Bulletin de Société belge de Géologie, T. 105 (3 & 4), 1996, pp.
Bulletin van de Belgische Vereniging voor Geologie. Ed. 1999

# ORGANIC-WALLED PHYTOPLANKTON BIOSTRATIGRAPHY OF THE EOCENE - OLIGOCENE TRANSITION IN THE KALLO BOREHOLE AND THE RUPELIAN STRATOTYPE AREA (NORTHWESTERN BELGIUM)

**Jan DE CONINCK**[1]

**ABSTRACT**. A detailed study of the assemblages of organic-walled phytoplankton in the Eocene-Oligocene transition beds in the Kallo borehole and its comparison with the assemblages around the same transition in boreholes at Niel, Hingene-Wintham and Terhagen (the Rupelian stratotype area), reveals a hiatus between the Wintham Silt Member and the Ruisbroek Sand Member (sensu Steurbaut, 1986, 1992) in the stratotype area. In the Kallo section the sedimentation history from the latest Eocene into the Early Oligocene is more completely represented than in the stratotype area of the Rupelian.

**KEYWORDS** : Eocene-Oligocene transition, dinocysts, biostratigraphy, Belgium.

**RESUME**. Les assemblages de phytoplancton à paroi organique ont été étudiés en détail dans les dépôts de la transition Eocène-Oligocène du sondage de Kallo. La comparaison avec les sondages de Niel, Hingene-Wintham et Terhagen (région-type du Rupélien), indique l'existence d'une lacune dans la région-type entre le Silt de Wintham et les Sables de Ruisbroek (sensu Steurbaut, 1986, 1992). Dans le sondage de Kallo, la sédimentation de l'Eocène terminal jusque à l'Oligocène inférieur est plus complète que dans la région-type du Rupélien (Nord-ouest de la Belgique).

**MOTS CLES** : Passage Eocène-Oligocène, dinokystes, biostratigraphie, Belgique.

## 1. INTRODUCTION

A first rough exploration of the organic-walled phytoplankton across the Eocene-Oligocene transition in the Belgian basin was carried out by De Coninck (1986 and 1995), respectively in the Woensdrecht borehole (southern Netherlands) and in the Kallo borehole 27E-148 (near Antwerp - Belgium). From the comparison of the phytoplankton assemblages in both boreholes it was concluded (De Coninck, 1995, figure 2) that a hiatus occurs at Woensdrecht between -220 and -219 m, which corresponds approximately with deposits in the Kallo borehole between approximately -110 and -106 m. A more detailed examination of the deposits spanning the Eocene-Oligocene transition in the Kallo borehole has been undertaken. Furthermore, in the Rupelian stratotype area, about 15 to 20 km to the south of Antwerp (Figure 1), some samples were examined representing the lithostratigraphic units (Watervliet Clay Member, Wintham Silt Member and Ruisbroek Sand Member) which span the same transition in three boreholes : the Niel borehole 43W-270 (stratotype of the Ruisbroek Sand Member), the Hingene-Wintham borehole 42E-212 (stratotype of the Wintham Silt Member) and the Terhagen borehole 58W-213. These new investigations are complementary to the detailed nannofossil biostratigraphy presented by Steurbaut (1986 and 1992) and to his sequence-stratigraphical interpretation of the Eocene-Oligocene transitional deposits in the Belgian basin (Steurbaut, 1992).

From the present study, it appears that the Kallo borehole 27E-148 is a good reference section for the Eocene-Oligocene transition in the southern North Sea basin.

## 2. BIOSTRATIGRAPHIC RESULTS

### 2.1. KALLO BOREHOLE 27E-148 (Figure 2) [all tables at end of text]

### 2.1.1. Samples and investigation techniques

De Coninck (1995) already examined the Eocene-Oligocene transitional deposits in the Kallo borehole in four samples only, taken at -115 m, -108 m, -98 m and -91 m. The more detailed study presented here is based on the examination of sixteen samples : -115 m, -112.1 m, -111 m, -110.5 m, -110 m, -109.5 m, -108.2 m, -108 m, -107 m, -106 m, -100 m, -98 m, -97 m, -96 m, -94 m and -92.6 m. According to Steurbaut (1992, fig. 7), this series of samples represents the top part of

---

[1] Laboratorium voor Paleontologie, Geologisch Instituut, Universiteit Gent, Krijgslaan 281/S8 - B-9000 Gent.

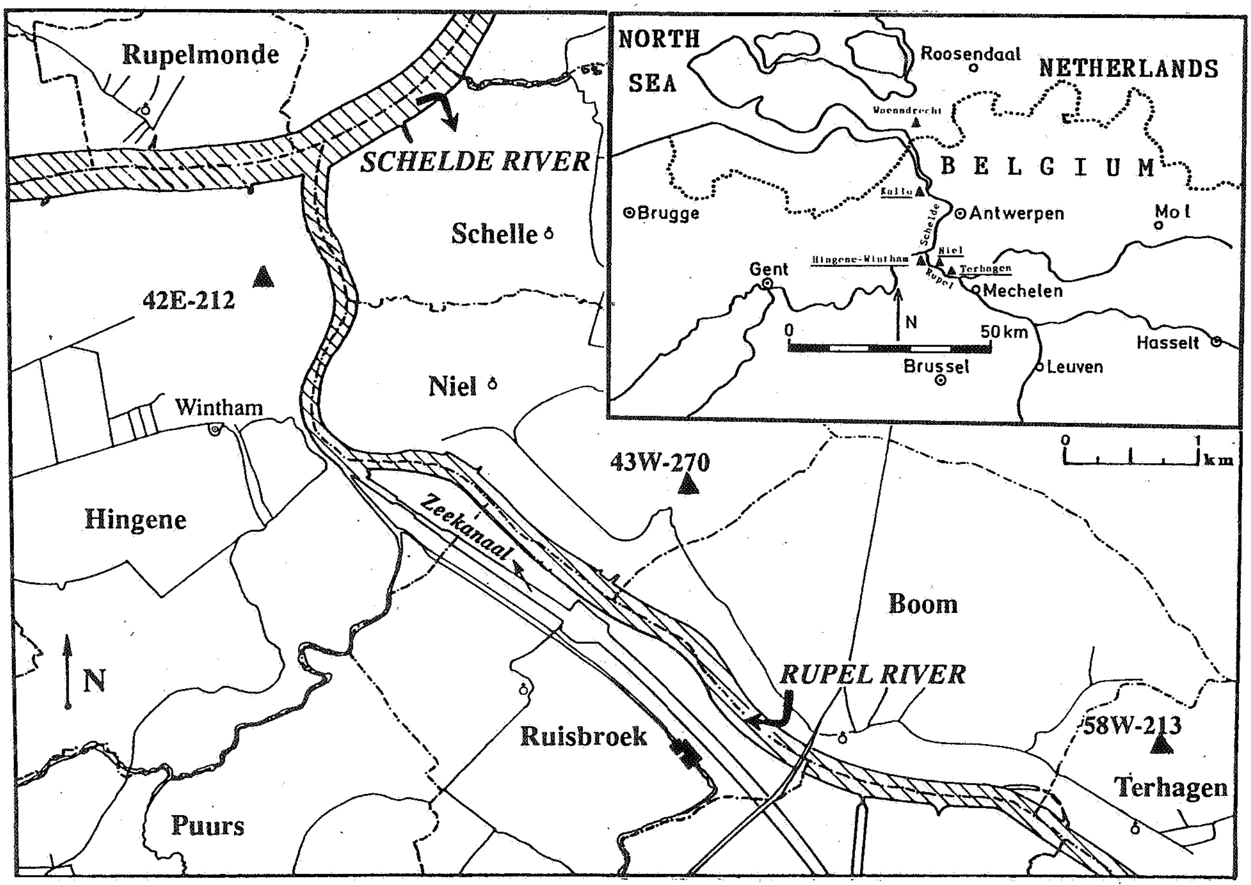


Figure 1. Localisation of the boreholes of Kallo, Hingene-Wintham, Niel and Terhagen.

the Bassevelde Sand Member (-115 m and -112.1 m), the Watervliet Clay Member (-111 m and -110.5 m), the Wintham Silt Member (-110 m?, -109.5 m), the Ruisbroek Sand Member (-108.2 m up to -96 m), the Boom Clay Formation (probably Belsele-Waas Clay Member) (-94 m and -92.6 m) (see Figure 2). The sampling gap between -106 m and -100 m could not be filled because no material was available from that part.

Table 1 presents the distribution of the Chlorophyceae, Dinophyceae, Prasinophyceae and Acritarcha in the examined section. Frequencies are indicated by the following symbols :
. sporadic <0.2 %; : rare >0.2 % to 0.7 %; I infrequent >0.7 % to 3 %; II frequent >3 % to 10 %; X common >10 % to 25 %; XX abundant >25 %.
The letters J, C, P, Y or L in front of certain taxa indicate reworking from respectively Jurassic, Cretaceous, Palaeocene, Ypresian or Lutetian deposits. At the end of Table 1 are indicated the numbers of species reworked from these older deposits, and the numbers of species considered as having been produced during the sedimentation of the deposits.

Fluctuations of the absolute number of reworked species, which in fact show the same tendencies as the changes of the summed relative frequencies of these taxa, give us a clue for the interpretation of changing intensities of erosion or of changing eustatic sea-levels. The occurrence at a few levels of rather frequent *Pediastrum* (fresh water planktonic green algae) can help us to decide for certain interpretations. Relative frequencies of the reworked taxa and of *Pediastrum* are also presented apart in Table 3; the fluctuations of the numbers of reworked species and high frequencies of *Pediastrum* are indicated in Figure 3.

Presence and frequency changes of plant tissue fragments in the residues are not listed, because these were not recorded systematically but they will be mentioned in the interpretation of the results.

### 2.1.2. Significant changes in the series of assemblages from the Kallo borehole

Among the dinocysts considered as contemporaneous with the sedimentation, a series of taxa were selected which might be useful for biostratigraphic application in the Eocene-Oligocene transitional deposits of the southern North Sea basin. Their distribution in the Kallo section is indicated in Table 2.
These selected species are used to correlate biostratigraphically the lithostratigraphical units defined by Steurbaut (1986 and 1992) in the Niel borehole 43W-

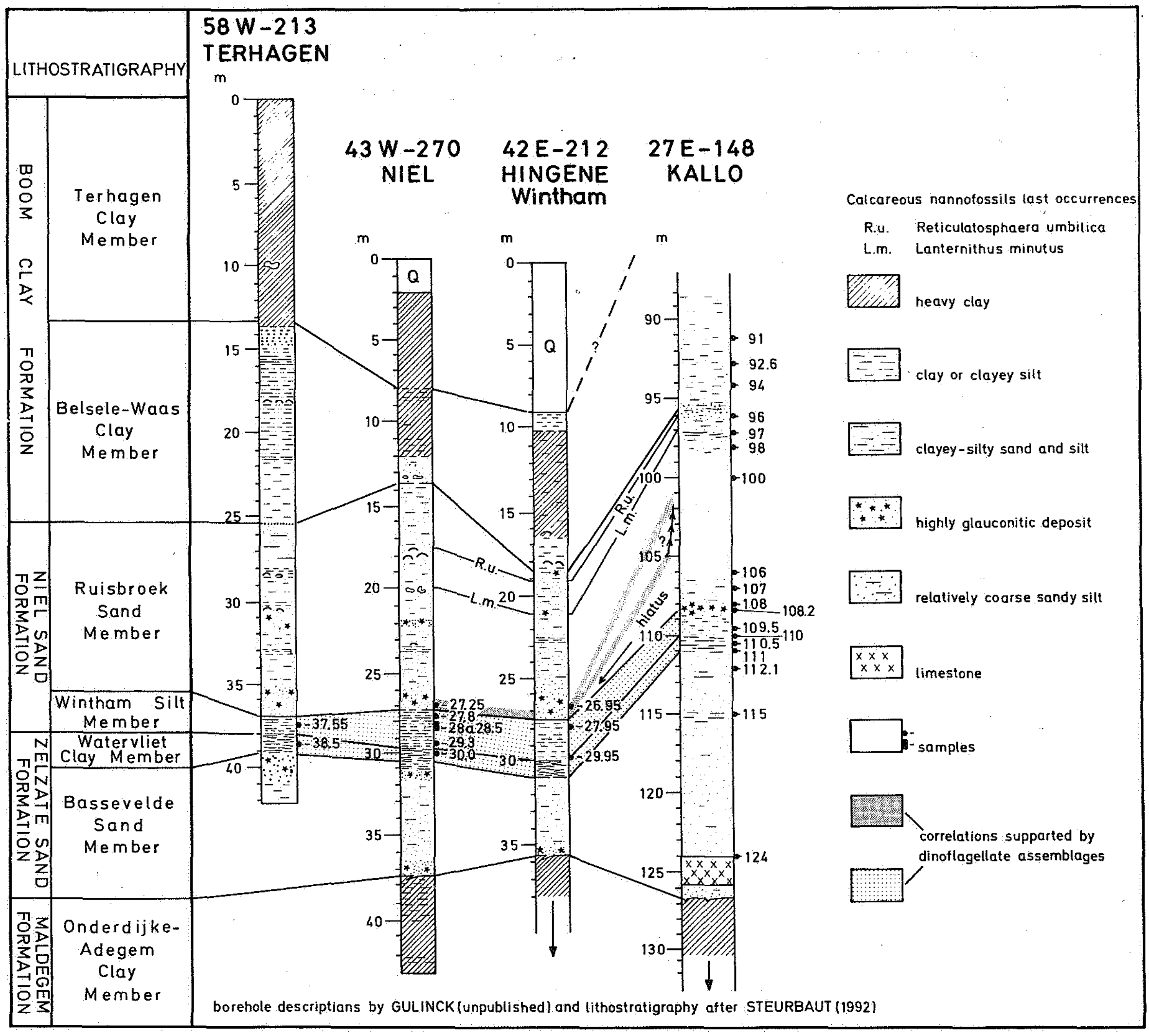


Figure 2. Lithology and lithostratigraphy of the studied borehole sections; biostratigraphic correlations.

270 and in the Hingene-Wintham borehole 42E-212 with the Kallo section (Figure 2).

Apart from these correlations, some accelerated or sudden changes in the composition of assemblages of significant taxa can reflect eventual decrease or interruptions of sedimentation, removal of deposits or changing hydrographical conditions affecting the southern North Sea basin.

When one examines Table 2, one notices a sudden change between -109.5 m and -108.2 to -108 m :

At -109.5 m are recorded the last occurrences of *Areosphaeridium diktyoplokus* (rather frequent), *Cerebrocysta bartonensis, Heteraulacacysta porosa, Membranophoridium aspinatum* forma A, *Rhombodinium perforatum, Homotryblium caliculum* and *Rhombodinium glabrum*. Other species such as *Charlesdowniea clathrata-coleothrypta, Glaphyrocysta* aff. *inculta* are still found in some higher levels but only sporadically. *Impletosphaeridium* sp. aff. I. sp. A - *Reticulatosphaera*? sp. A is recorded a last time at -108.2 m.

In -108.2 m to -108 m, one encounters the first *Impagidinium maculatum, Gerlachidium* spp. indet., *Hystrichokolpoma* aff. *cinctum, Gerdiocysta conopeum* and *Operculodinium*? sp. cf. *O. placitum*. *Membranophoridium aspinatum* forma B and *Selenopemphix selenoides*, which were sporadically recorded at some deeper levels, are regularly found at -108.2 m and higher. The sudden change between -109.5 m and -108.2 m is also marked by a sharp decrease of reworked Mesozoic (Jurassic and Cretaceous) dinocyst taxa and by the sudden appearance of frequent *Pediastrum* (freshwater green algae) (Table 3 and Figure 3). I will try to give an interpretation of this event after having correlated the Niel-, Hingene-Wintham- and Terhagen sections with the Kallo section.

Above -108 m, the changes among the significant taxa are rather gradual up to level -97 m.

Between -97 m and -94 m, one notices an accelerated change involving the disappearance of *Hystri-*

*chokolpoma* aff. *cinctum*, a rarefaction of *Membranophoridium aspinatum* forma C, a temporary rarefaction of *Wetzeliella symmetrica, Vozzhennikovia cearaichia* and *Reticulatosphaera*? sp. A. *Membranophoridium aspinatum* forma D first appears at -97 m and disappears already above -92.6 m. *Achilleodinium* aff. *biformoides* (only once recorded at -107 m) and *Vozzhennikovia spinula* are observed in -96 m and all higher levels.
*Chiropteridium* spp. and *Horologinella*? sp. 1 make their first appearance at -94 m. *Apteodinium spiridioides* is recorded at -94 m only, but rather frequently. *Charlesdowniea limitata* is sporadically recorded at -94 m only.
These changes between -97 m and -94 m correspond with a certain decrease of the numbers of reworked taxa, which attained a sudden peak at -97 m (Table 3 and Figure 3). Further discussion of the changes between -97 m and -94 m is delayed, until after the section dealing with the correlation of the Niel-, Hingene-Wintham- and Terhagen deposits with the Kallo section.

## 2.2. NIEL BOREHOLE 43W-270 (Figure 2)

Steurbaut (1986, p. 55 and Table 2) defined the Ruisbroek Sand Member in the Niel borehole as occurring between -29.50 m and -13.20 m below the surface. At -29.50 m, a sharp boundary corresponds with the top of the Watervliet Clay Member. In 1992, Steurbaut (p. 289, 295 and figure 2) reduced the Ruisbroek Sand Member in its stratotype, the Niel borehole, to a somewhat thinner part of the section, between -27.25 m and -13.20 m : he intercalated between -29.50 m (top of the Watervliet Clay Member) and -27.25 m (base of the newly delimited Ruisbroek Sand Member) a new unit, the Wintham Silt Member, of which the stratotype was chosen in the Hingene-Wintham borehole 42E-212.
Five samples have been examined in the Niel section : -30.00 m (top part of the Watervliet Clay Member), -29.30 m, -28.5 to -28 m, -27.80 m (Wintham Silt Member) and -27.25 m (base of the Ruisbroek Sand Member).
Several of the taxa which, after the study of the Kallo section, are considered as potentially significant for biostratigraphic correlations, have been recorded in the samples from Niel. Their occurrence is presented in Table 4.

A comparison of these occurrences with the distribution in the Kallo borehole (Table 2) reveals that the groups of significant species, at -30.00 m (top part of the Watervliet Clay Member) and at -29.30 m, -28.5 to -28 m, and -27.80 m (Wintham Silt Member) which differ only slightly from each other, characterize more precisely the assemblages at -110.5 m and at -110 m in the Kallo borehole. Biostratigraphically no significant change (e.g. hiatus or the effect of a hydrographical change) is detected between the Watervliet Clay Member and the Wintham Silt Member in the Niel borehole.

