

## NEW DINOFLAGELLATE CYST SPECIES FROM UPPER CRETACEOUS SUBSURFACE DEPOSITS OF WESTERN BELGIUM<sup>1</sup>

Stephen LOUWYE<sup>1</sup>

(1 figure and 2 plates)

2. Laboratorium voor Paleontologie, Universiteit Gent, Krijgslaan 281, 9000 Gent, Belgium.

**ABSTRACT.** Eight new dinoflagellate cyst species from the Upper Cretaceous (latest Cenomanian - Late Campanian) of western Belgium are described: *Canningia keiemensis* (latest Cenomanian - Santonian), *Eisenackia? knokkensis* (Campanian), *Invertocysta flandriensis* (Turonian - Campanian), *Microdinium minutum* (latest Cenomanian - Santonian), *Microdinium? sinfalensis* (Turonian - Campanian), *Pervosphaeridium elegans* (Campanian), *Rhynchodiniopsis saliorum* (Campanian) and *Senoniasphaera palla* (Turonian).

**KEY-WORDS:** Dinoflagellate cysts, Upper Cretaceous, western Belgium.

**RESUME.** Huit nouvelles espèces de cystes de dinoflagellés du Crétacé Supérieur (Cénomanien terminal - Campanien Supérieur) de la Belgique occidentale sont décrites: *Canningia keiemensis* (Cénomanien terminal - Santonien), *Eisenackia? knokkensis* (Campanien), *Invertocysta flandriensis* (Turonien - Campanien), *Microdinium minutum* (Cénomanien terminal - Santonien), *Microdinium? sinfalensis* (Turonien - Campanien), *Pervosphaeridium elegans* (Campanien), *Rhynchodiniopsis saliorum* (Campanien) and *Senoniasphaera palla* (Turonien).

**MOTS-CLES:** Kystes de dinoflagellés, Crétacé Supérieur, Belgique occidentale.

### 1. INTRODUCTION

This paper gives the description of eight new dinoflagellate cyst species encountered during a biostratigraphical study of the Upper Cretaceous subsurface deposits from five wells drilled in the western part of Belgium (Fig. 1) on behalf of the Belgian Geological Survey. The Upper Cretaceous deposits formed the subject of several multidisciplinary biostratigraphical studies (Bal & Verbeek, 1990; Louwye, 1990; Nuyts, 1989). A detailed sampling of the cores allowed the recovery of 205 organic-walled microfossil species. The relative dating with dinoflagellate cysts gives a latest Cenomanian - Late Campanian age for the compiled stratigraphical section. We refer to Louwye (1992) for the lithostratigraphical descriptions of the analyzed sections and for a comprehensive overview of the correlations and chronostratigraphical interpretations of the Cretaceous sections intercepted by these wells. A full account of the dinoflagellate cyst associations is gi-

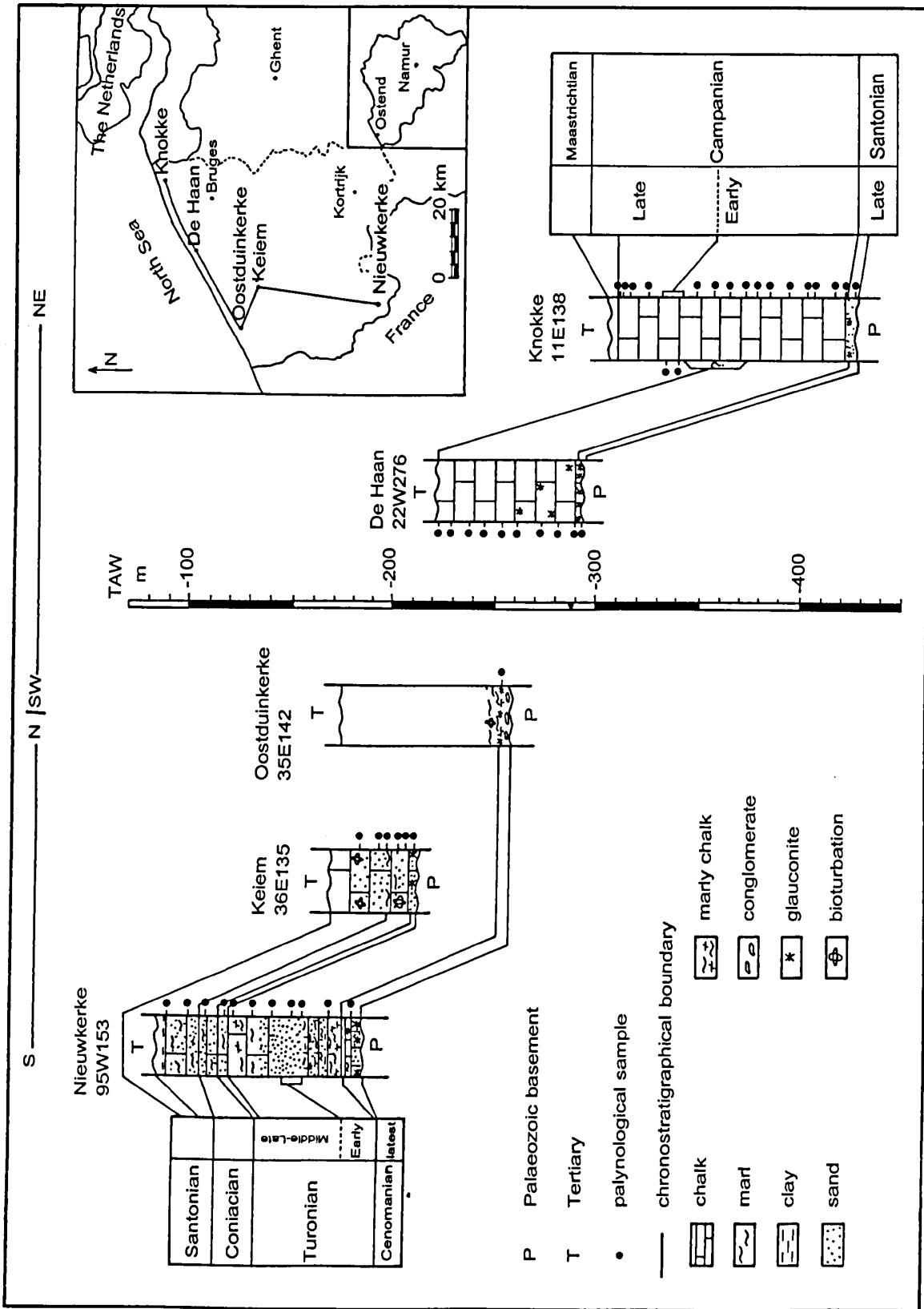
ven in Louwye (1990). The Taylor-Evitt notation for the paratabulation of the cysts is used throughout this paper. The occurrences of the species in the wells refer to depths below T.A.W. (Belgian ordnance datum) and the well reference numbers refer to the archive numbers of the Belgian Geological Survey.

