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MAASTRICHTIAN-EARLY TERTIARY STRATA IN THE SE NETHERLANDS (CURFS QUARRY, RUR VALLEY GRABEN) AND THE CAMPINE MINING DISTRICT (NE BELGIUM): LITHOLOGY, GAMMA RADIATION AND BIOCLAST ASSEMBLAGES

by

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Data obtained from the analysis of the lithology, the gamma radiation and the bioclast assemblages of Late Maastrichtian and Dano-Montian strata exposed in the former Curfs quarry (Geulhem, The Netherlands) are compared with those obtained from several boreholes in adjacent Belgian and Dutch areas (Campine Mining District, Molenbeersel, Rur Valley Graben). It is concluded that lenticular sediment bodies are involved, and that bed-by-bed correlations are hardly possible because of ever-changing lithological characteristics. The only horizon to be easily distinguished in the Curfs quarry is the Vroenhoven Horizon, the lithological boundary between the Maastricht and Houthem Formations. There are no apparent changes in lithology, bioclast assemblages and gamma radiation across the K-T (Cretaceous-Tertiary) boundary in the Curfs quarry. Assemblages are either dominated by serpulids, bryozoans, anthozoans, foraminifers or calcareous algae. Future multidisciplinary studies on fossil groups with biostratigraphical potential are necessary to check and strengthen correlations on the basis of gamma-ray logs and on ecological (bioclast assemblages) grounds.

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SAMENVATTING

Maastrichtien - Vroeg-Tertiaire afzettingen in ZO Nederland (groeve Curfs, Roer-slenk) en in de Kempense Mijnstreek (NO België): lithologie, gamma straling en bioklast-associaties.

De resultaten verkregen uit analyses van de lithologie, gamma straling en bioklasten-associaties in de Laat-Maastrichtien en Dano-Montien afzettingen ontsloten in de voormalige groeve Curfs (Geulhem) worden vergeleken met die uit diverse boringen op aangrenzend Belgisch en Nederlands grondgebied (Kempense Mijnstreek, Molenbeersel, Roer-slenk). Geconcludeerd wordt dat sprake is van lensvormige sedimentlichamen, en dat laagsgewijze correlaties nauwelijks mogelijk zijn vanwege de steeds veranderende lithologische kenmerken. De enige horizont die in de groeve Curfs gemakkelijk herkend kan worden, is de Vroenhoven Horizont, de lithologische grens tussen de Formaties van Maastricht en Houthem. Er zijn geen duidelijke verschillen in de lithologie, de gamma straling en de bioklasten-associaties te constateren bij de Krijt-Tertiair grens in de groeve Curfs. Bioklasten-associaties worden dan weer door serpuliden, dan weer door bryozoën, anthozoën, foraminiferen of kalkalgen gedomineerd. Toekomstige multidisciplinaire studies van biostratigrafisch belangrijke fossielgroepen zal de correlaties gebaseerd op gamma-ray logs en op oecologische gronden (bioklasten-associaties) moeten controleren en verstevigen.

INTRODUCTION

Over a period of some forty years, several lithological sections for the former Curfs quarry at Geulhem (The Netherlands) have been constructed, from which it appears that the chalk deposits exposed in this quarry represent parts of lenticular sediment bodies. Field characteristics of these bodies are usually not fit to base correlations upon, not even within a single quarry. In the former Curfs quarry (now Ankersmit Holding B.V.), the Vroenhoven Horizon, the lithological boundary between the Maastricht and Houthem Formations (*sensu* W.M. Felder, 1975) can be distinguished by a slight difference in colour of the sediments below and above this boundary, a distinction that is not necessarily present at other localities. Chemical analyses and grain size determinations of the homogeneous chalk deposits (Fig. 1) did reveal slight differences in grain size between the Maastrichtian chalks and the Dano-Montian ones, but, on the whole, the samples studied differ only insignificantly. The same holds true for the gamma radiation of the sediments below and above this horizon (Fig. 3). The values found in the Curfs quarry are closely comparable to those measured in boreholes in the Campine Mining District, in the Rur Valley Graben and at Limbricht (Fig. 5).

The bioclast (1.0-2.4 mm) assemblages from below and above the Vroenhoven Horizon do not show any significant changes (Fig. 2). It is interesting to note that similarities are more easily found than differences.

Because of the fact that lenticular sediment bodies are involved and that the bioclast assemblages are all nearly identical it is very difficult to establish bed-by-bed correlations over greater distances.

