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Calcareous nannoplankton of the Geulhemmerberg K/T boundary section, Maastrichtian type area, the Netherlands

A.J.T. Romein[1], H. Willems[2] & H. Mai[2]

[1] *Nederlandse Aardolie Maatschappij B.V., P.O. Box 28000, 9400 HH Assen, the Netherlands;* [2] *Geological Department, University of Bremen, P.O. Box 330440, D-28334 Bremen, Germany*

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Abstract

Light-microscopic analysis of the calcareous nannoplankton of the Geulhemmerberg section indicates the presence of the Late Maastrichtian *Nephrolithus frequens* Zone and the Early Danian *Biantholithus sparsus* Zone, separated by a hiatus encompassing the earliest Danian.

SEM analysis, however, indicates the presence throughout the section of *Neobiscutum romeinii, N. parvulum* and small forms of *Cruciplacolithus primus*, taxa reported so far only from the Early Danian. If these are *in situ*, a Danian age for the whole Geulhemmerberg section cannot be excluded.

Introduction

Probably as the result of the classic mix-up of litho- and chronostratigraphy, the Cretaceous/Tertiary (K/T) boundary in the Maastrichtian type area has often been equated with the Vroenhoven Horizon (Figure 1), a hardground at the base of the Geulhem Member of the Houthem Formation, overlying the Maastricht Formation (Albers and Felder, 1979). However, this hardground clearly represents an unconformity. The subterranean Geulhemmerberg section, situated in a paleodepression, is therefore expected to contain a more complete basal Danian succession.

The nannofossil assemblages were studied with both the light-microscope (LM; A.J.T.R.) and the scanning electron microscope (SEM; H.W., H.M.). For the LM study, standard smear slides were prepared and analysed at a magnification of 1200 ×. For the SEM analysis a new preparation technique was applied (Mai et al., 1994). The biozonal scheme applied here (Figure 2) is after Perch-Nielsen (1981, 1985) and Brinkhuis et al. (1994).

Previous investigations

The results of previous nannofossil studies of the type Maastrichtian area are rather ambiguous (Figure 3). Sissingh (1977) assigned the Mb–Md of the Maastrichtian stratotype in the ENCI quarry at Maastricht to zones CC25c and 26. He reported *Nephrolithus frequens*, the marker species for the CC26 Zone, only from two samples of the basal part of the Mb. A study by Van Heck (1979) of the same set of samples analysed by Sissingh, however, indicated that *N. frequens* occurs from the upper part of the underlying Gulpen Formation to the top of the Md.

Verbeek (1977) assigned the Mb to his *Lithraphidites quadratus* Zone, and the Mc and Md to his *Micula murus* Zone; he did not report the presence of *N. frequens*.

Cepek and Moorkens (1979), who studied floras from the ENCI and Curfs quarries, assigned the basal part of the Mb to the *N. frequens* Zone, and the overlying Maastrichtian to a 'post *N. frequens* interval'. They placed the K/T boundary at the Vroenhoven Horizon, at the base of the *Biantholithus sparsus* Zone.

Verbeek (1986) also drew the K/T boundary at the Vroenhoven Horizon in a study of a section near Vroenhoven, a few kilometres west of Maastricht. Both

