

velsbos. Op de hoogte hadden wij een prachtig gezicht op de omgeving. Na het Savelsbos wordt de excursie ontbonden en voldaan gaat iedereen naar huis. Wij zijn de heer Diemont zeer dankbaar voor de genotvolle en leerzame middag, die wij onder zijn leiding hebben mogen doorbrengen.

#### FORAMINIFERA FROM THE CRETACEOUS OF SOUTHERN LIMBURG, NETHERLANDS, XIX.

#### PLANCTONIC FORAMINIFERA OF THE CHALK TUFF OF MAESTRICHT AND ENVIRONMENTS.

by J. HOFKER

In many parts of the world investigators are working on planctonic Foraminifera as indicators for stratigraphic parallelisation. In this way many new data have been revealed especially in respect to the Cretaceous-Tertiary boundary. As a result more and more students are inclined to believe that the Danian already is, in any case partially, belonging to the Tertiary.

In the Cretaceous the genera *Globotruncana* and allied genera, the *Gümbelinidae* with many typical genera, and *Globigerinidae* of the type of *Globigerina cretacea* are typical. These genera extinguish at the end of the Cretaceous period, but for some species of primitively built *Gümbelina*. The *Globigerina cretacea* type is characterised by foramina opening into the open umbilicus, whereas Tertiary *Globigerines* often have a closed umbilical area and the foramen becomes sutural in many forms. A group which seems to have derived from *Globotruncanidae* with a single keel of the Maestrichtian period is the Tertiary group of the *Globorotaliae*, in which group the umbilicus is partly closing and the often wide foramen also suturally placed. This difference in both groups of planctonic Foraminifera is so striking, that many authors believe that the end of the Cretaceous period is marked by the lacking of highly-developed *Gümbelinae*, *Globotruncaninae* and Cretaceous *Globigerinae*.

So it was of much interest to find whether the so-called Maestrichtian Tuff Chalk of South Limburg in Holland, being the type-locality for many authors of the Maestrichtian period, yielded any planctonic forms. Since, however, most

of the Maestrichtian Chalk is a riffal and coastal formation, planctonic forms in most of the samples are rare or even totally absent.

Yet it was possible by careful examination of thousands of samples to trace some in which also planctonic forms were deposited. Three of these forms have already been mentioned by M. A. Visser in her Monograph of the Foraminifera of the Maestrichtian Chalk of Maestricht (Thesis, Leyden, 1950). All, however, have been determined by this author erroneously. Her *Globigerinella aspera* from the Mb is not that typical Cretaceous species, but had to be renamed in *G. biforaminata* Hofker. A second form, by Visser believed to be the recent and Miocene form *Globigerina bulloides* d'Orbigny, in reality is a quite different form, allied to *Globigerina linaperta* Bronnimann. A third form, given by her as *Globotruncana marginata* (Reuss), a species of the Turonian, showed to be *Marginotruncana esnehensis* (Nakady).

Planctonic forms were found in the layers between the Cr 4, the lowest part of the visible chalk at the ENCI-quarry at Maestricht and the Lower Mb; these layers are not always present, since in several localities they have been replaced by transgressional layers, forming the so-called Ma. In those cases in which they are preserved (Savelsbos, Loën in Belgium), they bear a very typical fauna in which rare but typical planctonic forms were found.

A very small primitive *Gümbelina*, belonging to the group *Gümbelina ultimatumida* White, is found in the Mb, Mc and Md, always in small quantities. The specimens in the upper layers moreover show some characters which recall those of *Gümbelina venezuelana* from the Paleocene-Eocene of America.

In the uppermost Mc and the Lower Md a very conspicuous form of real *Globorotalia*, *Globorotalia mosae* Hofker, was found. It always is rare in the samples, yet in many samples from the Lower Md it could be traced, as well in Holland as in Belgium (Tranché du Canal Albert). In the highest levels of what hitherto has been believed to belong to the Upper Md, but which now has been recognised as to belong to the Paleocene (Lowest Tertiary), several other *Globorotaliae* were found, such as *Globorotalia membranacea* (Ehrenberg),



*Globorotalia lobata* Brotzen, and some other forms.

