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LITHOSTRATIGRAPHIC CORRELATION OF RUPELIAN DEPOSITS (OLIGOCENE) IN THE BOOM AREA (BELGIUM), THE WINTERSWIJK AREA (THE NETHERLANDS) AND THE LOWER RHINE DISTRICT (F.R.G.)

by

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Recently established lithostratigraphic correlation of Rupelian deposits in the Belgian Boom area and the Dutch Winterswijk area can be extended to the German Lower Rhine district. Criteria discussed are: amount of calcareous matter, septaria layers, colours, grain sizes and geophysical bore hole logs. In a reference well (41E.3-230) log response can be compared to the standard lithostratigraphy valid for all three areas. An important colour change from light grey to dark (bituminous) clays coincides with increasing amounts of Uranium and Thorium, possibly indicating an "event". It can be easily recognized in gamma ray logs. It is proposed to apply the Belgian and Dutch lithostratigraphic subdivision of the Rupelian also to the Lower Rhine district. Some details of biostratigraphic subdivisions elaborated earlier in the Lower Rhine district may need re-examination.

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Contents:

SAMENVATTING

De onlangs door M. van den Bosch (1984) vastgestelde lithostratigrafische correlatiemogelijkheid tussen afzettingen van Rupelien (Midden Oligoceen) ouderdom in de belgische Rupelstreek en het gebied rond Winterswijk blijkt te kunnen worden uitgebreid tot het duitse Niederrhein-gebied. Dit artikel houdt zich alleen bezig met correlatie-vraagstukken. De verspreiding van de Rupel Formatie in het Niederrhein-gebied, in het zuidelijke deel waarvan de formatie uitwigt onder laat-oligocene afzettingen, zal in een later stadium onderzocht moeten worden.

De hier besproken kriteria zijn: kalkgehalte, septariënlagen, kleur, korrelgrootten en geophysische boorgatmetingen. Boorlogs van de boring Miste (41E.3-230) kunnen worden vergeleken met de standaardlithostratigrafie, geldig voor alle drie de onderzochte gebieden. Een belangrijke verandering in kleur van lichtgrijze naar donkere (bitumineuze) kleien valt samen met een toeneming in het gehalte aan Uranium en Thorium, wat mogelijkerwijs duidt op een "event" (belangrijke gebeurtenis). Dit punt in de secties kan gemakkelijk worden herkend op gamma ray logs.

In dit artikel wordt tevens voorgesteld om de belgische en de nederlandse lithostratigrafische onderverdeling van het Rupelien tevens toe te passen op de afzettingen in het Niederrhein-gebied. Enkele details van vroeger opgestelde biostratigrafische onderverdelingen van het Rupelien in het Niederrhein-gebied dienen wellicht heronderzocht te worden.

INTRODUCTION

In a compilation concerning the NW European Tertiary basin, Kockel (1980) demonstrated that lithostratigraphic correlation of the Tertiary basin-fill is greatly aided by three marker horizons. They are considered to be of synchronous origin and have a fairly wide distribution. The upper one of these horizons is the base of the Rupel Formation. From a rock stratigraphic section published in the same year (Hageman & Hooykaas, 1980), it can be derived that the exceptional lithostratigraphic qualification of the Rupel Formation is particularly well recognizable in the southern part of the Netherlands and the Lower Rhine district. In fact, the base, the top, and the subdivision of the Rupel Formation were represented by straight horizontal lines thus accentuating the synchronous character of these boundaries. The lines end in the southern Lower Rhine district where the marine Rupel Formation is supposed to interfinger with deposits of terrestrial origin (Niederrheinische Braunkohlenformation).

Recent data now cast additional light at the lithostratigraphy of the Rupelian deposits. It is believed that the data will allow to define the generally agreed conceptions more exactly. The following contribution is only concerned with the questions of correlations. The distribution of the Rupel Formation in the Lower Rhine district near to its southern margin, where the formation wedges out below Late Oligocene deposits, will have to be discussed later.

BOOM AREA AND WINTERSWIJK AREA

Vandenberghe's publication about the sedimentology of the Boom Clay (1978) contains an admirable description of the methods available in order to identify Rupelian deposits by means of lithostratigraphy. In the preceding issue of this periodical, van den Bosch (1984) reported that Vandenberghe's lithostratigraphic subdivision of Rupelian deposits in Belgium can also be applied layer by layer to Rupelian deposits in the Winterswijk area of the Netherlands. For details the reader may be referred to the publications mentioned.

Both areas are near to 200 km apart. As the Rupelian deposits can be correlated in a very detailed way irrespective of this distance, it can be expected that appropriate correlations ought to be possible as well for the region situated between Boom and Winterswijk. The Lower Rhine district forms part of this region (see fig. 1).