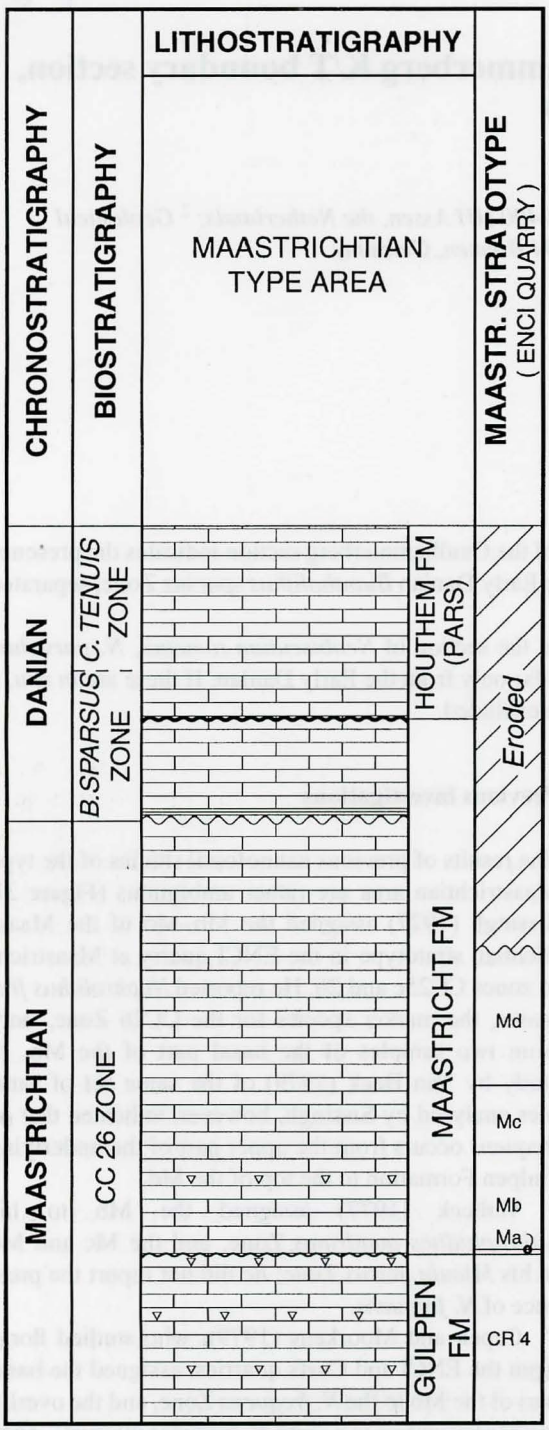

Figure 1. Stratigraphy for the Maastrichtian type area and calcareous nannoplankton zones (not to scale).

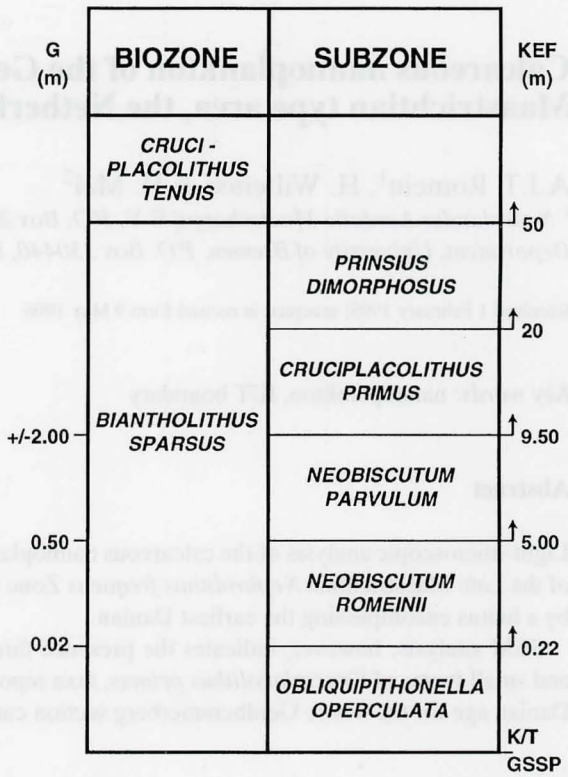

Figure 2. Calcareous nannoplankton biozonation and comparison of thicknesses of (sub)zones in the Geulhemmerberg section (G) and the El Kef section. GSSP: Global Boundary Stratotype Section and Point.

N. frequens and *B. sparsus* are missing here. It is noteworthy that the author mentioned the presence of *Markalius inversus* (our *M. astroporus*), and a high frequency of *Braarudosphaera bigelowii* in a sample taken 2 m below the Vroenhoven Horizon. The latter sample was interpreted as reflecting 'a rather restricted environment'. In view of our findings in the Geulhemmerberg section, however, this level is probably close to, or at the K/T boundary.