### 2. SYSTEMATIC PALEONTOLOGY

Division Pyrrhophyta Pascher, 1914  
Class Dinophyceae Fritsch, 1929  
Order Peridiniales Haeckel, 1894

Genus *Canningia* Cookson & Eisenack, 1960a;  
emend. Dörhöfer & Davies, 1980; emend.  
Below, 1981; emend. Helby, 1987.

**Type species.** *Canningia reticulata* Cookson & Eisenack, 1960a; emend. Below, 1981; emend. Helby, 1987.



**Diagnose.** Cookson & Eisenack, 1960a, p. 251; Dörhöfer & Davies, 1980, p. 36; Below, 1981, p. 30; Helby, 1987, p. 321.

*Canningia kelemensis* n.sp.

Pl. 1: 1-6

**Derivatio nominis.** Keiem, the location of the well.

**Holotype.** Keiem well 36E135, -211.6 m, P.9, coord. E.F. K-32 (Pl. 1, figs. 1-3, 6), repository: collection of the Laboratory of Paleontology, University of Ghent.

**Locus typicus and stratum typicum.** Keiem, West Flanders, Belgium, well no. 36E135, -211.6 m, Turonian.

**Dimensions.** Holotype: total length, 91  $\mu\text{m}$ ; length without operculum, 65  $\mu\text{m}$ ; length of central body without operculum, 57  $\mu\text{m}$ ; total width, 81  $\mu\text{m}$ ; width of central body, 67  $\mu\text{m}$ . Variation: total length: 86-101  $\mu\text{m}$ ; total length without operculum, 54-78  $\mu\text{m}$ ; length of central body without operculum, 54-68  $\mu\text{m}$ ; total width, 64-87  $\mu\text{m}$ ; width of central body, 54-71  $\mu\text{m}$ . Number of measured specimens: 21.

**Diagnosis.** The proximate cyst is bilayered. The autocyst is mostly subcircular with a small, rounded apical horn. Two lateral protrusions at the paracingulum are developed and occasionally a faint, left antapical horn. The autophragm is relatively thick (approx. 2  $\mu\text{m}$ ), scabrate to slightly granular. The cyst is lenticular-like: the ventral surface is, in apical-antapical view, straight while the dorsal surface is convex. Solid, pillar-like protrusions (height max. 6  $\mu\text{m}$ ) and irregular septa cover the autophragm dorsally and laterally. Both types of processes occupy an intratabular and penitabular position, are fibrous and flare distally and proximally. They support a scabrate, perforate ectophragm. The unevenly distributed perforations of the ectophragm are circular or subcircular, ranging in diameter from 2  $\mu\text{m}$  to 3  $\mu\text{m}$ . The widest perforations occupy a penitabular position. The ectophragm displays a small but distinct apical horn, two rounded or sometimes slightly indented protrusions at the paracingulum and a left antapical protrusion. The right antapical protrusion is mostly absent or strongly reduced. The separation between the autophragm and ectophragm is more or less constant (about 5  $\mu\text{m}$ ), except at the antapex and paracingulum (max. separation 12  $\mu\text{m}$ ). The ectophragm is always absent from the ventral surface of the cyst, where occasionally some isolated septa or pillarlike protrusions

occur. Some characteristics of the gonyaulacean paratabulation: 3, 4 and 5 are well developed on the dorsal surface, the position of 2, 6 and 1i can be inferred from the accessory archeopyle parasutures. The paracingulum is undivided and the postcingular paraplates III, IV and V are visible on the dorsal surface with IV large and trapezoidal. The parasulcal notch is offset. The archeopyle is of type (ta) with a slightly zigzag margin and clearly developed accessory archeopyle parasutures. The operculum is usually free.

**Comparison.** *Canningia transitoria* Stover & Helby, 1987 (Barremian - Early Aptian) differs by having an ectophragm that covers the cyst completely, a wider ectocoel and a less clearly but completely developed paratabulation. *Canningia bassensis* Marshall, 1990 (Campanian) is holocavate and has an ectophragm that covers the cyst completely although it is frequently discontinuous on the midventral surface. Furthermore, this species is not lenticular-like.

**Occurrence.** Keiem: -211.6 m, -204.0 m, -196.3 m (Turonian - Santonian); Nieuwerkerke, -103.0 m (Santonian); Oostduinkerke well, -254.5 m (Cenomanian).

**Genus** *Eisenackia* Deflandre & Cookson, 1955; emend. Sarjeant, 1966; emend. McLean, 1973.

**Type species.** *Eisenackia crassitabulata* Deflandre & Cookson, 1955; emend. McLean, 1973.

**Diagnosis.** Deflandre & Cookson, 1955, p. 258; Sarjeant, 1966, p. 152; McLean 1973, p. 262.

*Eisenackia? knokkensis* n.sp.

Pl. 1: 7-9

**Derivatio nominis.** "Knokke": the location of the well.

**Holotype.** Knokke well 11E138, -420.7 m, P.1, coord. E.F. G-23.4 (Pl. 1, figs. 8-9), repository: collection of the Laboratory of Paleontology, University of Ghent.