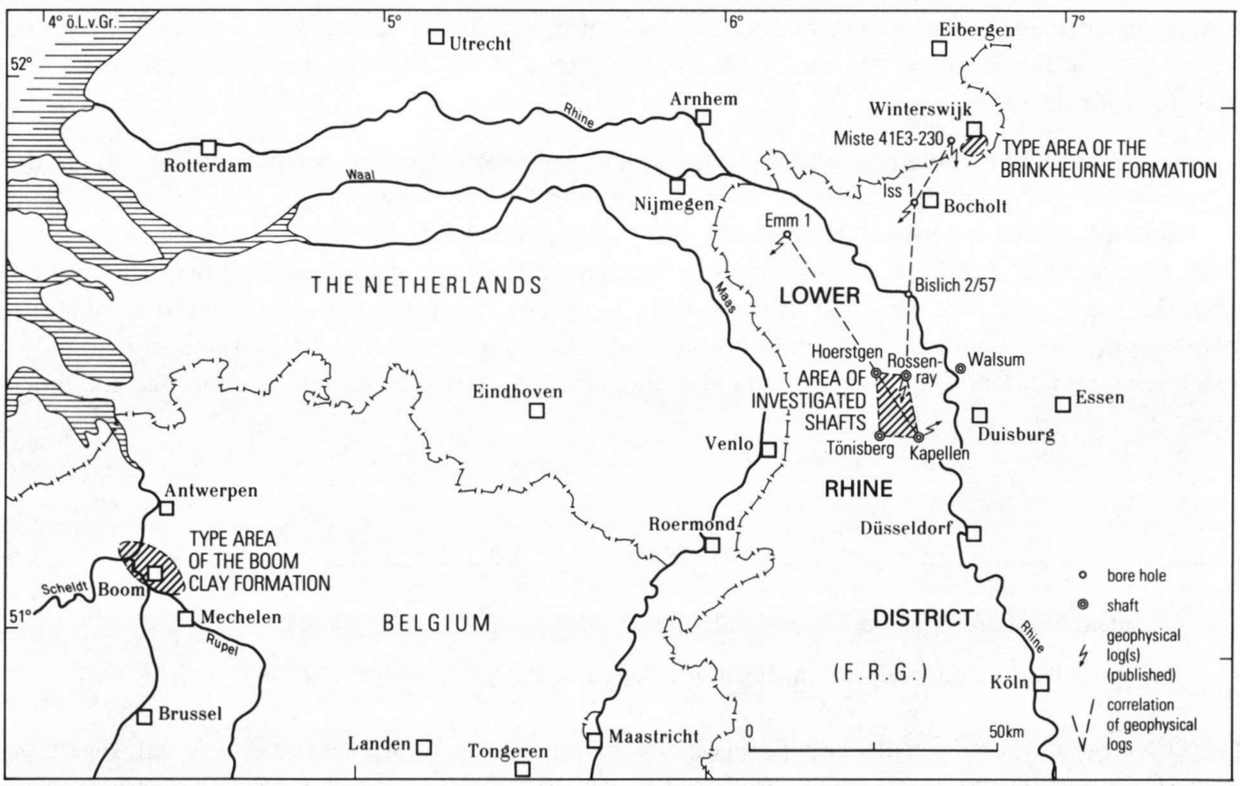


Fig. 1. Location of areas with correlated deposits of Rupelian age in Belgium, The Netherlands and the Lower Rhine district.

Ligging van de gebieden met gecorreleerde afzettingen van Rupelien-ouderdom in België, Nederland en het Niederrhein-gebied.

RUPELIAN DEPOSITS IN THE LOWER RHINE DISTRICT

In the German part of the Lower Rhine region, deposits of Rupelian age are widely distributed. Along the eastern margin of the region, the geological maps present a broad strip of outcropping Rupelian (e.g. Geological map of Northrhine-Westfalia 1:100 000, sheets Düsseldorf-Essen and Recklinghausen). Many details of the Rupelian lithostratigraphy in the deeper subsurface could be studied whenever the mining industry carried out shafts. After having inspected numerous samples derived from shafts, Breddin (1931) proposed a subdivision. It comprised a basal sand member ("Walsumer Meeressand"), a clay member in the middle ("Ton-Mergel-Stufe", later also named "Ratinger Ton"), and on top of it a thick member consisting predominantly of fine sand ("Mehlsand-Schichten"). Wölk had good reasons to revise this proposal and to replace the name "Mehlsand-Schichten". He introduced the name "Lintforter Schichten" instead (Wölk, 1941, p. 83, table 1).

Wölk's ideas were approved and the Rupelian deposits in the Lower Rhine district are usually subdivided as follows:

- Lintforter Schichten
- Ratinger Schichten
- Walsumer Schichten

But due to the quite similar grain size-ranges of the Rupelian deposits and numerous transitions between more clayey, more silty or more sandy layers, the application of this subdivision turned out to be difficult. Occasionally, confusions could not be avoided (compare Fricke & Schürmann, 1958, p. 260, fig. 1 where the sand in depth 160.0 to 174.5 m was erroneously considered to be Walsumer Meeressand).

Geophysical bore hole logs improved the situation remarkably (see Schaub, 1958). About the same time, biostratigraphic subdivisions had been worked out. They were based on investigations of sediment samples derived from shafts (see Ellermann, 1958; Goerlich, 1958; Indans, 1958; later von Benedek & Müller, 1974). As these samples were obviously uncontaminated (in contrast with the usual bore hole samples), results were thought to be particularly representative for stratigraphic purposes. Subdivision boundaries were defined making use of observations from the few localities investigated. The need for more and independent control could not be conceded too much urgency.

Fig. 2. Content of calcareous matter in samples from shaft Hoerstgen (location see Fig. 1).

Kalkgehalte in monsters uit schacht Hoerstgen (ligging zie Fig. 1).

Fig. 3. Content of calcareous matter in Rupelian deposits of the Boom area, the Winterswijk area and shaft Hoerstgen. Calcareous (marly) layers, possibly equivalent to septaria layers are hatched. Calcareous layers containing septaria are indicated with > S < .

Kalkgehalte in Rupelien-afzettingen in de Rupelstreek, het gebied van Winterswijk en in schacht Hoerstgen. Kalkhoudende (mergelige) lagen die overeen kunnen komen met septariënniveau's zijn gearceerd. Kalkhoudende niveau's die septariën bevatten zijn aangegeven met > S < .