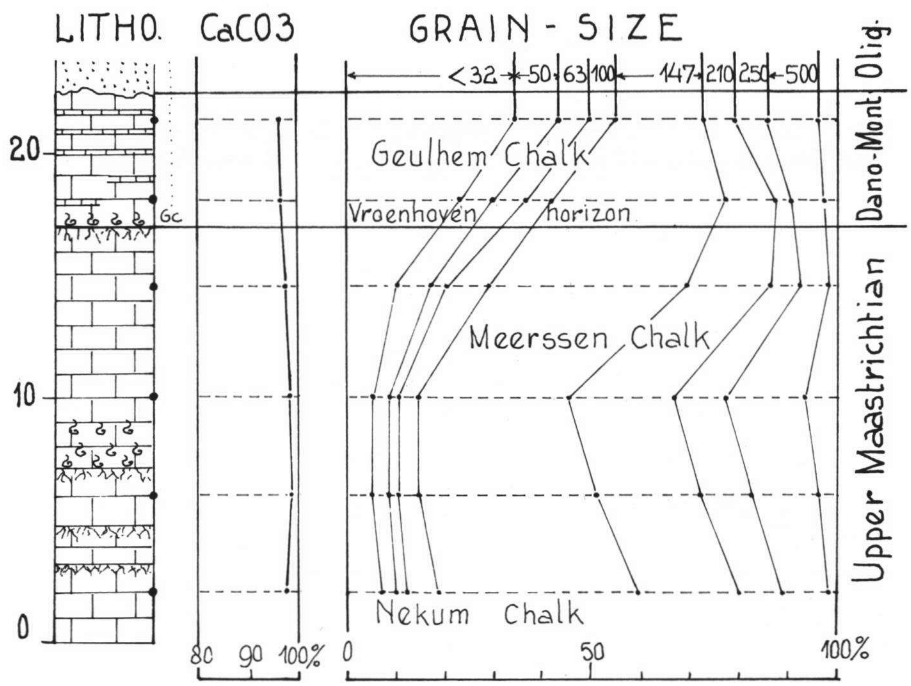

Fig. 1. $CaCO_3$ content and grain size distribution of samples taken from homogeneous chalks in the former Curfs quarry at Geulhem, municipality of Valkenburg aan de Geul (The Netherlands). In the lithological section (as measured in 1972) fossil grit layers, 'hardgrounds' and indurated layers are indicated.

Local sediment bodies are the result of slight changes in the sedimentation/erosion cycles (induced by tectonic movements) during the latest Maastrichtian and Dano-Montian. Minor fluctuations in temperature and/or water depth resulted in changes in the bioclast assemblages, which are either dominated by serpulids, bryozoans, anthozoans, foraminifers, or by calcareous algae.

LITHOLOGICAL SECTION OF THE CURFS QUARRY

The section exposed in the former Curfs quarry shows a series of homogeneous chalks (medium to coarse-grained biocalcarenites) separated by fossil grit layers (bioclast concentrations) and/or 'hardgrounds'. On top of the chalk rests a quartz-rich silty deposit with some clay and glauconite. Locally, a thin pebble bed is present at the very base of this silty deposit of Oligocene age.

For more than 40 years lithological sections have been measured in this quarry, with the aim of precisely locating collected fossils. It soon became clear, however, that it was extremely difficult to find again on the basis of field characteristics the previously distinguished units. Quarrying activities over a period of several months had changed the lithological sections considerably: a certain number of beds had turned into one thick bed of fossil grit or 'hardgrounds' with bioclast concentrations on top of them had vanished or the bioclasts were missing. The ever-changing section exposed in this quarry resulted in the publication of five different sections by W.M. Felder (1958). At that time, the quarry was still divided into an eastern and a western part; correlations between these parts were not deemed possible (W.M. Felder, 1958). Sections published subsequently (W.M. Felder,