Higher in the sequence however, the difference between the assemblage at -27.80 m (top part of the Wintham Silt Member) and the one at -27.25 m (lowermost part of the Ruisbroek Sand Member) is striking : the significant species composition at -27.25 m corresponds best with the one found in the Kallo borehole at -100 m and -98 m. As no samples for examination were disponible from the Kallo borehole between -106 and -100 m, we think that the base of the Ruisbroek Sand Member at Niel can only imprecisely be correlated with a part of the Kallo section somewhere between -106 and -98 m. This means that in the Niel borehole there exists a hiatus between the Wintham Silt Member and the Ruisbroek Sand Member. This hiatus is represented at Kallo by at least 3 meters and at most 10 meters of sediments.

## 2.3. HINGENE-WINTHAM BOREHOLE 42E-212 (Figure 2)

Steurbaut (1992, p. 289, 295 and fig. 2) has designated this Hingene-Wintham borehole as stratotype of the Wintham Silt Member which rests with a sharp boundary at -30.00 m on the Watervliet Clay Member, and is followed at -27.55 m by the Ruisbroek Sand Member. Three samples have been examined in the Hingene-Wintham borehole : -29.95 m (lowermost part of the Wintham Silt Member) and -27.95 m (top part of the Wintham Silt Member), and -26.95 m (lower part of the Ruisbroek Sand Member). The biostratigraphically significant taxa in these three samples are indicated in Table 5.

At -29.95 m and -27.95 m (Wintham Silt Member) the assemblages of significant species suggest a correlation with -111 to -109.5 m in the Kallo borehole. A similar species composition has also been encountered in the top of the Watervliet Clay Member and in the Wintham Silt Member of the Niel borehole 43W-270 (see higher). The assemblage at -26.95 m, from the Ruisbroek Sand Member some 60 cm above its base, presents several significant species : *Glaphyrocysta semitecta, Wetzeliella symmetrica, Membranophoridium aspinatum* forma C and a form which seems intermediary between our *Svalbardella* sp. indet. and *Palaeocystodinium golzowense* are regularly encountered. *Vozzkennikovia cearaichia* and *Reticulatosphaera*? sp. A appear only sporadically. Only a few *Achilleodinium* aff. *biformoides* and *Chiropteridium* sp. indet. are recovered. Apart from the two last species, no *Membranosphaeridium aspinatum* forma D nor other significant species which appear at Kallo -97 m or higher are found in the assemblage.

Most of the significant species mentioned can be found together at Kallo from -106 to -98 m. The relatively frequent *Svalbardella-Palaeocystodinium*-like specimens suggest a correlation with the lower part of this interval. Only the presence of some *Chiropteridium* specimens, never recorded at these levels at Kallo, where this form is found a first time at -94 m, is confusing. The Wintham-Hingene assemblage at -26.95 m might eventually give evidence of an earlier short term appearance of *Chiropteridium*, which in that case was not observed in the Kallo traject because of sampling gaps.
A correlation of -26.95 m with some level at Kallo between -106 and -100 m, rather close to -106 m, seems nevertheless the best option, especially when one considers also the data from lithostratigraphic and calcareous nannoplankton studies by Steurbaut (1986, table 2 . 1999, fig. 2 and p. 297). In our Figure 2 the last occurrences of the nannofossil species *Lanternithus minutus* and *Reticulofenestra umbilica* are indicated in the three boreholes.

The proposed correlation corresponds approximately with the one concluded for the base of the Ruisbroek Sand Member in the Niel borehole. If correct, it reveals again a certain hiatus between the Wintham Silt Member and the Ruisbroek Sand Member, apparently a marked break of continuity in the type area of the Rupelian.

### 2.4. TERHAGEN BOREHOLE 58W-213 (Figure 2)

Steurbaut (1986, p. 58) had designated this Terhagen borehole as a parastratotype for the Ruisbroek Sand Member. After having introduced the Wintham Silt Member (Steurbaut, 1992, p. 295), the succession of lithostratigraphic units in the Terhagen borehole was interpreted by Steurbaut (ibid., fig. 2) as follows : the boundary between the Watervliet Clay Member and the Wintham Silt Member is situated at about -37.80 m, the boundary between the Wintham Silt Member and the overlying Ruisbroek Sand Member at -37.0 m.

Organic-walled phytoplankton has been examined in two samples : -38.50 m in the middle of the Watervliet Clay Member, and -37.55 m in the middle of the Wintham Silt Member. The biostratigraphically significant species recorded in both samples are indicated in Table 6.

The significant species association recorded at -38.50 m is found in the Kallo borehole between -115 and -111 m. The association at -37.55 m corresponds best with these from -111 m to -109.5 m in the Kallo borehole. Only little differences exist between both associations of significant species, indicating once more that between the Watervliet Clay Member and the Wintham Silt Member no biostratigraphical hiatus can be detected.

## 3. TENTATIVE INTERPRETATION OF THE KALLO BOREHOLE; CONFRONTATION WITH THE OBSERVATIONS IN THE OTHER BOREHOLES

The data obtained from the boreholes Niel, Hingene-Wintham and Terhagen are valuable for the interpretation of the changes observed in the Kallo borehole (Table 3 and Figure 3).

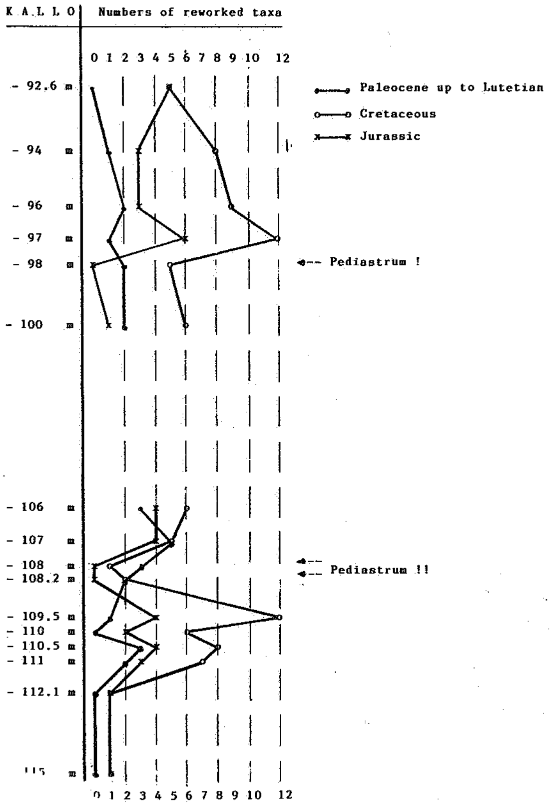


**Figure 3.** Numbers of reworked dinocyst taxa and frequencies of Pediastrum in the Kallo section.

### -115 up to -109.5 m

There are no significant changes in the composition of the contemporaneous organic-walled phytoplankton assemblages from the top part of the Bassevelde Sand Member over the Watervliet Clay Member to the top of the Wintham Silt Member. No biostratigraphic hiatuses can be detected between these units. When one examines the assemblages of the Watervliet Clay and Wintham Silt Members in the Niel- and Terhagen boreholes, one can not differentiate them on their contents of contemporaneous phytoplankton. The assemblages contain the same significant species as those in Kallo between -115 and -109.5 m.

Unlike the monotony of the composition of significant species, one notices in this part of the Kallo traject a marked contrast between the low frequencies of reworked phytoplankton at -115 m and -112.1 m, on the one hand, and their high frequencies, especially of Mesozoic taxa, from -111m up to -109.5 m, on the other hand. Between both parts of the traject, I observed also the absence of plant tissue fragments in -115 m and -112.1 m, followed by their presence, although not frequent, in -111 m up to -109.5 m. These differences can be explained by a suddenly lowered sea level. The reworked taxa (as well more diverse as more frequent) offer evidence of intensified erosion, while the presence of plant tissue fragments indicates the nearness of the coast during the sedimentation of the Watervliet Clay and Wintham Silt Members.

In the preceeding period, when the top part of the Bassevelde Sand Member was deposited (-115 m and -112.1 m), the sea level was probably still high, erosion of older deposits negligible and the coast far away as marine sediments of this age are present at Oret, Entre-Sambre-et-Meuse, about 100 km to the south of the Rupel type-area. The lower sea level which followed (-111 m up to -109.5 m), enhanced erosion probably of coastal cliffs to the west or north-west of the Belgian basin. The eroded material was probably carried towards the Kallo area by currents, which in the North Sea basin are normally counterclockwise. Maybe the regression was not the only cause of the erosion of unweathered deposits in which microfossils were well preserved. Ziegler (1990, p. 150 and 161) summarises some studies revealing a Late Eocene-Oligocene phase of regional uplift which affected, among others, the region of Yorkshire, its eastern prolongation towards the Sole Pit basin, also the Channel, the Celtic Sea and other parts of England. We do not know if that phase is coeval with any part of the Eocene-Oligocene transitional deposits studied here. Anyway, a cummulative effect of an eventual regional uplift to the west or north-west of the basin and the lowered sea level could explain more easily the erosion of Mesozoic rocks from which the reworked microfossils came.

In the Watervliet Clay and Wintham Silt of the Rupel type-area reworked dinocysts are less frequent and less diverse than in the corresponding deposits at Kallo. No doubt, the distribution of reworked microfossils in the Belgian basin was confined to the course followed by the current carrying eroded material.

**Transition from -109.5 m to -108.2 and -108 m**
This transition is marked by a prompt substitution of significant taxa (see higher) probably reflecting a temporary break or strong decrease of the sedimentation. Furthermore, the number of reworked Mesozoic dinocysts declines drastically and fresh-water green algae *Pediastrum* appear suddenly and frequently at -108.2 and -108 m while plant-tissue fragments become more frequent.
The reduction or break of sediment supply can reflect a temporary rise of the sea-level relative to the nearby coastal regions. If so, drainage of the coastal plain became first of all less effective and freshwater lakes may have formed. When the further rising sea finally invaded the coastal plain area, plant tissues and *Pediastrum* from the lakes and from their bottom sediments were redistributed on the sea bottom.

In the Niel- and Hingene-Wintham boreholes, no deposits corresponding to this supposed sea-level rise are found; instead a hiatus is detected between the Wintham Silt Member and the Ruisbroek Sand Member, probably not an erosional one but rather one marking the absence of sedimentation. If we maintain the proposed model of temporarily rising sea-level and regional palaeogeographic evolution based on the observations in the Kallo section between -109.5 m and -108.2 to -108 m, the sea-level rise affected only a restricted area and was thus relatively limited. The sudden fall of the number of reworked species between -109.5 m and -108.2 m (before their renewed but less pronounced increase at -107 m and -106 m) may be explained, not only by the slight sea-level rise but also by a change in position of the currents carrying the reworked material. The discontinuity at this transition is much more important than the earlier or later changes observed in this study of the Late Eocene-Early Oligocene deposits. It corresponds furthermore with the disappearance of *Areosphaeridium diktyoplokus*, a widely observed biostratigraphic event which is a reliable candidate for the determination of the Eocene-Oligocene boundary.

**-107 m and -106 m**
After the former particular intermezzo, sedimentation went on in the Kallo area only, because no time-equivalent deposits are found in the Rupel type-area. A number of reworked taxa are again recorded in -107 and -106 m, while *Pediastrum* disappears and plant tissue fragments become less frequent. Maybe currents with reworked microfossils affected again more or less the Kallo area. The presence of *Svalbardella* sp. indet. in -106 m only, is worth mentioning as the genus is characteristic of relatively cold water, according to Head & Norris (1989, p. 533).

**-106 m to -100 m**
As no samples could be studied between -106 m and -100 m, data are lacking. In the Rupelian type-area sedimentation probably started again at some time in the course of deposition of this interval.

**-100 m to -98 m**

Between both levels, the number of reworked Mesozoic taxa diminishes only slightly and at -98 m *Pediastrum*, only sporadically found at -100 m, becomes relatively frequent. These moderate changes reflect probably a slight sea-level rise and a redistribution of some invaded coastal plain fresh-water deposits.

**Transition from -98 m to -97 m**

At -97 m we note an impressive increase of Jurassic and Cretaceous microfossils in the assemblage. The sudden arrival of this reworked material is probably the result of a regression. In the Ruisbroek Sand Member studied in boreholes near the mouth of the Rupel river, Steurbaut (1992, figs. 3 and 4) found traces of a regression marking the transition of subsequence $A_1$ to subsequence $A_2$. This regression may have been important enough to explain the increase of reworked forms. The top of subsequence $A_1$ is, according to Steurbaut (ibid., p. 297 and Fig. 3), characterized by the last occurrence of the calcareous nannoplankton species *Lanternithus minutus*, which was indeed found at -97 m (see Steurbaut, 1986, Table 1).

**-96 to -94 m**

At -96 m the number of reworked forms decreases. It possibly reflects a rising sea-level, eventually corresponding to the flouding surface 2 in subsquence $A_2$, according to the sequence-stratigraphical interpretation by Steurbaut (1992, fig. 7).

At -94 m appear four species : *Apteodinium spiridoides, Charlesdowniea limitata, Chiropteridium* spp. indet. and *Horologinella*? sp. 1. The frequency of *Vozzhennikovia spinula*, which was first recorded sporadically at -96 m, increases clearly at -94 m.

The change observed between -96 and -94 m corresponds in fact with the transition at -95.5 m of the Ruisbroek Sand Member (Niel Sand Formation) to the Belsele-Waas Clay Member (Boom Clay Formation). It follows here immediately the last occurrence of the calcareous nannoplankton species *Reticulofenestra umbilica* (see Steurbaut, 1986, Table 1).

**-94 to -91 m**

There are no significant changes to mention among the succeeding assemblages in the Belsele-Waas Clay Member.

## 4. CONCLUSION

From the distribution of dinoflagellate cyst species produced by the plankton at the time of sedimentation of the Bassevelde Sand Member, the Watervliet Clay Member and the Wintham Silt Member, it is obvious that biostratigraphically there are no significant hiatus between these three lithostratigraphic units.

The sharp lithological boundary between the Watervliet Clay Member and the Wintham Silt Member in the Niel, Hingene-Wintham and Terhagen boreholes, with locally deep bioturbations descending from the Wintham Silt in the Watervliet Clay, does not represent a long-time interruption of sedimentation between both units.

In the Watervliet Clay and Wintham Silt Formations the appearance of plant tissue fragments and especially at Kallo of many reworked dinocysts in the assemblages indicates a sea-level drop and the resulting approach of the coast; this in contrast with the earlier high sea-level and remote coast during sedimentation of the Bassevelde Sand Member. A major change of the assemblages, with among others the disappearance of *Areosphaeridium diktyoplokus*, is noted at the transition from the Wintham Silt Member to the overlying Ruisbroek Sand Member. Probably sedimentation stopped for a while or became very limited in the Kallo area as a result of a slight rise of the sea-level which must have hindered temporarily drainage of the nearby coastal plain. Indeed, subsequent invasion by the sea redistributed freshwater deposits with their *Pediastrum* and plant tissue fragments. At the mean time the Rupel type-area was temporarily excluded from further sedimentation. During this interval of slowly rising sea-level and restricted sedimentation, about four or a little more meters of deposits were laid down in the Kallo area where some colder water influx seems to have occurred, indicated by the presence of *Svalbardella* at Kallo -106 m. Soon afterwards, the sedimentation of the Ruisbroek Sand Member spread into the Rupel type-area. There nearly the same lithological changes and calcareous nannofossil successions are observed as in the remaining Ruisbroek Sands at Kallo. At Kallo -97 m the sudden increase of the number of reworked dinocysts in the assemblage indicates a regression corresponding with the transition of subsequence $A_1$ to subsequence $A_2$. At Kallo -96 m the decreasing number of reworked dinocysts may indicate a transgression which eventually corresponds with the flooding surface 2 in subsequence $A_2$. The boundary between the Ruisbroek Sand Member and the Belsele-Waas Clay Member is situated at Kallo -95.5 m and accompanied by a relatively marked change of the assemblages, although less pronounced than the change at the boundary between the Wintham Silt Member and the Ruisbroek Sand Member, which reflects the most important discontinuity in sedimentation - underlined by a hiatus in the Rupelian stratotype area - and in succession of dinocyst-assemblages in the Late Eocene-Early Oligocene sequences of North-western Belgium.

## 5. REMARKS ON CERTAIN TAXA NOT YET COMMENTED ON IN EARLIER STUDIES BY THE AUTHOR (DE CONINCK, 1986 AND 1995)

***Achilleodinium*** aff. ***biformoides*** (EISENACK, 1954)
Pl. 7, figs. 4 and 5

Remark : Our specimens differ from *A. biformoides* (EISENACK, 1954, p. 68; pl. 11, figs. 16-20) by their elongate shape.
Dimensions of the cyst body : 70 to 78 µm long, 45 to 50 µm wide.

***Elytrocysta breva*** STOVER & HARDENBOL 1994
Pl. 3, figs. 12, 13, 14 and 15.

Remark : *E. breva* STOVER & HARDENBOL, 1994 (p. 35; pl. 2, figs. 10-12) corresponds with *Elytrocysta*? sp. B in De Coninck, 1995 (p. 85; pl. 1, figs. 10-11) and is larger than *Elytrocysta*? sp. A in De Coninck, 1986 (p. 12; pl. 2, figs. 15-18).
Dimensions : between 37 and 45 µm.

***Gerlachidium***? spp. indet.
Pl. 2, figs. 6, 19 and 20.

Remark : Our *Gerlachidium*? spp. indet. bear small, short and capitate processes, some of which are relatively wide and flattened, especially these on the anterior and posterior margin of the paracingulum. The cysts general form is rather similar to that of *Lejeunecysta* spp. than to that of *G. aechmophorum* (BENEDEK, 1972).
Dimensions of the cyst : 40 à 50 µm (two specimens), 60 à 65 µm (two other specimens).

***Hologinella***? sp. 1
Pl. 2, figs. 11, 16 and 17.

Remark : Our *Horologinella*? sp. 1 are thin walled organisms, with a general form which resembles a quadrangular pillow which is somewhat assyµmetrically invaginated at one of its sides. An attribution of this species to the genus *Horologinella* COOKSON & EISENACK, 1962 (p. 271) emend. STOVER & EVITT, 1978 (p. 53) emend. BACKHOUSE, 1988 (p. 90) is questionable.
Dimension : 15 to 18 µm.

***Hystrichokolpoma*** aff. ***cinctum*** KLUMPP, 1953
Pl. 4, figs. 1, 2 and 3.

Remark : Our *H.* aff. *cinctum* differ from the species (KLUMPP, 1953, p. 389; pl. 17, figs. 3-5a-d) by their distally widening, more tubiform processes.
Dimensions :
cyst body : ± 50 µm
antapical process : about 30 to 40 µm long, 8 to 13 µm wide below its distal evasion.
pre- and post cingular processes : about 20 to 25 µm long, 10 to 15 µm wide below their distal evasion.
paracingular and parasulcal processes : about 15 to 20 µm long, 2 to 3 µm wide below their distal evasion.