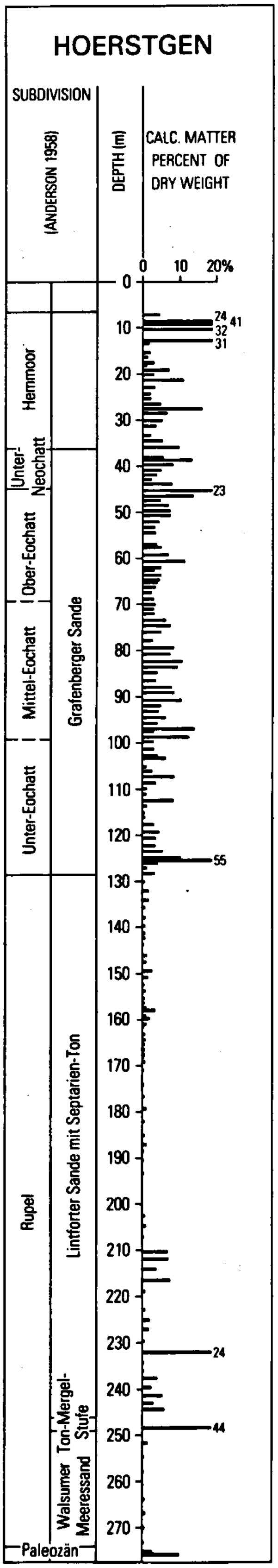

HOERSTGEN
SUBDIVISION
(ANDERSON 1958)
DEPTH (m)
CALC. MATTER PERCENT OF DRY WEIGHT
0 10 20%
Hemmoor
Unter-Neochatt
Ober-Eochatt
Mittel-Eochatt
Unter-Eochatt
Grafenberger Sande
Rupel
Lintforter Sande mit Septarien-Ton
Walsumer Meeressand
Ton-Mergel-Stufe
Paleozän
24
41
32
31
23
55
24
44

Fig. 2

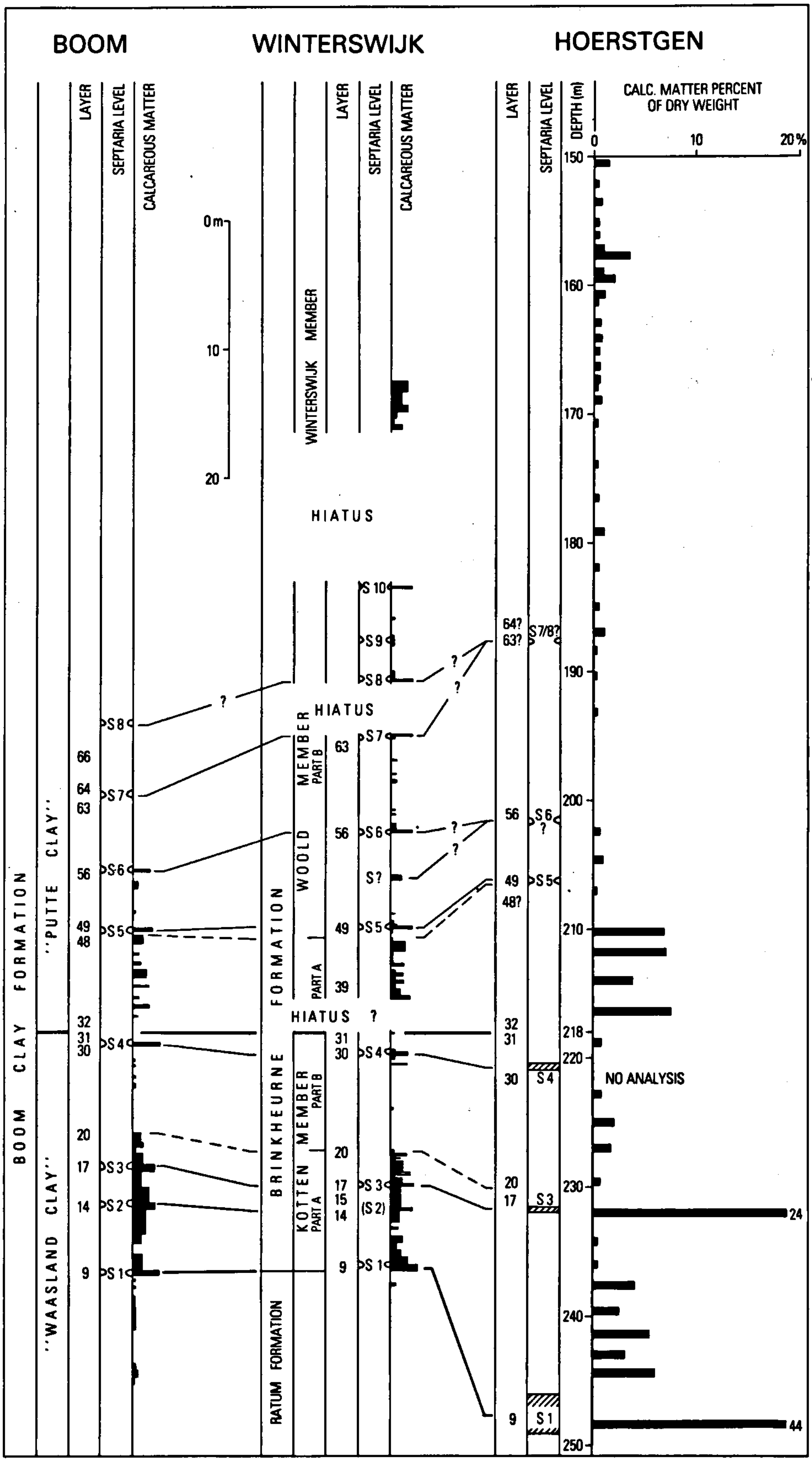

BOOM
WINTERSWIJK
HOERSTGEN
LAYER
SEPTARIA LEVEL
CALCAREOUS MATTER
DEPTH (m)
CALC. MATTER PERCENT OF DRY WEIGHT
0 10 20%
0 m
10
20
WINTERSWIJK MEMBER
HIATUS
HIATUS
HIATUS ?
BOOM CLAY FORMATION
"PUTTE CLAY"
"WAASLAND CLAY"
WOOLD MEMBER PART B
PART A
FORMATION
BRINKHEURNE
KOTTEN MEMBER PART B
PART A
RATUM FORMATION
S 10
S 9
S 8
S 7
S 6
S 5
S 4
S 3
S 2
S 1
(S 2)
S ?
S 7/8?
64?
63?
NO ANALYSIS
24
44

Fig. 3

LITHOSTRATIGRAPHIC CRITERIA

Calcareous matter

When Vandenberghe (1978) established his detailed lithostratigraphic subdivision of the Rupelian deposits in Belgium, he disposed of various criteria. Septaria layers, colours and certain grain size anomalies proved to be of particular importance (p. 34 and following). These criteria can be applied with more or less ease wherever Rupelian deposits are appropriately exposed and accessible. Regarding samples obtained from bore holes or shafts, the difficulties to identify distinct layers increase.