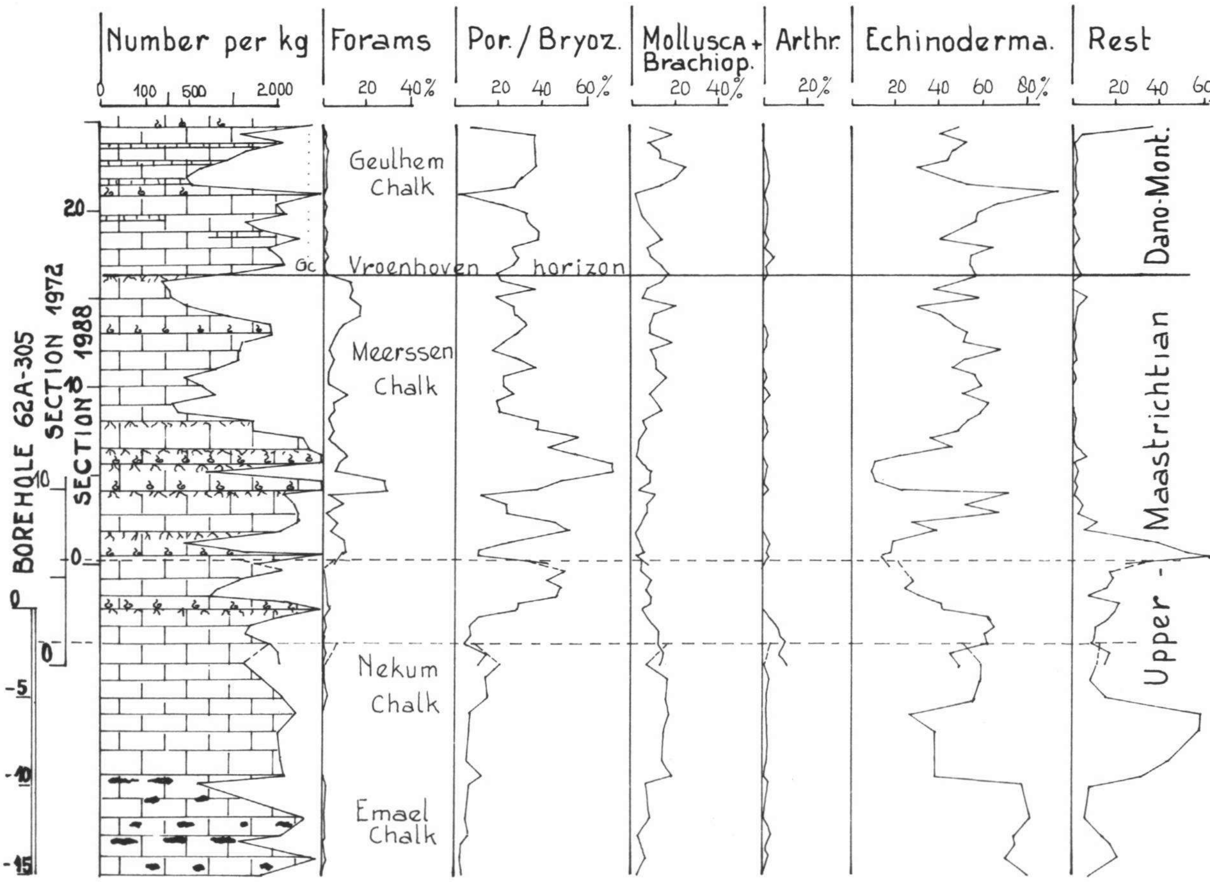

Fig. 2. Bioclasts (1.0-2.4 mm) in the strata exposed in the former Curfs quarry. The section measured in 1988 is here complemented with the lower part of the 1972 section and with the uppermost 15 m of borehole 62A-305.

1975) differ significantly from the ones published in 1958. A section measured by the present author in 1972 also differs from all other sections published.

From field observations it has become apparent that characteristics as used in the field are, on the whole, not suitable for correlations or only with considerable difficulties. A single fossil grit layer may divide up into several such layers over a short distance, see for instance the single layer at 7-9 m in Fig. 1 (1972 section) and several layers between 4-8 m in Fig. 2 (1988 section). It is also possible that a fossil grit layer disappears over a short distance, see *e.g.* the Vroenhoven Horizon in Figs 1 and 2. The above holds also true for 'hardgrounds', some of which divide up into two separate 'hardgrounds', so that over a distance of only 100 m, already 1.5 m of sediment has become intercalated between them (the 1988 section).

The fossil grit layers often contain pebbles, apparently originating from the underlying 'hardground'. For other pebbles (including flints) the origin is less easily determined. P.J. Felder (1971) suggested an origin from local 'hardgrounds' through erosion. Voigt (1979a, b), however, suggested on the basis of the fossil content of the flint pebbles, that these originated from erosion of the Lanaye-Lixhe 3 Chalks (Gulpen Formation), which are much lower in the Late Cretaceous section in southern Limburg and which are also further away geographically speaking. Whatever their origin,

