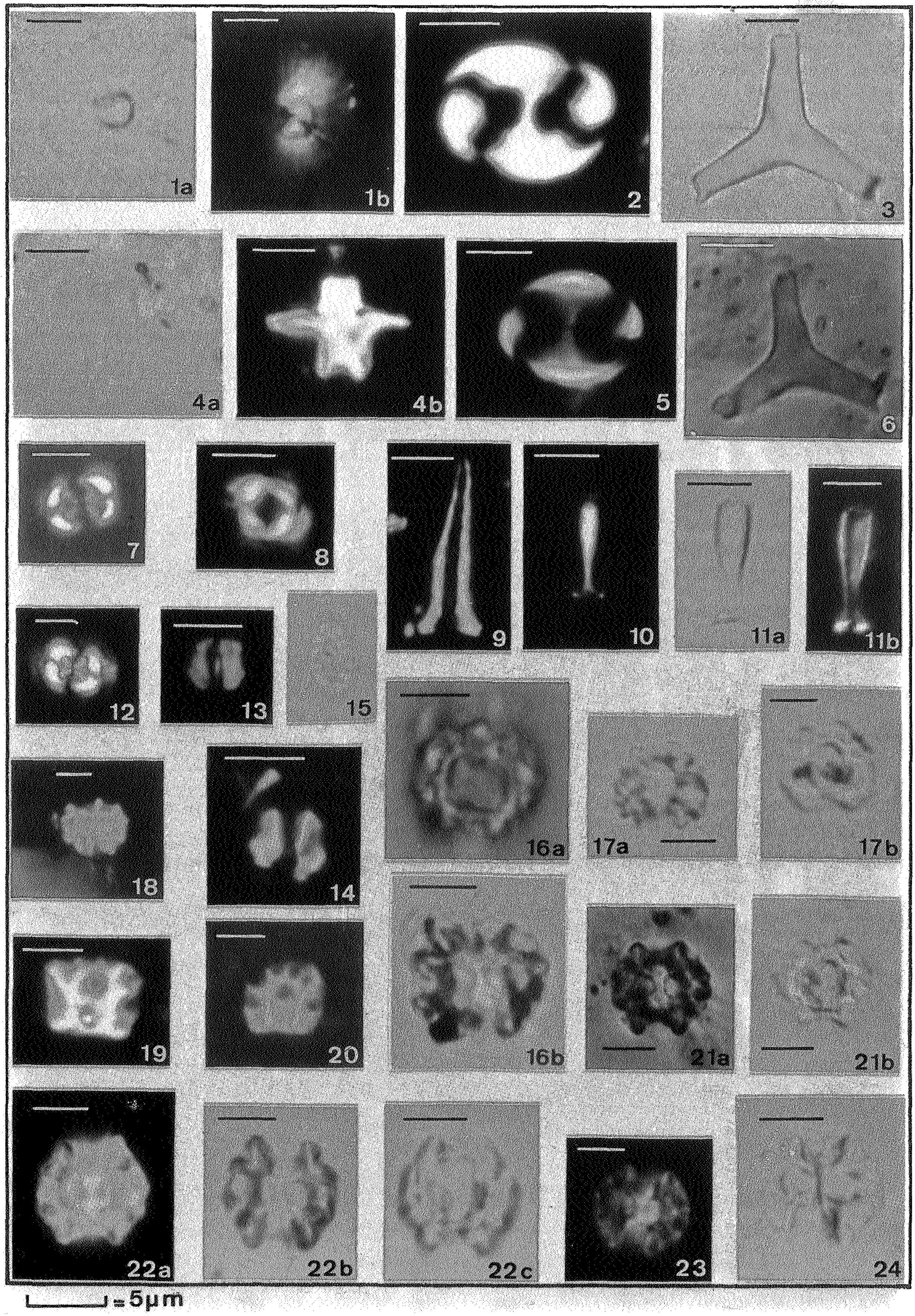
Fig. 16-22 : *Aubrysphaera deconinckii* n. sp.
16. Kruishoutem borehole (84E-1362I), sample 8, 41.50 m depth; nanno-zone IIIb2, base NP12; paratype; a. low focus, basal face; b. high focus, upper face.
17. Lauwe, sample 1, lowermost part of quarry "Céramique et Briqueteries du Littoral"; nanno-zone IIIb2, base NP12; paratype; a. high focus, upper face; b. low focus, basal face.
18. Lauwe, ibidem; upper face; paratype.
19. Kruishoutem borehole (84E-1362I), sample 8 (see Fig. 16); side view, parallel to central axis; paratype.
20. Lauwe, sample 1 (see Fig. 17); side view, perpendicular to central axis; paratype.
21. Kruishoutem borehole (84E-1362I), sample 8 (see Fig. 16); paratype; a. high focus, upper face; b. low focus, basal face.
22. Kruishoutem borehole (84E-1362I), sample 8; 41.50 m depth; nanno-zone IIIb2, base NP12; holotype; a. & b. high focus, upper face; c. low focus, basal face.