In the Winterswijk area, the subdivision of Rupelian deposits had to be based – at least to a great extent – on samples from suitable bore holes. But observations about septaria layers, colours and grain size portions provided sufficient data in order to retrace most details as they had been described from Belgium (van den Bosch, 1984).

An additional criterion could be established. It could be demonstrated that the content of calcareous matter may serve as a reliable guide. The vertical succession of layers with low, medium or high content of calcareous matter in the Winterswijk area coincides closely with the succession as observed in the Boom area. It was this observation which stimulated the attempt to look for comparable data in the Lower Rhine district.

Calcareous matter in Rupelian deposits of the Lower Rhine district

When shaft Hoerstgen (location see fig. 1) was under construction, samples were saved for stratigraphic, lithologic and geomechanic investigations. Not all of the final results have been published. The authors were permitted to present the analytical results concerning the calcareous matter of the samples out of shaft Hoerstgen. From fig. 2 it can be seen that the content of calcareous matter varies considerably. The Rupel Formation (comprising "Walsumer Meeressand", "Ton-Mergel-Stufe", and "Lintforter Sande mit Septarien-Ton") contains relatively little calcareous matter (it is not before the beginning of the Chattian deposition that a general rise of the percentage of calcareous matter becomes evident).

In fig. 3 a presentation of the succession of calcareous and less calcareous layers as observed in the lower part of the Rupel Formation in shaft Hoerstgen has been placed besides two columns with data from the Boom and the Winterswijk area (a more detailed comparison of the lithostratigraphic subdivision in the Boom and the Winterswijk area can be found in van den Bosch, 1984, encl. 3). From fig. 3 it can be derived that the vertical succession of lower and higher percentages of calcareous matter in shaft Hoerstgen displays some similarity with the respective successions in the Boom and Winterswijk area. The similarities served as a first approximation to establish a tentative correlation between the Rupel Formation in the Winterswijk area and the Lower Rhine district. The following paragraphs discuss further criteria and some implications of this correlation.

Septaria layers

Up to 1978, Vandenberghe could incorporate all his observations of layers containing septaria into a sequence of eight different horizons (S1-S8). Later on, he detected somewhat younger septaria layers near Antwerpen (S9-S12, unpublished; for details see van den Bosch, 1984, encl. 3). The distinction of septaria levels S1-S10, discovered in the Winterswijk area, was described by van den Bosch (1984, p. 102).

From observations which were performed when the construction of shaft Hoerstgen was under way and from later investigations of the samples preserved it can be made sure that three layers with septaria were penetrated. Three marly layers were found which may be accounted for equivalents of levels containing septaria.

The informations available from shaft Hoerstgen are not sufficiently specified in order to allow an opinion on the shape and other particularities of the septaria encountered. Considering the vertical distances between the septaria layers and the marly levels, it seems reasonable to assume that in shaft Hoerstgen the "Ton-Mergel-Stufe" is equivalent to septaria level S1 in the Boom and the Winterswijk area. The marly horizon at the depth of 231.7 m could correspond to level S3. The layer of marl from 220.5 to 221.0 m is thought to represent level S4 (it appears that material, belonging to this calcareous layer, was not included when the chemical analysis was carried out of the respective depth interval).

Septaria layers at the depth of 206.0 m and 201.5 m are supposed to be identical with levels S5 and S6. The uppermost septaria layer of shaft Hoerstgen which was observed at a depth of 187.6 m can possibly be regarded as an equivalent to either level S7, level S8, or a combination of both within a single layer (see van den Bosch, 1984, p. 102-103). Fig. 3 summarizes the present knowledge about the content of calcareous matter, the septaria levels, and their numbering within the areas under consideration.

Colours

Colours and colour changes played a decisive rôle when Vandenberghe (1978) tried to establish a lithostratigraphic correlation between the outcrops of the Boom Clay in Belgium (the same applies to the Winterswijk area, see van den Bosch, 1984). In the Lower Rhine district, no sufficiently detailed descriptions of colours and colour changes occurring in the Rupelian deposits are available.

Breddin (1931 a,b) quoted some observations of colours based on exposures as well as samples from shafts. His descriptions allow to verify that in the Lower Rhine district a pronounced difference between Rupelian deposits of dark brownish grey and of light grey colours can be presumed. A necessarily tentative interpretation of what Breddin reported may come to the conclusion that in shaft "Norddeutschland 1" at a depth of about 177 m a change between a predominantly dark series and a series of light colours occurred. If this opinion is correct, a comparable boundary between darker and lighter sediments can be supposed to exist in shaft Hoerstgen at 215 to 220 m depth, in other words a very few meters above the marly layer designated as septaria level S4.

The (assumed) presence of this boundary may actually deserve particular attention. In the Boom and the Winterswijk area an unmistakable boundary between a lower grey clay and an upper dark to blackish clay has been proved to be of importance. In the standard lithostratigraphy of the Boom area this colour change figures as the perhaps most obvious boundary. It separates the "Waasland Clay" from the "Putte Clay". In the Winterswijk area, the same colour change is identical with the boundary between the "Kotten Member" and the "Woold Member". The colour change is caused by the so called "black bands" in the upper dark clay. In the next paragraph it will be shown that the increasing frequency of black bands when passing from the lower grey clay to the upper dark clay coincides exactly with a noticeable increase of natural radioactivity.

Geophysical bore hole logs

It is well known that in the Rupel Formation of the North Sea basin geophysical bore hole logs have displayed striking similarities irrespective of the distances of the bore hole locations. The logs have been used for correlations in various parts of the basin (concerning the Lower Rhine district, see Fahrion, 1958; Schaub, 1958; Thienhaus, 1962). Some correlations have been confirmed by paleontological evidence, a very few correlations turned out to be premature or simply erroneous.