***Hystrichokolpoma*** aff. ***rigaudae*** DEFLANDRE & COOKSON, 1955
Pl. 1, figs. 15 and 16.

Remark : Our *H.* aff. *rigaudae* have an elongate cyst body, as our *H.* cf. *rigaudae* (in De Coninck, 1986, p. 13; pl. 4, fig. 5). The paracingular and parasulcal processes are relatively narrow, but not as tenuous as in *H.* cf. *rigaudae.*
Dimensions :
cyst body : 42 to 50 µm long; 30 to 35 µm wide.
antapical process : 25 to 30 µm long; 6 to 8 µm wide below its distal evasion.
pre- and postcingular processes : 15 to 22 µm long; 5 to 10 µm wide below their distal evasion.
paracingular and parasulcal processes : about 1 to 2 µm wide below their distal evasion.

***Impletosphaeridium*** sp. aff. *I.* sp. A in De Coninck, 1986 -
***Reticulatosphaera***? sp. A in De Coninck, 1995
Pl. 2, fig. 4.

Remark : This form differs from our *Reticulatosphaera*? sp. A in De Coninck, 1995 (p. 87; pl. 6, figs. 11-16) by the shorter and thinner filaments spreading from the distally evased extremity of the processes. It is not clear whether the filaments from neighbouring processes are connected with each other or not. In *Reticulatosphaera*? sp. A the filaments are stronger and connections are very clearly observed. The form may be considered as a precursor of *Reticulatosphaera*? sp. A and seems related to *Impletosphaeridium* sp. A in De Coninck, 1986 (p. 15; pl. 5, figs. 16-19).
Dimensions :
cyst body : about 25 to 30 µm.
processes : about 12 to 18 µm long, about 1 to 4 µm wide in the middle and 5 to 7 µm wide distally.

***Litosphaeridium***? aff. ***mamellatum*** DE CONINCK, 1977
Pl. 1, figs. 8, 9 and 10.

Remark : *L.*? aff. *mamellatum* is considerably larger than the species described by De Coninck, 1977 (p. 42; pl. 6, figs. 8-13). Its mamella-like processes are relatively flattened and enlarged. The wall of the central cyst body is often invisible.

Dimensions :
cyst body : about 33 to 35 µm.
processes : 5 to 8 µm high, 20 to 26 µm wide.
Overall dimensions : about 45 to 55 µm.

***Membranophoridium aspinatum*** GERLACH, 1961

The species was first described by Gerlach, 1961 (p. 199; pl. 29, figs. 7, 8) in Oligocene deposits of Northern Germany. In the Latest Eocene and Early Oligocene deposits of the Belgian basin the morphology of *M. aspinatum* changes more or less gradually with the age of the deposits. These changes can be expressed as a series of four forms :

*forma A* : Pl. 1, figs. 1, 2, 3 and 4.
The central part of the dorsal and ventral surfaces of the cyst presents irregular thickenings of the periphragm. These thickenings are more frequent on the ventral surface than dorsally and compose in several specimens a kind of reticulum; dorsally an allignment in paracingular position, of these thickenings, is observed in some specimens.

*forma B* : Pl. 3, figs. 1 up to 11.
Irregularities of the wall thickness, which are seen in the central part of the dorsal and ventral cyst surfaces of forma A, have disappeared in forma B.
The antapical extremity of each lateral ventral flange, especially of the left one, is somewhat more protruding than the rest of the flanges. In some specimens the antapical extremity of both dorsal and ventral lateral flanges is rather conical; the left ventral one again most protruding.

*forma C* : Pl. 6, figs. 1 up to 5.
Compared with forma B, the antapical protrusion of both lateral ventral flanges is larger more like a blunt process. Especially the left one of these ventral protrusions is well developed. In some specimens this left antapical process is only in its lower part in connection with the lateral flange, and has than a rather fluted appearance.

*forma D* : Pl. 6, figs. 6 up to 10. Pl. 7, fig. 8.
The distal border of the lateral flanges presents several concave incisions, more frequent on the ventral flanges than on the dorsal ones. The incisions on the posterior part of the ventral flanges are in general wide and deep. Antapically, the lateral dorsal and ventral flanges are elongated into a distally closed and truncated process; ventrally, these processes (especially the left one) are more developed than dorsally and may present some rudimentary ramifications. The processes communicate only proximally with the corresponding lateral flange. Forma D approaches *Chiropteridium*, in which the flanges are more deeply incised and for their greater part replaced by series of hollow processes, eventually communicating with each other up to a certain heighth. Morphotypes A and B of «*Chiropteridium aspinatum*», described by Schindler, 1992 (p. 201-204, figs. 1, 2, 3, 4, 5) seem to correspond with forma D.

***Selenopemphix*?** sp. 3 in Head & Norris, 1989
Pl. 7, figs. 11, 12 and 13.

Remark : This species was only figured by Head & Norris, 1989, pl. 7; figs. 4 and 8. They recorded it in the Early Oligocene NP22 Zone and basal part of the NP23 Zone in the Labrador Sea borehole 647A.

***Tectatodinium*?** sp. cf. ***Filisphaera*** sp. A in Head, Norris & Mudie, 1989
Pl. 1, fig. 14.

Remark : This species, resembling *Tectatodinium pellitum* WALL 1967 (p. 113; pl. 16, figs. 11-12), presents a granular periphragm of slightly uneven thickness, appressed to a thin, hyaline endophragm. In some specimens the apex and the margins of a paracingulum are very weakly marked by slightly thicker periphragm. A relation with *Filisphaera* sp. A in Head, Norris & Mudie, 1989 (p. 435; pl. 7, fig. 1, 7, 11) seems likely.
Dimensions :
cyst body : about 50 to 62,5 µm.
cyst wall : about 1 to 2,5 µm thick.

***Xenicodinium*?** sp. indet.
Pl. 1, figs. 11, 17 and 18.

Remark : Solid, conical to blunt processes, at a distance of about 1 to 3 µm from each other, are scattered on the surface of a globular cyst. The cyst wall is two-layered, with a thin endophragm and an appressed thicker periphragm. In one specimen a precingular opercular plate (3") is seen inside the cyst body; the archaeopyle seems however larger than that one opercular plate. Other specimens are often sliced. I have attributed this form tentatively to the genus *Xenicodinium* KLEMENT, 1960 (p. 53).
Dimensions :
cyst : 40 to 55 µm
endophragm : less than 1 µm thick.
periphragm : 1 to 2 µm thick.
processes : ±1 µm long and 1 µm wide.

## 6. ACKNOWLEDGEMENTS

I thank Dr. P. Laga, Geological Survey of Belgium, for authorizing the study of samples from the Kallo, Niel, Hingene-Wintham and Terhagen boreholes. Special thanks are due to Dr. E. Steurbaut, at the Royal Institute of Natural Sciences of Belgium, for his stimulating cooperation and encouraging interest in the results of the study when in progress. I appreciate very much also the work and goodwill of Mr. Daniel Bavay who drew the figures and helped to assemble the plates, and of Mrs Nelly Reynaert who prepared the manuscript.

## 7. REFERENCES

BACKHOUSE, J., 1988. Late Jurassic and Early Cretaceous palynology of the Perth Basin, Western Australia. *Geol. Surv. Western Australia, Bull.*, 135: 1-233.

BENEDEK, P.N., 1972. Phytoplanktonten aus dem Mittel- und Oberoligozän von Tönisberg (Niederrheingebiet). *Palaeontographica*, B 137: 1-71.

BENEDEK, P.N. & SARJEANT, W.A.S., 1981. Dinoflagellate cysts from the Middle and Upper Oligocene of Tönisberg (Niederrheingebiet) : a morphological and taxonomic restudy. *Nova Hedwigia*, 35: 313-356.

BUJAK, J. & MATSUOKA, K., 1986. Taxonomic reallocaion of Cenozoic dinoflagellate cysts from Japan and the Bering Sea. *Palynology*, 10: 235-241.

COOKSON, I.C. & EISENACK, A., 1962. Some Cretaceous and Tertiary microfossils from Western Australia. *Proc. Royal Soc. Victoria*, 75: 269-273.

DE CONINCK, J., 1977. Organic-walled microfossils from the Eocene of the Woensdrecht borehole, southern Netherlands. *Meded. Rijks Geol. Dienst, N.S.*, 28: 34-63.

DE CONINCK, J., 1986. Organic-walled phytoplankton from the Bartonian and Eo-Oligocene transitional deposits of the Woensdrecht borehole, Southern Netherlands. *Meded. Rijks Geol. Dienst, N.S.*, 40-2: 1-49.

DE CONINCK, J., 1995. Microfossiles à paroi organique du Bartonien, Priabonien et Rupélien inférieur dans le sondage de Kallo, espèces significatives dans les sondages de Woensdrecht, Kallo et Mol. *Meded. Rijks Geol. Dienst*, 53: 65-105.

DEFLANDRE, G. & COOKSON, I.C., 1955. Fossil microplankton from Australian Late Mesozoic and Tertiary sediments. *Austral. J. Mar. Freshw. Res.*, 6: 242-313.

EISENACK, A., 1954. Mikrofossilien aus Phosphoriten des samländischen Unteroligozäns und über die Einheitlichkeit der Hystrichosphaerideen. *Palaeontographica*, A 105: 49-95.

GERLACH, E., 1961. Mikrofossilien aus dem Oligozän und Miozän Nordwestdeutschlands, unter besonderer Berücksichtigung der Hystrichosphären und Dinoflagellaten. *Neues Jb. Geol. Pal., Abh.*, 112: 143-228.

HEAD, M.J. & NORRIS, G., 1989. Palynology and dinocyst stratigraphy of the Eocene and Oligocene in ODP leg 105, Hole 647A, Labrador Sea. *In* : Srivastava, Clement *et al.*, Proc. ODP, *Sci. Results*, 105: 515-550.

HEAD, M.J., NORRIS, G. & MUDIE, P.J., 1989. Palynology and dinocyst stratigraphy of the Upper Miocene and Lowermost Pleistocene, ODP Leg 105, site 646, Labrador Sea. *In* : Srivastava, Clement *et al.*, Proc. ODP, *Sci. Results*, 105: 423-451.

KLEMENT, K., 1960. Dinoflagellaten und Hystrichosphaerideen aus dem unteren und mittleren Malm Südwestdeutschlands. *Palaeontographica*, A 114: 1-104.

KLUMPP, B., 1953. Beitrag zur Kenntnis der Mikrofossilien des mittleren und oberen Eozän. *Palaeontographica*, A 103: 377-406.

MATSUOKA, K., 1983. Late Cenozoic dinoflagellates and acritarchs in the Niigata District, central Japan. *Palaeontographica*, B 187: 89-154.

MORGENROTH, P., 1966. Mikrofossilien und Konkretionen der nordwesteuropäischen Untereozäns. *Palaeontographica*, B 119: 1-53.

SCHINDLER, K., 1992. Taxonomie der Gattung *Chiropteridium* GOCHT (Dinophyceae) im Rupelium des Mainzer Beckens (Mitteloligozän, SW-Deutschland). *Paläont. Z.*, 66: 199-211.

STEURBAUT, E., 1986. Late Middle Eocene to Middle Oligocene calcareous nannoplankton from the Kallo well, some boreholes and exposures in Belgium and a description of the Ruisbroek Sand Member. *Meded. Werkgr. Tert. Kwart. Geol.*, 23: 49-83.

STEURBAUT, E., 1992. Integrated stratigraphic analysis of Lower Rupelian deposits (Oligocene) in the Belgian Basin. *Ann. Soc. Géol. Belgique*, 115: 287-306.

STOVER, L.E. & EVITT, W.R., 1978. Analyses of pre-Pleistocene organic-walled dinoflagellates. *Stanford Univ. Publ., Geol. Sc.*, 15: 1-300.

STOVER, L.E. & HARDENBOL, J., 1994. Dinoflagellates and depositional sequences in the Lower Oligocene (Rupelian) Boom Clay Formation, Belgium. *Bull. Soc. belge Géol.*, 102: 5-77.

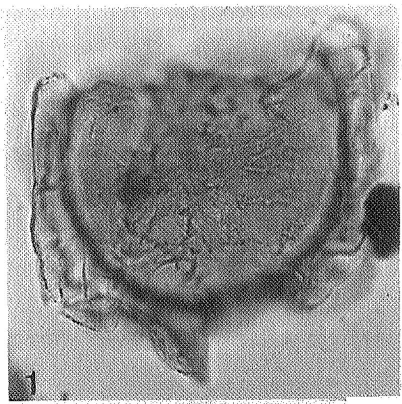
WALL, D., 1967. Fossil microplankton in deep-sea cores from the Caribbean Sea. *Palaeontology*, 10: 95-125.

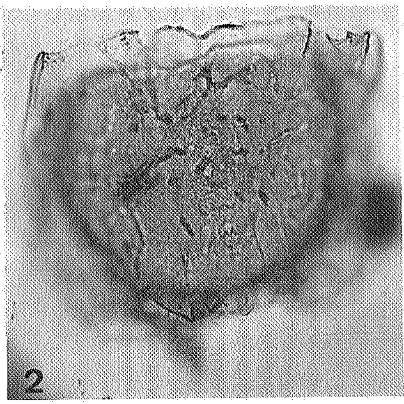
ZIEGLER, P.A., 1990. Geological Atlas of Western and Central Europe. Second and completely revised edition. *Shell Internationale Petroleum Maatschappij B.V.*, 239 p., 56 enclosures.

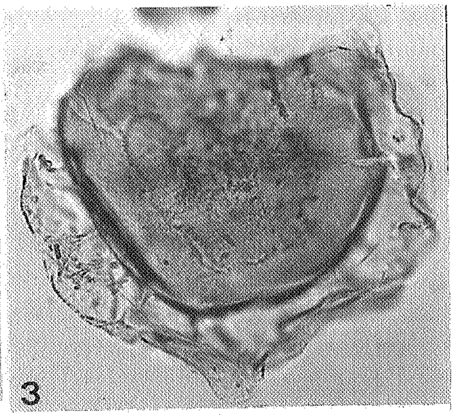
Manuscript received on 04.03.1996 and accepted for publication on 12.08.1996.

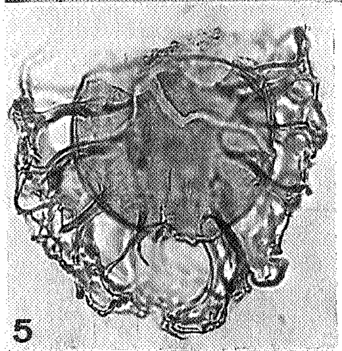
# PLATE 1

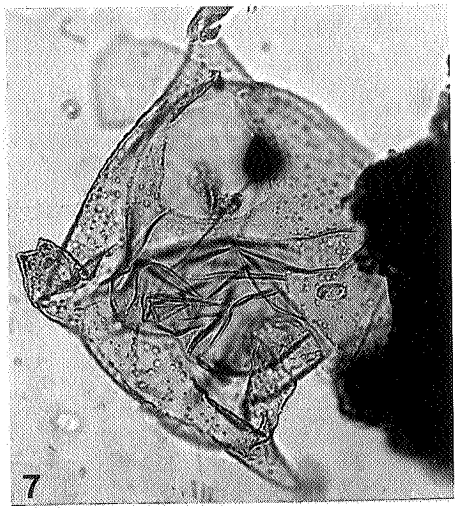
| | |
|---|---|
| Figures 1, 2. | *Membranophoridium aspinatum* GERLACH, 1961 forma A<br>Kallo -110 m; slide 1. 500x. |
| Figures 3, 4. | *Membranophoridium aspinatum* GERLACH, 1961 forma A<br>Kallo -109.5 m; slide 1. 500x. |
| Figures 5, 6. | *Glaphyrocysta* aff. *inculta* (MORGENROTH, 1966)<br>Kallo -115 m; slide 5. 500x. |
| Figure 7. | *Rhombodinium perforatum* (JAN DU CHENE and CHATEAUNEUF, 1975)<br>Kallo -115 m; slide 4. 500x. |
| Figures 8, 9. | *Litosphaeridium* ? aff. *mamellatum* DE CONINCK, 1977<br>Kallo -108 m; slide 1. 500x. |
| Fig. 10. | *Litosphaeridium* ? aff. *mamellatum* DE CONINCK, 1977<br>Kallo -108 m; slide 2. 500x. |
| Figure 11. | *Xenicodinium* ? sp. indet.<br>Kallo -106 m; slide 1. 500x. |
| Figure 12. | *Rhombodinium draco* GOCHT, 1955<br>Kallo -111 m; slide 2. 500x. |
| Figure 13. | *Paucilobimorpha spinosa* (COOKSON, 1965)<br>Kallo -110 m; slide 3. 500x. |
| Figure 14. | *Tectatodinium* ? sp. cf. *Filisphaera* sp. A in HAED, NORRIS and MUDIE, 1989<br>Kallo -92.6 m; slide 2. 500x. |
| Figure 15. | *Hystrichokolpoma* aff. *rigaudae* DEFLANDRE and COOKSON, 1955<br>Kallo -106 m; slide 1. 500x. |
| Figure 16. | *Hystrichokolpoma* aff. *rigaudae* DEFLANDRE and COOKSON, 1955<br>Kallo -107 m; slide 1. 500x. |
| Figures 17, 18. | *Xenicodinium* ? sp. indet.<br>Kallo -92.6 m; slide 3. 500x. |