Fig. 24 : *Aubrysphaera deconinckii* n. sp.
Kruishoutem borehole (84E-1362I), sample 8, 41.50 m depth; nanno-zone IIIb2, base NP12; upper face; paratype.

Mons-en-Pévèle Sand Member, Steenhuize-Wijnhuize (Herzele) borehole (86W-142 VII, C), 18 m depth; nanno-zone IIIb2; base NP12.

Fig. 23 : *Aubrysphaera deconinckii* n. sp.
upper face; paratype.

Pl.1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11a
11b
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16a
17a
17b
18
14
19
20
16b
21a
21b
22a
22b
22c
23
24
= 5µm

PLATE 2

Roubaix Clay Member, nanno-zone III.

Fig. 1-3 : *Naninfula dupuisii* n. sp.
side view; nanno-zone IIIa1, upper part NP11.
1. Ooigem borehole (83E-407), 35.50 m depth; paratype.
2. Kallo borehole (27E-148), 310.80 m depth; paratype.
3. Ooigem borehole (83E-407), 38.50 m depth; paratype.

Fig. 4 : *Lophodolithus nascens* BRAMLETTE & SULLIVAN, 1961
Kruishoutem borehole (84E-1362I), sample 8, 41.50 m depth; nanno-zone IIIb2, base NP12; distal view.

Fig. 5 : *Chiasmolithus eograndis* PERCH-NIELSEN, 1971
Bossuit Canal section, Moen, sample N9; nanno-zone IIIb2, base NP12; distal view.

Fig. 6-7 : *Ellipsolithus macellus* (BRAMLETTE & SULLIVAN, 1961)
6. Ooigem borehole (83E-407); 33.50 m depth; nanno-zone IIIa2, top NP11; distal view.
7. Tielt borehole (68E-169), 102.50 m depth; nanno-zone IIIa1, NP11; distal view.

Fig 8 : *Discoaster lodoensis* BRAMLETTE & RIEDEL, 1954
Marke, clay pit Koekelberg, sample N6; nanno-zone IIIb2, NP12; distal view.

Fig. 9-10 : *Pontosphaera fimbriata* (BRAMLETTE & SULLIVAN, 1961)
distal view.
9. Kruishoutem borehole (84E-1362I), sample 8, 41.50 m depth; nanno-zone IIIb2, base NP12.
10. Bossuit Canal section, sample N3; nanno-zone IIIa1; upper part NP11.

Fig. 11-12 : *Chiasmolithus consuetus* (BRAMLETTE & SULLIVAN, 1961)
distal view.
11. Melle borehole (70E-183), 67 m depth; nanno-zone IIIb, zone NP12.
12. Kruishoutem borehole (84E-1362I), sample 8, 41.50 m depth; nanno-zone IIIb2, base NP12.

Fig. 14-16 : *Rhabdosphaera truncata* BRAMLETTE & SULLIVAN, 1961
side view; nanno-zone IIIb2, base NP12.
14. Kruishoutem borehole (84E-1362I), sample 8, 41.50 m depth.
15. Marke, clay pit Koekelberg, sample N6.
16. Kruishoutem borehole, sample 8 (see Fig. 14).

Fig. 18 : *Toweius* sp.
Ooigem borehole (83E-407), 26.50 m depth; nanno-zone IIIb3, NP12; distal view.

Fig. 19 : *Pontosphaera pulchra* (DEFLANDRE in DEFLANDRE & FERT, 1954)
Ooigem borehole (83E-407), 38.50 m depth; nanno-zone IIIa1, upper part NP11; proximal view.

Fig. 20 : *Toweius magnicrassus* (BUKRY, 1971)
Kallo borehole (27E-148), 308.50 m depth; nanno-zone IIIa2, top NP11; proximal view.

Fig. 21 : *Zygrhablithus bijugatus* s.l. (DEFLANDRE, 1959)
Kallo borehole, 303.90 m depth; nanno-zone IIIb3, NP12; side view.

Fig. 22 : *Cruciplacolithus cribellus* (BRAMLETTE & SULLIVAN, 1961)
Ooigem borehole, 35.50 m depth; nanno-zone IIIa1, NP11; distal view.

Fig. 24-25 : *Hayella* sp.
Bossuit Canal section, Moen; nanno-zone IIIb2, NP12; distal view.
24. Sample N9;
25. Sample N10.