**Locus typicus and stratum typicum.** Knokke, West Flanders, Belgium, well no. 11E138, -420.7 m, Campanian.

**Dimensions.** Holotype: width, 58  $\mu\text{m}$ ; length (without operculum), 50  $\mu\text{m}$ . Variation: width, 54-63  $\mu\text{m}$ ; length (without operculum), 45-58  $\mu\text{m}$ . Number of measured specimens: 11.

**Diagnosis.** The proximate, moderately compressed cyst has a subcircular outline in dorsoventral view. A small apical protrusion is sometimes developed while the antapex is rounded. The thin autophragm is ornamented with a low but rather dense and coarse granulation of the intratabular areas. The paratabulation is clearly reflected by the absence of this ornamentation in the parasutural areas. The hypocyst is somewhat larger than the epicyst. The hypocystal arrangement is sexiform gonyaulacoid with an almost symmetrical Y. The contact between Y and VI, and Y and X is reduced. Z has a blocked appearance, is almost square in outline and has a convex contact with Y. Im is larger than Ii, the latter is poorly delineated and seems sometimes to be bipartite, ai has an elongated shape, while fu is triangular with concave sides. The archeopyle is of type (ta). The free operculum consists of four apical paraplates and has been observed adherent in a few cases only. A deep parasulcal notch is developed.

**Comparison.** *Eisenackia crassitabulata* Deflandre & Cookson, 1955 (Paleocene - Early Eocene) differs by the ellipsoidal ambitus, the thick wall, the type of ornamentation and the hypocystal quinqueform arrangement. *Stoveracysta ornata* (Cookson & Eisenack, 1965) Clowes, 1985 (Late Eocene) differs by the presence of the two short antapical lobes, the penitabular ledges, the circular ambitus in apical view and the ventral organisation and ornamentation.

**Remarks.** This species has the essential characteristics (type of ornamentation, shape) of the genus *Eisenackia* but differs by its sexiform hypocystal arrangement; hence the doubtful assignment to this genus.

**Occurrence.** Knokke: -420.7 m, -414.4 m (Campanian).

**Genus *Invertocysta* Edwards, 1984.**

**Type species.** *Invertocysta tabulata* Edwards, 1984. **Diagnosis.** Edwards, 1984, p. 585.

*Invertocysta flandriensis* n.sp.

Pl. 1: 10-13

**Derivatio nominis.** The type locality, Knokke, is situated in Flanders (Vlaanderen).

**Holotype.** Knokke well 11E138, -347.6 m, P.1, coord. E.F. X-35 (Pl. 1, figs. 10-13), repository: collection of the Laboratory of Paleontology, University of Ghent.

**Locus typicus and stratum typicum.** Knokke, West Flanders, Belgium, well no. 11E138, -347.6 m, Campanian.

**Dimensions.** Holotype: length of pericyst, 62  $\mu\text{m}$ ; breadth of pericyst, 62  $\mu\text{m}$ ; diameter of endocyst, 37  $\mu\text{m}$ . Variation: length of pericyst, 56-72  $\mu\text{m}$ ; breadth of pericyst, 55-68  $\mu\text{m}$ ; diameter of endocyst, 34-41  $\mu\text{m}$ . Number of measured specimens: 10.

**Diagnosis.** The outline of the cavate cyst is hexagonal with rounded angles to subcircular. Both endo- and periphragm are scabrate, the endophragm being slightly thicker than the periphragm. The outline of the endocyst is circular with a small apical boss, giving it a tear-like appearance. A similar small apical boss is sometimes developed on the pericyst. The size of the endocyst is considerably smaller than the pericyst. Both walls are only in contact in the lower ventral region, the endocyst not being centered within the pericyst. The outward extended periphragm forms a well developed dorsal pericoel. Low, smooth parasutural ridges on the pericyst delineate a partial, probably gonyaulacean, paratabulation: four apical paraplates, precingulars 3 to 6 are the most clearly reflected paraplates. It is not clear whether the paracingulum is divided into paraplates. The paracingulum on the dorsal side is antapically displaced. The endoarcheopyle is of type P and formed by the release of paraplate 4. A large subquadratic opening occupies most of the dorsal side and corresponds to paraplate 4. The form and dimensions of the endo- and periarcheopyle are fairly constant.

**Comparison.** The paratabulation of *Invertocysta tabulata* Edwards, 1984 (Middle-Late Miocene) is completely expressed on the pericyst. Furthermore, the endocyst of the latter species is centered within the pericyst. *I. lacrimosa* Edwards, 1984 (Middle-Late Miocene) differs in that the boss of the endocyst is connected to the inner lip of the bowl-shaped pericyst. It differs furthermore from our species by the wide variation in size, shape, degree of reflection of the paratabulation and the size of the dorsal opening.

**Remarks.** Due to the fragile nature of the periphragm, *I. flandriensis* is often found distorted in preparations.

**Occurrence.** Knokke: -405.1 m - -315.1 m (Campanian); De Haan, -229.0 m (Campanian); Keiem, -211.6 m, -204.0 m, -199.6 m (Turonian - Santonian); Nieuwkerke, -91.0 m (Santonian).

**Genus *Microdinium* Cookson & Eisenack, 1960b; emend. Sarjeant, 1966; emend. Stover & Evitt, 1978.**

**Type species.** *Microdinium ornatum* Cookson & Eisenack, 1960b.

**Diagnosis.** Cookson & Eisenack, 1960b, p.6; Sarjeant, 1966, p. 148-149; Stover & Evitt, 1978, p.65-66.

***Microdinium minutum* n.sp.**

Pl. 1: 14-16, Pl. 2: 5

**Synonymy.**

1974 *Histiocysta palla* Davey 1969 - Foucher, p. 130, pl. 3, figs. 5, 6, Late Turonian, France.

1975 *H. palla* Davey 1969 - Foucher, pl. 1, fig. 2, Turonian, France.

**Derivatio nominis.** «Minutus», latin: small.

**Holotype.** Keiem well 36E135, -211.6 m, P.1, coord. E.F. V-41.4 (Pl. 1, figs. 14-16, Pl. 2, fig. 5), repository: collection of the Laboratory of Paleontology, University of Ghent.