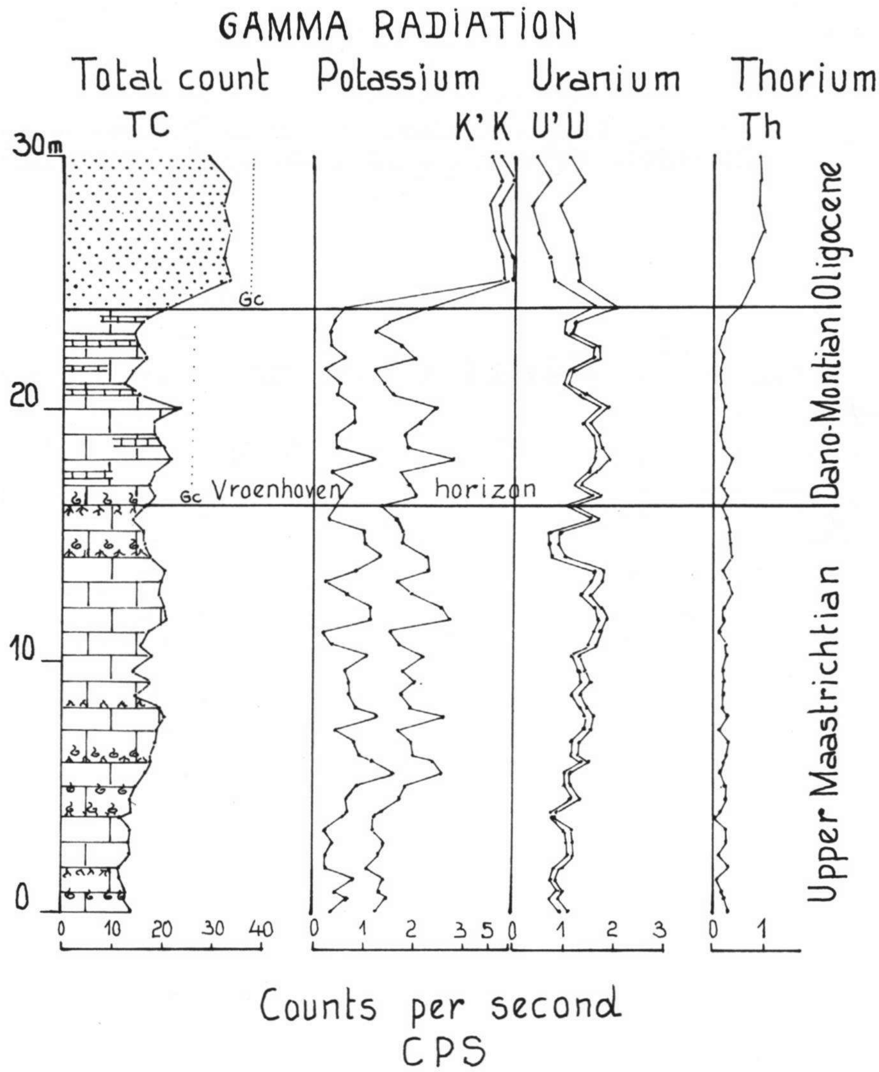

Fig. 3. Gamma-ray logs for the strata in the former Curfs quarry. K' and U' are the computed, stripped values for K and U respectively.

the presence of such pebbles and the lithological diversity of the deposits containing them indicates deposition under turbulent conditions.

The entire section exposed in the Curfs quarry was originally referred to as a single lithological unit, the Md (see Uhlenbroek, 1912). After 1955, following Hofker (1955), the uppermost part was designated Early Palaeocene or Post-Md. From that moment on more attention was paid to the differences between the sediments below and above the Vroenhoven Horizon.

In 1975 W.M. Felder introduced a formal lithostratigraphy for the Late Cretaceous-Early Tertiary in southern Limburg. In this scheme the sediments below the Vroenhoven Horizon were designated as Maastricht Formation, Nekum and Meerssen Members, with the Caster Horizon separating these units. The strata above the former horizon were referred to as Houthem Formation, Geulhem Member (W.M. Felder, 1975).