Results

Use was made of the 'G'-labled set of samples (G1A–G7B; see Brinkhuis and Smit, this issue) and characteristic taxa are depicted on Plates 1 and 2. The results of the LM analysis (Figure 4) differ markedly from those gained with the SEM; they are discussed separately below. The discrepancies are thought to be due to the application of different preparation techniques

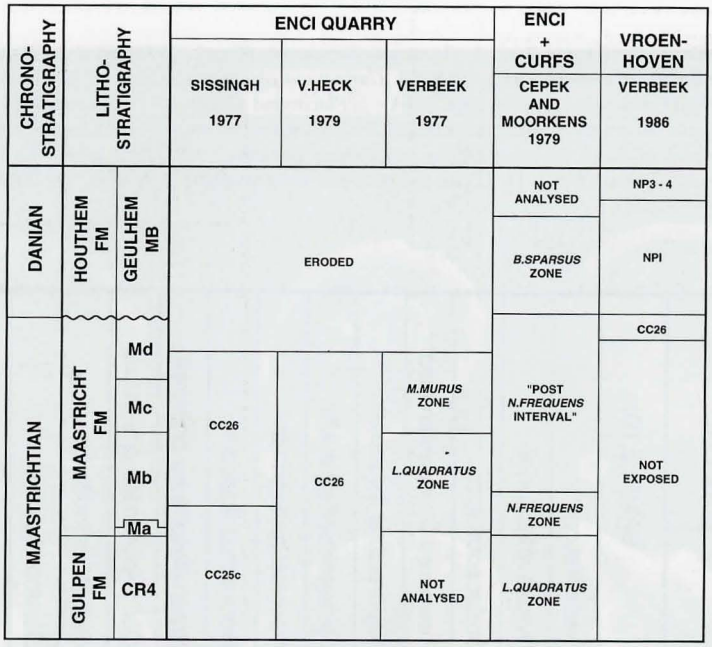

Figure 3. Overview of calcareous nannofossil biozonations for the Maastrichtian type area.

and/or to the high resolution of the SEM technique (magnifications > 30 000 ×).

LM analysis

The overall abundances of specimens vary from common to rare, but all floras are dominated by Cretaceous taxa. The preservation is poor in most samples from the calcarenitic intervals, and fair to good in samples from the clay layers.

The interval covered by the samples G1A to G1C is tentatively assigned to the Late Maastrichtian *Nephrolithus frequens* Zone (CC26). The nominative species does not occur in these samples, which is in line with previous reports on the area. Other Late Maastrichtian markers like *Micula murus* and *M. prinsii* are also absent, the youngest marker present being *Lithraphidites quadratus* (CC25a). The presence of *Cyclagelosphaera alta* and *Neobiscutum romeinii* in sample G1A is thought to be due to contamination as a result of burrowing.

The sequence covered by the samples G2A to G7B is assigned to the Early Danian *Biantholithus sparsus* Zone. The zone can be subdivided into the *Neobiscutum romeinii* and *Neobiscutum parvulum* subzones based on the first occurrences (FOs) of the former species in sample G2B, and of the latter species in sample G5B. Sample G2A is tentatively placed in the *Obliquipithonella operculata* Subzone; Danian nannofossil taxa are lacking in this sample, but other fossil groups (e.g. Calcispheres) indicate a Tertiary age.

Typical specimens of *Cruciplacolithus primus* (4–5 μm), the marker species for the top of the *B. sparsus* Zone, do not occur in the section, but they were found in a set of test samples from an interval above the Geulhemmerberg cave ceiling. In addition to the FO of *N. romeinii*, sample G2B is marked by the presence of reworked Campanian species (e.g. *Reinhardtites anthophorus*), reworked *N. frequens*, and the FO of *Goniolithus fluckigeri* (FO in the Md, according to Van Heck, 1979).

