

CORRELATION BETWEEN MIOCENE BEDS OF THE SE NETHERLANDS AND ITALY BASED ON DINOFLAGELLATE BIOZONATION

by
G.F.W. Herngreen,
Rijks Geologische Dienst,
Haarlem, The Netherlands

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Samples from Miocene and lowermost Pliocene strata in two boreholes, Broeksittard and Cuyk, were examined for dinoflagellates. The stratigraphic results indicate the presence of the Middle and Upper Miocene. These beds can be correlated with the Danish Hodde and Gram formations. The dinoflagellate biozonation permits a first order correlation with the succession described from the Piedmont Miocene stratotypes in Italy. Moreover, it was found that only the upper part of the Gram Formation is Late Miocene.

Dr G.F.W. Herngreen, Rijks Geologische Dienst, P.O. Box 157, 2000 AD Haarlem, The Netherlands.

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SAMENVATTING

Kernen en steekmonsters van de boringen Broeksittard in de Centrale Slenk en Cuyk in de Venlo Slenk zijn op dinoflagellaten onderzocht. De associaties kenmerkend voor zone I in Broeksittard, zijn te correleren met die beschreven uit de *Nematosphaeropsis aquaeducta* Zone van de Hodde Formatie in Denemarken. Zone II, waarvan de top bepaald wordt door het jongste voorkomen van *Palaeocystodinium golzowense*, is in beide boringen aanwezig. De karakteristieke associaties van zone II zijn te vergelijken met die uit de diepere delen van de Deense Gram Formatie. De ouderdom van zone II is o.g.v. correlatie met de miocene stratotypes in het Piedmont Bekken, Serravallien (laat

Midden Mioene). Diverse gidsvormen van zone III bezitten in het Piedmont gebied hun jongste voorkomen in het Tortonien (vroeg Laat Mioeen).

Mede op grond van de lithologische ontwikkeling en malacologische gegevens, kan geconcludeerd worden dat in boring Cuyk rond 67.80 m een stratigrafisch hiaat aanwezig is.

Uit dit onderzoek blijkt tevens dat de grens Midden/Laat Mioeen die in Denemarken traditioneel aangegeven wordt op de overgang Hodde/Gram Formatie, gelegd moet worden in de Gram Formatie.

INTRODUCTION

In the south-eastern part of The Netherlands the marine Miocene beds are grouped in the Breda Formation. This formation is composed mainly of glauconiferous shelly sands and glauconiferous clays. In the Lower Rhine Embayment, which forms the adjacent area in Germany, time-equivalent strata are included in the Lower Rhine Brown-coal Formation. These continental beds consist of sands, clays, and several thick lignite horizons (van Staalduinen et al., 1979). In the area under discussion marine sequences of the Breda Formation interfinger with continental deposits of the Lower Rhine Embayment.

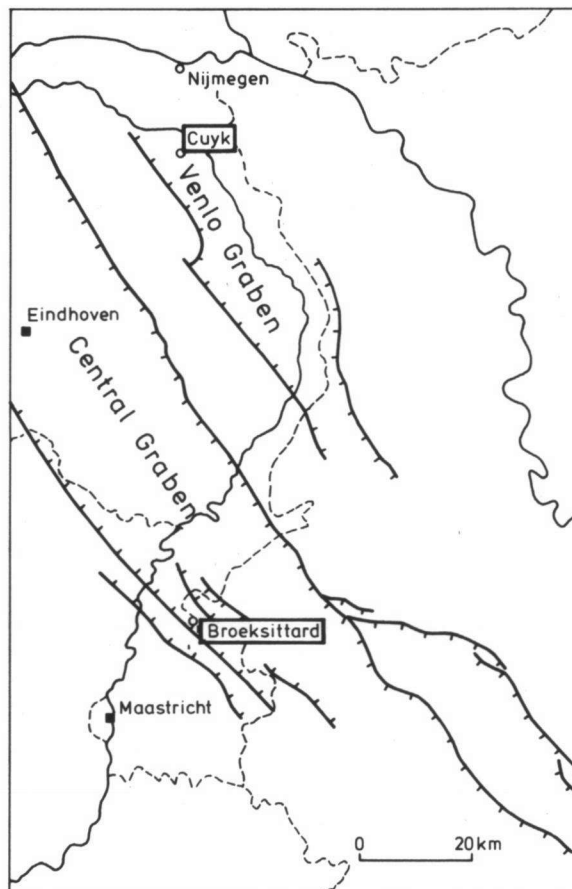


Fig. 1. Map of the south-eastern Netherlands showing location of the Broeksittard and Cuyk boreholes.