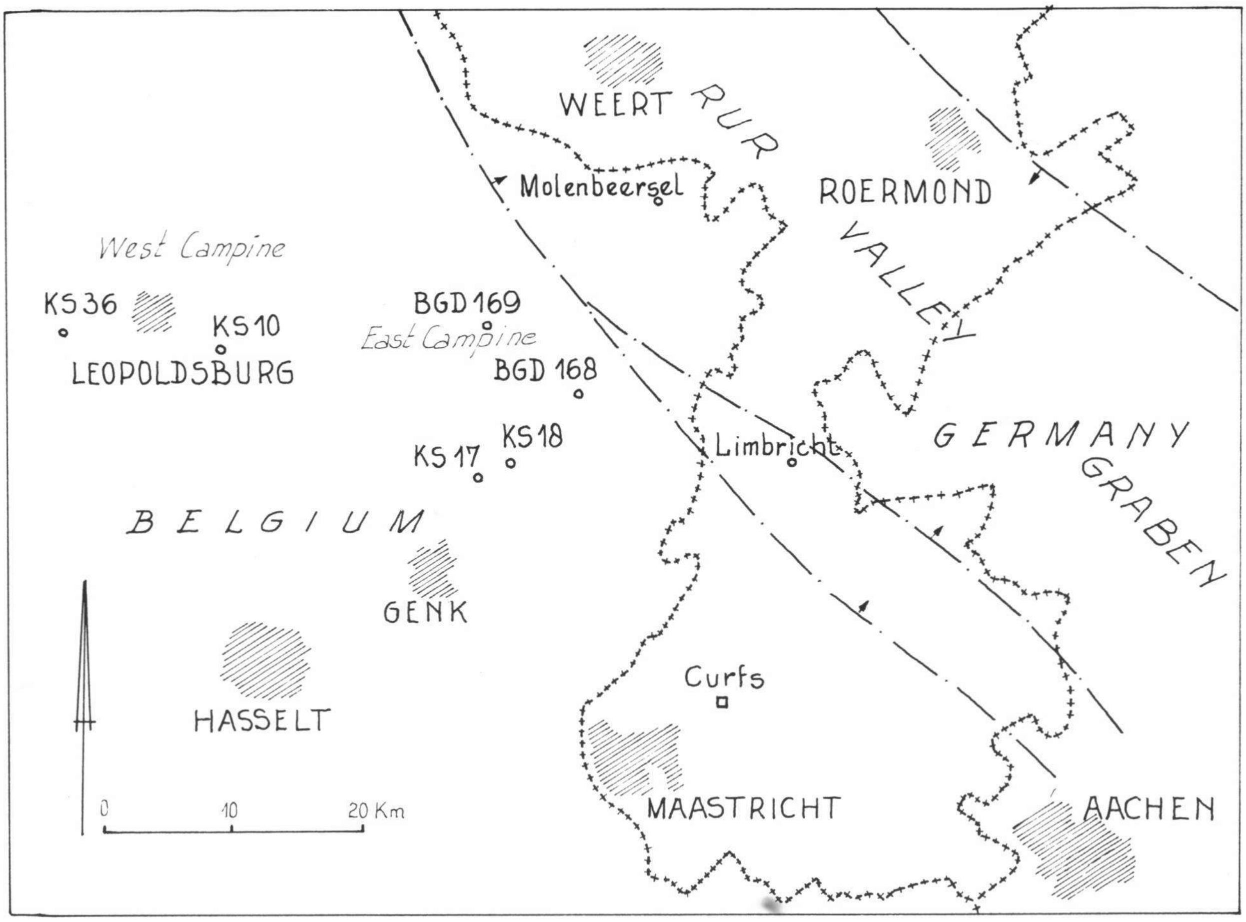

Fig. 4. Location map showing the former Curfs quarry and the boreholes discussed in the text. Only the most important faults in the Rur Valley Graben are indicated.

On the basis of an analysis of bioclast assemblages (P.J. Felder, 1984) the Caster Horizon was located at a different level from the one that was designated in 1975 by W.M. Felder, which shows how difficult it is to have unequivocal lithological boundary levels.

From the data available to me, I am quite certain that, in the former Curfs quarry, the only horizon that can be easily distinguished on lithological grounds is the Vroenhoven Horizon. It can be recognized by a slight difference in colour; the overlying sediments are somewhat more greyish. Occasionally, this boundary is marked by a thick 'hardground' and a fossil grit layer, but, as pointed out above, these may disappear rather quickly over short distances. The change in colour, however, has always been visible in the quarry. It must be noted that there is no such change in other localities (*e.g.* Campine Mining District and Molenbeersel, Fig. 4).

Indurated layers and fossil grit beds encountered above the Vroenhoven Horizon are not constantly developed either. The fossil grit layers indicated in Fig. 2 are therefore best considered lenses of local occurrence only. Since the sediment bodies in the Curfs quarry are lenticular, it is essential to construct new sections whenever new samples are taken. The Vroenhoven Horizon is then to serve as the level on which the measurements are based.

CHEMICAL ANALYSES AND GRAIN SIZE DETERMINATIONS

In 1972, six samples were taken in the Curfs quarry in the scope of a study of the entire Late Cretaceous and Dano-Montian in southern Limburg and adjacent Belgian territory. Samples were only taken from the homogeneous chalk units; fossil grit layers and 'hardgrounds' were not taken into consideration. The chemical analyses were kindly performed at the laboratories of the ENCI cement plant at Maastricht. The grain size determinations I did myself with the help of simple sieves and a balance of the type formerly used by chemists. The picture that emerged from these analyses illustrated the changes in chemical composition and grain size (P.J. Felder, 1976). Within the Curfs quarry the chemical changes were only very small (96.1-98.6% $CaCO_3$). Although a slight change in grain size of the chalks below and above the Vroenhoven Horizon was noted, no additional analyses were considered necessary.

BIOCLAST ANALYSES

In 1972 the complete section as exposed at that time (*i.e.* including fossil grit layers and 'hardgrounds') was also sampled with the aim of analyzing the bioclast assemblages. A total of 58 samples was taken, with each sample comprising approximately 0.50 m of section. Publication of the data obtained followed in 1984 (P.J. Felder, 1984).