**Locus typicus and stratum typicum.** Keiem, West Flanders, Belgium, well no. 36E135, -211.6 m, Turonian (Coniacian?).

**Dimensions.** Holotype: total length, 31  $\mu\text{m}$ ; total width, 27  $\mu\text{m}$ . Variation: total length, 28 - 36  $\mu\text{m}$ ; total width, 22-31  $\mu\text{m}$ . Number of measured specimens: 12.

**Diagnosis.** The small, proximate and suturocavate cyst has an ellipsoidal silhouette. The cyst is circular in equatorial view. The maximum width is situated near the posterior end of the paracingulum. The endophragm is scabrate while the periphragm is hyaline and in optical section only recognisable as a thin line. The endophragm and periphragm are appressed except in the parasutural areas where discrete, cavate parasutures are developed which reflect the paratabulation. The barely visible parasutural ridges give the impression of unornamented parasutural strips. The sparse, intratabular ornamentation consists of isolated granules and irregular crests. The slightly offset paracingulum divides the cyst in a hypocyst which is roughly twice as large as the epicyst. Paratabulation: 4 apicals, 4 anterior intercalaries, 6 precingulars, 6 paracingulars and 6 postcingulars, X and Y in partiform hypocystal arrangement, the exact arrangement of the parasulcal plates could not be determined. The precingular paraplate 2 is distinctively triangular. The apical archeopyle is of type (tAtI). An adherent operculum was observed in a few cases.

**Comparison.** *Microdinium granocarinarum* (Below, 1987) Lentin & Williams, 1989 (Late Campanian) differs by the higher parasutural crests and the dense granular, intratabular ornamentation. *M. densigranulatum* (Below, 1987) Lentin & Williams, 1989 (Middle Albian) is acavate and densely ornamented with granules.

**Remarks.** The cavate parasutures are discrete, giving the impression of unornamented parasutural strokes bordered with penitabular crests.

**Occurrence.** apart from the Turonian occurrences reported by Foucher (1974 & 1975), the species is encountered at Keiem: -211.6 m (Turonian), at Nieuwkerke, -103.0 m (Santonian) and at Oostduinkerke, -254.5 m (Cenomanian).

***Microdinium? sincfalensis* n.sp.**

Pl. 2: 7-8, 12-14

**Derivatio nominis.** "Sincfal": medieval geographical name of the well site area.

**Holotype.** Knokke well 11E138, -385.1 m, P.4, coord. E.F. O-46.4 (Pl. 2, figs. 12-14), repository: collection of the Laboratory of Paleontology, University of Ghent.

**Locus typicus and stratum typicum.** Knokke, West Flanders, Belgium, well no. 11E138, -385.1 m, Campanian.

**Dimensions.** Holotype: length of cyst, 40  $\mu\text{m}$ ; width of cyst, 38  $\mu\text{m}$ ; height of processes, max. 6  $\mu\text{m}$ . Variation: length of cyst, 33-44  $\mu\text{m}$ ; width of cyst, 34-41  $\mu\text{m}$ ; height of processes, max. 4-7  $\mu\text{m}$ . Number of measured specimens: 21.

**Diagnosis.** The small cyst has a subcircular to ovoidal outline. The endophragm is scabrate and forms parasutural crests. The crests are low and distally smooth. The intratabular ornamentation consists of one or two discrete protrusions which sometimes emanate from the centre of the paraplates. The protrusions have never been observed on the paracingular and parasulcal paraplates. These protrusions appear to be solid with a slightly broadened base and they recurve distally. The parasutural crests and the protrusions support a hyaline, thin periphragm. Paratabulation: 4 apicals, no anterior intercalaries, 6 precingulars, 6 paracingulars, 6 postcingulars, parasulcus undivided, X, Y, Z. Iu is strongly reduced. The antapical plate is pentagonal (quinqueform hypocystal arrangement) and the shape of VI is nearly triangular. The relatively small paracingulum divi-

des the cyst in a somewhat larger hypocyst than epicyst. The apical archeopyle is free and of type (ta). An adherent operculum has been observed in a few cases. The parasulcal notch is deep.

**Comparison.** This species resembles *Genus A* Benson, 1976 but differs by the smaller paracingulum and the absence of paracingular protrusions. *Genus A* cannot, according to Benson, 1976 be placed in the genus *Microdinium* because of the incomplete apical paratabulation and the unusual ornamentation in the centre of the paraplates.

**Remarks.** The incompletely developed parasulcal area and the quinqueform hypocystical arrangement makes a definite assignment to the genus *Microdinium* doubtful.

**Occurrence.** Knokke: -405.1 m - -315.1 m (Campanian); De Haan, -222.0 m (Campanian); Keiem, -211.6 m, -204.0 m, -196.3 m (Turonian - Santonian); Nieuwerkerke, -91.0 m (Santonian).

#### **Genus *Pervosphaeridium* Yun, 1981.**

**Type species** *Pervosphaeridium pseudohystrichodinium* (Deflandre, 1937) Yun, 1981.

**Diagnosis.** Yun, 1981, p. 26-27.

*Pervosphaeridium elegans* n.sp.  
Pl. 2: 10-11

**Derivatio nominis.** «Elegans» (adj.), latin: elegant.

**Holotype.** Knokke well 11E138, -311.8 m, P.4, coord. E.F. Q-56.1 (Pl. 2, figs. 10-11), repository: collection of the Laboratory of Paleontology, University of Ghent.

**Locus typicus and stratum typicum.** Knokke, West Flanders, Belgium, well no. 11E138, -311.8 m, Campanian.

**Dimensions.** Holotype: diameter of central body, 44  $\mu\text{m}$ ; max. length of processes, 27  $\mu\text{m}$ . Variation: diameter of central body, 37 - 49  $\mu\text{m}$ ; length of processes, 21 - 29  $\mu\text{m}$ . Number of measured specimens: 11.