The lower part of the *N. romeinii* Subzone contains the successive FOs of *Braarudosphaera bigelowii* and *Obliquiphithonella operculata* (sample G2C), *Octolithus multiplus* and *Biantholithus sparsus* (sample G2D) and of *Markalius astroporus* (sample G4A). Acmes of *O. operculata* and/or *B. bigelowii*, used to delineate the K/T boundary in many other boundary sections, do not occur. The middle part of the subzone contains only reworked Cretaceous taxa, while the upper part contains the FOs of *Scapholithus rhombiformis* and *Braarudosphaera discula* (sample G4G).

The *N. parvulum* Subzone lacks additional first occurrences.

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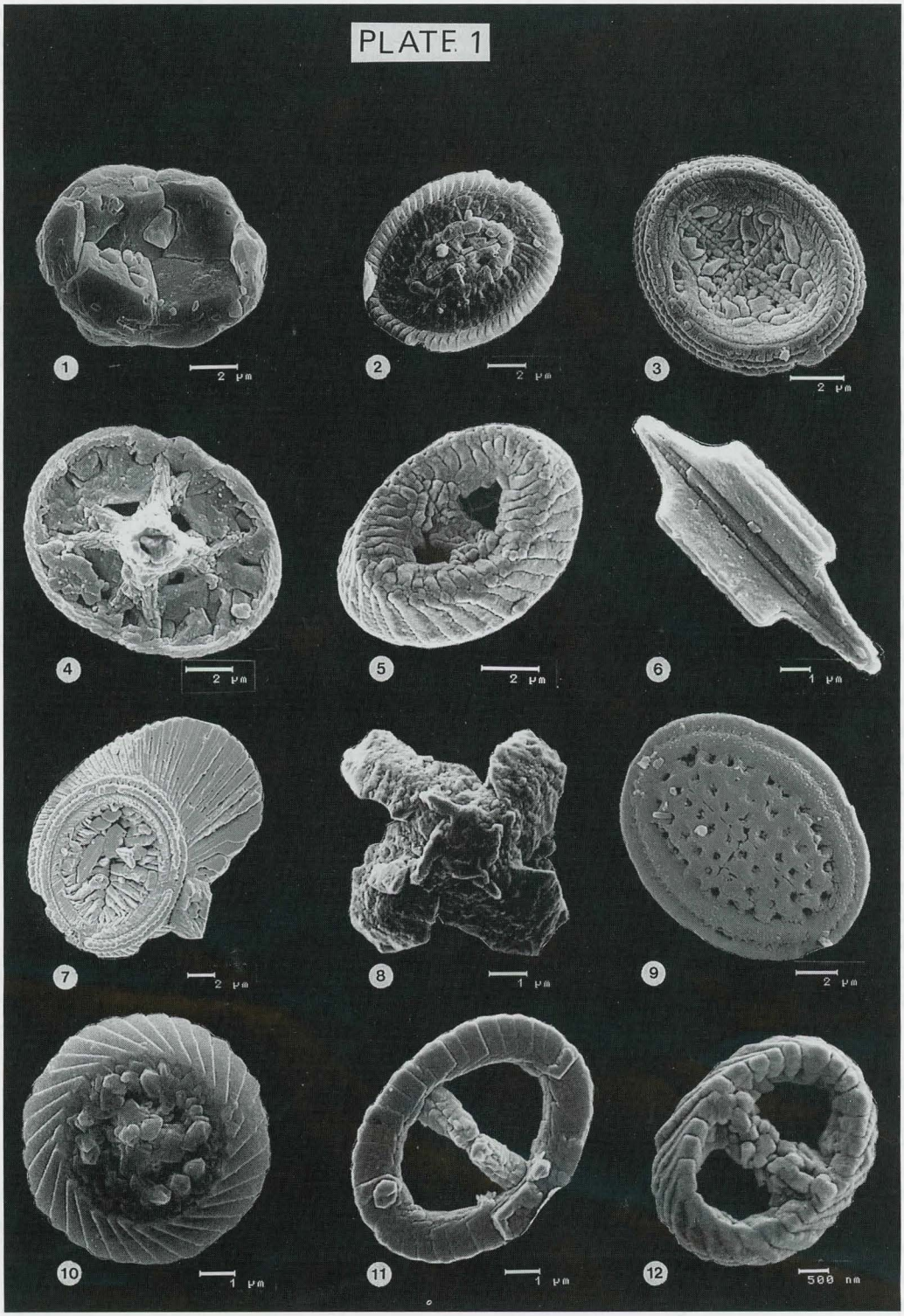
Plate 1. Calcareous nannoplankton, Geulhemmerberg. 1. *Orastrum campanensis* (Cepek, 1970) Wind & Wise, 1977. proximal, G4A – 2. *Broinsonia parca* (Stradner, 1963) Bukry, 1969. distal, G4A – 3. *Gartnerago obliquum* (Stradner, 1963) Noël, 1970. proximal, G4A – 4. *Eiffellithus eximius* (Stover, 1966) Perch-Nielsen, 1968. distal, G4A – 5. *Placozygus fibuliformis* (Reinhardt, 1964) Hoffmann, 1970. proximal, G2D – 6. *Lithraphidites quadratus* Bramlette & Martini, 1964. G2D – 7. *Kamptnerius magnificus* Deflandre, 1959. distal, G2D – 8. *Micula prinsii* Perch-Nielsen, 1979. distal, G4A – 9. *Arkhangelskiella cymbiformis* Vekshina, 1959. distal, G4A – 10. *Cyclagelosphaera reinhardtii* (Perch-Nielsen, 1968) Romein, 1977. distal, G5C – 11, 12. *Placozygus sigmoides* (Bramlette & Sullivan, 1961) Romein, 1979. distal, proximal, G4C.