In 1979 the Rijks Geologische Dienst (mapping department) performed a drill in the quarry Curfs (borehole 62A-305). Samples taken from the upper 15 m of the section penetrated were kindly put at my disposal in order to analyze the bioclast content. Snellings (1985) presented the results of this analysis. The total section was again sampled in 1988. The lower strata were now no longer accessible. A total of 52 samples (each of them comprising approximately 0.50 m of section) was taken, which were analyzed according to standard procedures (P.J. Felder, 1981, 1984). The data thus obtained are presented in Fig. 2, complemented with the results of previous analyses of parts of the section no longer accessible in 1988.

GAMMA RADIATION

In October 1987 the gamma radiation was measured of all the strata exposed in the Curfs quarry, including the Oligocene and Pleistocene ones (P.J. Felder & Boonen, 1988). This was done with a Sintrex GAD-6 four channel stabilized gamma-ray spectrometer and a Sintrex GSP-4 portable gamma-ray sensor. These instruments were provided by the Koninklijke Shell Exploratie en Productie Laboratorium at Rijswijk, through the kind offices of Messrs van de Graaf and Schwander.

The following values of the gamma radiation were measured by means of the above instruments: total gamma radiation (= total count, TC), the gamma radiation of potassium (40K, = K), that of uranium (= U) and that of thorium (= Th). These values were read digitally, either converted into counts per second (CPS) or not.

The gamma radiation was measured at 51 spots (3 measurements each) in the chalk deposits of the quarry. In each case the measuring time was 10 seconds. The average of three measurements was then taken as the correct value. The stripping ratios were calculated by means of the calibration