**Diagnosis.** The skolochorate cyst has an almost spherical central body. The wall of the cyst is bilayered: the endophragm is slightly granular and the periphragm is scabrate. Both layers are normally appressed except where the hollow, slender processes

are developed. The base of the processes is faintly striate. They taper slowly, are distally open and have a recurved margin. The distal end of the processes is aculeate. All processes stand apart and neither the apical nor the antapical process is of different shape or morphology. The position of the processes is intratabular; there seem to be three to four processes per paraplate, two processes per paracingular paraplate. The parasulcal processes are thinner and smaller. The large archeopyle is of type 2P with a free operculum. The large archeopyle and the smaller parasulcal processes facilitate the orientation of the cyst.

**Comparison.** *P. elegans* differs from all other *Pervosphaeridium* species by the slender, hollow and distally open processes. It is furthermore characterized by the absence of an apical or antapical differentiated process.

**Occurrence.** Knokke: -405.1 m - -311.8 m (Campanian).

**Genus *Rhynchodiniopsis* Deflandre, 1935; emend. Below, 1981; emend. Sarjeant, 1982; emend. Jan du Chêne et al., 1985.**

**Type species.** *Rhynchodiniopsis aptiana* Deflandre, 1935.

**Diagnosis.** Deflandre, 1935, p. 231; Below, 1981, p. 117; Sarjeant, 1982, p. 34-35; Jan du Chêne et al., 1985, p. 116, 118, 120.

*Rhynchodiniopsis sallorum* n.sp.  
Pl. 2: 1-2, 4, 9

**Derivatio nominis.** "Salii", Salic Franks, early medieval tribe from the western low countries.

**Holotype.** Knokke well 11E138, -377.6 m, P.6, coord. E.F. R-41.3 (Pl. 2, figs. 1-2, 4), repository: collection of the Laboratory of Paleontology, University of Ghent.

**Locus typicus and stratum typicum.** Knokke, West Flanders, Belgium, well no. 11E138, -377.6 m, Campanian.

**Dimensions.** Holotype: total length (apical horn included but without crests), 109  $\mu\text{m}$ ; width (without crests), 65  $\mu\text{m}$ ; length of apical horn, 29  $\mu\text{m}$ ; height of paracingular crests, 12  $\mu\text{m}$ . Variation: length (apical horn included but without crests), 90-121  $\mu\text{m}$ ; width (without crests), 55-72  $\mu\text{m}$ ; length of apical

horn, 25-34  $\mu\text{m}$ ; height of paracingular crests, 9-15  $\mu\text{m}$ . Number of measured specimens: 14.

**Diagnosis.** The elongated, large acavate cyst has in dorsoventral view an almost symmetrical, quasi pentagonal outline. The epicyst is prolonged into an apical horn, the hypocyst is trapezoidal. The long apical horn can almost make up to 1/3 of the total cyst length, which renders the hypocyst half as long as the epicyst. The flanks of epicyst and hypocyst are slightly convex to almost straight. The wall of the cyst is scabrate and a microreticular structure in penitabular position was observed on a few specimens. The paratabulation pattern is clearly reflected by parasutural crests with a smooth to indented or broken distal margin. The paracingular crests are the widest and usually indented. Large, simple gonal spines exceed the crests in height. Paratabulation pattern: 1 preapical (difficult to observe with a light microscope), 4 apicals, no anterior intercalaries, 6 precingulars, 6 paracingulars, 6 postcingulars, Y, X, parasulcal Z, li, lm, fu and ai difficult discernible. A is large and irregular rectangular. The contacts between A, 1i and 1u are vague. li is almost triangular. The contact between IV and V lies in the middle below 4. Contact between X and Z is vague. X is long and narrow and has a small contact with Y. Z is small and quasi symmetrically square. The precingular archeopyle is of type P and formed by the release of paraplate 4. The operculum is free.

**Comparison.** *R. saliorum* differs from *R. aptiana* Deflandre, 1935 (Senonian) by the smoother crests, the wall structure, the absence of anterior intercalaries and the presence of only one preapical. Other *Rhynchodiniopsis* species differ by the shorter apical horn, the wall structure and the ornamentation. *Rhynchodiniopsis* sp. cf. *R. aptiana* in Jarvis *et al.*, 1988, fig. 24 k (Cenomanian, SE England) resembles but the photographs don't allow a detailed comparison. *Gonyaulacysta prominoseptata* in Wilson, 1974 (Late Campanian) differs by the absence of the gonal spines, the higher parasutural crests and the larger dimensions of the cyst.

**Occurrence.** Knokke: -420.7 m - -356.8 m (Campanian); De Haan, -222.0 m (Campanian).

**Genus *Senoniasphaera* Clarke & Verdier, 1967.**

**Type species.** *Senoniasphaera protrusa* Clarke & Verdier, 1967.

**Diagnosis.** Clarke & Verdier, 1981, p. 61.

***Senoniasphaera palla* n.sp.**

Pl. 2: 3, 6

**Derivatio nominis.** «Palla», latin: long robe, referring to the nature of the periphragm.

**Holotype.** Nieuwkerke well 95W153, -159.0 m, P.3, coord. E.F. F-23.4 (Pl. 2, figs. 3, 6), repository: collection of the Laboratory of Paleontology, University of Ghent.

**Locus typicus and stratum typicum:** Nieuwkerke, West Flanders, Belgium, well no.95W153, -159.0 m, Turonian.

**Dimensions.** Holotype: length of endocyst, 66  $\mu\text{m}$ , width of endocyst, 60  $\mu\text{m}$ , length of pericyst, 71  $\mu\text{m}$ , width of pericyst, 65  $\mu\text{m}$ . Variation: length of endocyst, 60-73  $\mu\text{m}$ ; width of endocyst, 56-69  $\mu\text{m}$ ; length of pericyst, 64-78  $\mu\text{m}$ ; width of pericyst, 55-70  $\mu\text{m}$ . Number of measured specimens: 19.