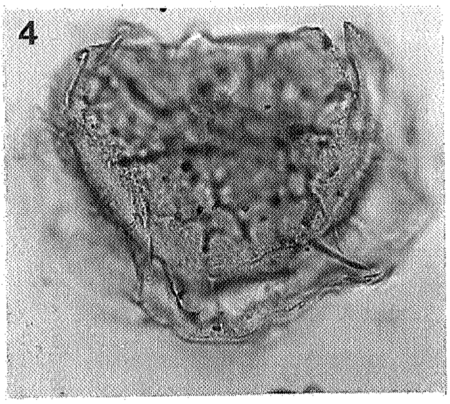

1

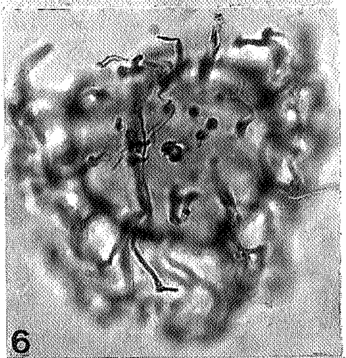

2

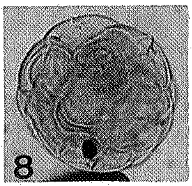

3

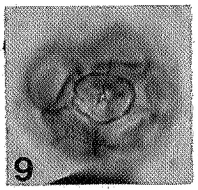

5

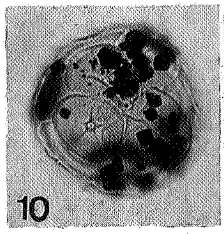

7

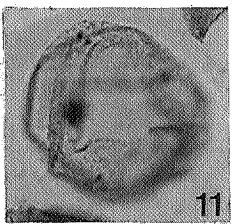

4

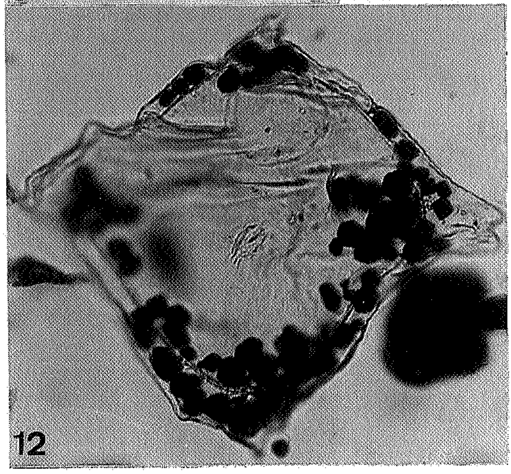

6

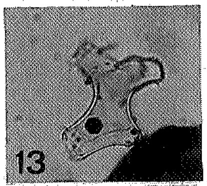

8

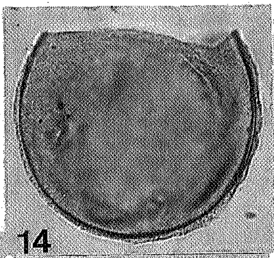

9

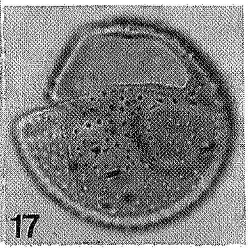

10

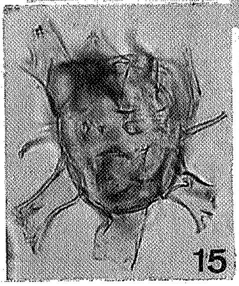

11

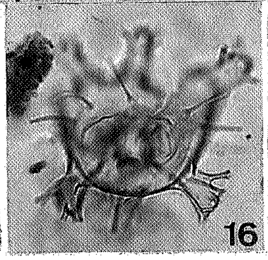

12

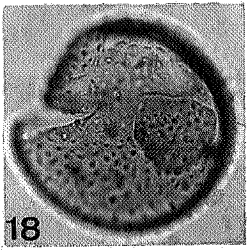

13


14


17

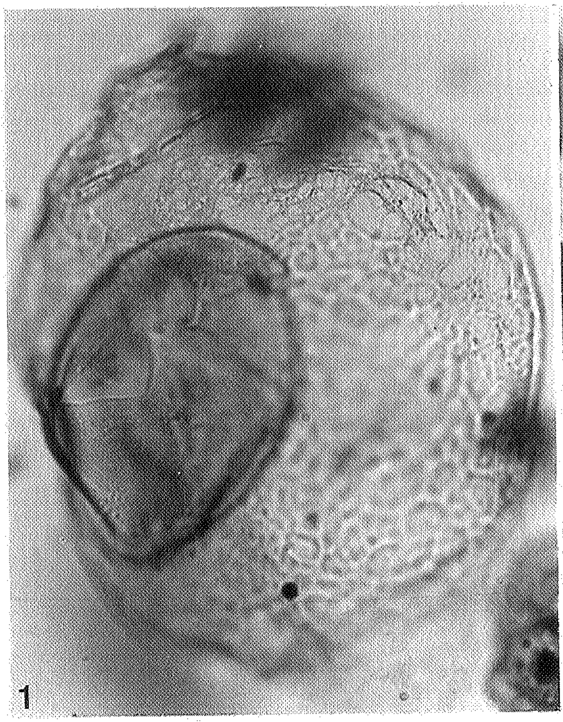

15

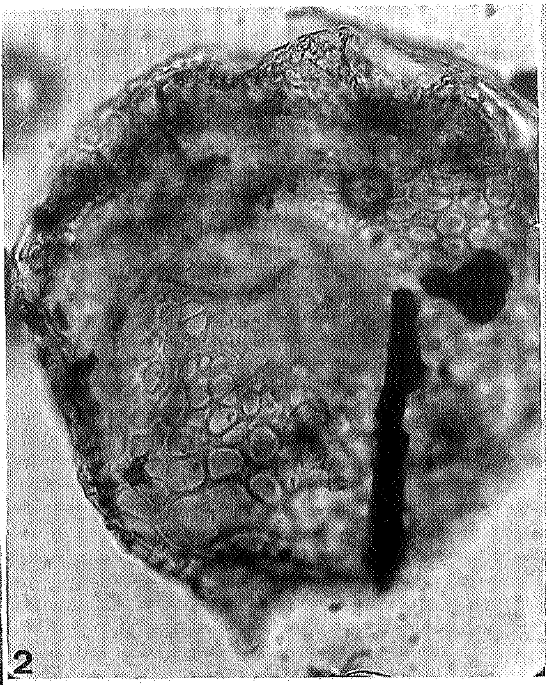

16

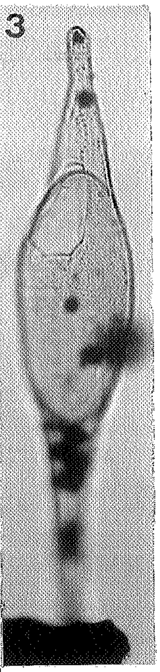

18

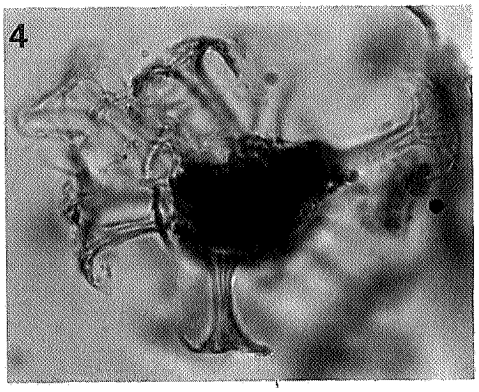
# PLATE 2

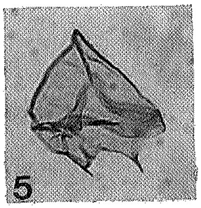
| | |
|---|---|
| Figure 1. | *Thalassiphora fenestrata* LIENGJARERN, COSTA and DOWNIE, 1980<br>Kallo -108.2 m; slide 1. 500x. |
| Figure 2 . | *Thalassiphora reticulata* MORGENROTH, 1966<br>Kallo -110.5 m; slide 1. 500x. |
| Figure 3. | *Svalbardella* sp. indet.<br>Kallo -106 m; slide 1. 500x. |
| Figure 4. | *Impletosphaeridium* sp. aff. *I.* sp. A in DE CONINCK, 1986 - *Reticulatosphaera* ? sp. A in DE CONINCK, 1995<br>Kallo -109.5 m; slide 2. 1000x. |
| Figure 5. | *Planoperidinium gracile* DE CONINCK, 1986<br>Kallo -108.2 m; slide 2. 500x. |
| Figure 6. | *Gerlachidium* ? sp. indet.<br>Kallo -100 m; slide 2. 500x. |
| Figures 7, 8. | Impagidinium maculatum (COOKSON and EISENACK, 1961)<br>Kallo -107 m; slide 2. 500x. |
| Figure 9. | *Svalbardella* sp. indet.<br>Kallo -106 m; slide 2. 500x. |
| Figure 10. | *Svalbardella* sp. indet.<br>Kallo -106 m; slide 1. 500x. |
| Figure 11. | *Horologinella* ? sp. 1<br>Kallo -92.6 m; slide 1. 1000x. |
| Figures 12, 13. | *Impagidinium torsium* STOVER and HARDENBOL, 1994<br>Kallo -108.2 m; slide 1. 500x. |
| Figures 14, 15. | Impagidinium torsium STOVER and HARDENBOL, 1994<br>Kallo -108.2 m; slide 2. 500x. |
| Figure 16. | *Horologinella* ? sp. 1<br>Kallo -94 m; slide 1. 1000x. |
| Figure 17. | *Horologinella* ? sp. 1<br>Kallo -94 m; slide 1. 1000x. |
| Figure 18. | *Impletosphaeridium machaeroides* STOVER and HARDENBOL, 1995<br>Kallo -110.5 m; slide 2. 500x. |
| Figure 19. | *Gerlachidium* ? sp. indet.<br>Kallo -107 m; slide 2. 500x. |
| Figure 20 : | *Gerlachidium aechmophorum* (BENEDEK, 1972)<br>Kallo -98 m; slide 3. 500x. |

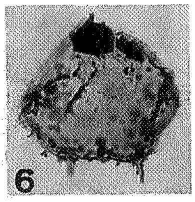

1

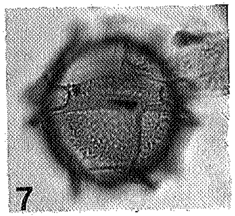

2

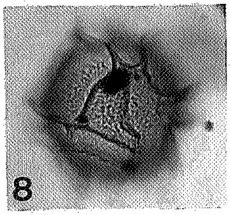

3


4

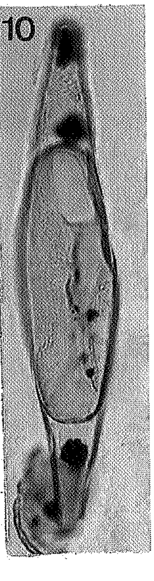

5

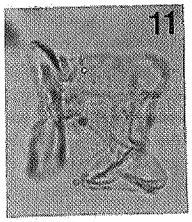

6

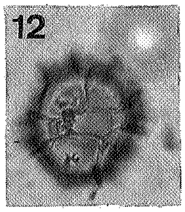

7

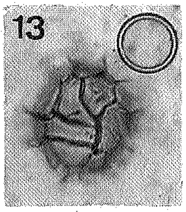

8

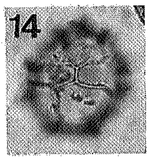

9

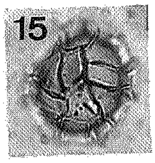

10

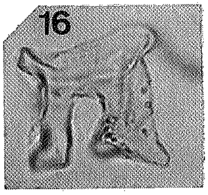

11

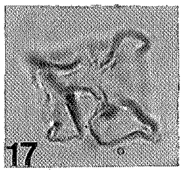

12

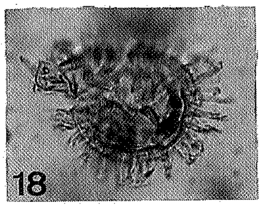

13

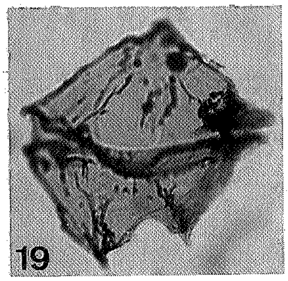

14

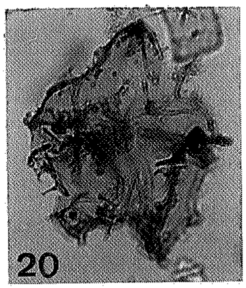

15


16


17

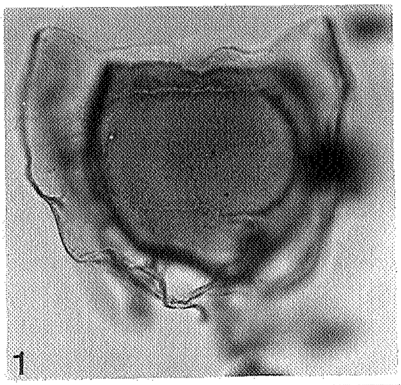

18

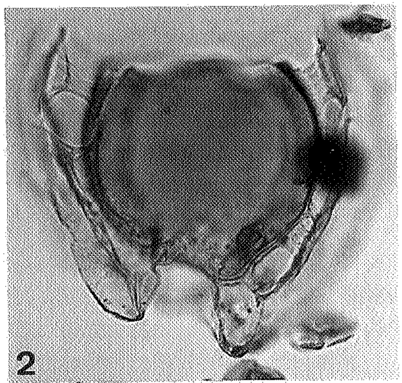

19

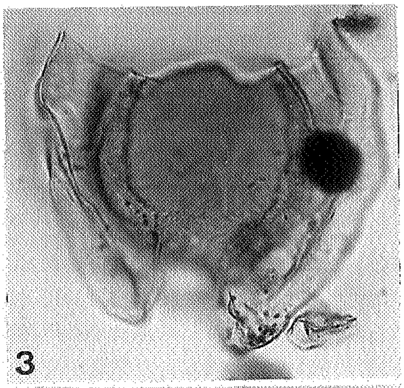

20

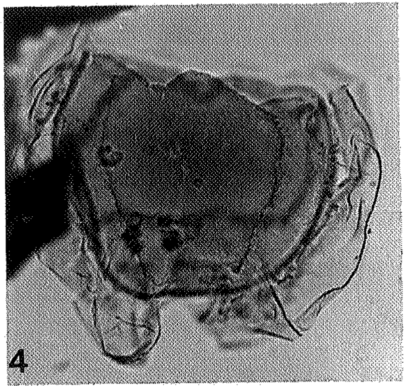
# PLATE 3

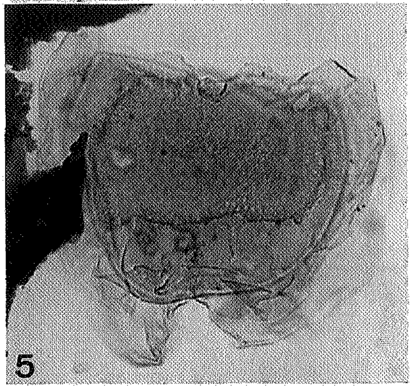
| | |
|---|---|
| Figures 1, 2, 3. | *Membranophoridium aspinatum* GERLACH, 1961 forma B<br>Kallo -107 m; slide 1. 500x. |
| Figures 4, 5. | *Membranophoridium aspinatum* GERLACH, 1961 forma B<br>Kallo -108 m; slide 3. 500x. |
| Figures 6, 7. | *Membranophoridium aspinatum* GERLACH, 1961 forma B<br>Kallo -107 m; slide 2. 500x. |
| Figures 8, 9. | *Membranophoridium aspinatum* GERLACH, 1961 forma B<br>Kallo -106 m; slide 1. 500x. |
| Figures 10, 11. | *Membranophoridium aspinatum* GERLACH, 1961 forma B<br>Kallo -106 m; slide 1. 500x. |
| Figure 12. | *Elytrocysta breva* STOVER and HARDENBOL, 1994<br>Kallo -94 m; slide 1. 500x. |
| Figure 13. | *Elytrocysta breva* STOVER and HARDENBOL, 1994<br>Kallo -100 m; slide 2. 500x. |
| Figure 14. | *Elytrocysta breva* STOVER and HARDENBOL, 1994<br>Kallo -92.6 m; slide 1. 500x. |
| Figure 15. | *Elytrocysta breva* STOVER and HARDENBOL, 1994<br>Kallo -94 m; slide 1. 500x. |

