ste zoon van de verzamelaar, Jhr. Mr. Dr. Adriaan Daniel van Riemsdijk (geboren Maastricht 1837: volgde zijn vader als voorzitter van het Muntcollege op) was voor dit deel echter te sterk dan dat hij daarvan zou kunnen scheiden. Ook deze Van Riemsdijk heeft gepubliceerd, over drinkwater en grondboringen te Utrecht. Na zijn overlijden in 1897 werd de verzameling van mineralen en kristalmodellen van zijn vader in juli van datzelfde jaar aan het Mineralogisch-Geologisch Instituut der Rijksuniversiteit te Utrecht geschonken, onder de voorwaarde dat zij in haar geheel in de mede aangeboden kast als afzonderlijke verzameling bewaard moest blijven. Die kast bevindt zich nog aldaar; zij draagt het opschrift In memoriam Jhr. A. W. G. Van Riemsdijk, en bevat in twee vitrines en 54 laden een zeer uitgebreide en fraaie, 2742 nummers beslaande verzameling van mineralogische specimina, die welhaast alle door ruil of koop verkregen zullen zijn: vindplaatsen uit de directe omgeving van Maastricht zijn nauwelijks vertegenwoordigd.

Aan de hoogleraren von Koenigswald en Rutten, die door hun vriendelijke toestemming tot inzage van de verzamelingen en het archief van het Geologisch Instituut te Utrecht deze studie mogelijk hebben gemaakt, ben ik veel dank verschuldigd.

Résumé

La collection Van Riemsdijk, qu'on a cru perdue, se trouve dans l'Institut Géologique de l'Université d'Utrecht. Elle contient e.a. des paratypoïdes des Ostracodes crétacés et tertiaires qui furent décrites par J. Bosquet; ceux du Tertiaire ont été récemment revus par A. J. Key.

AN ANALYSIS OF THE Ma DEPOSITS, SOUTH LIMBURG, NETHERLANDS

by R. G. BLEZARD (Aveley, England)

Apart from the work of Hofker the nature and faunal content of the Ma deposit does not appear to have been widely discribed, in fact, it is difficult to find more than a passing reference to its lithology.

The Ma deposit is a thin regression-transgression sequence separating the Upper Gulpen Chalk (Cr 4) from the overlying Lower Mb-type Maastrichtian. Hofker (1959) described the Ma layer as consisting of rubbish and this description can be best appreciated by the examination of the debris which constituted this peculiar layer. The foraminiferal content of the Ma has been shown by Hofker to be not only similar to the Danish Fiskeler but to show an identical orthogenetic stage of development. Unfortunately the relationship between the Ma and the Fiskeler does not extend to the lithological comparison of the two deposits — both of which are regression-transgression zones of approximately equal thickness.

The Fiskeler, as its name implies, is essentially of an argillaceous nature — the Ma deposit is essentially calcareous. The essential clay mineral of the Fiskeler clay fraction is montmorillonite — this was shown by Unmack (1947) through X-Ray methods. The lower silica and aluminium content of the Ma deposit illustrated this difference and it is obvious that the nature of the regression was different. The real similarity of these two deposits is the character of the original unworked chalk from which the regression-transgression material was derived — in both cases it contained Pseudotextularia-zone foraminifera.

Analytical aspects:

Three borings (4 mm diameter) were made in a typical section of the Cr 4 - Ma - Mb junctions from the E.N.C.I.-quarry, south of Maastricht. The Cr 4 boring was made 5 cm. below the Ma lower limit. The thickness of the Ma at the point examined was 4 cm. and the boring was taken through the centre of the zone. The Mb boring was made at a point 5 cm. above the Ma upper limit. All three borings were taken in the same vertical plane. The following table shows the variation of the carbonaceous components and the discolouring components.

	% $CaCO_3$	% $MgCO_3$	% Fe_2O_3	% Mn_2O_3
Cr 4	97.1	1.48	0.07	0.019
Ma	88.3	2.11	1.57	0.019
Mb	94.5	1.53	0.51	0.017

The whiteness of the Cr 4 is reflected in the high carbonate content and low ferruginous

contamination. Both the Ma and Mb zones have a slight brown discolouration — the iron content being the cause of the discolouration. An average sample covering the whole range of the Ma zone was prepared and its analysis was compared with that of an average Fiskeler sample.

	Ma:	Fiskeler:
SiO_2	3.48	22.96
TiO_2	0.02	0.28
Al_2O_3	0.76	6.34
Fe_2O_3	1.78	1.70
MnO	0.03	Trace
MgO	1.01	3.00
CaO	51.20	30.34
Na_2O	0.07	0.22
K_2O	0.33	0.48
*loss	41.08	33.50
P_2O_5	0.25	0.70
SO_3	0.08	Trace
	100.09	99.52

* Ignition loss at 950° C.