AGE	BIOZONE	SUBZONE	SAMPLE (G)	Preservation	Overall abundance	Cretaceous spp.	Reworked Campanian taxa	*Nephrolithus frequens*	*Cyclagelosphaera alta*	*Neobiscutum romeinii*	*Goniolithus fluckigeri*	*Braarudosphaera bigelowii*	*Obliquipithonella operculata*	*Octolithus multiplus*	*Biantholithus sparsus*	*Markalius astroporus*	*Scapholithus rhombiformis*	*Braarudosphaera discula*	*Neobiscutum parvulum*	*Cruciplacolithus primus* *
DANIAN	*Biantholithus sparsus*	*Neobiscutum parvulum*	7B	g	c	c				*			f		*	*			f*	*
			7A	g	c	c				*	r		f		*	*			f*	*
			6	g	c	c				*	r	f			*	*			f*	*
			5D	g	c	c				*					*	*			f*	*
			5C	g	c	c				*	r	f	*	r	*	*			f*	*
			5B	g	c	c				*				r	*	*			f*	*
		Neobiscutum romeinii	5A	g	c	c			f	r*					*	r*			*	*
			4I	g	c	c			r	r*		r	f*		*	r*			*	*
			4H	p	r	c				*					*	*			*	*
			4G	g	c	c	f		r	*			f		*	r*	r	r	*	*
			4F	g	r	c				*		r			*	*			*	*
			4E	g	c	c				r*		r	f		*	*			*	*
			4D	p	r	r				*					*	*			*	*
			4C	p	r	r				*					*	*			*	*
			4B	p	r	r				*					*	*			*	*
			4A	p	r	r				r*	r	f	*		r*	r*			*	*
			3	p	r	r	r			r*		r							*	*
			2D	g	c	c			r	r*			r	r	r				*	*
			2C	g	c	c	f			f*		r	r						*	*
			2B	p	c	c	f	r		f*	r								*	*
		O o	2A	p	r	c				*									*	*
MAASTR		CC26	1C	p	r	c				*									*	*
			1B	p	r	c				*									*	*
			1A	p	r	c			r	r*									*	*

Figure 4. LM-based distribution chart and biozonation, calcareous nannofossils, Geulhemmerberg. g: good, p: poor, c: common, f: few, r: rare, *: SEM observation, *O.o.: Obliquipithonella operculata*. For sample positions see Brinkhuis and Smit, this issue.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2 µm
10
1 µm
11
1 µm
12
500 nm