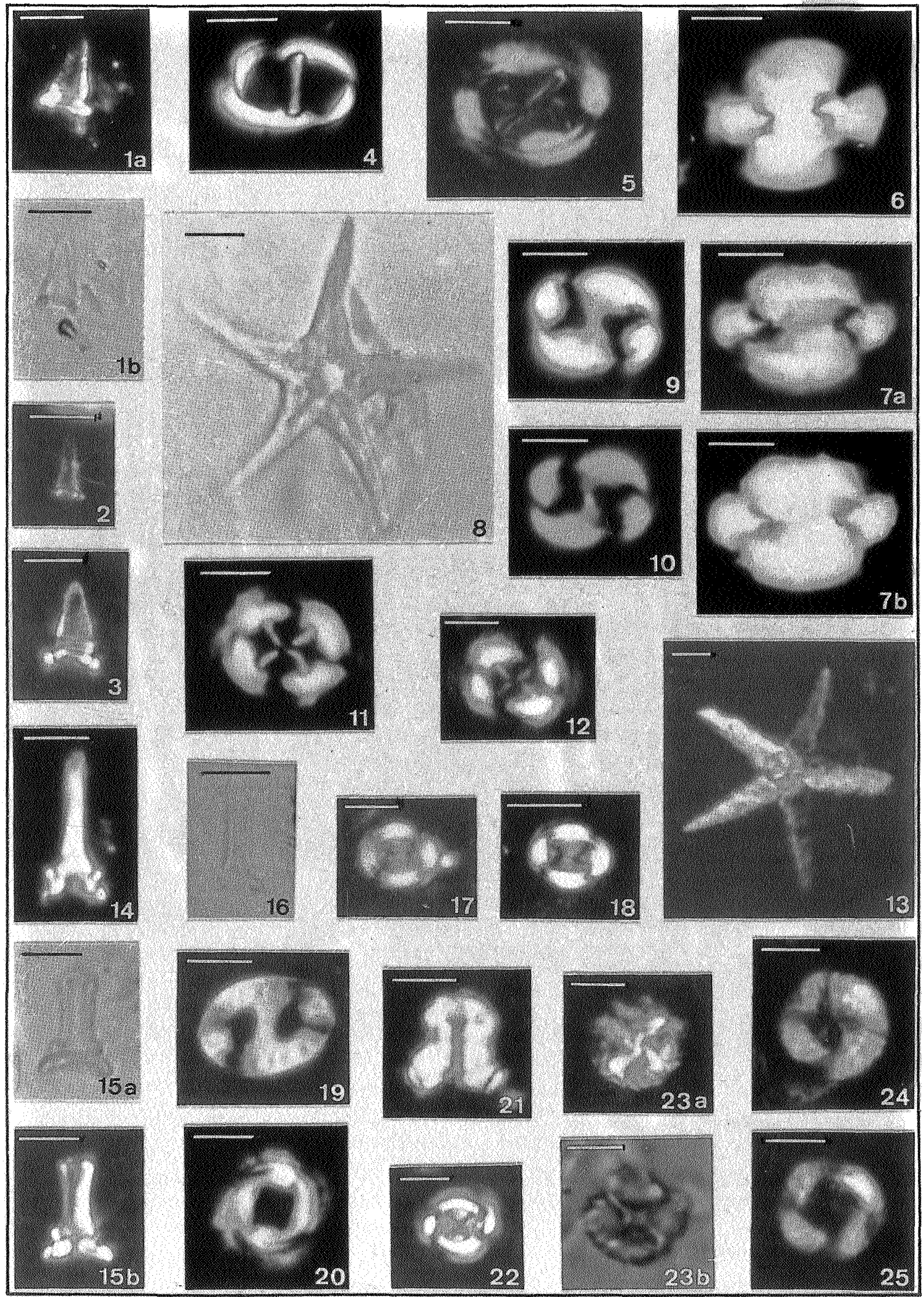
Mons-en-Pévèle Sand Member, Steenhuize-Wijhuize (Herzele) borehole (86W-142 VII, C); nanno-zone IIIb2, base NP12.

Fig. 13 : *Micrantholithus mirabilis* LOCKER, 1965
18.00 m depth; proximal view.

Fig. 17 : *Toweius* sp.
24.50 m depth; distal view.

Fig. 23 : *Chiphragmalithus calathus* BRAMLETTE & SULLIVAN, 1961
18.00 m depth; distal view.

Pl. 2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18
15a
19
21
23a
24
15b
20
22
23b
25

= 5µm

PLATE 3

Roubaix Clay Member; nanno-zone IV and V.

Fig. 1-3 : *Micrantholithus mirabilis* LOCKER, 1965.
1. Kallo borehole, 297 m depth; nanno-zone IV, NP12; proximal view.
2. Moeskroen, "Bois Fichau" clay pit, 17.60m depth; nanno-zone V, NP12; proximal view.
3. Kallo borehole, 295m depth; nanno-zone V; NP12; proximal view.