Part of these formations are traditionally assigned to the Late Miocene, but correlation with the Neogene standard sequence in the Piedmont area has been uncertain.

Samples from the Broeksittard and Cuyk boreholes were examined for dinoflagellates (fig. 1). In the Broeksittard hole, which is located in the Central Graben, exclusively Miocene beds are dealt with. The Cuyk hole, eighty kilometres to the North and located in the Venlo Graben, includes the lowermost Pliocene strata as well.

Full details concerning the taxonomy, and the distribution of species, together with illustrations, will be published in a special volume of the Mededelingen Rijks Geologische Dienst planned to appear in 1988. Nomenclature of the dinoflagellates is according to Lentin & Williams (1985).

BROEKSITTARD

During sporomorph analyses of Broeksittard borehole material, recently carried out in the Department of Cenozoic Palaeobotany of the RGD, some dinoflagellates were found. The presence of dino's is concentrated in four levels, from top to bottom: just below 200 m, between 260 and 281 m, 304 m, and 356 to 395 m (fig. 2). Twenty samples taken from these four levels were processed and sieved, using a 20-micron mesh sieve to concentrate the dinoflagellates.

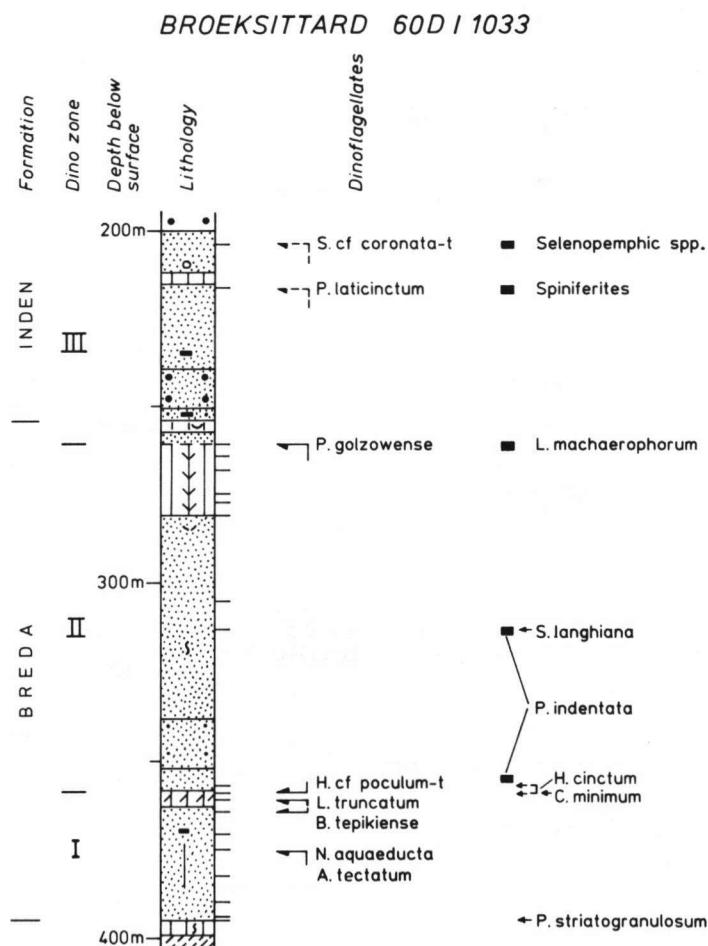


Fig. 2. Summarized palynological and lithostratigraphical data of the Broeksittard borehole.