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Plate 2. Calcareous nannoplankton, Geulhemmerberg. 13, 14. *Goniolithus fluckigeri* Deflandre, 1957. proximal, distal, G5D – 15. *Braarudosphaera bigelowii* (Gran & Braarud, 1935) Deflandre, 1947. proximal, G4A – 16. *Biantholithus sparsus* Bramlette & Martini, 1964. distal, G4A – 17. *Markalius astroporus* (Deflandre, 1954) Bramlette & Martini, 1964. proximal, G4A – 18. *Cyclagelosphaera alta* Perch-Nielsen, 1979. distal, G4A – 19. *Braarudosphaera discula* Bramlette & Riedel, 1954. G4G – 20. *Obliquipithonella operculata* (Bramlette & Martini, 1964) Fütterer, 1987. G4A – 21, 22. *Cruciplacolithus primus* Perch-Nielsen, 1977. coccosphere, G2A – 23. *Repagulum parvidentatum* (Deflandre & Fert, 1954) Forchheimer, 1977. distal, G2A – 24. *Neobiscutum romeinii* Perch-Nielsen, 1981. proximal, G2A.

SEM analysis

The most striking difference with the results of the LM observations is formed by the presence of coccospheres and isolated specimens of *Cruciplacolithus primus, Neobiscutum parvulum* and *Neobiscutum romeinii* throughout the section, i.e. including the interval considered to be definitely of Maastrichtian age based on other fossil groups. Excluding contamination (burrowing, percolating ground water, sample handling) these discrepancies could be explained as follows:

- the species have their FOs in the Maastrichtian; they have not been recorded previously from this interval in other K/T boundary sections (e.g. El Kef) due to their small size; alternatively, their FOs might be diachronous due to provincialism;
- the whole Geulhemmerberg section is indeed of Tertiary age; as a consequence the K/T boundary should occur even lower in the Maastricht Formation, in line with Hofker's (1962) conclusion that 'the type Danian and the type Maastrichtian are contemporaneous'.

Additional SEM investigations of the Maastrichtian in the area are obviously needed to establish the ranges of the abovementioned taxa. In the present paper we prefer to place more weight on the results of the LM analysis.

Comparison with El Kef

In the El Kef section, NW Tunisia, *N. romeinii* first appears 22 cm above the K/T boundary, as defined by the iridium spike, following a virtually barren interval (Figure 2). In the Geulhemmerberg section this interval, probably represented by sample G2A, is only a few centimetres thick. This reduced thickness in combination with the absence of high levels of iridium is thought to indicate the presence of a hiatus at the K/T boundary.

N. parvulum first occurs 5 m above the boundary at El Kef, while it first occurs 50 cm above the boundary in the Geulhemmerberg section; the *N. romeinii* Subzone is thus either strongly condensed or it contains hiatuses. The latter seems to be more likely as the successive acmes of *O. operculata* and *B. bigelowii* occurring in this interval at El Kef are not observed in the Geulhemmerberg section.

The *N. parvulum* Subzone has a thickness of approximately 4.5 m in the El Kef section. Preliminary analysis of an interval above sample G7B from the Geulhemmerberg section indicates that the FO of typical *C. primus*, which marks the top of the subzone, occurs 2 m above the K/T boundary. This suggests a thickness of about 1.5 m for the *N. parvulum* Subzone. Again, the absence in this interval of acmes recorded in the El Kef section (amongst others that of *N. parvulum*) is thought to indicate the presence of hiatuses, rather than condensation.

Conclusion

Calcareous nannofossil evidence suggests that the succession exposed in the Geulhemmerberg section contains the least incomplete K/T boundary section in the type area of the Maastrichtian. Comparison with the sequence of bioevents in the El Kef section, however, indicates the absence of the earliest Danian, and strongly reduced thicknesses for the Early Danian subzones. This is thought to be the result of non-deposition rather than condensation.