Fig. 4 : *Chiasmolithus* aff. *expansus* (BRAMLETTE & SULLIVAN, 1961)
Moeskroen, "Bois Fichau" clay pit, 17.60m depth; nanno-zone V, NP12; distal view.

Fig. 5 : *Chiphragmalithus calathus* BRAMLETTE & SULLIVAN, 1961
Moeskroen, "Bois Fichau" clay pit, 17.60m depth; nanno-zone V, NP12; distal view.

Fig. 6 : *Zygrhablithus bijugatus* s.l. (DEFLANDRE, 1959)
Ooigem borehole, 22m depth; nanno-zone IV, NP12; side view.

Mons-en-Pévèle Sand Member; nanno-zones II and III.

Fig. 7 : *Semihololithus kerabyi* PERCH-NIELSEN, 1971
Mol borehole (31W-237), 394.70m depth; nanno-zone IIIa1, NP11; side view.

Fig. 8 : *Ellipsolithus macellus* (BRAMLETTE & SULLIVAN, 1961)
Mol borehole, 394.70m depth; nanno-zone IIIa1, NP11; proximal view.

Fig. 9 : *Chiasmolithus eograndis* PERCH-NIELSEN, 1971
Mol borehole, 390.80m depth; nanno-zone IIIa1, NP11; distal view.

Fig. 10 : *Discoaster binodosus* MARTINI, 1958
Mol borehole, 392.20m depth; nanno-zone IIIa1, NP11; distal view.

Fig. 11 : *Neochiastozygus concinnus* (MARTINI, 1961)
Mol borehole, 394.70m depth; nanno-zone IIIa1, NP11; distal view.

Fig. 12 : *Zygodiscus plectopons* BRAMLETTE & SULLIVAN, 1961
Mol borehole, 394.70m depth; nanno-zone IIIa1, NP11; distal view.

Fig. 13 : *Zygodiscus adamas* BRAMLETTE & SULLIVAN, 1961
Mol borehole, 392.20m depth; nanno-zone IIIa1, NP11; proximal view.

Fig. 14-18 : *Zygrhablithus bijugatus* subsp. *nolfii* n. subsp.
side view; cross-polarised light.
14. Mol borehole, 394.70m depth; nanno-zone IIIa1, NP11; holotype.
15. Mol borehole, 386.80m depth; nanno-zone IIIa2, top NP11; paratype.
16. Mont Panisel borehole (151E-340), 39.85m depth; nanno-zone IIIa1, NP11; paratype.
17. Mol borehole, 394.70m depth; nanno-zone IIIa1, NP11; paratype.
18. Mont Panisel borehole, 41.75m depth; nanno-zone IIb, NP11; paratype.