The Fiskeler specimen was taken south of Höjerup Church, Stevns Klint, Denmark.

Lithological aspects:

The majority of the calcium in the Ma is combined as the carbonate (88.3 %) but there is 1.8% CaO which is combined otherwise— partially with the phosphate as apatite. All the magnesium, on the other hand, appears to be as the carbonate. Glauconitic grains may account for a certain amount of the iron but the general faint buff-coloured discolouration must be attributed to limonite. This discolouration by iron staining may infer a tropical sequence — a colder environment could lead to the formation of more glauconite. The warm chalk sea of Gulpen time was not deep and the Gulpen chalk was not entirely homogeneous but always with a high carbonate content. The Ma rubble is not laminated, the thickness is variable but often about 4 cm. but occasionally up 20 cm. At some points near Maastricht, in Pieterberg, it is divided into two layers with an intercalation of normal calcarenite. The normal appearance of the Ma is of hard, often whitish nodules and calcitic tests in a discoloured chalk matrix. It is a harder sediment than the Cr 4 which in turn is considerably harder than the soft Mb which is a comparitively homogeneous deposit.

The relative whiteness of the chalk around regression-transgression sequence was examined by means of an Eel reflectance spectrophotometer using pure magnesium carbonate as the whiteness standard (100%). Table I.

The samples were the same as used for the analytical work (ground finer than 170 B.S. sieve) and the influence of the iron compounds may be seen from the above table in depressing the reflectivity of the Ma and Mb chalk, particularly in the blue end of the spectrum and very slightly in the red range of the visible spectrum.

If, as foraminiferal examinations suggest, the age of the Ma is equivalent to the Fiskeler (Hofker 1959), and the same movement was responsible for both depositions the apparent absence of the clay fraction in the Ma is striking. It is feasible that the Limburg Sea was on the fringe of the volcanic tuff spread. The Upper Maastrichtian (Valeton 1960) and early Danian (Rosenkrantz 1955) times included periods of volcanic activity in N.W. Europe.

Fauna of the Ma

The foraminiferal content of the Ma has been described by Hofker (1959) in great detail. The technique of pore diameter measurements developed by Hofker has resulted in the demonstration of the orthogenetic relationship of Ma foraminifera. This technique could, if more

TABLE I

wave - length mμ	425	470	490	520	550	580	600	660	684
Cr 4	80.0	77.5	79.0	79.5	81.7	83.0	84.3	87.2	89.5
Ma	58.4	54.5	59.5	64.0	70.0	74.0	74.5	77.0	78.5
Mb	67.0	62.5	66.0	69.2	74.9	77.5	79.2	82.0	83.8

(Relative reflectivity with respect to $MgCO_3$)

widespread, be an important advance in micro-palaeontology. This orthogenetic relationship shown by Hofker, indicates that the Ma time (although underlying the Maastrichtian Chalk Tuff, Dumont's type Maastrichtian) is contemporary with the Fiskeler in Denmark (which overlies the "Maastrichtian" Skrivekridt) — an apparent contradiction but it is reconcilable by micro-palaeontological comparison.

Although the name Fiskeler suggests a piscatorial relationship, the evidence of fish remains is more noticeable in the Ma zone. The appearance of the Ma suggests that it was not subjected to the greater attrition forces that were applied to the Fiskeler sediments and this may account for the better preservation of the Ma fossils. Teeth of Heterodontid sharks may be found in the Ma but exact identification is difficult, though the roots resemble *Heterodontus* sp. (Casier 1947) from the Lower Senonian, the crown is not a good match. Casier (1946) gives the range of *Heterodontus* as *Jurassic* to Recent, and as the genus occurs in such dis-similar deposits as the Chalk and London Clay its range is thus no help. Its character is described as neritic, tropical to temperate, nectonic and conchyphagous.

Coprolites are very numerous and they have been the subject of many papers (Willcox 1953, Vangerow 1953). They are generally considered to be of invertebrate origin though it must be admitted the evidence is slender.

In considering the echinoderma found in the Ma sediments, first mention must be made of crinoids. Wet sieving of slices of the Ma show the high content of columnals and cirrals of *Bourgueticrinus aequalis*. The species *B. aequalis* sensu stricto is restricted to the Upper Maastrichtian "Tufkrijt" of Limburg where it has been recorded from the zones of Cr 4, Ma and Mb. It is very common in the Ma zone. Crushed echinoid shells are quite common, particularly the large and thick shelled Holasteroid. *Hemipneustes striatoradiatus* (Leske) — a typical Maastrichtian echinoid . Crushed fragments of *Phymosoma* sp., are common.