Regarding controllable log correlation a bore hole in the Winterswijk area near Miste furnishes new data (bore hole 41E.3-230; coordinates: 439.860/242.265; 26.6 m above N.A.P.). The bore hole is thought to be quite exceptional as it may be one of the first which allows to compare the standard lithostratigraphy of the Rupel Formation and the biostratigraphic zonations (van den Bosch, Cadée & Janssen, 1975; van den Bosch, 1980; Gaemers, in press; Janssen & King, in press) with a resistivity log (RES) and a log of the natural radioactivity (GR). In this bore hole it is possible to check if any parallels can be established between such lithostratigraphic criteria as septaria layers, colour changes or grain size anomalies and the response of the logs.

Fig. 4 presents some preliminary results. No attempt is made to give an account layer by layer. From fig. 4 it is obvious that the lower boundary of the Brinkheurne Formation coincides with a noticeable change in resistivity (RES). The same applies to the upper boundary of this formation but the resistivity change is less pronounced. The response of resistivity may be due to differences in (effective) porosity and/or the chemical composition of the pore water.

In accordance with the observed lithology, the GR-log confirms that the Brinkheurne Formation is more clayey-silty than the Ratum Formation and the Winterswijk Member. But this statement needs to be supplemented. The Woold Member exhibits an interval with an anomalously high radiation. It does not seem to be caused by a particularly high content of clayey matter. Radiation sharply increases at the lower boundary of the Woold Member and decreases to "normal" values in its upper part. The bore hole samples demonstrate that the increasing radiation at the lower boundary coincides with the colour change from the lower grey to the upper dark clay. As the dark clay contains numerous black bands and an increased amount of organic matter it is obvious to draw parallels between the increase of organic matter and the increase of radiation.

It was mentioned that in the Lower Rhine district the lithostratigraphic position of the change from light grey to dark clays can nowhere be pinpointed. But the authors believe that this lack of data can be overcome by two observations:

- wherever the radiation of Rupelian deposits has been recorded in the Lower Rhine district, the logs display a similar increase of radioactivity in the same lithostratigraphic position;
- from a spectrometric GR-log it can be derived that the increased radiation in the Woold Member is caused by increased amounts of Uranium and Thorium.

The authors are convinced that the increasing radiation at the base of the Woold Member may be taken as a sufficiently reliable indication of the colour change in question.

In fig. 4, the bore hole logs of "Miste" have been combined with some previously published logs. They are intended to give an impression of log correlations between the Winterswijk area and the area of the shafts Hoerstgen, Rossenray, Kapellen and Tönisberg (locations see fig. 1). The resistivity log from Emmerich was included for two reasons: the well penetrated the Rupel Formation in considerable depth and it is situated quite close to a line connecting the Boom area with the Winterswijk area.

The decrease of radiation in the upper part of the Woold Member cannot yet be unambiguously interpreted. This question needs further consideration.

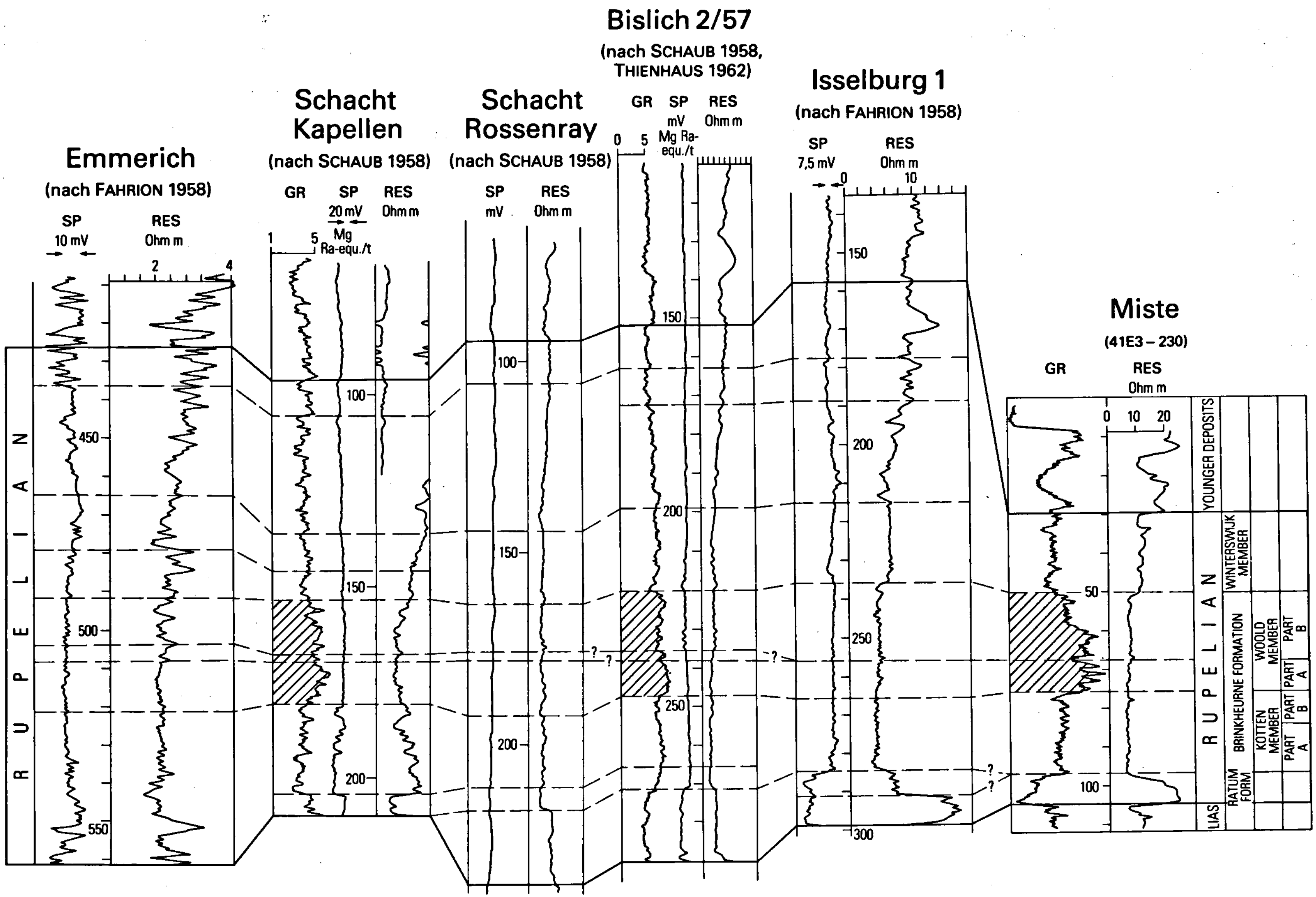


Fig. 4. Deposits of Rupelian age with response of resistivity logs (RES), self-potential logs (SP) and gamma ray logs (GR).