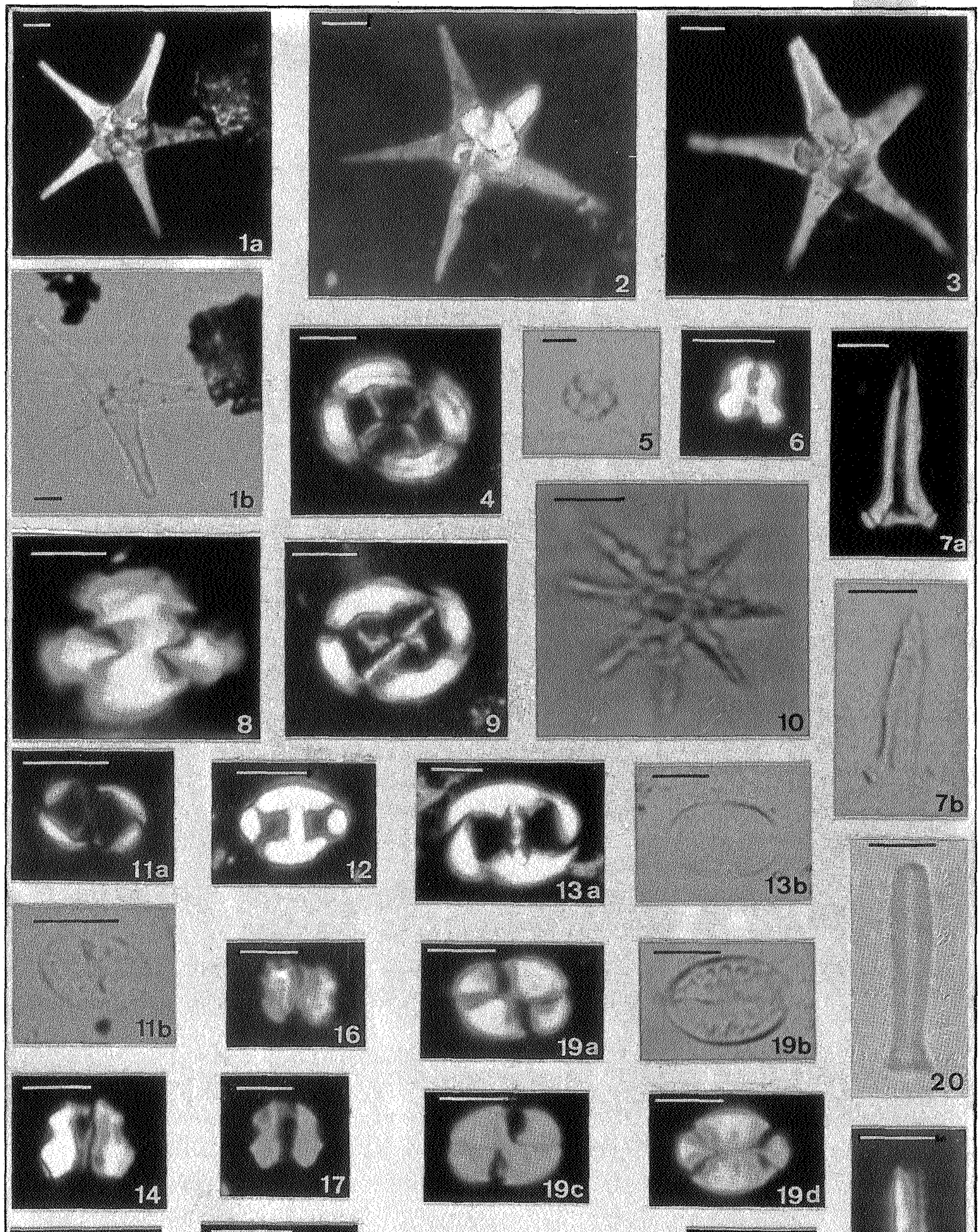
Fig. 19 : *Pontosphaera kingii* n. sp.
Mol borehole, 386.80m depth; nanno-zone IIIa2, top NP11; proximal view; holotype, a. viewed at 25° in clockwise direction, b. & d. viewed at 45° to the polarisation directions; c. almost parallel to the polarisation directions.

Fig. 20-21 : *Rhabdosphaera sola* PERCH-NIELSEN, 1971
Mol borehole, side view.
20. 394.70m depth; nanno-zone IIIa1, NP11.
21. 398.50m depth; nanno-zone II, NP11.

Fig. 22 : *Naninfula* sp.
Mol borehole, 388.50m depth; nanno-zone IIIa1; NP11; side view.

Fig. 23 : *Toweius pertusus* (SULLIVAN, 1965)
Mol borehole, 394.70m depth; nanno-zone IIIa1, NP11; distal view.

Pl. 3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7b
11a
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13 a
13b
11b
16
19a
19b
20
14
17
19c
19d
21
15
18
22a
22b
23

= 5µm

PLATE 4

Mons-en-Pévèle Sand Member

Fig. 1-4 : *Naninfula dupuisii* n. sp.
Mol borehole (31W-237); nanno-zone IIIa1, NP11; side views.
1. 394.70 m depth, paratype;
2. 388.50 m depth, paratype;
3. 388.50 m depth, holotype;
4. 388.50 m depth, paratype.

Fig. 5-6 : *Pontosphaera exilis* (BRAMLETTE & SULLIVAN, 1961)
5. Mol borehole, 394.70 m depth; nanno-zone IIIa1, NP11; proximal view.
6. Mons-en-Pévèle, sample G55/4; nanno-zone IIIa1, NP11; distal view.

Fig. 7 : *Neochiastozygus junctus* (BRAMLETTE & SULLIVAN, 1961)
Rillaar borehole (75E-128), 127 m depth; nanno-zone IIIa1, NP11; distal view.

Fig. 8 : *Calcidiscus* aff. *protoannulus* (GARTNER, 1971)
Rillaar borehole (75E-128), 128 m depth; nanno-zone IIIa1, NP11; distal view; coccosphere.

Fig. 9-10 : *Rhabdosphaera truncata* BRAMLETTE & SULLIVAN, 1961
side view.
9. Kwaadmechelen borehole (46E-179), interval 219.80-224 m depth; nanno-zone IIIb2, base NP12.
10. Mons-en-Pévèle, sample G55/5; nanno-zone IIIa1, NP11.
11. Ronse, Waaienberge, sample 1, 11 m below surface; nanno-zone IIIb2, base NP12.

Fig. 12 : *Ellipsolithus macellus* (BRAMLETTE & SULLIVAN, 1961)
Mons-en-Pévèle, sample G55/4; nanno-zone IIIa1, NP11; proximal view.