**Diagnosis.** Bilayered, circumcavate cyst with an ovoidal to subpolygonal ambitus in dorsoventral view. The cyst is dorsoventrally compressed with the ventral side almost straight. One antapical horn is weakly developed while the other antapical horn mostly is reduced. The paracingular protrusions are weakly developed. The maximal width of cyst is located at the paracingular protrusions. A faint apical horn is developed. The endophragm is scabrate, the thin periphragm densely pitted. The endophragm forms low, solid and pillarlike protrusions which support the periphragm and mark subcircular thickenings on the periphragm. The periphragm is closely draped around the endocyst, giving it a wrinkly appearance. The endo- and pericyst have a similar outline. The apical archeopyle is of type (ta) or (ta)a. The apical margin is zigzag. The offset sulcal notch is mostly well developed. The paratabulation pattern is not reflected, only 4 apicals and 6 precingulars can be deduced from the archeopyle margin.

**Comparison.** *Senoniasphaera protrusa* Clarke & Verdier, 1967 (Santonian) differs by its well developed horns, *S. tabulata* Backhouse & Helby in Helby, 1987 (Hauterivian) has a rather clearly expressed paratabulation pattern and well developed antapical horns. *S. ptomatis* Helby, May & Partridge, 1987 in Helby, 1987 (middle Berriasian) differs by the large pericoels and the expressed paratabulation pattern. *S. edenensis* Marshall, 1990 (Campanian) has more pronounced antapical horns, a more clearly expressed paratabulation pattern and a different spatial arrangement between the endophragm and the periphragm.

**Occurrence.** Nieuwkerke: -153.0 m, -159.0 m (Turonian).

### 3. ACKNOWLEDGEMENTS

The critical reading of the manuscript and the fruitful discussions on the taxonomy and morphology of some species by Dr. J. De Coninck and H. Slimani are greatly appreciated. The technical assistance of D. Bavy and N. Reynaert is appreciated. Thanks are due to Dr. J. Bouckaert, Director of the Geological Survey of Belgium, for providing the samples. The «Instituut voor Wetenschappelijk Onderzoek in Landbouw en Nijverheid» provided a grant which made part of this study possible.

### 4. REFERENCES

- BAL, S.G. & VERBEEK, J.W., 1990. Upper Cretaceous nannoplankton in the Knokke well. In: LAGA, P. & VANDENBERGHE, N. (eds.). *The Knokke well (11E/138). With a description of the Den Haan (22W/276) and Oostduinkerke (35E/142) wells*, pp. 63-66. Mémoires pour servir à l'Explication des Cartes Géologiques et Minières de la Belgique / Toelichtende Verhandelingen voor de Geologische en Mijnkaarten van België No. 29, Ch. VI.
- BELOW, R., 1981. Dinoflagellaten-Zysten aus dem oberen Hauterive bis unteren Cenoman Süd West-Marokkos. *Palaeontographica*, B176: 1-145, pl. 1-15.
- BELOW, R., 1987. Evolution und Systematik von Dinoflagellaten-Zysten aus der Ordnung Peridiniales. II. Cladopyxiaceae und Valvaodiniaceae. *Palaeontographica*, B206: 1-135, pl. 1-29.
- BENSON, D.G., 1976. Dinoflagellate taxonomy and biostratigraphy at the Cretaceous-Tertiary boundary, Round Bay, Maryland. *Tulane Studies in Geology and Paleontology*, 12: 169-233.
- CLARKE, R.F.A. & VERDIER, J.-P., 1967. An investigation of microplankton assemblages from the Chalk of the Isle of Wight, England. *Verhandelingen der Koninklijke Nederlandse Akademie van Wetenschappen, afdeling Natuurkunde (Eerste Reeks)*, 24: 1-96, pl. 1-17.
- CLOWES, C.D., 1985. *Stoveracysta*, a new gonyaulacacean dinoflagellate genus from the upper Eocene and lower Oligocene of New Zealand. *Palynology*, 9: 27-35, pl. 1-2.
- COOKSON, I.C. & EISENACK, A., 1960a. Upper Mesozoic microplankton from Australia and New Guinea. *Palaeontology*, 2 (1): 243-261, pl. 37-39.
- COOKSON, I.C. & EISENACK, A., 1960b. Microplankton from Australian Cretaceous sediments. *Micropalaeontology*, 6 (1): 1-18, pl. 1-3.
- COOKSON, I.C. & EISENACK, A., 1965. Microplankton from the Browns Creek Clays, SW. Victoria. *Proceedings of the Royal Society of Victoria*, 79: 119-131, pl. 11-15.
- DAVEY, R.J., 1969. Non-calcareous microplankton from the Cenomanian of England, northern France and North America, Part I. *Bulletin of the British Museum (Natural History), Geology*, 17: 103-180, pl. 1-11.
- DEFLANDRE, G., 1935. Considérations biologiques sur les microorganismes d'origine planctonique conservés dans les silex de la craie. *Bulletin biologique de la France et de la Belgique*, 69: 213-244, pl. 5-9.
- DEFLANDRE, G., 1937. Microfossiles des silex crétacés. Deuxième partie. Flagellés incertae sedis Hystrichosphaeridés. Sarcodins. Organismes divers. *Annales de paléontologie*, 26: 51-103, pl. 11-18.
- DEFLANDRE, G. & COOKSON, I.C., 1955. Fossil microplankton from Australian Late Mesozoic and Tertiary sediments. *Australian Journal of Marine and Freshwater Research*, 6: 242-313, pl. 1-9.
- DORHOFER, G. and DAVIES, E.H., 1980. Evolution of archeopyle and tabulation in Rhaetogonyaulacinean dinoflagellate cysts. *Royal Ontario Museum, Life Sciences Miscellaneous Publications*, 1-91, figs. 1-40.
- EDWARDS, L.E., 1984. Miocene dinocysts from Deep Sea Drilling Project Leg 81, Rockall Plateau, eastern North Atlantic Ocean. In: Roberts, D.G. & Schnitker, D. et al. Initial Reports of the Deep Sea Drilling Project, vol. LXXXI, pp. 581-594, pl. 1-5. Washington.
- FOUCHER, J.C., 1974. Microfossiles des Silex du Turonien Supérieur de Ruyaulcourt (Pas-de-Calais). *Annales de Paléontologie (Invertébrés)*, 60 (2): 113-164, XI pl.
- FOUCHER, J.C., 1975. Dinoflagellés et acritarches des silex crétacés du bassin de Paris : une synthèse stratigraphique. *Annales de l'Université A.R.E.R.S. (Reims)*, 13 (1/2): 8-10, 2 pl.
- HELBY, R., 1987. *Muderongia* and related dinoflagellates of the latest Jurassic to Early Cretaceous of Australia. In: JELL, P.A. (ed.). *Studies in Australian Mesozoic Palynology*, Association of Australasian Palaeontologists, Memoir 4: 297-336.
- JAN DU CHENE, R., FAUCONNIER, D. and FENSOME, J.P.G., 1985. Problèmes taxonomiques liés à la révision de l'espèce «*Gonyaulax*» *cornigera* Valensi, 1953, kyste fossile de dinoflagellé. *Revue de micropaléontologie*, 28 (2): 109-124, pl. 1-5.
- JARVIS, I., CARSON, G.A., COOPER, M.K.E., HART, M.B., LEARNY, P.N., TOCHER, B.A., HORNE, D. & ROSENFELD, A., 1988. Microfossil Assemblages and the Cenomanian-Turonian (late Cretaceous) Oceanic Anoxic Event. *Cretaceous Research*, 9: 3-103.
- LENTIN, J.K. & WILLIAMS, G.L., 1989. Fossil Dinoflagellates : Index to Genera and Species 1989 Edition. *American Association of Stratigraphic Palynologists Foundation*, 20.
- LOUWYE, S., 1990. Top occurrence of selected Dinophyceae from the Cretaceous of the De Haan well and correlation with the Knokke well. In: LAGA, P. & VANDENBERGHE, N. (eds.). *The Knokke well (11E/138). With a description of the Den Haan (22W/276) and Oostduinkerke (35E/142) wells*: 103-105. Mémoires pour servir à l'Explication des Cartes Géologiques et Minières de la Belgique / Toelichtende Verhandelingen voor de Geologische en Mijnkaarten van België No. 29, Ch. VI.
- LOUWYE, S., 1990. De Dinophyceae uit het Boven-Krijt van West-België: Systematiek en Biostratigrafie. Unpublished PhD thesis, University of Gent, 289pp. 2 vol.
- LOUWYE, S., 1992. Dinoflagellate cyst stratigraphy of the Upper Cretaceous of western Belgium. *Bulletin de la Société belge de Géologie*, T. 101 (3-4), pp. 255-275.
- MARSHALL, N.G., 1990. Campanian dinoflagellates from southeastern Australia, *Alcheringa*, 14: 1-38.
- McLEAN, D.M., 1973. Emendation and transfer of Eisenackia (Pyrrhophyta) from the Microdiniaceae to the Gonyaulacaceae. *Geologiska Föreningens i Stockholm Förhandlingar*, 95: 261-265.