In ascending order, three dinoflagellate zones can be distinguished.

Zone 1.

Between 358 and 395 m there are rich and varied assemblages, with:

- Apteodinium tectatum*
- Hystrichokolpoma rigaudiae* (common)
- Labyrinthodinium truncatum*
- Nematosphaeropsis aquaeducta*
- Palaeocystodinium golzowense*
- Systematophora placacantha* (common)

Additional finds include *Bitectatodinium tepikiense* (364 m), *Cordosphaeridium minimum* (358 m), and *Palaeocystodinium* sp. A (393 m).

These assemblages are identical with those described by Piasecki (1980) from the Hodde and lowermost Gram formations in Denmark (fig. 3). *Nematosphaeropsis aquaeducta* (top in Broeksittard at 374 m) is restricted to the Hodde Formation. *Labyrinthodinium truncatum* (last occurrence in Broeksittard at 358 m) is also found in slightly younger strata of the glauconitic clay at the base of the Gram Formation. The boundary between the Hodde and Gram formations is traditionally considered to represent the transition from Middle to Late Miocene.

PIASECKI 1980

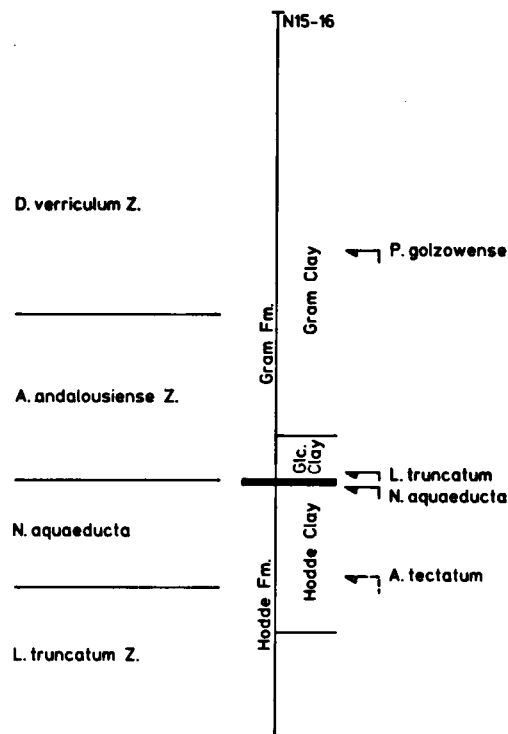


Fig. 3. Summary of the results obtained by Piasecki (1980) from the Hodde and Gram formations in Denmark.

Zone II.

At 358 and 356 m first appears *Hystrichokolpoma* cf. *poculum* type in Harland (1979), which occurs in association with *Palaeocystodinium golzowense*, *Pentadinium laticinctum*, and low values of *Systematophora placacantha*. The simultaneous occurrence of *P. golzowense* and *P. laticinctum* persists up to 260 m. Locally, *Paralecaniella indentata* is very common at 356 and 312 m, probably reflecting a more restricted marine environment.

Additional findings include:

Bitectatodinium tepikiense (312 m)

Hystrichokolpoma cinctum (358, 356 m)

Selenopemphix sp. (= *S. 'langhiana'* in Powell) at 312 m.

Zone III.

The topmost samples, from just below 200 m, show peculiar assemblages with an abundance of *Spiniferites* (216 m) and common *Selenopemphix* (204 m). The last occurrence of *Pentadinium laticinctum* is at 216 m.

Similar high frequencies of *Spiniferites* have been described from estuarine and lagoonal environments. Powell (personal communication July 1986) found that *Selenopemphix* spp. are particularly abundant in Messinian sediments preceding the 'Messinian salinity crisis'. He suspects that there is an intimate link between *Selenopemphix* abundance and increasing salinity. For Broeksittard, a lagoonal environment with temporarily higher salinity seems plausible.

Assemblage II, characterized by *Palaeocystodinium golzowense*, is comparable to dinoflagellate floras from the lower part of the Gram Formation (Piasecki, 1980).