In some samples with a fauna which indicates the boundary Mc—Md at the quarry Zeversprong near Kroubeek, several specimens of *Globigerina hornibrooki* Bronnemann were discovered. In the Lower Mb a rare form was found, similar to a high-built *Globigerina cretacea* with more than 5 chambers in the last formed whorl, named now *Globigerina supracretacea* Hofker. Moreover in the layers forming the boundary Cr 4—Mb many other Globigerines were detected, *Globigerina triloculinoides*, *Globigerina pseudobulloides*. Many more Globigerines were found in hollows in hard grounds forming the base of the Lower Md and the base of the Paleocene. From the Lower Md a species was found with the aspects of *Globigerina triloculinoides*, but with the apertural conditions of *Globigerina linaperta* Finlay; moreover specimens with the type of *Globigerina eocaena* Gumbel occurred here. In the Upper Md, not yet the Paleocene, *Globigerina linaperta*, and a new species, *Globigerinoides hyalina* Hofker, together with forms named here *Globigerina compacta* Hofker, were found abundantly.

All these forms indicate, that the boundary Cr 4—Mb, with *Marginotruncana contusa*, *Marginotruncana esnehensis*, *Globigerina triloculinoides*, *Globigerinella biforaminata*, is of the same time as the so-called *Pseudotextularia*-zone of W i c h e r, forming the uppermost part of the Cretaceous; that the Mb must belong to the Danian, and that the Mc—Md cannot belong to the Cretaceous (Maestrichtian) but already belongs to the Dano-Paleocene. So the planctonic Foraminifera of the Tuff Chalk of Maestricht indicate that, in the case that the authors in various parts of the world are right, it is not real Cretaceous, but already belongs to the Dano-Paleocene boundary. This result is in agreement with the occurrence of many other groups of Foraminifera with Tertiary rather than Cretaceous characters, such as *Pararotalia tuberculifera* (Reuss), *Lepidocyclina media* d'Archiac, *Siderolites calcitrapoides*, *Mississippina binkhorsti* (Reuss), *Linderina douvillei* Silvestri, *Orbignyna franki* (Brotzen), *Dictyoconus mosae* Hofker, *Bolivinoidea polonica*, and many other forms. It is, however, in contradiction with the occurrence of large Dinosaurs, Belemnites (but Belemnites also occur in the

Danian), Rudists, Cretaceous Bryozoans, the last occurring real Ammonites. But large groups of Foraminifera typical for the Cretaceous are totally absent (though the conditions were very good), such as *Neoflabellina*, large *Bolivinoidea*, *Globotruncanae*, highly specialised *Gumbelinae* etc., all groups very typical for the Upper Maestrichtian in tropical seas, and the sea of the Maestrichtian Tuff was without any doubt a tropical sea (Corrals, subtropical Molluscs etc.). In the uppermost Md very rare reworked *Globotruncanae* were found belonging to the middle Maestrichtian (Paleocene transgression).

When we consider the report of the french investigators on the Cretaceous-Tertiary boundary in the mediterranean area, (Proc. 4th Petroleum Congress, Rome, 1955, I, D. 6) we find a striking resemblance with our results (See Range-chart). In the Upper Maestrichtian in the Mediterranean area we are confronted with many *Globotruncanae*, together with Globigerines already of the *pseudobulloides* and *triloculinoides* types. Then a horizon is found with many small Globigerines without *Globotruncanae*, and above that horizon believed to be of Danian age, the *Globorotaliae* appear together with these new forms of *Globigerinae*; this horizon is believed to be of Paleocene age.

Quite the same sequence of species has been found in the upper layers of the chalk of South-Limburg and North Eastern Belgium. Here in the Cr 4 the last *Globotruncanae* are found, firstly together with Globigerines known from the Uppermost Cretaceous, higher on, at the boundary between Cr 4 and lowest Mb, together with Globigerines of the *pseudobulloides-triloculinoides* types; then during the Mb-Lower Md small thin-walled Globigerines are found together with the first species of *Globorotaliae*; then, in the Md and the overlying Paleocene, the typical Tertiary *Globorotaliae* are found with typical Tertiary Globigerines.