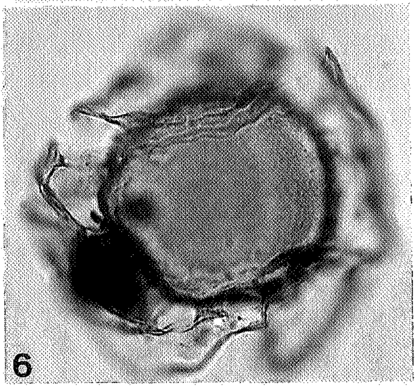

1

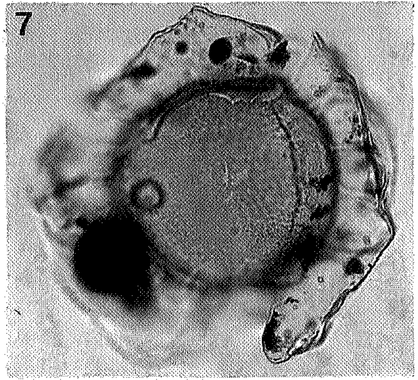

2

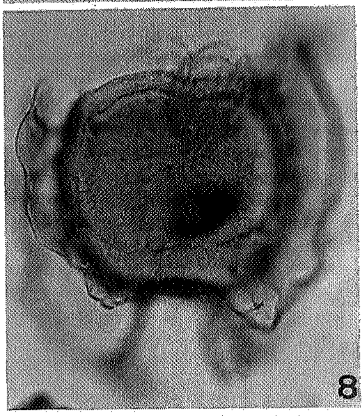

3

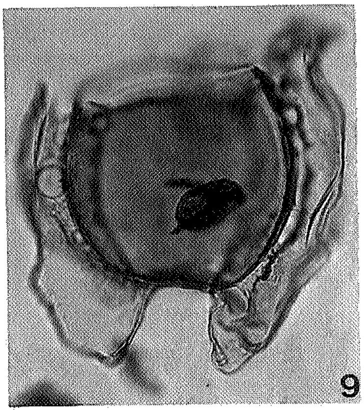

4

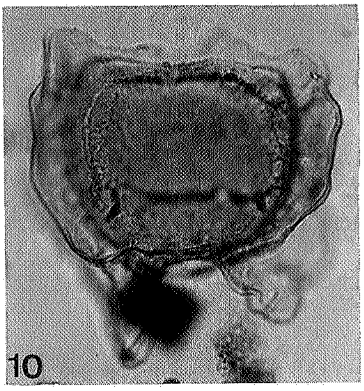

5

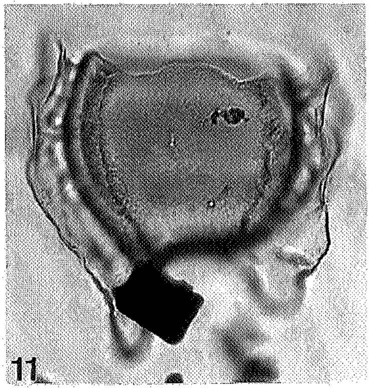

6

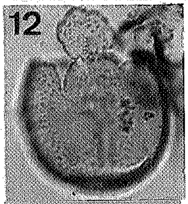

7

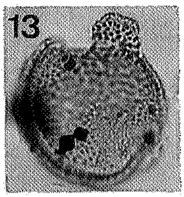

8

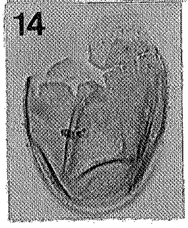

9

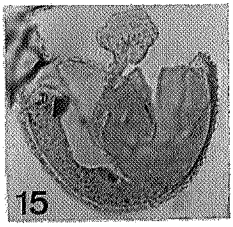

10


11


12

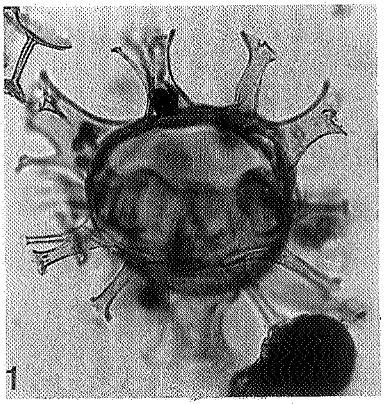

13

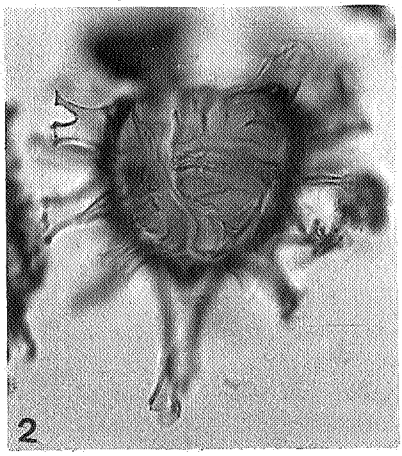

14

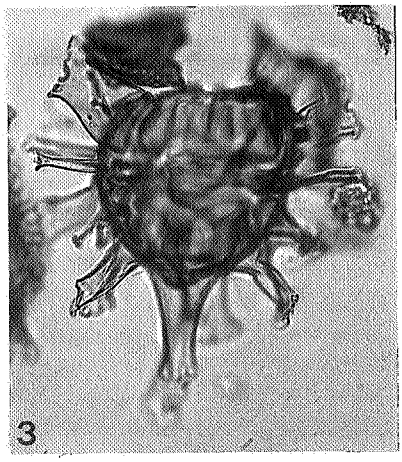

15

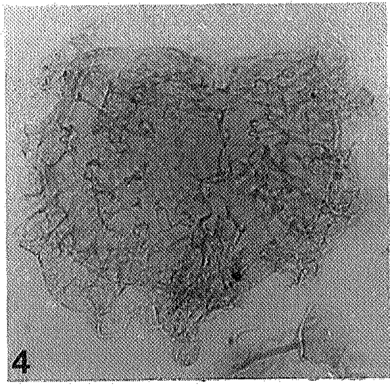
# PLATE 4

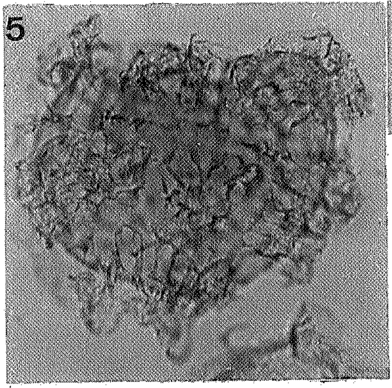
| | |
|---|---|
| Figure 1. | *Hystrichokolpoma* aff. *cinctum* KLUMPP, 1953<br>Kallo -107 m; slide 3. 500x. |
| Figures 2, 3. | *Hystrichokolpoma* aff. *cinctum* KLUMPP, 1953<br>Kallo -106 m; slide 1. 500x. |
| Figures 4, 5. | *Gerdiocysta conopeum* LIENGJARERN, COSTA and DOWNIE, 1980<br>Kallo -98 m; slide 4. 500x. |
| Figures 6, 7. | *Gerdiocysta conopeum* LIENGJARERN, COSTA and DOWNIE, 1980<br>Kallo -96 m; slide 1. 500x. |
| Figure 8. | *Vozzhennikovia spinula* STOVER and HARDENBOL, 1994<br>Kallo -96 m; slide 2. 500x. |
| Figure 9. | *Selenopemphix selenoides* BENEDEK, 1972<br>Kallo -106 m; slide 1. 500x. |
| Figure 10. | *Selenopemphix selenoides* BENEDEK, 1972<br>Kallo -96 m; slide 1. 500x. |
| Figures 11, 12. | *Areoligera semicirculata* (MORGENROTH, 1966)<br>Kallo -106 m; slide 1. 500x. |
| Figure 13. | *Selenopemphix* sp. aff. *S. nephroides* BENEDEK, 1972 - *S. selenoides* BENEDEK, 1972.<br>Kallo -108 m; slide 1. 500x. |

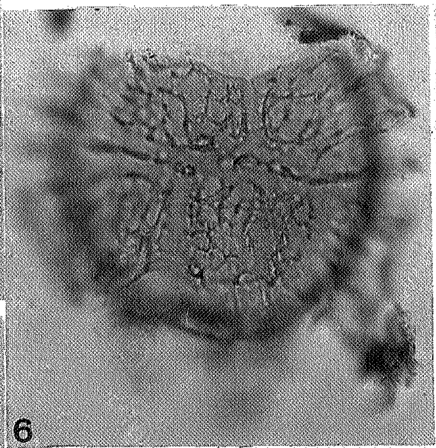

1

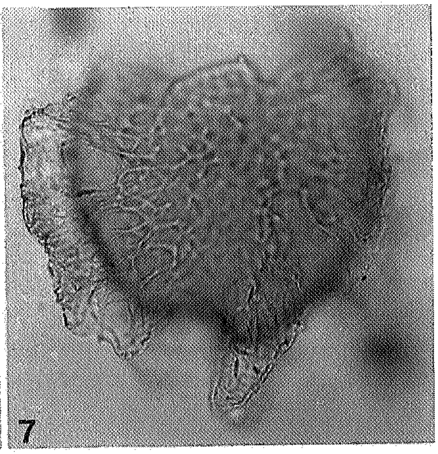

2

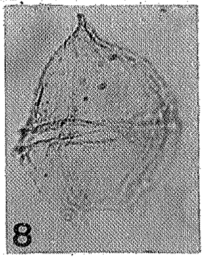

3

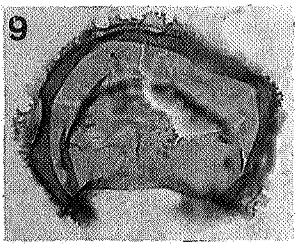

4

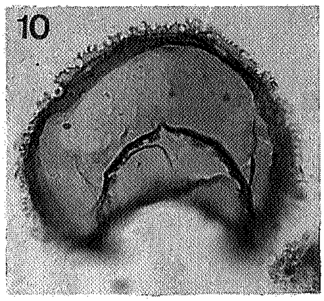

5

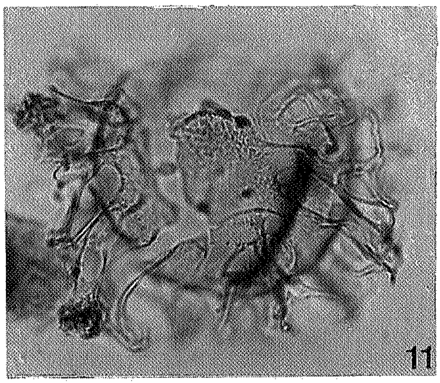

6

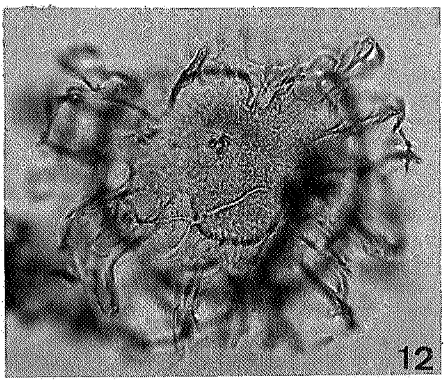

7

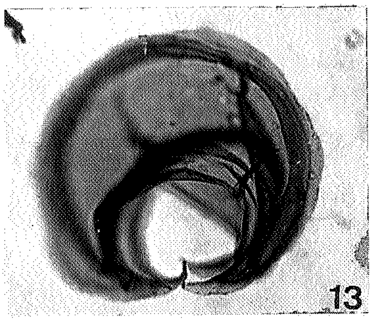

8


9


10

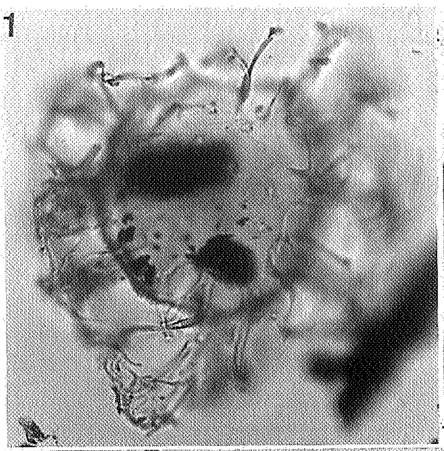

11

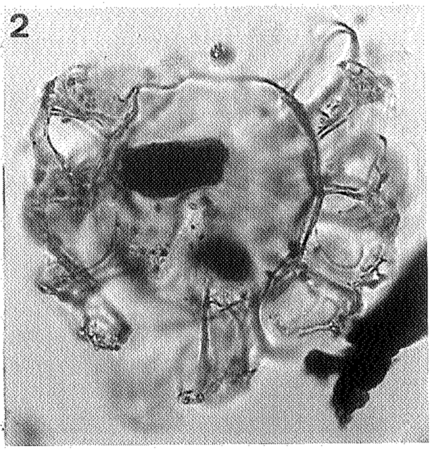

12

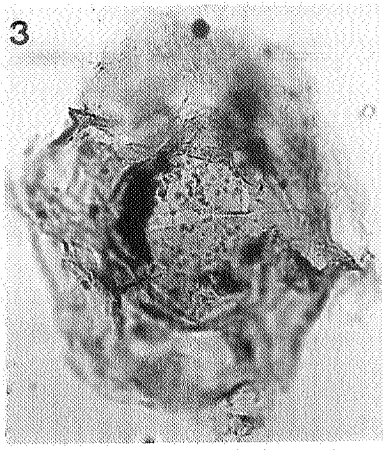

13

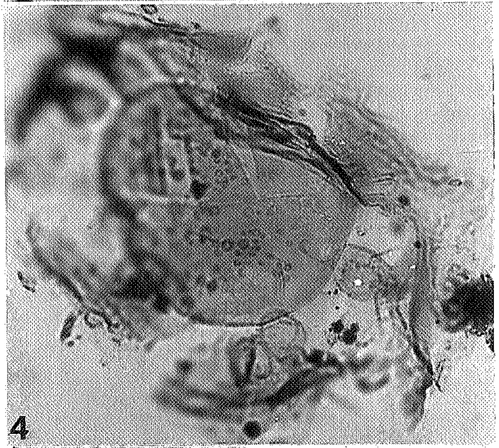
# PLATE 5

| | |
|---|---|
| Figures 1, 2. | *? Areoligera semicirculata* (MORGENROTH, 1966)<br>Kallo -111 m; slide 3. 500x. |
| Figure 3. | *Tuberculodinium vancampoae* (ROSSIGNOL, 1962)<br>Kallo -100 m; slide 2. 500x. |
| Figure 4. | *Tuberculodinium vancampoae* (ROSSIGNOL, 1962)<br>Kallo -92.6 m; slide 2. 500x. |
| Figure 5. | *Caligodinium amiculum* DRUGG, 1970<br>Kallo -97 m; slide 1. 500x. |
| Figure 6. | *Wetzeliella symmetrica incisa* GERLACH, 1961<br>Kallo -96 m; slide 1. 500x. |
| Figure 7. | *Vozzhennikovia cearaichia* STOVER and HARDENBOL, 1974<br>Kallo -100 m; slide 1. 500x. |
| Figure 8. | *Trigonopyxidia fiscellata* DE CONINCK, 1986<br>Kallo -108 m; slide 3. 500x. |
| Figure 9. | *Trigonopyxidia fiscellata* DE CONINCK, 1986<br>Kallo -108 m; slide 4. 500x. |
| Figure 10. | *Reticulatosphaera* ? sp. A in DE CONINCK, 1995<br>Kallo -97 m; slide 1. 1000x. |
| Figure 11. | *Wetzeliella symmetrica symmetrica* WEILER, 1956<br>Kallo -106 m; slide 2. 500x. |

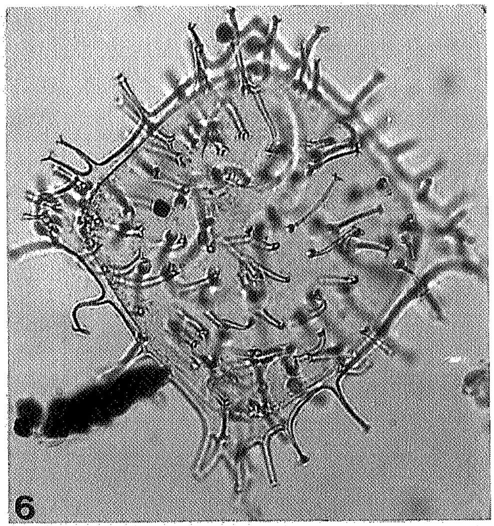

1

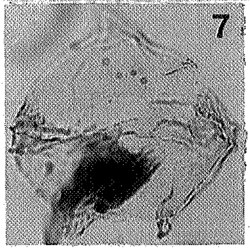

2

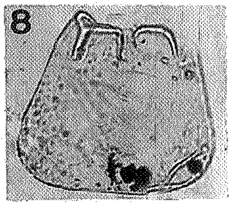

3

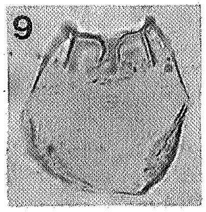

4

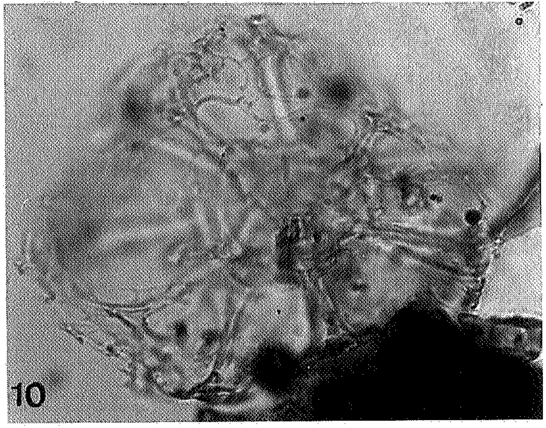

5

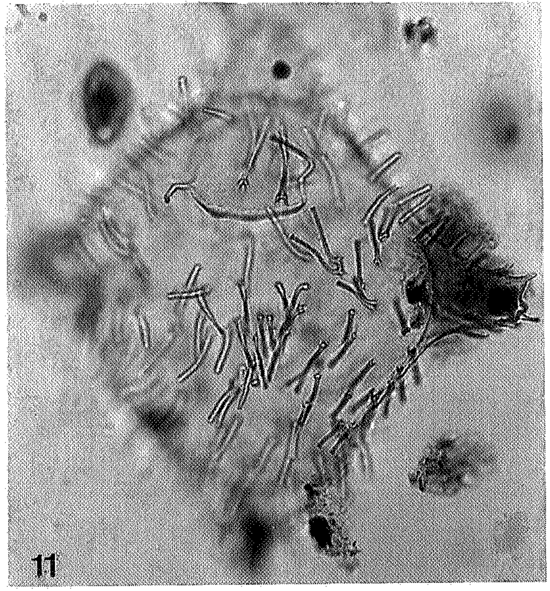

6


7


8

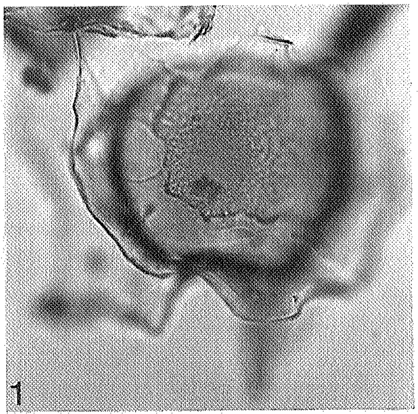

9

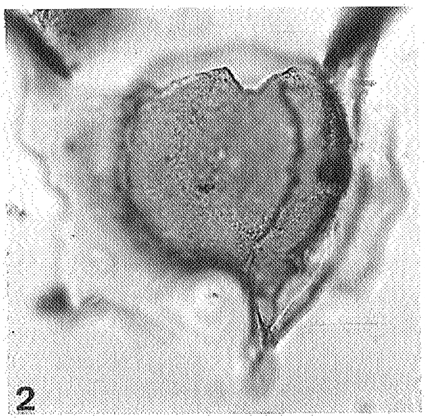

10

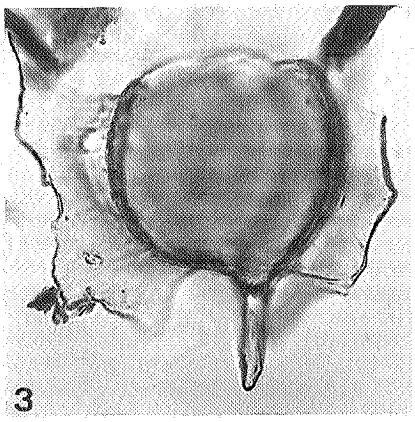

11

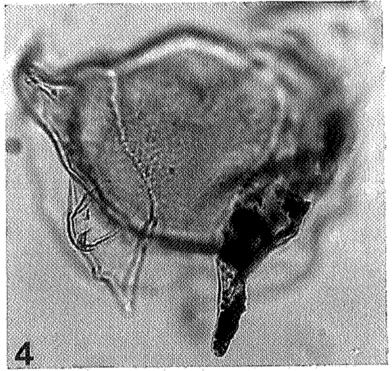
# PLATE 6

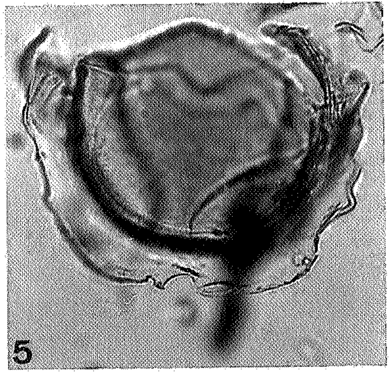
| | |
|---|---|
| Figures 1, 2, 3. | *Membranophoridium aspinatum* GERLACH, 1961 forma C<br>Kallo -100 m; slide 1. 500x. |
| Figures 4, 5. | *Membranophoridium aspinatum* GERLACH, 1961 forma C<br>Kallo -100 m; slide 2. 500x. |
| Figures 6, 7. | *Membranophoridium aspinatum* GERLACH, 1961 forma D<br>Kallo -97 m; slide 3. 500x. |
| Figure 8. | *Membranophoridium aspinatum* GERLACH, 1961 forma D<br>Kallo -96 m; slide 2. 500x. |
| Figures 9, 10. | *Membranophoridium aspinatum* GERLACH, 1961 forma D<br>Kallo -94 m; slide 1. 500x. |