Fig. 13-15 : *Aubrysphaera deconinckii* n. sp.
nanno-zone IIIb2; base NP12, paratypes.
13. Kwaadmechelen borehole (46E-179), interval 219.80-224 m depth; upper face.
14. Kwaadmechelen borehole; interval 219.80-224 m depth; basal face.
15. Ronse, Waaienberge, sample 1, 11 m below surface; upper face.

Fig. 16-17 : *Toweius magnicrassus* (BUKRY, 1971).
16. Mont-Panisel borehole (151E-340), 41.75 m depth; nanno-zone IIb, NP11; distal view.
17. Ronse, Waaienberge, sample 1, 11 m below surface; nanno-zone IIIb2, NP12; distal view.

Fig. 18 : *Chiphragmalithus calathus* BRAMLETTE & SULLIVAN, 1961
Mont-Panisel borehole (151E-340), 39.85 m depth; nanno-zone IIIa1, NP11; distal view.

Fig. 19 : *Discoaster lodoensis* BRAMLETTE & RIEDEL, 1954
Ronse, Waaienberge, sample 1, 11 m below surface; nanno-zone IIIb2, NP12; proximal view.

Fig. 20 : *Pontosphaera excelsa* (PERCH-NIELSEN, 1971)
Mol borehole (31W-237), 382.80 m depth; nanno-zone IIIb3, NP12; proximal view.

Fig. 21 : *Discoaster barbadiensis* TAN SIN HOK, 1927
Mons-en-Pévèle, sample G55/4; nanno-zone IIIa1, NP11; distal view.

Fig. 22 : *Pentaster* sp.
Kwaadmechelen borehole (46E-179); interval 219.80-224 m depth; nanno-zone IIIb2, NP12; plane view.

Pl.4

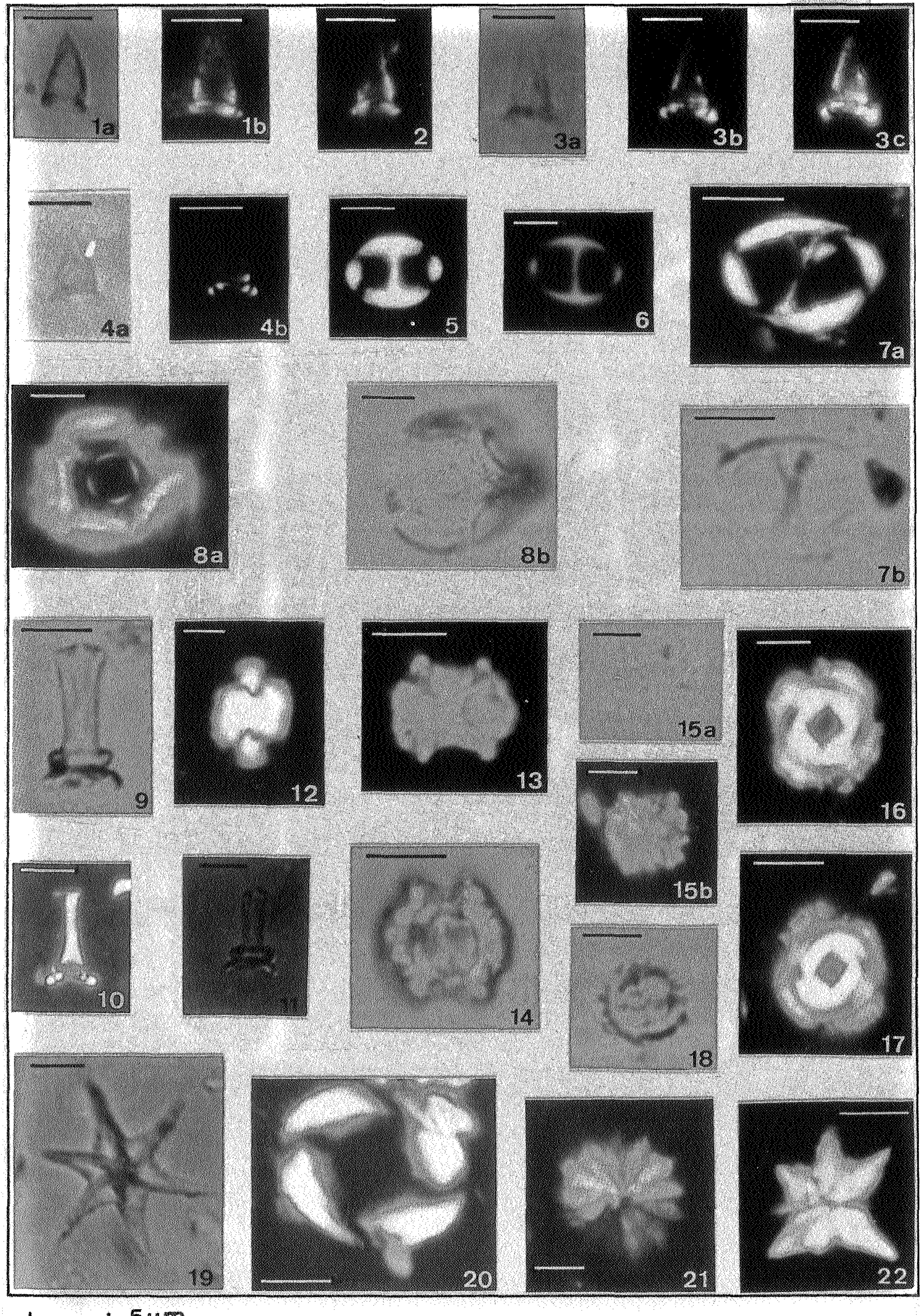
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PLATE 5