Afzettingen van Rupelien-ouderdom met de bijbehorende electrische weerstandsmeting (RES), spontane potentiaal (SP) en gamma ray log (GR).

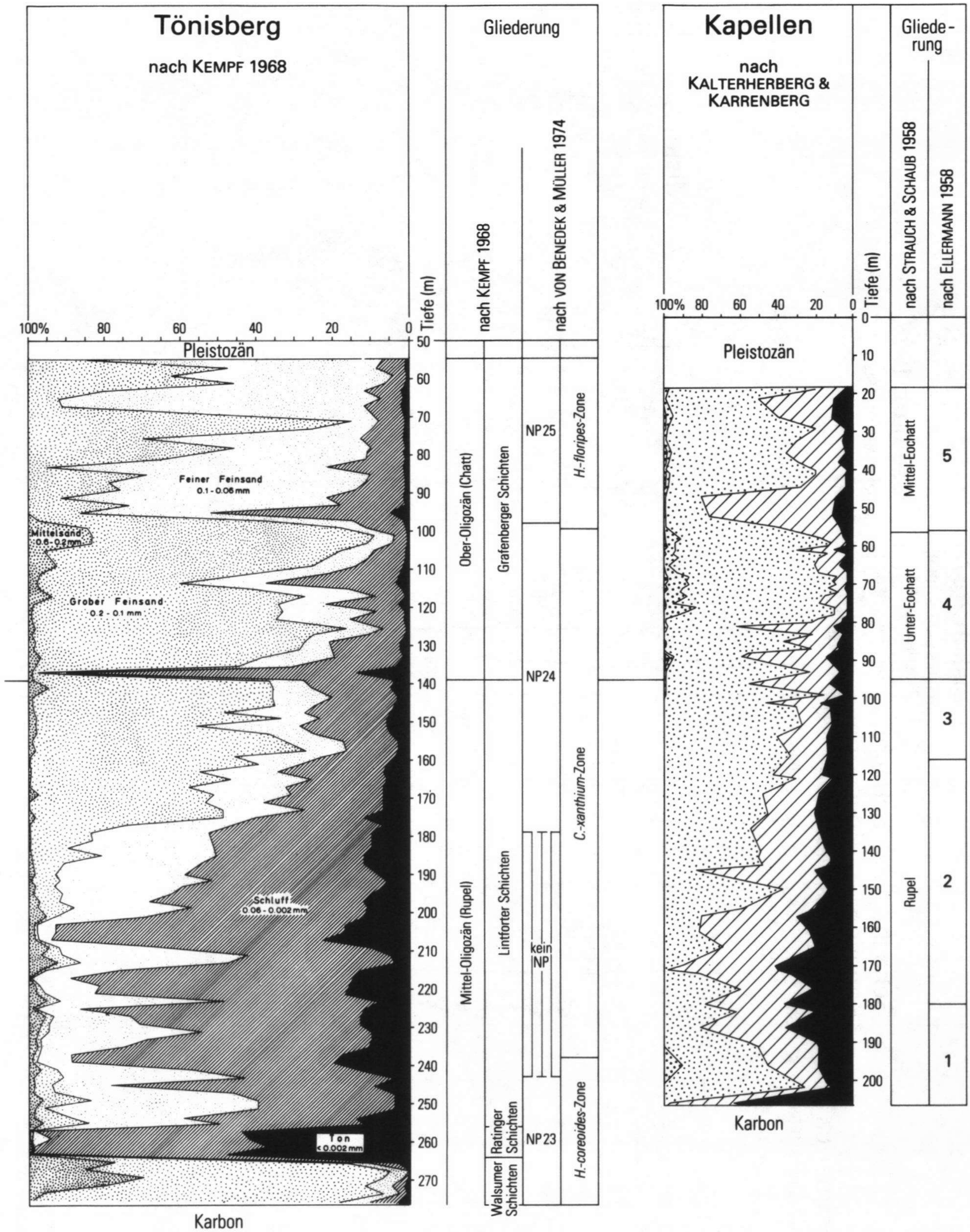
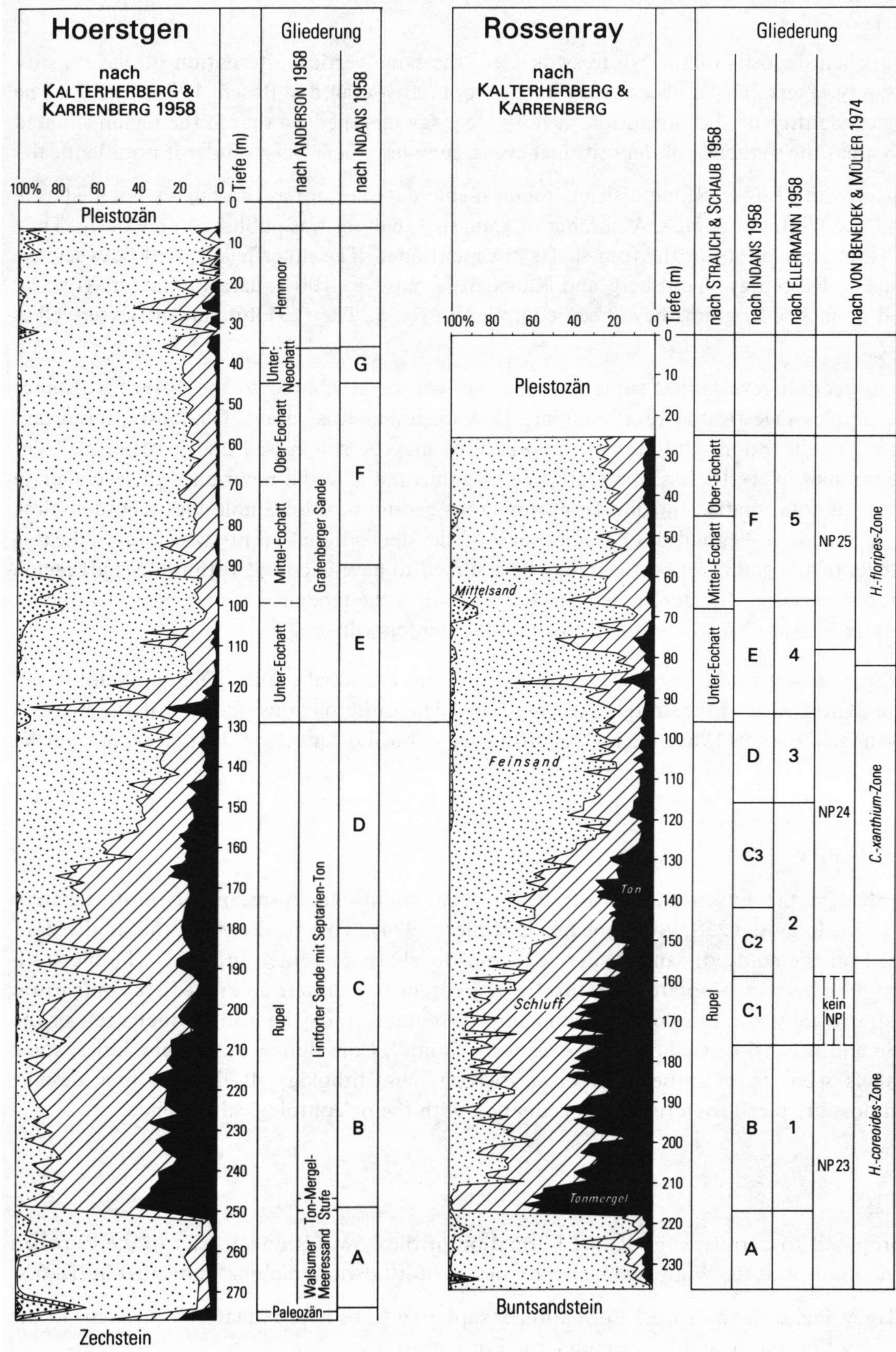