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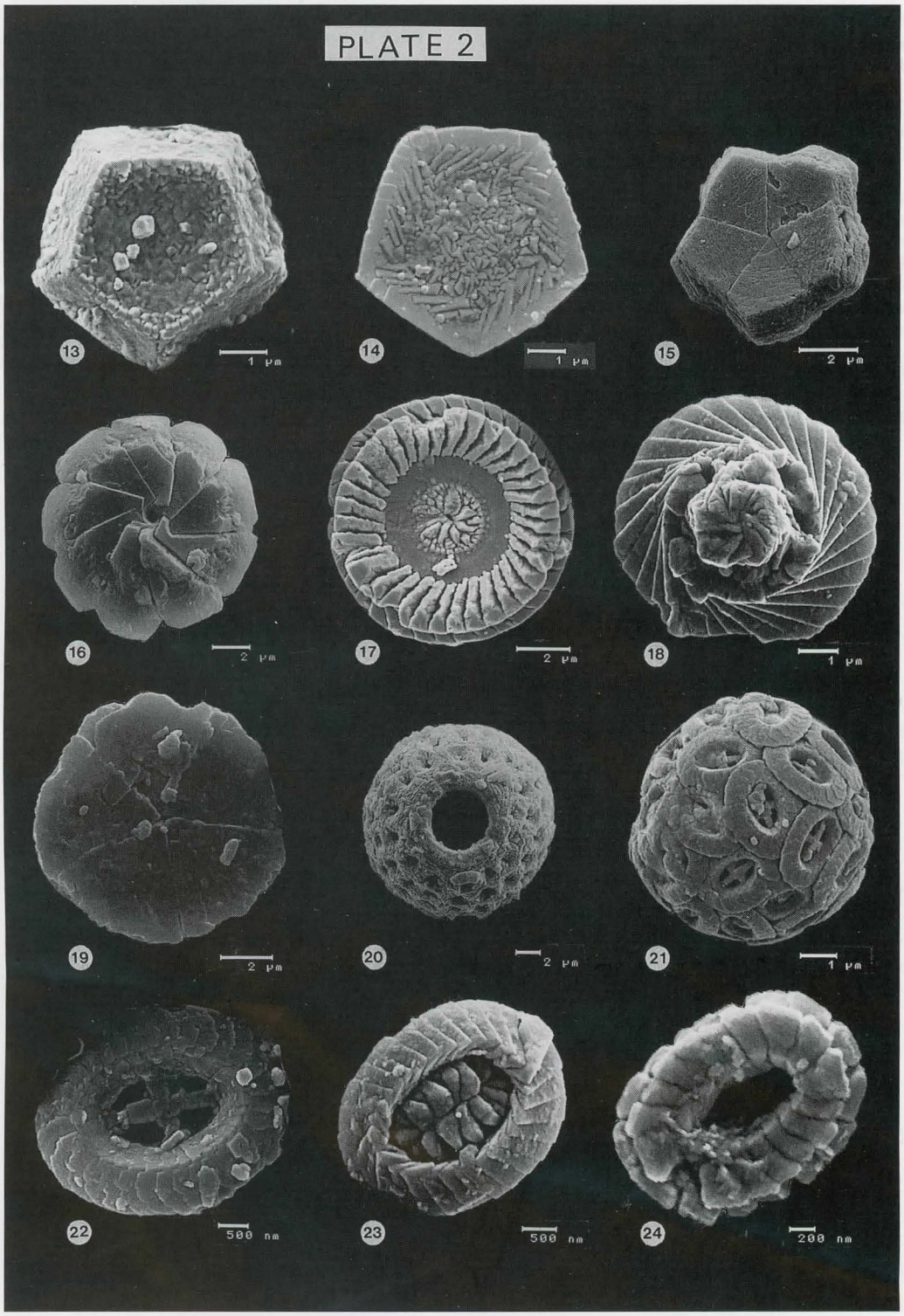
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500 nm
23
500 nm
24
200 nm

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