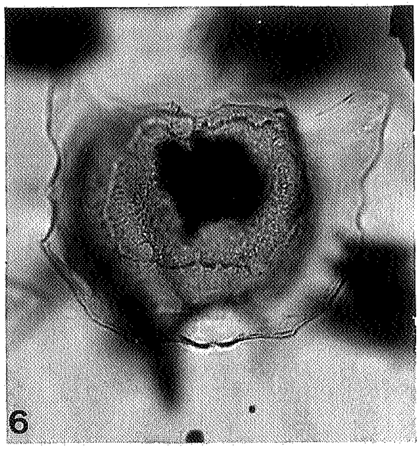

1

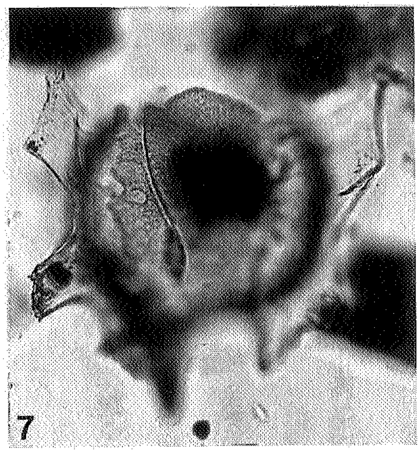

2

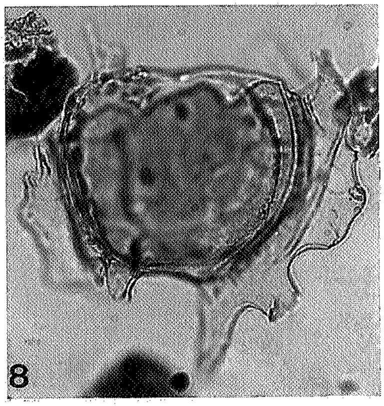

3

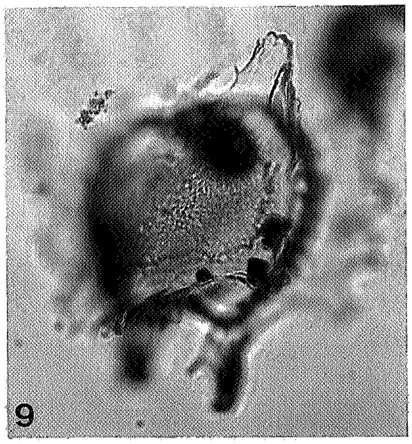

4

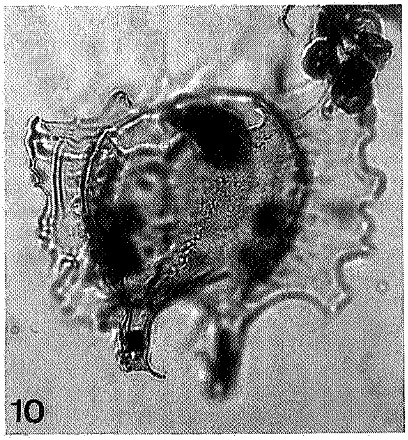

5


6


7

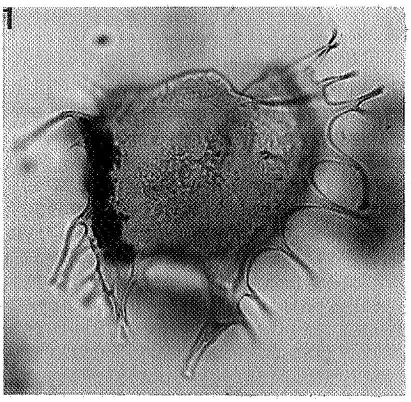

8

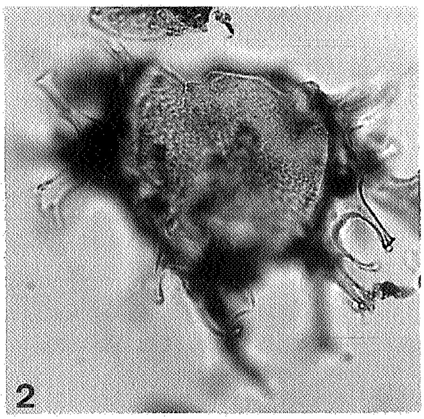

9

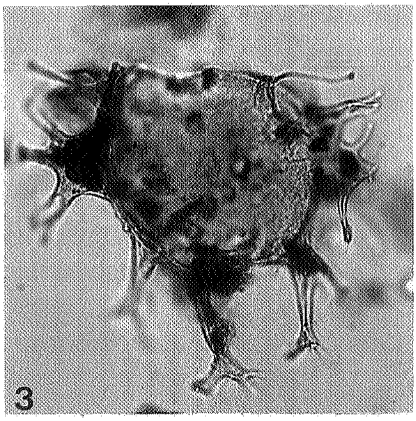

10

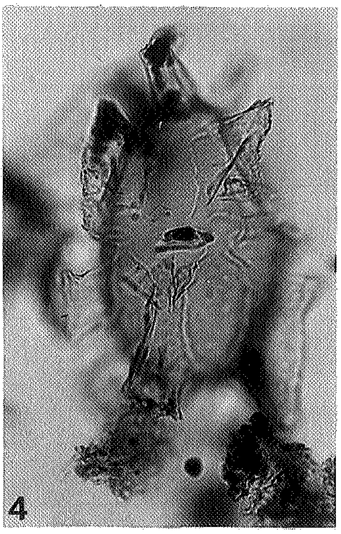
# PLATE 7

| | |
|---|---|
| Figure 1. | *Chiropteridium* sp. indet.<br>Kallo -94 m; slide 3. 500x. |
| Figures 2, 3. | *Chiropteridium* sp. indet.<br>Kallo -94 m; slide 3. 500x. |
| Figures 4, 5. | *Achilleodinium* aff. *biformoides* (EISENACK, 1954)<br>Kallo -94 m; slide 3. 500x. |
| Figures 6, 7. | *Apteodinium spiridoides* BENEDEK, 1972<br>Kallo -94 m; slide 1. 500x. |
| Figure 8. | *Membranophoridium aspinatum* GERLACH, 1961 forma D<br>Kallo -96 m; slide 3. 500x. |
| Figures 9, 10. | *Apteodinium spiridoides* BENEDEK, 1972<br>Kallo -94 m; slide 1. 500x. |
| Figure 11. | *Selenopemphix* ? sp. 3 in HEAD and NORRIS, 1989<br>Kallo -92.6 m; slide 2. 500x. |
| Figures 12, 13. | *Selenopemphix* ? sp. 3 in HEAD and NORRIS, 1989<br>Kallo -92.6 m; slide 2. 500x. |


1


2

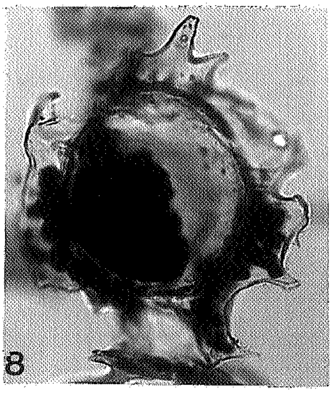

3

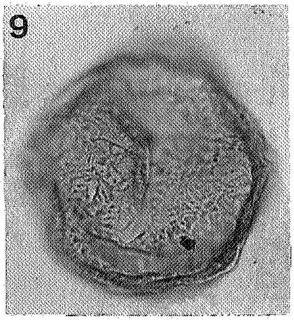

4

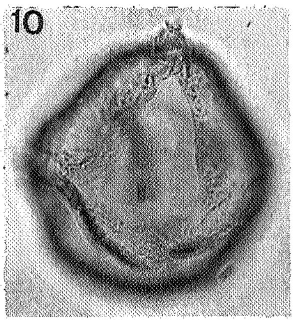

5

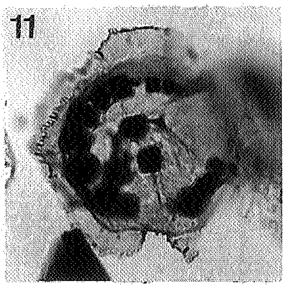

6

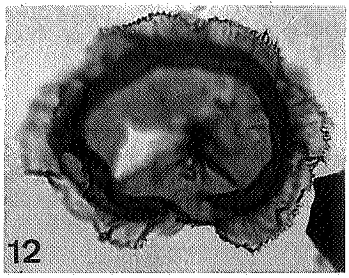

7


8


9


10


11


12

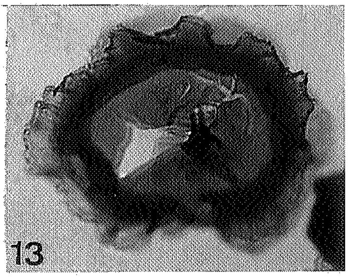

13

Table 1. Distribution and frequencies of organic-walled phytoplankton taxa in the Kallo section.

**T A B L E 1 :** Distribution and frequencies of taxa in the Kallo borehole

| Depth in meters below the surface | 115 | 112.1 | 111 | 110.5 | 110 | 109.5 | 108.2 | 108 | 107 | 106 | 100 | 98 | 97 | 96 | 94 | 92.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **C h l o r o p h y c e a e** | | | | | | | | | | | | | | | | |
| Paralecaniella indentata (DEFLANDRE and COOKSON 1955) | I | | | I | I | . | I | I | . | I | I | I | | I | I | . |
| Pediastrum sp. | | | . | | | | II | II | | | . | I | . | | | |
| **D i n o p h y c e a e** | | | | | | | | | | | | | | | | |
| Acanthaulax cf. aculeata (KLEMENT 1960) | | | | | | . | | | | . | | | | | | |
| Achilleodinium biformoides (EISENACK 1954) | : | I | : | . | . | : | . | | | . | . | . | . | | | |
| A. aff. biformoides (EISENACK 1954) | | | | | | | | | . | | | | | . | : | . |
| Achomosphaera alcicornu (EISENACK 1954) | | . | . | | | . | | | | I | : | : | . | : | . | . |
| Achomosphaera spp. indet. | II | X | II | II | X | X | II | II | X | II | II | II | II | II | II | II |
| Adnatosphaeridium robustum (MORGENROTH 1966) | | | | | | | | | . | | | | | | | |
| Apteodinium australiense (DEFLANDRE and COOKSON 1955) | | | | | | | | . | | | | | | . | . | |
| A. granulatum EISENACK 1958 | | | | | | . | | | | . | | | | . | . | . |
| A. spiridoides BENEDEK 1972 | | | | | | | | | | | | | | | I | |
| A. tectatum PIASECKI 1980 | | | | . | . | | | | | | | | | | | |
| Araneosphaera araneosa EATON 1976 | I | | . | . | . | | | | | | | | | | | |
| Areoligera semicirculata (MORGENROTH 1966) | | | ? | | | | | | : | : | | | | ? | | |
| A. cf. senonensis LEJEUNE CARPENTIER 1938 | | | | | | | | | | | | II | | | | |
| Areosphaeridium pectiniforme (GERLACH 1961) | II | X | X | X | II | X | : | | II | II | II | II | I | I | I | : |
| A. diktyoplokus (KLUMPP 1953) | II | I | I | I | I | I | | | | | . | | | | | |
| Ascostomocystis potane DRUGG and LOEBLICH 1967 | | | | . | | | . | | : | . | : | : | | | | |
| Batiacasphaera compta DRUGG 1970 | . | | | | . | | | | | | | | | | | |
| Broomia longicornuta ALBERTI 1961 | | | | | | . | | | | | | | | | | |
| Caligodinium amiculum DRUGG 1970 | | | | | | : | | | | : | . | | : | . | . | : |
| C. endoreticulum STOVER and HARDENBOL 1994 | | | | | | | | | | | | | | | . | |
| Callaiosphaeridium asymmetricum (DEFLANDRE and COURTEVILLE 1939) | | | | | | . | | | | | . | | | | | |
| Canninginopsis sp. indet. | | | | | | | | | | | | | | . | | |
| Cerodinium depressum (MORGENROTH 1966) sensu BUJAK 1980 | . | | | | | . | | | | | | | | | | |
| Cerebrocysta bartonensis BUJAK 1980 | | : | I | : | I | : | | | | | | | | | | |
| Charlesdowniea clathrata (EISENACK 1938) | : | I | I | II | I | I | . | . | . | | | . | | | | |
| C. aff. clathrata (EISENACK 1938) in DE CONINCK 1976 | | | | | | | | | | . | | | | | | |
| C. crassoramosa (WILLIAMS and DOWNIE 1966) | | | . | | | | | | | | | | . | | | |

|  | 115 | 112.1 | 111 | 110.5 | 110 | 109.5 | 108.2 | 108 | 108 | 106 | 100 | 98 | 97 | 96 | 94 | 92.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C. limitata STOVER and HARDENBOL 1994 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | . |  |
| Chiropteridium mespilanum (MAIER 1959) |  |  |  |  |  |  |  |  |  |  |  |  |  |  | . | I |
| Chlamydophorella spp. indet. |  |  |  | . |  | : |  |  | . |  | . |  | . | . |  | . |
| Circulodinium colliveri (COOKSON and EISENACK 1960) |  |  |  |  |  |  |  |  |  |  |  |  |  |  | . | . |
| Cordosphaeridium cantharellum (BROSIUS 1963) |  | . | : |  |  | I | : | I | I | I | I | II | I | I | I | II |
| C. cf. cantharellum (BROSIUS 1963) | . |  |  |  |  |  |  | . |  | . | I | . |  |  |  |  |
| C. gracile (EISENACK 1954) | . |  |  | . |  |  |  |  |  |  |  |  |  |  |  | . |
| C. inodes (KLUMPP 1953) |  |  | . |  |  |  | . |  |  |  | ? |  |  |  | . |  |
| C.? minimum MORGENROTH 1966 sensu BUJAK 1980 |  |  |  | . |  |  |  | . |  |  |  | . |  |  |  |  |
| Corrudinium incompositum (DRUGG 1970) | : |  |  |  |  | : |  |  |  | . |  | . |  |  |  |  |
| C.? sp. cf. C. incompositum (DRUGG 1970) - Cerebrocysta bartonensis BUJAK 1980 | I |  |  | . |  |  |  |  |  |  |  |  |  |  |  |  |
| Cribroperidinium giuseppei (MORGENROTH 1966) | I | I | . |  |  | I | II | X | I | II | I | I | I | II | : |  |
| Cribroperidinium spp. indet. |  | . | . | . | . | . |  |  | . | . | . |  | I | . | . | . |
| Ctenidodinium sp. indet. |  |  |  |  |  |  |  |  |  |  |  |  | . |  |  | ? |
| Cyclonephelium distinctum DEFLANDRE and COOKSON 1955 |  |  |  |  | . |  | . |  | . | . |  |  | . |  |  |  |
| C. compactum DEFLANDRE and COOKSON 1955 |  |  |  |  |  | . |  |  |  |  |  |  |  | . |  |  |
| C. hystrix (EISENACK 1958) |  |  | . |  |  | : |  |  |  |  |  | . |  |  |  |  |
| Cyclopsiella sp. indet. |  |  |  |  |  |  |  |  |  | . | ? |  |  |  |  |  |
| Dapsilidinium pseudocolligerum (STOVER 1977) | I | . | : | I | . | : | . | I | . | I | I | II | ? | I | II | I |
| Deflandrea phosphoritica EISENACK 1938 |  |  | I |  | I |  | II |  |  |  |  | . |  |  |  | . |
| D. sp. aff. D. phosphoritica EISENACK 1938 - D. heterophlycta DEFLANDRE and COOKSON 1955 | I | I |  | I |  |  |  | : |  |  | . | : | . | . |  |  |
| D. aff. spinulosa ALBERTI 1959 | . |  |  |  |  |  | I |  | I | II | . |  |  |  | : | : |
| Dingodinium tuberosum (GITMEZ 1970) |  |  | . |  |  | : |  |  | . |  |  |  |  |  | : | : |
| Dinopterygium fehmarnense (LENTIN and WILLIAMS 1973) | I | I |  | I | II | II |  | . | I | . | : |  |  |  |  | I |
| Diphyes colligerum (DEFLANDRE and COOKSON 1955) |  |  | I |  | . | I |  |  | . |  |  |  |  | . |  | I |
| Distatodinium craterum EATON 1976 | . |  |  |  |  |  | . | I |  |  |  |  | . |  |  | . |
| D. ellipticum (COOKSON 1965) | . | . |  |  | . | . |  | . |  | . | I | . |  | . |  | . |