Yet, together with these striking resembling microfaunes, *Belemnitella junior* and *B. cassimirovensis* are found in the Mc—Md, and typical Ammonites are joining then. There seem to be two explanations: these macrofossils here are living longer up into the Tertiary, or the conclusions of the french (and other) micropaleontologists are wrong, and the Cretaceous boundary lies above that as scoped by them.



## NOTES ON THE PLANCTONIC FORAMINIFERA.

- Globigerina rugosa* Plummer. The species has been incorporated into the genus *Rugoglobigerina*, of which it is the type. But it is a real *Globigerina*, as I will point out elsewhere; it is typical for the uppermost Maestrichtian. Fig. 1;  $\times 60$ ; quarry at Glons, Belgium, Cr 4.
- Globigerinella biforaminata* Hofker. This species has been described by the author in a paper on the *Pseudotextularia*-zone, now in press. It is characterised by two apertures separated by a lip reaching the chamberwall on which the last formed chamber rides. It has been figured as *G. aspera* by Cushman from the Selma-Chalk (Geology of Tennessee, Bull. 41, 1931, Pl. 11, fig. 5). In Holland and Belgium it is found in the whole Maestrichtian. Typical in the Cr 4 and Lower Mb. Figs. 2, 5:  $\times 60$ ; 2: quarry Glons, Belgium; 5: Loën, Belgium, top. Cr 4.
- Globigerina trilocolinoides* Plummer. This species with many somewhat aberrant forms is found from the Danian up into the Lower Eocene. Fig. 3;  $\times 130$ ; Loën, Belgium, top. Cr 4—Mb.
- Globigerina pseudobulloidis* Plummer. Often specimens in our samples show the flaring lip at the aperture; it is known from the Danian into the Paleocene, but may be found also in the boundary-layers of the uppermost Maestrichtian. Fig. 4;  $\times 130$ ; Loën, Belgium, top; Cr 4—Mb.
- Marginotruncana elevata* Brotzen. The specimens found only in the typical layers forming the boundary between Cr 4 and Mb at the top of the old quarry at Orp-le-Petit in Belgium, are somewhat more compressed than the real *elevata* from the South of Europe. They are known there in the Lower and Upper Maestrichtian. Fig. 6;  $\times 60$ ; Orp-le-Petit; top; Cr 4—Mb.
- Marginotruncana esnehensis* (Nakady). The specimens found in the top-layers at the quarry at Loën, Belgium, seem to be identical with type-material. Fig. 7;  $\times 130$ ; Loën, Belgium, top; Cr 4—Mb.
- Marginotruncana contusa* (Cushman). Typical specimens were found at the top of the quarry at Loën, Belgium. They differ from typical *contusa* by the lack of raised sutures at the dorsal side, and they are smaller. Fig. 9;  $\times 130$ ; Loën, Belgium, top; Cr 4—Mb.
- Globigerina supracretacea* Hofker. This species seems to have derived from the cretacea-type; only it always shows more than 5 chambers in the last-formed whorl, and the chambers seem to be more clustered. It has been found in the *Pseudotextularia*-zone, from where it has been described by the author (in press), and in the Mb in Holland and Belgium. Fig. 8;  $\times 130$ ; quarry Nelissen, Rooth; upper Mb, sample 291.
- Globigerina hornibrooki* Bronnimann. This species has been described from the Upper Danian of Denmark, where it is common in some samples studied by the author. Some specimens were found in a quarry near Kroubeek (Zeversprong) together with a typical fauna from the boundary Mb—Mc. Fig. 10; quarry Zeversprong, Kroubeek;  $\times 130$ ; Mb—Mc.
- Globorotalia mosae* Hofker. This very conspicuous species of the *Truncorotalia*-type was found in many samples from the Upper Mc and the Lower Md. in Holland and in Belgium. Fig. 24;  $\times 60$ ; ENCI-quarry, Maestricht, 15.50 m; Mc.
- Globigerina eocaena* Gumbel. Though this species was described from the Lower Eocene of Bavaria, Hamilton (Journ. Pal. 27, p. 222) mentions it from the Paleocene. The specimens are very typical, as compared with topotypic material. Fig. 13;  $\times 60$ ; hard ground Lower Md; quarry Curfs, Houthem, Md.
- Globorotalia membranacea* (Ehrenberg). This flattened species in reality seems to contain several forms not yet properly analysed. The group as such however is typical for the Dano-Paleocene. Fig. 12;  $\times 60$ ; same locality.
- Globigerina wilsoni* Cole. The specimens found in the Lower Md in Holland are somewhat more involute than the typical forms; so it may be that they belong to the variety *bolivariana* Petters from the Middle Eocene. They are very conspicuous, and may have been taken for *Pullenia* by other authors. Fig. 14;  $\times 60$ ; same locality.
- Globigerina linaperta* Finlay. Though quite different forms have been gathered in this species, the total form somewhat equal to *G. triloba* from the Tertiary is typical. Fig. 15; hard ground in Upper Md; quarry Curfs, Houthem. Fig. 11;  $\times 60$ ; Lowest Md; same locality.
- Globigerina compacta* Hofker. A very small species with very thin walls. Always four chambers in the last formed whorl, close-coiled, spiral side high, sutures not very depressed, aperture large, crescent-shaped, umbilical, but the umbilicus closed. Upper Mb, Lower Paleocene. Figs. 16, 17, 21;  $\times 130$ ; Fig. 16: Curfs, Upper Md; Fig. 17: Curfs, Lower Paleocene; Fig. 21: Curfs, Lower Paleocene.
- Globigerinoides hyalina*, Hofker. Small, irregularly coiled tests with more than one sutural openings in the last-formed chamber. Wall finely porous, extremely thin and hyaline. No umbilical hollow. Upper Mb.
- Globigerina daubjergensis* Bronnimann. This somewhat rough species has been described from the upper Danian of Denmark. It belongs to the *linaperta*-group. Figs. 19, 20; quarry Curfs, Houthem; Lower Paleocene.
- Globorotalia compressa* (Plummer). Specimens which may belong to this group, but may also belong to some unknown form, have been found in the Paleocene just above the Md-layers in Limburg and Belgium. Fig. 22;  $\times 60$ ; quarry Curfs, Houthem; Lower Paleocene.
- Globorotalia lobata* Brotzen. This species has been described by Brotzen from the Paleocene of Sweden. It is common also in our Paleocene. Fig. 23;  $\times 130$ ; quarry Curfs, Houthem, sample 256; Paleocene.