Mons-en-Pévèle Sand Member, nanno-zones III and IV

Fig. 1-3 : *Zygrhablithus bijugatus* s.1 (DEFLANDRE, 1959).
1. Ronse, Waaienberge, sample 1, 11 m below surface; nanno-zone IIIb2, NP12; side view.
2-3. Mol borehole, 376.30m depth; nanno-zone IV, NP12; side views.

Fig. 4-5 : *Discoaster lodoensis* BRAMLETTE & RIEDEL, 1954
Mol borehole; nanno-zone IV, NP12.
4. 376.30m depth; 5-rayed specimen; proximal view.
5. 374.50m depth; 6-rayed specimen; proximal view.

Fig. 6-7 : *Zygrhablithus bijugatus* s.1. (DEFLANDRE, 1959)
Mol borehole; nanno-zone IV, NP12; side views.
6. 370.80m depth;
7. 374.50m depth.

Kortemark Silt Member; Kallo borehole (27E-148), 265m depth; nanno-zone VIb, NP12.

Fig. 8 : *Zygrhablithus bijugatus* s.1. (DEFLANDRE, 1959)
side view.

Fig. 9 : *Discoaster lodoensis* BRAMLETTE & RIEDEL, 1954
7-rayed specimen; proximal view.

Fig. 10 : *Discoaster elegans* BRAMLETTE & SULLIVAN, 1961
distal view.

Fig. 11 : Inc. sed. sp.
plane view.

Fig. 12 : *Discoaster mirus* DEFLANDRE in GRASSE, 1952
distal view.

Egem Sand Member, nanno-zones VII and VIII, NP12.

Fig. 13 : *Toweius occultatus* (LOCKER, 1967)
Kallo borehole (27E-148), 242.60m depth; nanno-zone VIII, top NP12; distal view.

Fig. 14 : *Zygrhablithus bijugatus* s.1. (DEFLANDRE, 1959)
Kallo borehole, 242.60m depth; nanno-zone VIII, top NP12; side view.

Fig. 16 : *Chiphragmalithus armatus* PERCH-NIELSEN, 1971
Kallo borehole, 242.60m depth; nanno-zone VIII, top NP12; distal view.

Fig. 17 : *Chiasmolithus grandis* BRAMLETTE & RIEDEL, 1954
Mol borehole, 354.20m depth; nanno-zone VIII, top NP12; proximal view.

Fig. 20 : *Pontosphaera fimbriata* (BRAMLETTE & SULLIVAN, 1961)
Maldegem borehole (39W-213), 101.50m depth; nanno-zone VII, NP12; distal view.

Panisel Sand Member; nanno-zones VII and VIII, upper part NP12.

Fig. 15 : *Zygrhablithus bijugatus* s.1. (DEFLANDRE, 1959)
Steenhuize-Wijnhuize (Herzele) borehole (86W-142, VII, C), sample 7, 6.50m depth; nanno-zone VII, NP12; side view.

Fig. 18-19 : *Zygrhablithus bijugatus* s.l. (DEFLANDRE, 1959)
18. Mater borehole (85W-18), sample 7, 30m depth; nanno-zone VII, NP12; side view.
19. Schepdaal borehole (87E-5), 13.50m depth; nanno-zone VIII(base), top NP12; side view.

Fig. 21 : *Reticulofenestra* sp.
Mater borehole (85W-18), sample 7, 30m depth; nanno-zone VII, NP12; proximal view.

Fig. 22 : *Zygrhablithus bijugatus* s.1. (DEFLANDRE, 1959)
Mater borehole, sample 7, 30m depth; nanno-zone VII, NP12; side view.

Fig. 23 : *Tribrachiatus orthostylus* SHAMRAI, 1963
Schepdaal borehole (87E-5), 13.50m depth; nanno-zone VIII(base), top NP12; plane view.

Fig. 24 : *Rhabdosphaera crebra* DEFLANDRE in DEFLANDRE & FERT, 1954
Mater borehole, sample 7, 30m depth; nanno-zone VII, NP12; side view.