In his doctoral thesis (Sheffield University 1983) Powell described Late Oligocene to Miocene deposits from the Piedmont region of northern Italy. Parts of this thesis have been published very recently (Powell 1986a, b and c). His results concerning the Middle and Late Miocene are of interest in relation to the present investigation (fig. 4).

The first column on the left shows the position of the Langhian and Tortonian stratotypes and the Serravallian with indication of the conventional planktonic foraminiferal and nannoplankton zonations in the second and third columns. The last column on the right shows the dinoflagellate zones established by Powell with first and last appearances of characteristic species. To the left of this column I have added the first and last occurrences of some species with relevance for the present discussion of Broeksittard.

It is evident from Powell's data on *Nematosphaeropsis aquaeducta* that the full marine assemblages of dinozone I between 358 and 395 m, are not earlier than the Serravallian. In view of the appearance of *Bitectatodinium tepikiense* (at 363 m) and the presence of *Cordosphaeridium minimum* (at 358 m), the early Serravallian is most likely.

The younger assemblages of dinozone II between 260 and 358 m are assigned to the late Serravallian on the basis of the consistent presence of *Palaeocystodinium golzowense* up to 260 m.

According to Harland (1979), the first appearance of the *Hystrichokolpoma* cf. *poculum* type is in Middle Miocene strata corresponding to NN 8/10.

The assemblages found just below 200 m will be discussed together with the results obtained from the Cuyk borehole.

POWELL 1983

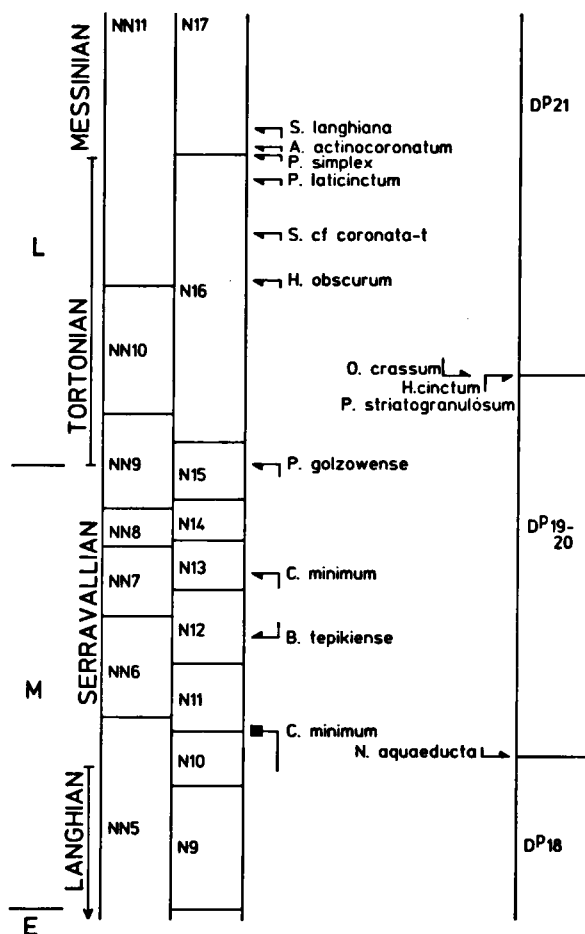


Fig. 4. Stratigraphical distribution of selected Middle and Late Miocene dinoflagellate cyst species, Piedmont Tertiary Basin, northern Italy (after Powell 1983).

CUYK

Fifteen samples taken from the Cuyk borehole generally at intervals of about five metres between 50 and 95 m and downhole of 10 metres were examined. This borehole had been studied by Benedek and the results discussed in Report No. 6, December 1980, on IGCP Project 124 (The NW European Tertiary Basin), but unfortunately, many species expected in Miocene sediments were not mentioned. Furthermore, Benedek applied rather confusing taxonomic concepts.

The results of the present dinoflagellate analyses will be discussed in descending order. Three dinozones were distinguished, i.e., between 50.10 and 66.88 m, 68.40 and 85.00 m, and from 89.00 to 135 m (fig. 5).