The commonest brachiopod of this sediment is *Thecidea papillata* (Schlotheim). Backhaus (1959) limits this species to the lower part of the Upper Maastrichtian, although it is also recorded from the Phosphatic Chalk of Ciply which Jeletzky puts in the Lower Maastrichtian. Backhaus comments on its rare occurrence in the Maastrichtian Mb - Md and also in the Cr 4 and Ma which he thought may be correlated with Maastrichtian. It is noteworthy to comment that older publications considered it to Senonian. It is said to occur in a near shore facies.

Considering the Polyzoan remains in the Ma, we were again hampered in exact identification by the fragmentary nature of the remains in the rubble. However, it was possible to confirm the presence of species of *Membranifera* and also of *Lunulites* — the latter fragments were in convex circular colonies like a miniature upturned bowl.

This brief suvey has indicated that all forms are characteristic of the Upper White Gulpen Chalk, Cr 4 and no new forms noted. The foraminiferal evidence is important indicating that the material corresponds to reworked material from the higher horizons of the Pseudotextularia zone. (Hofker 1960).

Further faunal considerations:

This faunal survey has considered macrofossils which, as Hofker (1960, a.) has stated, are susceptible to induced changes in the surrounding sea and thus the use of orthogenetic comparison of foraminifera has the advantage of being independent of benthonic guide fossils.

Birkelund (1957) has zoned the Upper Cretaceous by means of Belemnite distribution. Romein (private communication) has stated that in the Cr 4. Belemnitella ex gr. junior, Nowak, has been found — also reworked forms in the Ma. The presence, however, of the same species in the Mb and Mc is disturbing, also in the Md, *Belemnella casimirovensis (B. C. casimirovensis* and *B. C. archangelskyi)* has been noted. This information is in contradiction to foraminiferal evidence. The foraminiferal content of the Maastrichtian Chalk Tuff has been examined in detail by Hofker (1959a) and correlated with the Danian of Denmark. Climatic acclimatisation may reconcile anomalous faunal correlations.

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FORAMINIFERA FROM THE CRETACEOUS OF SOUTH LIMBURG, NETHERLANDS, LIII.

Some smaller Rotaliid species from the holes in the hard ground over the Md in the quarry Curfs, near Houthem, West-side.

by J. HOFKER

In a sample, taken by B. J. Romein from holes, about 1,50 m below the boundary between the Upper Md and the Lower Paleocene, an extremely well preserved fauna was discovered (Sample 2708 Geol. Bureau). Some of the species found are described here.

Rosalina ystadensis Brotzen. Fig. 1.

Test small, round. Dorsal side convex, somewhat conical, smoothly finished, with about three whorls of chambers with strongly oblique and curved sutures, with fine pores allover the surface. Margin acute. Ventral side flat and slightly concave in the centre, about 6 chambers visible, with strongly curved sutures which are distinctly depressed. Last formed chamber with protoforamen and slit-like deuteroforamen with a distinct thickened tenon between; the tena of older chambers form small distinct knobs in the umbilical depression in the centre. Pores fine, except for the tena which are poreless.

The species was described by Brotzen, 1948, p. 72, pl. 9, fig. 9. It is not found in the upper Danian beneath the Paleocene greensands in Denmark, where it is common.

Rosalina koeneni Brotzen. Fig. 2.

Test small, rounded. Dorsal side flatly conical, smooth, with about 2 whorls of chambers with slightly curved smooth sutures bending backward; no pores at the dorsal side; especially the spiral suture is distinct, all other sutures very thin. Margin acute, with poreless rim. Ventral side flat or concave, about 6-7 chambers visible, with distinct curved sutures bending backward, not reaching the centre. In the umbilical cavity a distinct chalk knob always visible. Few, distinct pores in the ventral chamber walls. Colour always brownish, as if the testwall consisted of aragonite.

The species has been described by Brotzen, 1948, p. 73, pl. 9, fig. 11 from the Paleocene of Sweden and is not found in the Danian below. It is a rare species, but occurred in the sample in several well-preserved specimens.

Rosalina brotzeni nov. spec. Fig. 3.

Test small, rounded. Dorsal side convex, with distinctly inflated chambers and depressed, rounded sutures, with very fine scattered pores in the thin walls. Margin rounded to slightly sub-acute. At the ventral side 4-5 chambers visible, with inflated chamber walls and depressed central parts of these walls, with open umbilicus. Each chamber forms a distinct tenon between proto-and deuteroforamen, which tenon covers part of the umbilical hollow, so that the free part of the umbilical hollow forms a star-like figure. Sutures at the ventral side radial, depressed. Walls with scattered fine pores.

The species has been mentioned by Brotzen as *Gavelinella*(?) sp., 1948, p. 76, pl. 9, fig. 10; in his specimen it seems that the very thin tena were partly broken away. It was typical for the lowest part of the Swedish Paleocene (greensands) and was refound by the author in the greensands at Hvallöse, Denmark. It does not occur in the upper Danian there. It is not rare in the sample studied.