Species	Cr 4	Cr 4—Mb boundary	Mb	Mc	Lower Md	Upper Md	Lowest Paleocene
<i>Globigerina rugosa</i>	_____						
<i>Globigerinella biforaminata</i>	_____	_____					
<i>Globigerina triloculinoides</i>		_____					
<i>Globigerina pseudobulloides</i>		_____					
<i>Marginotruncana elevata</i>		_____					
<i>Marginotruncana esnehensis</i>		_____					
<i>Marginotruncana contusa</i>		_____					
<i>Globigerina supracretacea</i>			_____				
<i>Globigerina hornibrooki</i>			_____				
<i>Globorotalia mosae</i>				_____			
<i>Globigerina eocaena</i>					_____		
<i>Globorotalia membranacea</i>					_____	_____	_____
<i>Globigerina wilsoni</i>					_____		
<i>Globigerina linaperta</i>					_____	_____	
<i>Globigerina compacta</i>						_____	_____
<i>Globigerinoides hyalina</i>						_____	
<i>Globigerina daubjergensis</i>						_____	_____
<i>Globorotalia compressa</i>							_____
<i>Globorotalia lobata</i>							_____
Stratigraphy based on planctonic Foraminifera (Bolli, Bron- nimann, Lys, Sigal, Reiss, etc.)	UPPERMOST MAESTRICHTIAN		DANO - PALEOCENE				
	Globigerines of the cretacea-type		Small Globigerines with thin tests		Globigerines with thicker tests		
	Globotruncanidae					Globorotalidae	

RANGE - CHART