NUYTS, H., 1989. Studie van de Ostracoda uit Boven-Krijt afzettingen in Noord-België (Systematiek, Biostratigrafie, Paleoecologie, vol. I : Tekst, vol. II : Figuren en platenatlas. Unpublished Ph. D. thesis, University of Ghent.

SARJEANT, W.A.S., 1966. Dinoflagellate cysts with Gonyaulax-type tabulation. In: DAVEY, R.J., DOWNIE, C., SARJEANT, W.A.S. & WILLIAMS, G.L. *Studies on Mesozoic and Cainozoic dinoflagellate cysts*: 107-156. Bulletin of the British Museum (Natural History), Geology, Supplement 3.

SARJEANT, W.A.S., 1982. The dinoflagellate cysts of the Gonyaulacysta group: a morphological and taxonomic study. *American Association of Stratigraphic Palynologists, Contributions Series*, 9: 1-80, pl. 1-12.

STOVER, L.E. & EVITT, W.R., 1978. Analyses of pre-Pleistocene organic-walled dinoflagellates. *Stanford University Publications, Geological Sciences*, 15: 1-300.

STOVER, L.E. & HELBY, R., 1987. Some Early Cretaceous dinoflagellates from the Houtman-1 well, Western Australia. In: JELL, P.A. (ed.). *Studies in Australian Mesozoic Palynology*, Association of Australasian Palaeontologists, Memoir 4: 261-295.

WILSON, G.J., 1974. Upper Campanian and Maastrichtian Dinoflagellate Cysts from the Maastricht Region and Denmark. Unpublished Ph. D. thesis, University of Nottingham Library.

YUN, H-S., 1981. Dinoflagellaten aus der Oberkreide (Santon) von Westfalen. *Palaeontographica*, B177: 1-89, pl. 1-16.

*Manuscrit reçu le 23/02/94; accepté le 05/05/94.*

**PLATE 1**

New dinoflagellate cysts from Upper Cretaceous subsurface deposits of western Belgium.

1-6, *Canningia keiemensis* n.sp.

1 & 2, holotype, Keiem well 36E135, -211.6 m, P.9, coord. E.F. K-32, total length 91  $\mu\text{m}$ , ventral face, exterior view; 3 & 6, holotype, total width 84  $\mu\text{m}$ , dorsal face, interior view; 4, Keiem well 36E135, -211.6 m, P.9, coord. E.F. E-45.4, total width 67  $\mu\text{m}$ , apical face, archeopyle, exterior view; 5, antapical face, interior view.

7-9, *Eisenackia? knokkensis* n.sp.