Fig. 5 (pp. 132 + 133). Grain size diagrams of shafts Hoerstgen, Rossenray, Tönisberg and Kapellen, and biostratigraphic subdivisions. Translation of German terms: Tiefe = depth, Gliederung nach = subdivision after, Mittelsand = medium sand, Feinsand = fine sand, Schluff = silt, Ton = clay, Ton-Mergel = marly clay, kein NP = no nannoplankton.



Korrelgrootte-diagrammen van de schachten Hoerstgen, Rossenray, Tönisberg en Kapellen, en biostratigrafische onderverdelingen. Vertaling van duitse begrippen: Tiefe = diepte, Gliederung nach = indeling volgens, Mittelsand = matig fijn zand, Feinsand = fijn zand, Schluff = silt, Ton = klei, Ton-Mergel = mergelige klei, kein NP = geen nannoplankton.

Grain sizes

In the Rupelian deposits of the Winterswijk area, the same vertical alternation of clayey, silty and slightly sandy layers can be observed as in the Boom area (van den Bosch, 1984, encl. 3). The nearly complete identity of the succession in both areas favours the idea that in the region situated between both areas the sequence of depositional events may have been very similar if not identical.

What concerns the Lower Rhine district, the available data are not as thoroughly detailed as in the Boom and the Winterswijk area. A number of grain size analyses was published previously. They were derived from samples out of the four shafts just mentioned. The superficial extent between the shafts Hoerstgen, Rossenray, Tönisberg and Kapellen is close to 100 square kilometers (fig. 1). The published grain size diagrams have been compiled in fig. 5. They exhibit similarities as well as discrepancies.

A closer inspection reveals that some discrepancies can be attributed to the differing distance between the samples investigated (e.g. compare Hoerstgen and Rossenray). Obviously, important details observed in the Boom and the Winterswijk area may be suppressed due to an insufficient frequency of samples. Nevertheless, the grain size diagrams indicate the recurrence of several grain size changes in all four shafts. Judging from numerous geophysical bore hole logs recorded close to the shaft region, it is beyond doubt that many of the depositional events which are indicated by slight changes of the grain size portions may be assumed to have occurred within the shaft region about contemporaneously. The bore hole logs clearly confirm the tendency of an identical sequence of grain size variations as observed in the Boom and the Winterswijk area.

Problems may arise from a hiatus in deposition or from erosional events. They are admittedly difficult to be identified by lithostratigraphic methods. The quite obvious question if the hiatuses noticed by van den Bosch (1984, encl. 3) continue into the Lower Rhine district cannot yet be answered.

BIOSTRATIGRAPHY

The Rupelian in the Lower Rhine district has been subdivided by means of biostratigraphy (Ellermann, 1958; Indans, 1958; von Benedek & Müller, 1974). To a great extent, the subdivisions could be based on the study of samples derived from the shafts presented in fig. 5. The biostratigraphic results have been incorporated into this figure in order to facilitate an immediate comparison between biostratigraphy and lithology. Looking into the details, it may be noticed that a few of the microfaunistic and microfloristic boundaries seem to "jump". Considering other boundaries, some obvious parallels seem to exist between biostratigraphy and lithology. Both cases may deserve attention and possibly plead for a renewed occupation with the paleontological evidence.

CONCLUSIONS

1) It is proposed to correlate the Rupel Formation of the Lower Rhine district to the Rupelian deposits of the Boom and the Winterswijk area by means of lithostratigraphy as indicated in fig. 6.

- The clayey facies of the Rupel Formation is supposed to be approximately equivalent to the Boom Clay Formation and the Brinkheurne Formation.
- The sandy facies is supposed to be approximately equivalent to the Winterswijk Member.