| | 115 | 112.1 | 111 | 110.5 | 110 | 109.5 | 108.2 | 108 | 107 | 106 | 100 | 98 | 97 | 96 | 94 | 92.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D. paradoxum (BROSIUS 1963) | | | | | | | I | . | II | I | I | . | : | : | | |
| Dracodinium samlandicum (EISENACK 1954) | | | | | | | . | | | | | | | | | |
| D. varielongitudum (WILLIAMS and DOWNIE 1966) | | | | | | | | . | | | | . | | | | |
| Eatonicysta ursulae (MORGENROTH 1966) | | | | | | | ? | . | . | | . | . | | . | | |
| Elytrocysta breva STOVER and HARDENBOL 1994 | I | | | | | : | . | . | | . | . | : | | | II | . |
| Emmetrocysta urnaformis (COOKSON 1953) | | | | | | | . | | . | . | | | | | | |
| Fibrocysta exiguapicis ISLAM 1983 | | . | | | | | | | . | | | . | | | | |
| F. vectensis (EATON 1976) | | | . | | . | . | | | | | . | . | . | . | | |
| Gardodinium sp. indet. | | | | | | . | | | | | | | | | . | |
| Gerdiocysta conopeum LIENGJARERN, COSTA and DOWNIE 1980 | | | | | ? | | I | : | : | . | : | : | : | I | I | . |
| Gerlachidium aechmophorum (BENEDEK 1972) | | | | | | | | | | | : | . | . | : | | . |
| Gerlachidium spp. indet. | | | | | | | . | | . | | . | | | | . | |
| Glaphyrocysta aff. inculta (MORGENROTH 1966) | : | I | I | : | : | : | ? | | | ? | . | | | | | |
| G. cf. reticulosa (GERLACH 1961) | | | | . | : | . | | | I | | | | | | | |
| G. semitecta (BUJAK 1980) | : | : | . | . | . | : | I | : | II | I | | I | | | | |
| G. semitecta ? (BUJAK 1980) | | | | | | | I | | : | . | | | | | | |
| G.? undulata (EATON 1976) | . | | | | | | | | | | | | | | | |
| Glossodinium dimorphum IOANNIDES, STAVRINOS and DOWNIE 1977 | | | | | | | | | | | | | . | | | |
| Glyphanodinium facetum DRUGG 1964 | : | . | | . | I | | I | . | : | | | : | I | | II | . |
| Gonyaulacysta sp. cf. G. helicoidea (EISENACK and COOKSON 1960) | | | ? | . | | | | | | | | | | | | |
| Gonyaulacystaceae spp. indet. | . | | | . | . | | | . | | . | | . | | | | |
| G. fastigiata DUXBURY 1977 | | | | . | | | | | | . | | | . | . | | . |
| Heslertonia ? sp. A in DE CONINCK 1986 | . | | . | | . | | | . | | | ? | . | ? | | ? | |
| Heteraulacacysta campanula DRUGG and LOEBLICH 1967 | | | | | | | | | | | | | | | | ? |
| H. porosa BUJAK 1980 | . | I | . | : | . | : | | | | | | | | | | |
| Homotryblium abbreviatum EATON 1976 | | | | | | | | . | | | | | | | | |
| H. caliculum BUJAK 1980 | | . | II | . | I | II | | | | | | | | | | |
| H. floripes (DEFLANDRE and COOKSON 1955) | II | I | I | I | : | I | | | . | | | . | . | . | | |
| H. pallidum ? DAVEY and WILLIAMS 1966 | . | I | I | II | I | I | II | . | II | I | II | | . | I | II | II |
| Horologinella ? corrugata DE CONINCK 1986 | II | | . | I | : | : | | I | | | | | | | I | |
| H. incurvata COOKSON and EISENACK 1962 | . | | | | | | I | | I | I | I | I | I | I | II | I |
| Horologinella ? sp. 1 | | | | | | | | | | | | | | | I | I |
| Hystrichodinium pulchrum DEFLANDRE 1936 | | | | . | | | | | | | | ? | . | . | | |
| H. voigtii (ALBERTI 1961) | | | | . | . | | | | | | | | | | | |
| Hystrichogonyaulax cladophora (DEFLANDRE 1938) | | | | | | | | | . | | | | | | | |

| | 115 | 112.1 | 111 | 110.5 | 110 | 109.5 | 108.2 | 108 | 107 | 106 | 100 | 98 | 97 | 96 | 94 | 92.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hystrichokolpoma cinctum (KLUMPP 1953) | . | | . | . | . | : | | | : | | | . | . | | . | . |
| H. aff. cinctum (KLUMPP 1953) | | | | | | | . | | . | . | | | : | . | | |
| H. granulatum EATON 1976 | . | | | | | | | . | | . | | . | | | | |
| H. rigaudae DEFLANDRE and COOKSON 1955 | : | . | : | : | : | | . | . | I | . | I | I | I | . | : | |
| H. aff. rigaudae DEFLANDRE and COOKSON 1955 | | | | | | | | | : | : | | | | : | | |
| H. cf. rigaudae DEFLANDRE and COOKSON 1955 | | . | . | | | : | | | | | | | | | | |
| Hystrichosphaeridium tubiferum (EHRENBERG 1838) | | | | . | | | . | . | | | | | | | | |
| Hystrichostrogylon coninckii HEILMANN CLAUSEN 1985 | : | . | | : | | | | : | I | : | : | . | I | . | . | I |
| Imbatodinium cf. radiculatum (DAVEY 1982) | | | | | | | | | | | | | . | | | |
| Impagidinium maculatum (COOKSON and EISENACK 1961) | | | | | | | I | : | : | . | | | | | | |
| I. (aff.) torsium STOVER and HARDENBOL 1994 | | | | : | | | : | : | | . | | | . | . | . | . |
| Impletosphaeridium implicatum MORGENROTH 1966 | | | | | | | | | | | | | | | . | |
| I. aff. implicatum MORGENROTH 1966 | | | | | | | | . | | | | I | | | | |
| I. krömmelbeinii MORGENROTH 1966 | . | | | | | | I | | | | | . | | | | |
| I. ligospinosum (DE CONINCK 1969) | . | | | | | | cf. | | | | | | | cf. | | cfI |
| I. machaeroides STOVER and HARDENBOL 1994 | | | | . | | I | . | | | | | | | | | . |
| I.? severinii (COOKSON and CRANWELL 1967) | | | | . | | | . | . | | | . | | | | | |
| I. sp. A in DE CONINCK 1986 | I | | | . | | | | | | | . | . | | | | |
| I. sp. I in MANUM 1976 | . | . | | . | II | | I | . | | I | I | . | I | : | II | II |
| I. sp. A in DE CONINCK 1986 - Reticulatosphaera sp. A in DE CONINCK 1994 | | | | | : | . | . | | | | | | | | | |
| Kallosphaeridium biornatum STOVER 1977 | | | | | | | | . | | | | . | | | | |
| K. brevibarbatum DE CONINCK 1969 | | | | | | | | | | | | | | | | . |
| K. capulatum STOVER 1977 | . | | | | | | ? | . | | . | | | | | . | ? |
| K. yorubaense JAN DU CHÊNE and ADEDIRAN 1984 | | | | | | | | | | | | | | | | . |
| K. nigeriaense JAN DU CHÊNE, STOVER and DE CONINCK 1985 | . | | | | | | | | ? | | | | | | | |
| Kleithriasphaeridium sp. indet. | | | | | | | | | | | | | ? | | . | |
| Lejeunecysta cinctoria (BUJAK 1980) | | | | | | | | . | | | | | | | | |
| L. fallax (MORGENROTH 1966) | | | | | | | | | | | | | | | . | |
| L. globosa BIFFI and GRIGNANI 1983 | | | | | | | | ? | | | | | | | | |
| L. hyalina GERLACH 1961 | | | | | | . | | | | | | | | . | | . |
| L. pulchra BIFFI and GRIGNANI 1983 | | | | | | | | | | | | | | | . | |
| Lentinia serrata BUJAK 1980 | | | ? | | | . | ? | . | | ? | | | | | | |
| L. wetzelii (MORGENROTH 1966) | | . | | . | | | | | . | . | | | | | | |
| Leptodinium spp. indet. | | | | | | | | | . | | | | . | . | . | . |
| Lingulodinium machaerophorum (DEFLANDRE and COOKSON 1955) | I | . | I | : | I | . | I | I | | II | I | I | | : | | : |
| Lithodinia ? sp. indet. | | | | | | | | | | | | | . | | | |

| | 115 | 112.1 | 111 | 110.5 | 110 | 109.5 | 108.2 | 108 | 107 | 106 | 100 | 98 | 97 | 96 | 94 | 92.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Litosphaeridium ? aff. mamellatum DE CONINCK 1977 | | | | | | | | : | I | : | | | | | | |
| Lophocysta sp. indet. | . | . | . | . | | cf. | | I | I | | | | | | | |
| Melitasphaeridium asterium EATON 1976 | . | . | | | . | . | I | | II | I | | . | I | . | | : |
| M. pseudorecurvatum (MORGENROTH 1966) | . | | | . | | | | | | | | | | | | |
| Membranophoridium aspinatum GERLACH 1961 forma A | : | I | I | I | : | I | | | . | | | | | | | |
| forma B | . | | | . | | | : | : | I | I | | ? | | | | |
| forma C | | | | | | | | | | | : | II | : | : | . | . |
| forma D | | | | | | | | | | | | | . | : | : | : |
| Microdinium reticulatum VOZZHENNIKOVA 1967 | | . | : | I | . | | : | . | . | II | | X | II | I | II | II |
| Membranilarnacia sp. A in DE CONINCK 1976 | | | | | | | ? | | . | ? | . | | | . | | |
| Muderongia sp. indet | | | | | | | | | | | | | . | | | |
| Nematosphaeropsis aff. balcombiana DEFLANDRE and COOKSON 1955 | . | | | . | . | . | | . | . | | | | ? | | | |
| N. reticulensis (PASTIELS 1948) | . | . | . | | | . | | | | | | | | . | | |
| Netrelytron ? sp. indet. | | | | | | | | | | | | | | | | . |
| Odontochitina spp. indet. | | . | . | | . | . | | | | | | . | | | . | |
| Oligosphaeridium complex (WHITE 1842) | | | | | | | | | | | | . | | . | | |
| O.? sp. cf. Hystrichokolpoma rigaudae DEFLANDRE and COOKSON 1955 | . | | | | . | | | | | | | | | | | |
| Oligosphaeridium spp. indet. | | | . | . | | : | | | | | | | . | | | |
| Operculodinium centrocarpum (DEFLANDRE and COOKSON 1955) | I | II | II | I | II | II | | II | I | | I | . | . | I | I | |
| O. microtriaina (KLUMPP 1953) | II | I | . | | | . | | I | . | II | I | I | | ? | | II |
| O. placitum DRUGG and LOEBLICH 1967 | . | | | : | . | | | | . | | | | | | | |
| O. aff. placitum DRUGG and LOEBLICH 1967 | : | . | I | | | : | | | | | | | | | | |
| O. deconinckii LENTIN and WILLIAMS 1989 | . | : | | | | | | | | | | | | | | |
| O. uncinispinosum (DE CONINCK 1969) | | I | I | : | I | I | ? | | | | | | | | | |
| O. sp. aff. O. divergens (EISENACK 1954) – Cordosphaeridium multispinosum DAVEY and WILLIAMS 1966 | . | : | . | . | . | | | . | : | I | I | . | | | | |
| O.? sp. cf. O. placitum DRUGG and LOEBLICH 1967 | | | | | | | | . | . | : | | . | | | | |
| Palaeocystodinium golzowense ALBERTI 1961 | | . | . | . | . | . | . | : | I | I | | : | . | I | II | I |
| Pareodinia ? sp. indet. | | | | . | | | | | | . | | | | | | |
| Pentadinium laticinctum GERLACH 1961 | . | | | | . | . | | | | | | | | | | ? |
| P. lophophorum (BENEDEK 1972) | | | | . | | | . | . | . | ?I | . | . | : | . | | |
| Phoberocysta neocomica (GOCHT 1957) | | | | | | | | | . | . | . | | | | | |
| Phthanoperidinium amiculum LIENGJARERN, COSTA and DOWNIE 1980 | | | | | | | | | II | | | | | | | |
| P. amoenum DRUGG and LOEBLICH 1967 | | | | | | | | | | | | | | | . | |
| P. comatum (MORGENROTH 1966) | II | I | II | II | II | II | X | X | II | . | XX | II | XX | XX | : | : |
| P. levimurum BUJAK 1980 | | | ? | | ? | | . | . | | ? | | . | | | | |
| P. multispinum BUJAK 1980 | . | | | | | | | ? | | | | | | | | |
| Planoperidinium gracile DE CONINCK 1986 | | | | I | | . | . | . | . | I | | : | | . | I | |
| Platycystidia ? sp. indet. | | | | . | | | | | | | | | I | . | . | |

|  | 115 | 112.1 | 111 | 110.5 | 110 | 109.5 | 108.2 | 108 | 107 | 106 | 100 | 98 | 97 | 96 | 94 | 92.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| cf. Platycystidia sp. II in MANUM 1976 |  |  |  |  |  |  |  |  |  | . |  |  |  |  |  |  |
| Polysphaeridium zoharyii (ROSSIGNOL 1962) |  | . |  |  | . | . | : | . | . |  |  |  |  |  |  |  |
| Prolixosphaeridium granulosum (DEFLANDRE 1937) |  |  |  | . |  |  |  |  |  |  |  |  | . |  |  |  |
| Pseudoceratium pelliferum GOCHT 1957 |  |  | . |  | . | . |  |  | . |  |  |  | . |  |  | . |
| Pterodinium ? cingulatum (O.WETZEL 1933) |  |  |  | . |  |  | . |  |  |  |  |  |  |  |  |  |
| Raetiadinium evitigracia KIRSCH 1991 |  |  | . |  |  | . |  |  |  |  | . |  | : |  | . |  |
| Reticulatosphaera ? sp. A |  |  |  |  |  |  |  |  |  |  | . | II | : |  |  | ? |
| Rhombodinium draco GOCHT 1955 | . |  | . | . | . |  |  |  |  |  |  |  |  |  |  |  |
| R. glabrum (COOKSON 1956) |  |  |  | . |  | . |  |  |  |  |  |  |  |  |  |  |
| R. perforatum (JAN DU CHÊNE and CHÂTEAUNEUF 1975) | . | : | . | : | : | : |  |  |  |  |  |  |  |  |  |  |
| R. pustulosum CHÂTEAUNEUF 1980 |  | : |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Rhynchodiniopsis spp. indet. |  |  |  |  |  |  |  |  |  |  |  |  |  | . | . |  |
| Rottnestia borussica (EISENACK 1954) | . | : | : | . | . | . |  |  |  |  |  |  |  |  |  |  |
| Rottnestia sp. indet. |  |  |  | . |  |  |  |  |  |  |  |  |  |  |  |  |
| Samlandia chlamydophora EISENACK 1954 | I | I | . | : | : | . |  | I | I | I | : | . | : | . |  | : |
| Scriniodinium campanulum GOCHT 1959 |  |  |  |  |  | . |  |  |  |  | . |  | . | . |  |  |
| Selenopemphix armata BUJAK 1980 | : |  | : | . | . | . |  |  |  |  |  |  |  |  |  |  |
| S. nephroides BENEDEK 1972 | . | . | . | . | . | : | . | : |  | I | . |  |  | . | II | : |
| S. selenoides BENEDEK 1972 |  | . |  |  |  |  | : | : | I | . | : | . |  | : |  | . |
| S. sp. cf. S. armata BUJAK 1980 - S. coronata BUJAK 1980 | : | . |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| S. sp. cf. S. nephroides BENEDEK 1972 - S. selenoides BENEDEK 1972 |  |  |  |  |  |  |  | . |  |  |  | . |  |  |  |  |
| Selenopemphix ? sp. 3 in HEAD and NORRIS 1989 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | : |
| Sentusidinium spp. indet. | . |  | . | . | . | . |  |  |  | . |  |  |  | . |  |  |
| Spiniferella cornuta (GERLACH 1961) |  |  | . | . | . | : |  |  |  | . |  | . | . | . |  |  |
| Spiniferites pseudofurcatus (KLUMPP 1953) |  |  | . |  | . | . | . | I |  | I | I | II |  | I | . | . |
| S. sp. cf. S. sp. A in POWELL 1986 |  |  |  | I |  |  | I | . |  | : |  |  |  |  |  | . |
| Spiniferites spp. indet. | XX | X | X | X | X | X | II | II | X | X | X | X | X | X | X | XX |
| Stiphrosphaeridium ? spp. indet. |  |  | . | : |  | . |  |  | . | ? | . |  |  |  |  |  |
| Svalbardella sp. indet. |  |  |  |  |  |  |  |  |  | : |  |  |  |  |  |  |
| Systematophora placacantha (DEFLANDRE and COOKSON 1955) | II | II | II | II | II | I | I |  | II | I | II | I | II | II | : | I |
| ? S. palmula DAVEY 1982 |  |  |  |  |  |  |  |  |  |  |  |  |  |  | . |  |
| Tanyosphaeridium spp. indet |  |  |  |  |  |  |  | . | . |  |  | . |  |  |  |  |
| Tectatodinium pellitum WALL 1967 | . | : | . | . | . |  | : |  |  | . | . |  | . |  | . |  |
| T. ? sp. cf. Filisphaera sp. A in HEAD, NORRIS and MUDIE 1989 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | : |
| Thalassiphora delicata WILLIAMS and DOWNIE 1966 |  |  |  | . |  | . |  |  |  |  |  |  |  |  |  |  |
| T. fenestrata LIENGJARERN, COSTA and DOWNIE 1980 | . | : | I |  | : | I | : |  | I |  | . | . |  |  |  |  |
| T. patula (WILLIAMS and DOWNIE 1966) |  |  |  |  | I | . | : |  |  |  | : |  | I | : | : | : |
| T. ? cf. pansa STOVER 1977 | : |  | . | . | : | . | : | I | . | . |  | . |  | . | . |  |