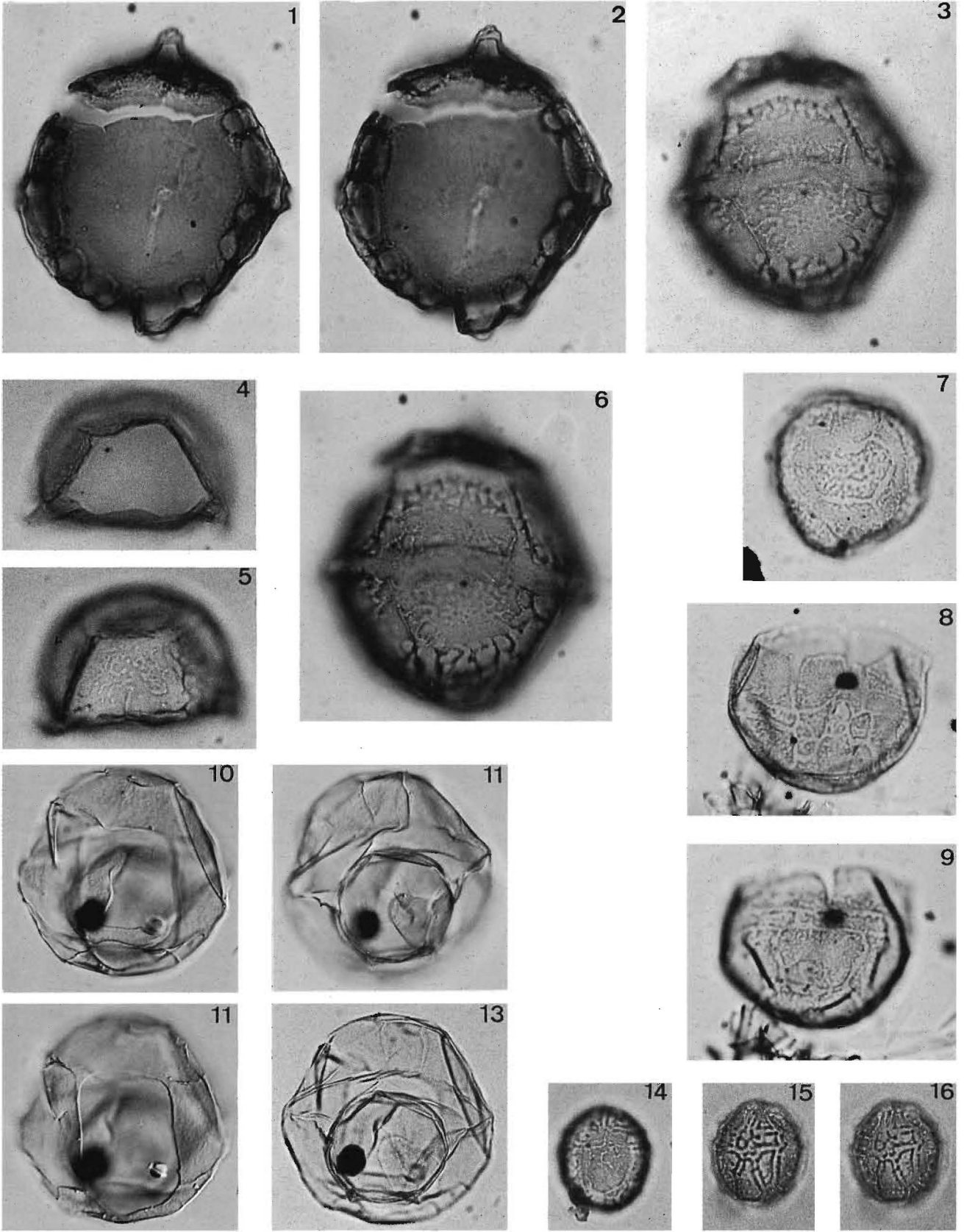
7, Knokke well 11E138, -414.4 m, P.8, coord. E.F. N-27, hypocyst, antapical face, exterior view, slightly distorted specimen; 8, holotype, Knokke well 11E138, -420.7 m, P.1, coord. E.F. G-23.4, total width 58  $\mu\text{m}$ , ventral face, exterior view; 9, holotype, dorsal face, interior view.

10-13, *Invertocysta flandriensis* n.sp.

10 & 12, holotype, Knokke well 11E138, -347.6 m, P.1, coord. E.F. X-35, length pericyst 62  $\mu\text{m}$ , dorsal face, exterior view; 11, holotype, ventral face, interior view; 13, holotype, optical section.

14-16, *Microdinium minutum* n.sp.

14, holotype Keiem well 36E135, -211.6 m, P.1, coord. E.F. V-41.4, length cyst 31  $\mu\text{m}$ , dorsal face, interior view; 15 & 16, holotype, ventral face, exterior view, slightly differing foci.



**PLATE 2**

New dinoflagellate cysts from Upper Cretaceous subsurface deposits of western Belgium.

1, 2, 4 & 9, *Rhynchodiniopsis saliorum* n.sp.

1, holotype, Knokke well 11E138, -377.6 m, P.6, coord. E.F. R-41.3, total length without crests 109  $\mu\text{m}$ , dorsal face, interior view; 2, holotype, ventral face, exterior view, focus on parasutural crests; 4, holotype, total length without crests 109  $\mu\text{m}$ , optical section; 9, Knokke well 11E138, -377.6 m, P.10, coord E.F. Y-28.4, total width without crests 72  $\mu\text{m}$ , epicyst, lateral face, exterior view, distorted specimen, note the absence of the anterior intercalary paraplate.

3 & 6, *Senoniasphaera palla* n.sp.

3, holotype, Nieuwkerke well 95W153, -159 m, P.3, coord E.F. F-23.4, length pericyst 71  $\mu\text{m}$ , ventral face, exterior view; 6, holotype, optical section.

5, *Microdinium minutum* n.sp.

5, holotype, Keiem well 36E135, -211.6 m, P.1, coord. E.F. V-41.4, length cyst 31  $\mu\text{m}$ , ventral face, exterior view, detail of the *parasulcus*.

7-8 & 12-14 *Microdinium? sinfalensis* n.sp.

7, Keiem well 36E135, -211.6 m, P.9, coord. E.F. K-24.3, diameter cyst without crests 34  $\mu\text{m}$ , apical face, exterior view; 8, antapical face, interior view; 12, holotype, Knokke well 11E138, -385.1 m, P.4, coord E.F. Q-46.4, length cyst 40  $\mu\text{m}$ , left lateral face, interior view; 13, holotype, optical section; 14, holotype, right lateral face, exterior view.

10 & 11 *Pervosphaeridium elegans* n.sp.

10, holotype, Knokke well 11E138, -311.8 m, P.4, coord E.F. Q-56.1, diameter central body 44  $\mu\text{m}$ , ventral face, interior view; 11, holotype, diameter central body 44  $\mu\text{m}$ , dorsal face, exterior view.