Pittem Clay Member, Vlierzele Formation; nanno-zone X, NP13.

Fig. 25 : *Micrantholithus inaequalis* MARTINI, 1961
Knokke borehole (11E-138), 124.70m depth; distal view.

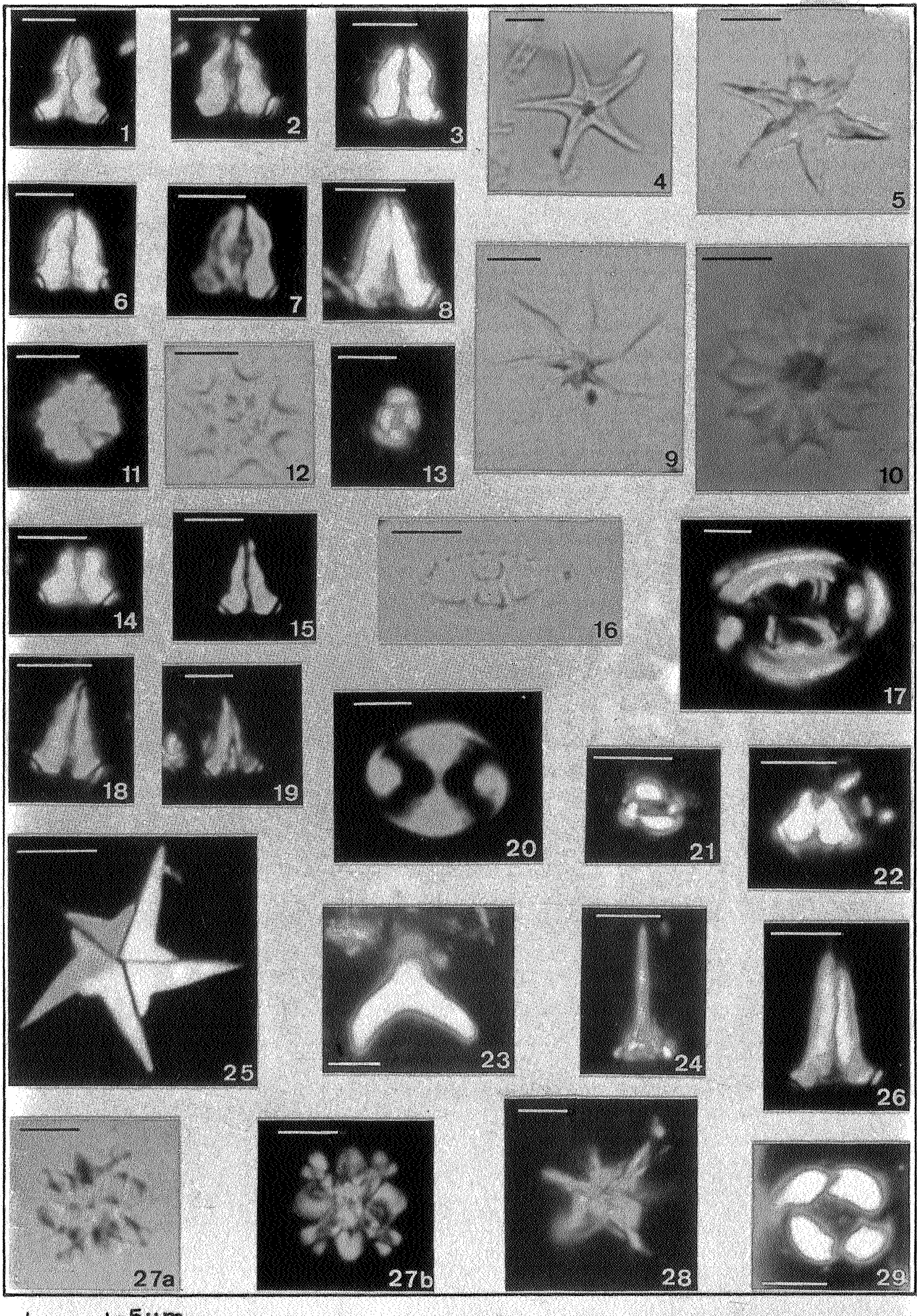
Fig. 26 : *Zygrhablithus bijugatus* s.1. (DEFLANDRE, 1959)
Kallo borehole, 234m depth; side view.

Fig. 27 : *Nannoturba robusta* MÜLLER, 1979
Kallo borehole, 234m depth; side view.

Fig. 28 : *Nannoturba spinosa* MÜLLER, 1979
Kallo borehole, 234m depth; side view.

Fig. 29 : *Cruciplacolithus mutatus* PERCH-NIELSEN, 1971
Kallo borehole, 234m depth; distal view.

Pl.5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