|  | 115 | 112.1 | 111 | 110.5 | 110 | 109.5 | 108.2 | 108 | 107 | 106 | 100 | 98 | 97 | 96 | 94 | 92.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| T. pelagica (EISENACK 1954) | : | : | I | I | I | I | I | II | I | : | I | . | I | : | . | . |
| T. reticulata MORGENROTH 1966 |  |  |  | . |  |  |  | . |  |  |  |  |  |  |  |  |
| T. ? spinifera (COOKSON and EISENACK 1965) | I |  | . |  |  | . | . | . | . | . |  | . | . | . |  | : |
| T. sp. aff. T. cf. velata (DEFLANDRE and COOKSON 1955) in MANUM 1976 | . |  |  | . |  |  |  |  |  |  | . |  |  |  |  |  |
| Trigonopyxidia fiscellata DE CONINCK 1986 |  |  |  |  | . | . |  |  |  |  |  | : |  |  |  |  |
| Tuberculodinium vancampoae (ROSSIGNOL 1962) |  |  |  |  |  |  |  |  |  |  | . |  |  |  |  | . |
| Turbiosphaera filosa (WILSON 1967) | : |  |  |  |  |  |  | . |  |  |  |  |  |  |  |  |
| Valensiella ? clathroderma (DEFLANDRE and COOKSON 1955) | . |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Valensiella spp. indet. |  |  |  | . |  |  |  |  |  |  |  |  |  |  |  |  |
| Vozzhennikovia cearaichia STOVER and HARDENBOL 1994 |  |  |  |  |  |  |  |  |  | . | : | II | : | I |  | . |
| V. spinula STOVER and HARDENBOL 1994 |  |  |  |  |  |  |  |  |  |  |  |  |  | . | II | : |
| Wetzeliella pachyderma CARO 1973 |  |  |  |  |  |  |  |  | . |  |  |  |  |  |  |  |
| W. symmetrica incisa GERLACH 1961 |  |  |  |  |  |  |  |  |  | . | I |  |  | I |  | . |
| W. symmetrica symmetrica WEILER 1956 |  |  |  |  |  |  |  |  |  | : |  | : | II |  |  |  |
| Xenicodinium conispinum STOVER and HARDENBOL 1994 |  |  |  | : |  |  |  |  |  |  |  |  |  | . |  |  |
| X. densispinosum KLEMENT 1960 |  |  |  |  |  |  |  |  |  |  |  |  | ? |  |  |  |
| Xenicodinium ? sp. indet |  |  |  |  |  |  |  |  |  | . |  |  |  |  | : | . |
| **Prasinophyceae** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Crassosphaera ? minima DE CONINCK 1986 | . |  |  | : |  |  |  | . |  |  |  | . |  |  |  |  |
| C. ? cf. minima DE CONINCK 1986 |  |  |  |  |  |  |  | . |  |  |  | . |  |  |  |  |
| Cymatiosphaera bujakii DE CONINCK 1986 |  |  |  | . |  |  | II | II | II | II | II | II | II | II |  | I |
| C. eupeplos (VALENSI 1948) | I | I |  |  |  |  | . | I |  |  |  | I |  |  |  | I |
| C. magnifica DE CONINCK 1986 |  |  |  |  |  |  |  |  |  |  | . | . |  |  |  |  |
| Pterospermella australiensis (DEFLANDRE and COOKSON 1955) |  |  |  |  | . |  |  | . |  |  |  |  |  |  |  |  |
| P. aff. barbarae (GORKA 1963) |  |  |  |  |  |  | . |  | . |  |  |  |  |  |  |  |
| P. eurypteris (COOKSON and EISENACK 1958) |  | . | . |  | . |  |  |  |  |  |  |  |  |  |  |  |
| P. helios (SARJEANT 1959) |  |  |  | . |  |  | . |  |  | . |  |  |  |  |  |  |
| P. microptera (DEFLANDRE and COOKSON 1955) |  |  |  |  |  |  | . |  | . |  |  |  | I | I |  |  |
| P. pastielsii (DURAND 1958) |  |  |  |  |  |  |  | . |  |  |  |  |  |  |  |  |
| Tasmanites spp. indet. |  |  |  | . |  |  |  |  |  |  | . |  |  |  |  |  |
| **Acritarcha** |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Comasphaeridium cometes (VALENSI 1940) |  |  |  | I | . |  |  |  |  |  |  |  |  |  |  |  |
| Leiofusa sp. indet. |  |  |  | . |  |  |  |  |  | . | . |  |  |  |  |  |
| Micrhystridium castaninum ? VALENSI 1953 | . |  |  | I |  |  | I | . | . | II | I |  | I | : | I | I |
| M. fragile DEFLANDRE 1947 | I | I | X | II |  | I | . | . | I |  | : |  | I |  | . | . |
| M. piliferum ? DEFLANDRE 1937 |  |  |  |  |  |  |  |  | . |  |  |  |  |  |  |  |
| M. recurvatum VALENSI 1953 |  |  |  | . |  |  | . |  |  | . |  |  |  | . |  |  |

| | 115 | 112.1 | 111 | 110.5 | 110 | 109.5 | 108.2 | 108 | 107 | 106 | 100 | 98 | 97 | 96 | 94 | 92.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M. stellatum DEFLANDRE 1942 | | | . | : | | : | | | | | | | | | | |
| M. ? tubulispinosum DE CONINCK 1976 | | | . | | | | | | . | | | | | | | |
| M. wattonense WALL 1965 | | | | | | | | | | | | . | | | | |
| Paucilobimorpha spinosa (COOKSON 1965) | : | | | . | . | | | | | | | | | | | |
| P. triradiata DE CONINCK 1986 | . | | | . | | | | . | : | . | | . | | | | |
| Quadrina pallida BUJAK 1980 | | | | | | . | | | | . | . | | | | | |
| Veryhachium europaeum STOCKMANS and WILLIERE 1960 | I | | | | | | | | | | | | | | | |
| Veryhachium ? - Micrhystridium ? spp. indet. | | | | I | | | | | | | | | | | | |
| **Number of dinocyst species reworked from the** Jurassic | 1 | 1 | 3 | 4 | 2 | 4 | 0 | 0 | 4 | 4 | 1 | 0 | 6 | 3 | 3 | 5 |
| Cretaceous | 1 | 1 | 7 | 8 | 6 | 12 | 2 | 1 | 5 | 6 | 6 | 5 | 12 | 9 | 8 | 5 |
| Paleocene-Lutetian | 0 | 0 | 2 | 3 | 0 | 1 | 2 | 3 | 5 | 3 | 2 | 2 | 1 | 2 | 1 | 0 |
| **Number of contemporaneous dinocyst species** | 74 | 54 | 55 | 68 | 61 | 66 | 63 | 69 | 63 | 66 | 55 | 69 | 47 | 57 | 57 | 64 |

Table 2. Distribution in the Kallo section of dinocyst taxa considered to be biostratigraphically significant.

TABLE 2 : Taxa selected for their eventual biostratigraphic significance

| Kallo borehole: depth in meters below the surface | | 115 | 112.1 | 111 | 110.5 | 110 | 109.5 | 108.2 | 108 | 107 | 106 | 100 | 98 | 97 | 96 | 94 | 92.6 | 91 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Areosphaeridium diktyoplokus | ← | II | I | I | I | I | I | | | | | | | | | | | | |
| Cerebrocysta bartonensis | ← | | : | I | . | I | . | | | | | | | | | | | | |
| Heteraulacacysta porosa | ← | . | I | . | : | . | : | | | | | | | | | | | | |
| Membranophoridium aspinatum forma A | ← | : | I | I | I | : | I | | | | | | | | | | | | |
| Charlesdowniea clathrata | ← | : | I | I | II | I | I | : | : | : | | | : | | | | | | |
| Glaphyrocysta semitecta | ← | : | : | . | . | . | : | I | : | II | I | | I | | | | | | |
| Achilleodinium biformoides | ← | : | I | : | . | . | : | . | | | . | . | . | . | | | | | |
| Paucilobimorpha spinosa | | : | | | . | . | | | | | | | | | | | | | |
| Rhombodinium draco | | . | | . | . | . | | | | | | | | | | | | | |
| Rhombodinium perforatum | | . | : | . | : | : | : | | | | | | | | | | | | |
| Glaphyrocysta aff. inculta | | : | I | I | : | : | : | ? | | | ? | . | | | | | | | |
| Thalassiphora fenestrata | | . | : | I | | : | I | : | | I | | . | . | | | | | . | |
| Impletosphaeridium sp. I (Reticulatosphaera actinocoronata) | | . | . | | . | II | | I | . | | I | I | . | I | : | II | II | . | → |
| Homotryblium caliculum | | | . | II | . | I | II | | | | | | | | | | | | |
| Thalassiphora reticulata | | | | | . | | | | . | | | | | | | | | | |
| Impletosphaeridium ? aff. severinii | | | | | . | | | . | . | | | . | | | | | | | |
| Rhombodinium glabrum | | | | | . | | . | | | | | | | | | | | | |
| Ascostomocystis potane | | | | | . | | | . | | : | . | : | : | | | | | | |
| Impletosphaeridium sp. aff. I. sp. A - Reticulatosphaera?sp.A | | | | | | : | . | . | | | | | | | | | | | |
| Planoperidinium gracile | | | | | I | | . | . | . | . | I | | : | . | . | I | | ? | |
| Impagidinium maculatum | | | | | | | | I | : | : | . | | | | | | | | |
| Membranophoridium aspinatum forma B | ← | . | | | . | | | : | : | I | I | | ? | | | | | | |
| Gerlachidium spp. indet. | | | | | | | | . | | . | | . | | | | . | | | |
| Hystrichokolpoma aff. cinctum | | | | | | | | . | | . | . | | | : | . | | | | |
| Selenopemphix selenoides | ← | | . | | | | | : | : | I | . | : | . | | : | | . | | → |
| Gerdiocysta conopeum | | | | | | ? | | I | : | : | . | : | : | : | I | I | . | | → |
| Operculodinium ? sp. cf. O. placitum | | | | | | | | | . | . | : | | . | | | | | . | |
| Areoligera semicirculata | | | | ? | | | | | | : | : | | | | ? | | | | → |
| Svalbardella sp. indet. | | | | | | | | | | | : | | | | | | | | |
| Wetzeliella symmetrica symmetrica | | | | | | | | | | | : | | : | II | | | | | → |
| Wetzeliella symmetrica incisa | | | | | | | | | | | . | I | | | I | | . | | → |
| Vozzhennikovia cearaichia | | | | | | | | | | | . | : | II | : | I | | . | | → |
| Reticulatosphaera ? sp. A | | | | | | | | | | | | . | II | : | | | ? | . | → |
| Gerlachidium aechmophorum | | | | | | | | | | | | : | . | . | : | | . | . | → |
| Membranophoridium aspinatum forma C | | | | | | | | | | | | : | II | : | : | . | . | | |
| Membranophoridium aspinatum forma D | | | | | | | | | | | | | | . | : | : | : | | |
| Achilleodinium aff. biformoides | | | | | | | | | | . | | | | | . | : | . | . | → |
| Vozzhennikovia spinula | | | | | | | | | | | | | | | . | II | : | : | → |
| Apteodinium spiridoides | | | | | | | | | | | | | | | | I | | | → |
| Charlesdowniea limitata | | | | | | | | | | | | | | | | . | | | → |
| Chiropteridium spp. indet. | | | | | | | | | | | | | | | | : | I | | → |
| Horologinella ? sp. 1 | | | | | | | | | | | | | | | | I | I | | |
| Selenopemphix ? sp. 3 | | | | | | | | | | | | | | | | | : | | |

**Table 3.** Distribution in the Kallo section of reworked dinocyst taxa and of Pediastrum.

TABLE 3 : Reworked dinocyst taxa

| Kallo borehole: depth in meters below the surface | 115 | 112.1 | 111 | 110.5 | 110 | 109.5 | 108.2 | 108 | 107 | 106 | 100 | 98 | 97 | 96 | 94 | 92.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jurassic | | | | | | | | | | | | | | | | |
| Acanthaulax cf. aculeata | | | | | | . | | | | . | | | | | | |
| Cribroperidinium spp. indet. | | . | . | . | . | . | | | . | . | . | | I | . | . | . |
| Ctenidodinium sp. indet | | | | | | | | | | | | | . | | | ? |
| Dingodinium tuberosum | | | . | | | : | | | . | | | | | | : | : |
| Glossodinium dimorphum | | | | | | | | | | | | | . | | | |
| Hystrichogonyaulax cladophora | | | | | | | | | . | | | | | | | |
| Leptodinium spp. indet. | | | | | | | | | . | | | | . | . | . | . |
| Lithodinia ? sp. indet. | | | | | | | | | | | | | . | | | |
| Netrelytron ? sp. indet. | | | | | | | | | | | | | | | | . |
| Pareodinia ? sp. indet. | | | | . | | | | | | . | | | | | | |
| Sentusidinium spp. indet. | . | | . | . | . | . | | | | . | | | | . | | |
| Valensiella spp. indet. | | | | . | | | | | | | | | | | | |
| Xenicodinium densispinosum | | | | | | | | | | | | | ? | | | |
| Cretaceous | | | | | | | | | | | | | | | | |
| Apteodinium granulatum | | | | | | . | | | | . | | | | . | . | . |
| Callaiosphaeridium asymmetricum | | | | | | . | | | | | . | | | | | |
| Canninginopsis sp. indet. | | | | | | | | | | | | | | . | | |
| Chlamydophorella spp. indet. | | | | . | | : | | | . | | . | | . | . | | . |
| Circulodinium colliveri | | | | | | | | | | | | | | | . | . |
| Cyclonephelium distinctum | | | | | . | | . | | . | . | | | . | | | |
| Cyclonephelium compactum | | | | | | . | | | | | | | | . | | |
| Cyclonephelium hystrix | | | . | | | : | | | | | | . | | | | |
| Gardodinium sp. indet. | | | | | | . | | | | | | | | | . | |
| Gonyaulacysta fastigiata | | | | . | | | | | | . | | | . | . | | . |
| Hystrichodinium pulchrum | | | | . | | | | | | | | ? | . | . | | |
| Hystrichodinium voigtii | | | | . | . | | | | | | | | | | | |
| Imbatodinium cf. radiculatum | | | | | | | | | | | | | . | | | |
| Kleithriasphaeridium sp. indet. | | | | | | | | | | | | | ? | | . | |
| Muderongia sp. indet. | | | | | | | | | | | | | . | | | |
| Odontochitina sp. indet. | | . | . | | . | . | | | | | | . | | | . | |

| | | 115 | 112.1 | 111 | 110.5 | 110 | 109.5 | 108.2 | 108 | 107 | 106 | 100 | 98 | 97 | 96 | 94 | 92.6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oligosphaeridium spp. indet. | | | . | . | | : | | | | | | . | . | . | | |
| | Phoberocysta neocomica | | | | | | | | | . | . | . | | | | | |
| | Prolixosphaeridium granulosum | | | | . | | | | | | | | | . | | | |
| | Pseudoceratium pelliferum | | | . | | . | . | | | . | | | | . | | | . |
| | Pterodinium aliferum | | | | | . | | | | | | | | | | | |
| | Pterodinium cingulatum | | | | . | | | . | | | | | | | | | |
| | Raetiadinium evitigracia | | | . | | | . | | | | | . | | : | | . | |
| | Rhynchodiniopsis spp. indet. | | | | | | | | | | | | | | . | . | |
| | Scriniodinium campanulum | | | | | | . | | | | | . | | . | . | | |
| | Stiphrosphaeridium ? spp. indet. | | | . | : | | . | | | . | ? | . | | | | | |
| | Systematophora palmula | | | | | | | | | | | | | | | ? | |
| | Paleocene - Ypresian - Lutetian | | | | | | | | | | | | | | | | |
| P-Y | Adnatosphaeridium robustum | | | | | | | | | . | | | | | | | |
| P-Y | Hystrichosphaeridium tubiferum | | | | . | | | . | . | | | | | | | | |
| P-Y | Kallosphaeridium brevibarbatum | | | | | | | | | | | | | | | . | |
| P-Y | Thalassiphora delicata | | | | . | | . | | | | | | | | | | |
| Y | Charlesdowniea aff. clathrata | | | | | | | | | | . | | | | | | |
| Y | Charlesdowniea crassoramosa | | | . | | | | | | | | | | . | | | |
| Y | Dracodinium varielongitudum | | | | | | | | . | | | | . | | | | |
| Y | Eatonicysta ursulae | | | | | | | | . | . | | . | . | | . | | |
| Y | Membranilarnacia sp. A | | | | | | | ? | | . | ? | . | | | . | | |
| Y-L | Lentinia wetzelii | | | ? | . | | | | | . | . | | | | | | |
| L | Wetzeliella pachyderma | | | | | | | | | . | | | | | | | |
| | **Fresh water algae: Pediastrum spp. indet.** | | | . | | | | II | II | | | . | I | . | | | |

Table 4

Niel boring 43W-270

| | Watervliet Clay | Wintham Silt | | | Ruisbroek Sand |
|---|---|---|---|---|---|
| | -30.00 | -29.30 | -28.5 to -28 | -27.80 | -27.25 |
| Areosphaeridium diktyoplokus | | x | x | x | |
| Cerebrocysta bartonensis | | x | x | x | |
| Heteraulacacysta porosa | x | x | | x | |
| Membranophoridium aspinatum forma A | x | | | | |
| Charlesdowniea clathrata-coleothrypta | x | x | x | | |
| Glaphyrocysta semitecta | | | x | x | x |
| Paucilobimorpha spinosa | | x | x | x | |
| Rhombodinium draco | x | | | | |
| Rhombodinium perforatum | x | x | | x | |
| Glaphyrocysta aff. inculta | x | x | | ? | |
| Thalassiphora fenestrata | x | | | | |
| Lophocysta sp. indet. | ? | | x | x | x |
| Homotryblium caliculum | x | | | | |
| Rhombodinium glabrum | | | | x | |
| Ascostomocystis potane | x | | | | x |
| Planoperidinium gracile | x | x | x | x | x |
| Operculodinium sp. cf. O. placitum | | | | | x |
| Gerlachidium sp. indet. | | | | | x |
| Selenopemphix selenoides | | ? | | | x |
| Gerdiocysta conopeum | | | | | x |
| Areoligera semicirculata | x | | | | ? |
| Wetzeliella symmetrica | | | | | x |
| Vozzhennikovia cearaichia | | | | | x |
| Reticulatosphaera? sp. A | | | | | x |
| Membranophoridium aspinatum forma C | | | | | x |
| Achilleodinium aff. biformoides | | | ? | | ? |

**Table 4.** Distribution in the Niel 43W-270 section of dinocyst taxa considered to be biostratigraphically significant.

Table 5

| Hingene-Wintham boring 42E-212 | Wintham Silt | | Ruisbroek Sand |
|---|---|---|---|
| | -29.95 | -27.95 | -26.95 |
| Areosphaeridium diktyoplokus | x | x | |
| Cerebrocysta bartonensis | x | | |
| Heteraulacacysta porosa | x | x | |
| Membranophoridium aspinatum forma A | | x | |
| Charlesdowniea clathrata | x | x | |
| Glaphyrocysta semitecta | x | x | x |
| Rhombodinium perforatum | x | x | |
| Glaphyrocysta aff. inculta | | x | |
| Lophocysta sp. indet. | | x | x |
| Thalassiphora fenestrata | x | x | |
| Rhombodinium glabrum | | x | |
| Ascostomocystis potane | | | ? |
| Planoperidinium gracile | | | x |
| Selenopemphix selenoides | | | x |
| Gerdiocysta conopeum | | | x |
| Operculodinium sp. cf. O. placitum | | | x |
| Areoligera semicirculata | x | | |
| Svallardella sp. indet. | | | ? |
| Wetzeliella symmetrica | | | x |
| Vozzhennikovia cearaichia | | | x |
| Reticulatosphaera? sp. A | ? | | x |
| Membranophoridium aspinatum forma C | | | x |
| Achilleodinium aff. biformoides | | | x |
| Chiropteridium sp. | | | x |

**Table 5.** Distribution in the Hingene-Wintham 42E-212 section of dinocyst taxa considered to be biostratigraphically significant.

Table 6

Terhagen boring 58W-213

| | Watervliet Clay | Wintham Silt |
|---|---|---|
| | -38.50 | -37.55 |
| Areosphaeridium diktyoplokus | x | x |
| Heteraulacacysta porosa | | x |
| Membranophoridium aspinatum forma A | x | |
| Charlesdowniea clathrata-coleothrypta | x | x |
| Galphyrocysta semitecta | x | |
| Paucilobimorpha spinosa | | x |
| Rhombodinium draco | x | x |
| Rhombodinium perforatum | x | x |
| Glaphyrocysta aff. inculta | x | x |
| Lophocysta sp. indet. | x | |
| Thalassiphora fenestrata | x | x |
| Thalassiphora reticulata | | x |

**Table 6.** Distribution in the Terhagen 58W-213 section of dinocyst taxa considered to be biostratigraphically significant.