The four samples from the first of these zones yielded non-diagnostic assemblages dominated by long-ranging species such as *Lingulodinium machaerophorum*, *Operculodinium crassum*, and representatives of the *Spiniferites* plexus.

Two taxa found additionally—*Achomosphaera andalusiensis* and *Melitasphaeridium choanophorum*—permit designation of a latest Middle Miocene to earliest Pliocene (NN 14) age.

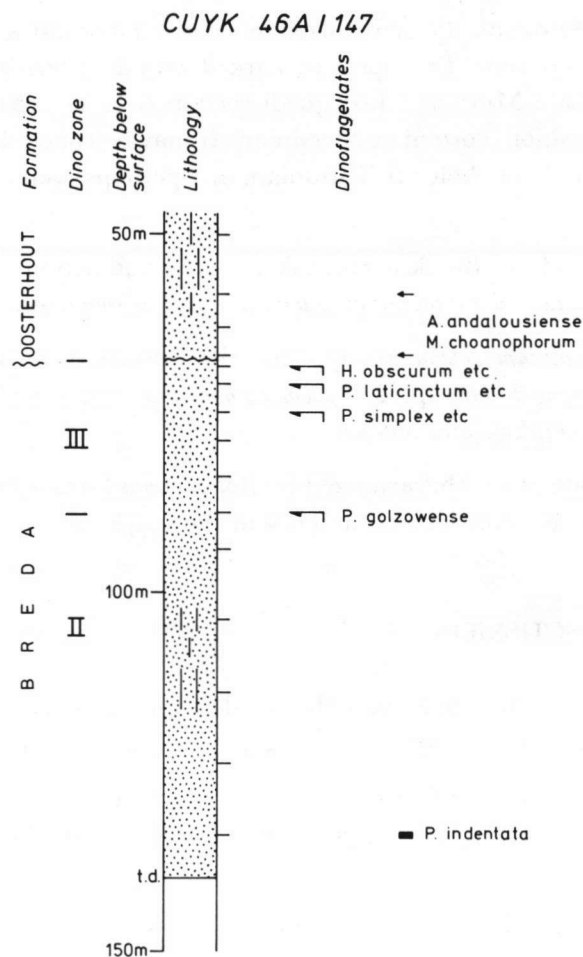


Fig. 5. Summarised palynological and lithostratigraphical data of the Cuyk borehole.

The assemblages between 68.40 and 85.00 m are characterized by the regular occurrence of *Bitectatodinium tepikiense* in proportions up to about 15 per cent. Many species appear at 68.40, 71.00, and 75.00 m:

- 68.40 m *Ascotomocystis* sp. I in Manum (1976)
- Bitectatodinium tepikiense*
- Dinocyst sp. I in Manum (1976)
- * *Hystrichosphaeropsis obscurum*
- * *Selenopemphix* cf. *coronata* type
- Spiniferites* spp.
- 71.00/72.00 m *Invertocysta*
- Paralecaneella indentata*
- * *Pentadinium laticinctum*
- 75.00/76.00 m * *Areosphaeridium actinocoronatum*
- Hystrichokolpoma rigaudiae*
- Millioudodinium* sp.
- Operculodinium* sp. II in Manum (1976)
- * *Pyxidiella simplex*

Most of these species (11 out of 14) are reported to have a first or last appearance datum in undifferentiated Middle to Late Miocene. Five species (marked with an asterisk) were found by Powell in his detailed study of the Late Miocene Mazzapiedi section (fig. 4). The last occurrence of these species is at or near the transition Tortonian/Messinian. It may be concluded that the strata between 68.40 and 85.00 m in the Cuyk borehole are Tortonian, and perhaps even represent the earlier part of that stage.

The uppermost samples from Broeksittard, taken at 204 and 216 m, are also assigned a Tortonian age based on the presence of *Pentadinium laticinctum* and *Selenopemphix* cf. *coronata* type.

At 89.00 m *Palaeocystodinium golzowense* appears; this species is regularly found downhole to 135.00 m together with *Impagidinium* sp. 2, *Systematophora placacantha* and other species previously found in Broeksittard between 260 and 358 m.