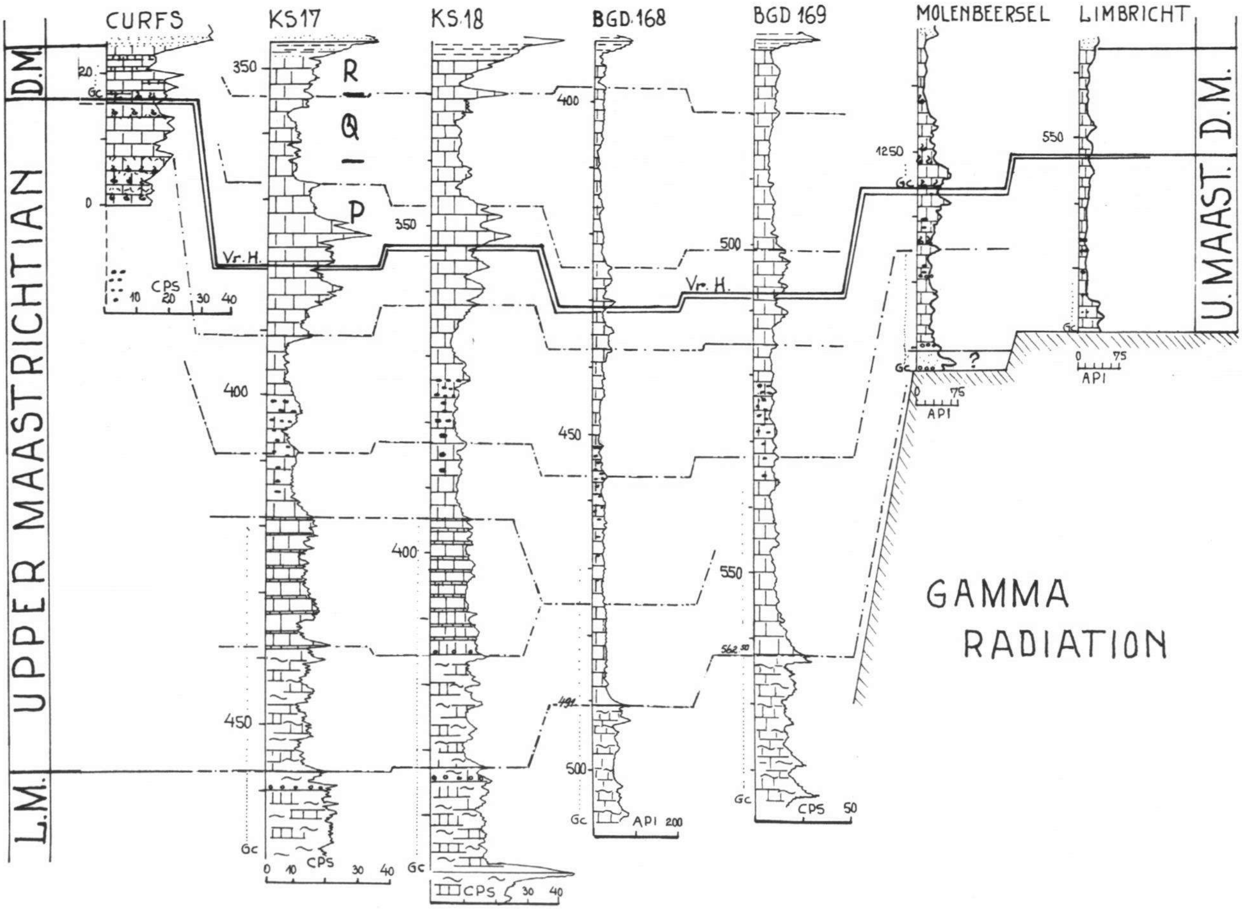

Fig. 5. Correlation of gamma-ray logs for the strata exposed in the former Curfs quarry and for the boreholes discussed in the text. Simplified lithological sections are given for the boreholes KS 17, KS 18, BGD 168, BGD 169 and Limbricht, since these yielded only mud samples. In the section of borehole KS 17 the foram zones P, Q and R (*sensu* Hofker, 1966) are indicated as determined by Meessen (*in* P.J. Felder *et al.*, 1985). 'Vr. H.' stands for Vroenhoven Horizon, the lithological boundary between the Maastricht and Houthem Formations.

data. The stripped values for K and U (K' and U') were computed with the stripping ratios (Fig. 3). The data obtained are shown in CPS in Fig. 3.

CORRELATIONS

The results obtained for the Curfs quarry were compared with similar data for a number of boreholes in the Campine Mining District and the Rur Valley Graben (Fig. 4).

The yield of the Limbricht borehole was put at my disposal by the Rijks Geologische Dienst at Heerlen, the Molenbeersel, BGD 168 and 169 boreholes, by the Geologische Dienst van België and the KS 17, KS 18, KS 10 and KS 36 boreholes by the Kempense Steenkoolmijnen.

With the exception of Molenbeersel all above boreholes were drilled with bits yielding mud samples from every 3-5 metres of section penetrated. It is obvious that, because of this method, no