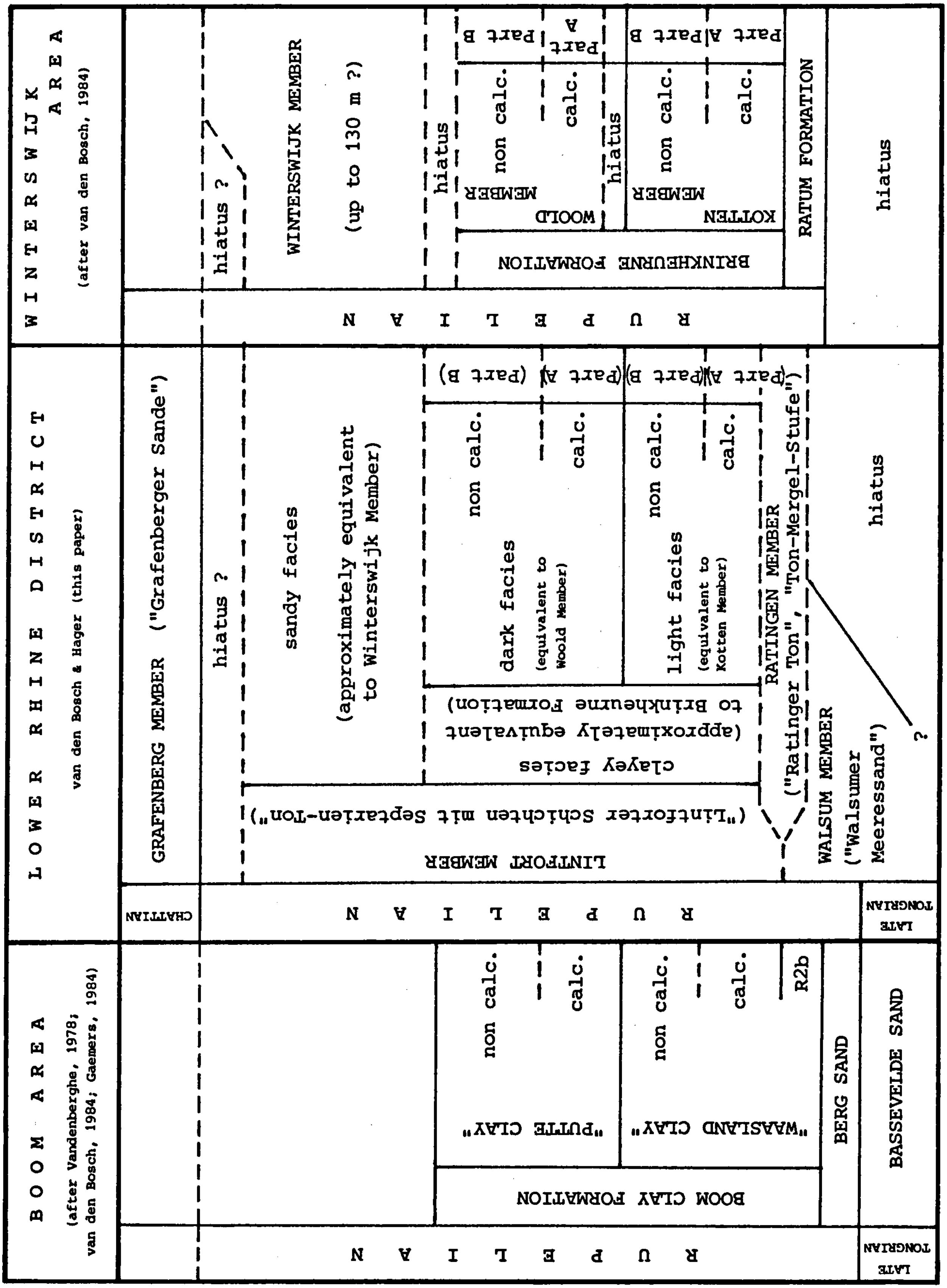


Fig. 6. Correlation of Rupelian deposits in the Boom area, the Winterswijk area and the Lower Rhine district.

Correlatie van Rupelien-afzettingen in de Rupelstreek, het gebied rond Winterswijk en het Niederrhein-gebied.

– The boundary between the light grey facies and the dark facies is supposed to be synchronous in all three areas.

The authors are of the opinion that the proposed subdivision can be applied by inspection of exposures, of freshly recovered bore hole samples and of geophysical bore hole logs.

The previously introduced names (Lintfort Member, Ratingen Member) are thought to be of restricted value only. Their use cannot any longer be recommended. With regard to the immediate continuation of Rupelian deposits passing from the Winterswijk area into the Lower Rhine district, it seems to be reasonable to make use of the lithostratigraphic subdivision which has been established in the Winterswijk area (the authors prefer to refrain from introducing new names for deposits which are believed to be identical in the Winterswijk area and the Lower Rhine district).

The Walsum Member as described by Breddin (1931a, p. 252; 1931b, p. 134) cannot be regarded as being fully equivalent to the Berg Sand Member. Following Janssen (1982) and Gaemers (1984), the Walsum Member or part of it has to be considered as synchronous with the Late Tongrian Basse-velde Sand.

2) Concerning the horizontal thickness variations of layers, Vandenberghe and van den Bosch demonstrated that in the Boom and the Winterswijk area constancy prevails. Correlation between the latter area and the Lower Rhine district now suggests that the Lower Rhine area subsided somewhat faster. The difference in subsidence possibly signals the future tectonic pattern which became spectacular short time after the beginning of the Late Oligocene.

3) The increased amount of Uranium (from about 5 PPM to about 7-12 PPM) and Thorium (from about 32 PPM to about 40-45 PPM) observed in the Woold Member poses some questions. One may be mentioned: is the (rather sharp) rise of the U- and Th-content in the deposits indicative of an "event" which may be believed to have occurred contemporaneously at all places where the same increase of radiation can be noticed (see Hageman & Hooykaas, 1980, increase of gamma radiation in logs "Doornspijk-2" depth 768 m and "L2-4" depth 987 m, possibly indicating a boundary between grey and black clay)?

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