The oldest dinoflagellate zone, characterized by *Apteodinium tectatum*, *Labyrinthodinium truncatum*, and *Nematophaeropsis aquaeducta*, was not encountered in the Cuyk hole.

COMPARISON AND DISCUSSION

The results of the dinoflagellate investigation of the Broeksittard and Cuyk boreholes are summarized in figure 6, where the positions of dinozones I to III are indicated in relation to depth.

The data collected by Piasecki in Denmark are shown in the left column with indication of the boundary Middle/Late Miocene, which is traditionally placed between the Hodde and Gram formations.

Powell's findings from the Middle and Late Miocene in the Piedmont Basin are shown in the last column.

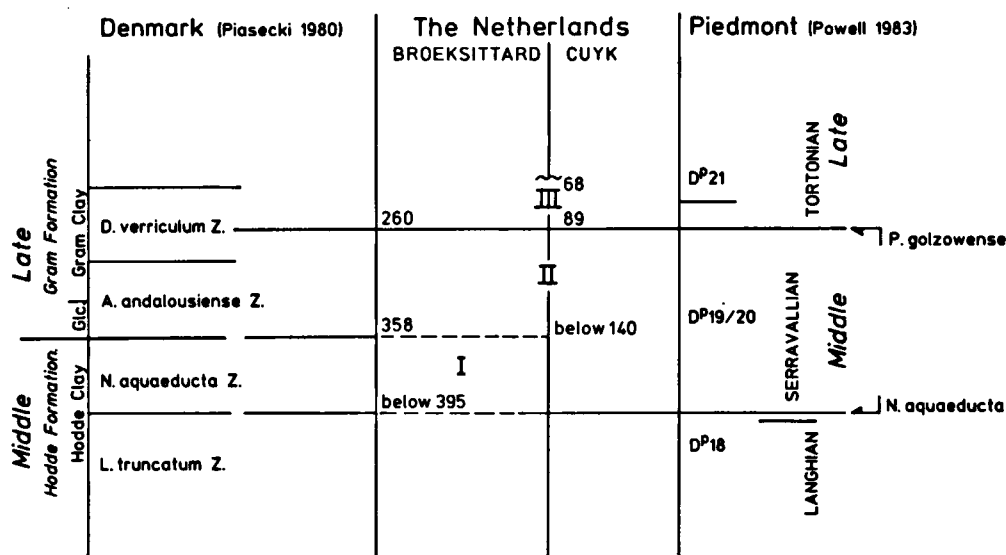


Fig. 6. Comparison of published Middle and Late Miocene dinoflagellate zonations (Denmark, Piasecki 1980 and Italy, Powell 1983) with that of the present study.

Reference levels applied for correlation are the first appearance of *Nematosphaeropsis aquaeducta* just above the Langhian/Serravallian transition and the last occurrence of *Palaeocystodinium golzowense* at the Serravallian/Tortonian boundary (= Middle/Late Miocene). In analogy with the situation in the Piedmont area the extinction of *P. golzowense* within the Gram Clay probably occurs just below the base of the Upper Miocene. In this case the upper part (not the whole) of the Gram Formation may be considered to be of Late Miocene age.

Large parts of the Miocene sequence in Broeksittard and Cuyk are assigned to the Middle Miocene. In both boreholes the Upper Miocene is definitely not younger than Tortonian. Dinoflagellates proved useful for the correlation of Middle to Late Miocene beds with the Mediterranean standard sequence in the Piedmont Tertiary Basin. From the results of this correlation it is concluded that the lower part of what is called the "Upper Miocene" strata in The Netherlands belongs to the Middle Miocene.

The uppermost part of the Cuyk hole (between 50.10 and 66.88) is Late Miocene to earliest Pliocene. If we also take into consideration the results of the malacological investigation, which point to Early Pliocene (zone Mol D) down to 66 m, a considerable break in sedimentation may be concluded. On the basis of a change in the colour of the sediments, this hiatus is thought to lie at 67.80 m.

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