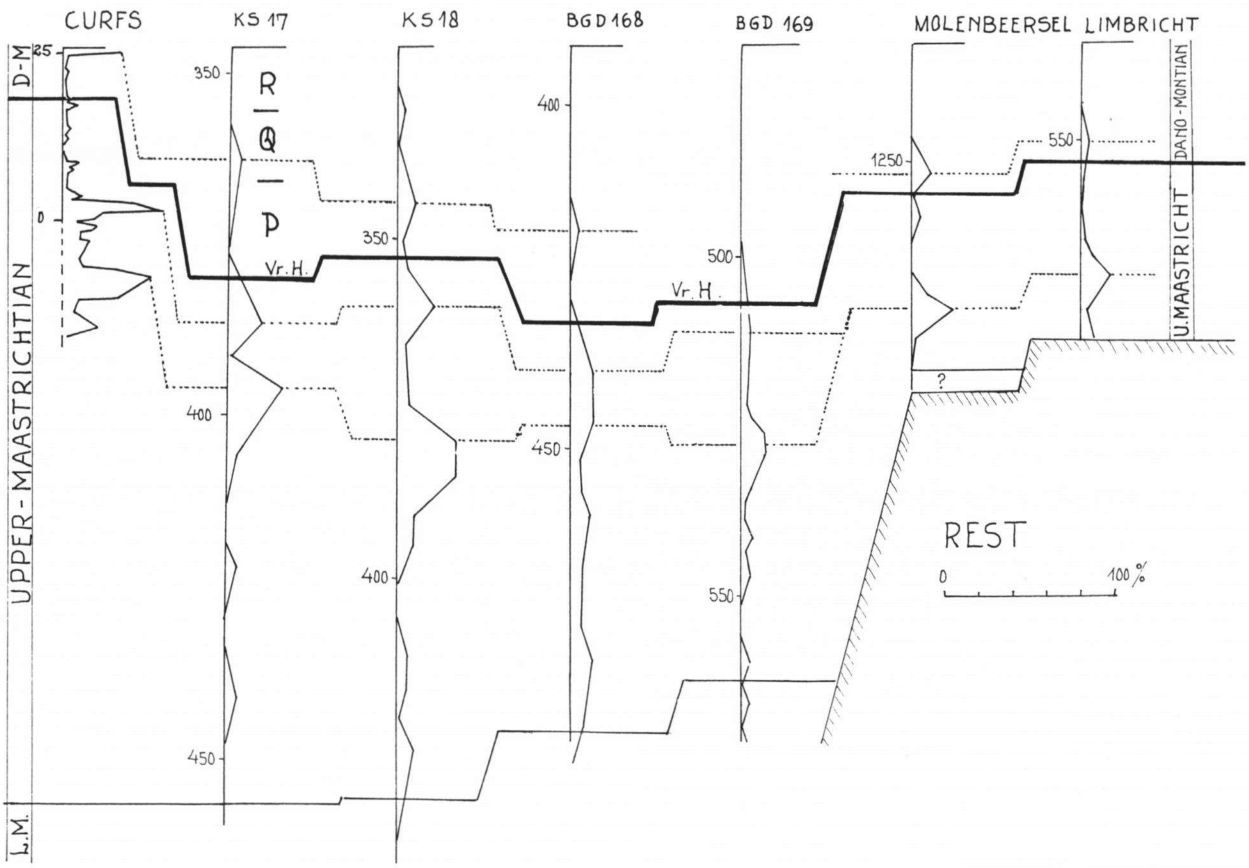

Fig. 6. Comparison of the bioclast content (1.0-2.4 mm) of the strata exposed in the former Curfs quarry with those obtained from the boreholes. Indicated is the so-called 'rest group' of bioclasts, which comprises mainly serpulids, some fish remains and an occasional coprolite. In the section of borehole KS 17 the foram zones P, Q and R (*sensu* Hofker, 1966) are indicated as determined by Meessen (*in* P.J. Felder *et al.*, 1985). The relative position of the Vroenhoven Horizon was determined on the basis of the results obtained for the gamma radiation.

detailed lithological descriptions of these boreholes can be given. The Molenbeersel borehole was cored so that here a lithologic picture could be drawn.

When comparing the available data (including those from Molenbeersel) it appears that the lithological picture does not really change within the study area. All sediments penetrated are nearly pure chalks with a regular alternation of hard and soft layers and fossil grit layers. However, all deposits are lenticular in structure. The underlying strata consist of flinty chalks which are found over the entire study area (Fig. 5).

From the gamma radiation measurements in the sections it appears that there are some peaks below and above the Vroenhoven Horizon (Fig. 5), but a distinct difference cannot be noted in the gamma-ray log. The same goes for the bioclast assemblages. More or less identical assemblages are found below and above the Vroenhoven Horizon. These are alternately dominated by Porifera, anthozoans, bryozoans or foraminifers, serpulids or calcareous algae. All these groups of bioclasts represent sessile life forms that react strongly and quickly to slight ecological changes. Changes in temperature or water depth together with alterations of the substrate, however small these may be, directly change the composition of the bottom fauna.

The highest bioclast assemblage in the Maastrichtian to be recognized over larger areas, is the serpulid peak. This peak was demonstrated at the deepest part of the Curfs quarry, as well as in other sections (Fig. 6).

On top of these serpulid-dominated deposits rest strata with bioclast assemblages dominated by Porifera/Bryozoa in the Curfs quarry (4-10 m in the 1988 section). The strata also yield calcareous algae which are not considered any further in the counts, but which clearly dominate elsewhere (*e.g.* Molenbeersel). In other localities these deposits in the uppermost Maastrichtian are missing. Deposits characterized by bioclast assemblages dominated by Porifera/Bryozoa are found in the Dano-Montian instead in these localities, for instance, at depths between 360- 370 m in borehole KS 17 and at 410-420 m in borehole BGD 168.

In the KS 18 and BGD 169 boreholes there are no signs of any assemblages dominated by Porifera/Bryozoa. Small peaks in the distribution of Bryozoa (at 335-345 m in KS 18 and at 480-490 m in BGD 169) appear to be associated with rather many foraminifers (especially of the genera *Rotalia* and *Valvulammina*). Such mixed assemblages seem to grade into assemblages that are dominated by foraminifers. These were found in KS 17 (355-360 m) and BGD 168 (405-410 m) on top of deposits characterized by assemblages dominated by Porifera/Bryozoa. The latter are, however, locally characterized by high percentages of anthozoans. These deposits were found in boreholes KS 10 and KS 36 (Fig. 4). Calcareous algae that were encountered in small numbers in the Porifera/Bryozoa interval between 4-8 m in the Curfs quarry appear to dominate the bioclast assemblages found in the Molenbeersel borehole (1232-1242 m) to such an extent that they may be classed as algae-dominated.

CONCLUSIONS

The lenticular structure of the sediment bodies in the Late Maastrichtian and Dano-Montian of the former Curfs quarry is the main reason why lithological correlations are very hard to establish, even within one and the same quarry. Characteristic layers, such as fossil grit beds and 'hardgrounds', are likely to disappear very quickly over short distances. Analysis of bioclast assemblages occasionally suggests that correlations purely based on lithology should be critically reviewed.

The K-T boundary (Vroenhoven Horizon) in the Curfs quarry is the only horizon to remain constant and to be easily distinguished. It should be noted that there are no apparent changes in bioclast assemblages, gamma radiation and lithology across this boundary.

Correlations here proposed between the Curfs quarry and several boreholes in adjacent Belgian and Dutch territories are primarily based on gamma-ray logs, bioclast assemblages and foram zones. It should be noted, however, that correlations between lithologically differing sections characterized by special bioclast assemblages will prove to be extremely difficult, and it is hoped that future multidisciplinary studies on fossil groups of particular stratigraphic value will check and reject or substantiate the correlations.

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