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

THE DANIAN AGE OF THE MAESTRICHTIAN CHALK TUFF PROVED BY THE ORTHOGENESIS OF *GAVELINOPSIS INVOLUTA* (REUSS).

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In a former paper (Foraminifera from the Cretaceous of southern Limburg, XXI, Natuurhist. Maandbl., vol 45, 1956, pp. 99—110) the author fully described *Gavelinopsis involuta* (Reuss), as Reuss gave it in 1862 in his description on the Maestrichtian Chalk Tuff. As the figures on p. 110, figs. 18, 17, show, this species is characterised by the chambers which reach the centre at the dorsal side and also have pores at that side. In most cases the test is nearly lenticular, the ventral side only slightly more flattened than the dorsal one.

In Holland this species begins its development in the upper Cr 4, and continues till in the Me, the highest level of the Maestrichtian Chalk Tuff. Also it is a constant species in the samples of the Danish Danian, the type-locality of the Danian. In many other papers the author already has proved the value of the orthogenetic changes in Foraminifera. Since in the Maestrichtian Chalk Tuff only in the Md-Me *Bolivinoides* is found in the aberrant form *B. polonica* Pozaryska, that group cannot be used for the purpose. But also the orthogeneses of the pore-diameters of many Gavelinellidae have already proved their usefullness in stratigraphic problems, and the author gave already a tentative stratigraphy on pore-diameters in the paper mentioned above. More detailed instances have been given in several later papers.

The material used for the preparation of the large range-chart of 1956 for the establishing of the Danian data was a poor one, and the results not fully satisfying; yet the author could show, that the pore-diameters of some Gavelinellidae from the Danian showed data comparable with those of the Mb, and that the specimens found in the underlying *Pseudotextularia*-zone showed pores which were comparable with those found in the Cr 4 of Holland. A much richer material obtained now from the Danish localities gave striking results. Not only that the different zones, as established by Troelsen and Wind (see Troelsen, J. C., 1957, U.S. Nat. Mus. Bull. 215, p. 127, fig. 24) proved to have *Gavelinopsis involuta* with different pore-diameters, but the orthogenesis of those pore-diameters agreed fully with the different ages of the zones.

The author got following averages of pore-diameters as will be found in the diagram:

Diagram, showing the orthogenesis of *Gavelinopsis involuta* (Reuss) in the type-Danian and the type Maestrichtian.
(diameters in μ)

DANIAN of DENMARK

	Pore-diameters											Zones	Averages
Hyttehusvej						1	5	20	5	1		Zone I	6,0
Hvallose					1	10	15	15	24	7		Zone II	5,2
Faxe				3	8	14	4					Zone III	4,3
Kagstrup			1	4	35	10						Zone IV	4,0
Stevns Klint			1	13	36	3						Zone V	3,9
Erslev Andelsbrud		2	9	12	7							Zone VI	3,4
Pseudotext. Stevns Klint	2	7	13	5								*Pseudotextularia*-Zone	2,9

MAESTRICHTIAN CHALK TUFF.

														Zones	Averages
h. gr. Md-Me, Can. Alb.							5	4	21	11	6	1	1	Me	6,1
D12 Canal Albert							2	3	3					Md/Me	5,7
h. gr. Mc/Md Curfs							3	7	9	3				Md	5,8
Q. de Tombe 147—148					1	5	12	10	2					Mc	5,1
C1/4 Canal Albert					6	5	3							Mc	4,4
B24 Canal Albert			1	1	6									Mc	3,9
B14 Canal Albert			1	6	5									Mb	3,6
B8 Canal Albert		3	5	5	1									Mb	3,2
A10 Canal Albert			6	8	7	2								Cr 4	3,6
Glons 126 m + N.P.	4	18	19	3										Cr 4	2,6
	2	2,5	3	3,5	4	4,5	5	5,5	6	6,5	7	7,5	8		2 3 4 5 6

This continuous increase of the pore-diameters strongly suggests a true and relatively undisturbed orthogenesis; the large material now at hand moreover proves that the tentative data on the range-chart of 1956, giving for the Danian averages of diameters 4—4,5 μ, are correct only for the lower part of the Danian, whereas in the upper Danian the averages amount to the vicinity of 6 μ.

In order to compare these new results with the diameters of the pores in *Gavelinopsis involuta* (Reuss) in the localities of Holland and North Eastern Belgium, the author studied new and very well preserved material.

The diagram shows that for the different stages of the Holland—Belgium area these diameters are in average:

Me	6,1 μ	Zone intermediate between Md and Paleocene
Boundary Me—Md	5,7 μ	Maestrichtian Chalk Tuff
Lower Md	5,8 μ	
Upper Mc	5,1 μ	
Middle-Lower Mc	4,4—3,9 μ	
Upper Mb	3,6 μ	
Lower Mb	3,2 μ	
Boundary Mb—Cr 4	3,6 μ	Uppermost Gulpen Chalk
Cr 4	2,6 μ	

These results show, that here also a gradual increase of the pore-diameter of *Gavelinopsis involuta* (Reuss) is found, ranging from 2,6 to 6,1 μ. That result in its lowest value is remarkable, since it corresponds fully with results obtained from the pore-diameter of this species in the *Pseudotextularia*-zone at Stevns Klint in Seeland and of Kjölby Gaard in Jutland, where that average diameter is 2,9 and 3,3. So we may assume that the *Pseudotextularia*-zone of the drill-hole Maasbühl I (average 3,5) is of comparable age. (which will be proved in another paper in this Maandblad). Since that is so, and since from the lowest values the increase in the Maestrichtichtian Chalk Tuff is very gradual, there is no reason at all to believe that this increase is not the result of a true orthogenesis as well. But then we find, that the increase of pore-diameter of *Gavelinopsis involuta* (Reuss) during the time of the Maestrichtian Chalk Tuff just shows the orthogenesis which also is found during the time in which the Danian of Den-

Hyttehusvej near Copenhagen Zone I, *T. vexilifera*	6,0 μ	Upper Danian
Hvallose, Jutland Zone II, *T. vexilifera*, *T. brünnichi*.	5,2 μ	
Faxe, Zone III, Seeland *T. brünnichi* — *T. abildgaardi*	4,3 μ	
Kagstrup, Jutland Zone IV, *T. abildgaardi*	4,0 μ	Lower Danian
Stevns Klint, Seeland Zone V, *T. ödumi*	3,9 μ	
Erslev Andelsbrud Zone VI, just above Fiskeler	3,4 μ	
Stevns Klint, Seeland *Pseudotextularia-Zone*	2,9 μ	Uppermost Cretaceous

mark (Danskekalk) was sedimented, and we are obliged to conclude that both formations, the Maestrichtian Chalk Tuff (type of the „Maestrichtian") and the Danskekalk in Denmark (type of the „Danian") are identical in age. This is proved also by the total of the Foraminiferal faunae, even the planctonic faunae; both formations show at their tops (Upper Md—Me, and *T. vexilifera*-zone) the typical development of *Globigerina daubjergensis* Brönnimann, deriving from a form which could be placed in the *Globigerina linaperta*-group. The result is the more striking, since in the Maestrichtian Chalk Tuff Mosasaurs, Belemnites and the last group of Ammonites occur.

Diameters	Denmark — Danian	Holland—Belgium Maestrichtian Chalk Tuff
6-5 μ	zones I—II	Me—Upper Mc
4,5-3,5 μ	zones III—VI	Lower Mc—Mb
3,5-2,5 μ	*Pseudotextularia*-Zone	Cr 4