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FORAMINIFERAL STUDIES IN THE BOOM FORMATION

by

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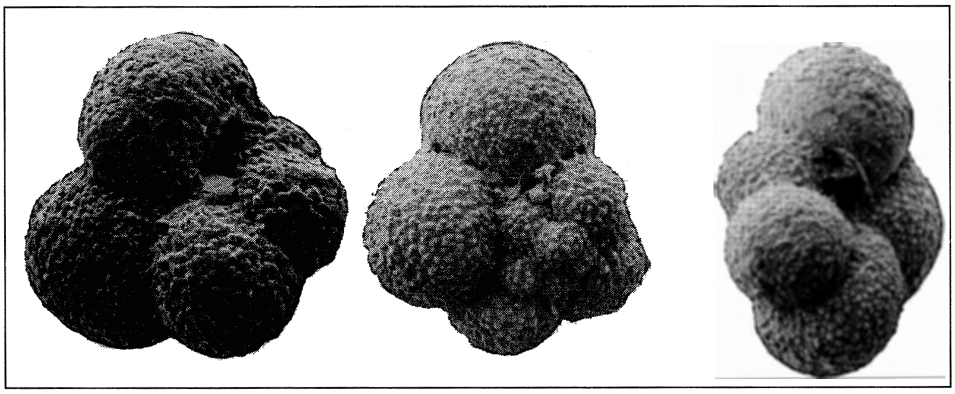

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PLANKTONIC FORAMINIFERAL BIOSTRATIGRAPHY IN THE BOOM FORMATION AT KRUIBEKE AND ANTWERP (NORTHERN BELGIUM)

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SUMMARY

In order to complete our knowledge of international correlation of the Boom Formation in Belgium, planktonic foraminifera are recorded from this Formation at Kruibeke and in two wells at Antwerp (Northern Belgium).
The associations observed at Kruibeke allows us to distinguish the biostratigraphical interval P19/P20 and P21 from the standard zonation of BLOW (1979). In the wells at Antwerp, we recognize Zone P21. The P19/P20-P21 interval is of Rupelian (Oligocene) age.

I. INTRODUCTION

Previous studies of planktonic foraminifera from the Boom Formation in Belgium have been worked out by BERGGREN (1969), BLOW (1969) and HOOYBERGHS (1976, 1983).
We will complete the previous work with information from localities that have not yet been studied in detail.
An important outcrop is the clay pit "GRALEX" at Kruibeke (Fig. 1, location map), which we resampled for this study. The study of this section was necessary also for the work of Dr. ERNA VAN ECHELPOEL (K.U.Leuven) who was elaborating the Milankovitch cyclicity in the Boom Formation.
Some more material was recorded from two wells (LA3 and RA3, respectively the numbers 28W - 627 and 28W - 626 of the archives of the Belgian Geological Survey) at Antwerp (fig. 3, location map). This material is interesting because the upper part of the Boom Formation is not exposed in any outcrop (S80-S150).
The samples from those localities were washed on a 0.074 mm sieve and the results were treated with CCl_4 in order to obtain quickly sufficient specimens of foraminifera.

II. LITHOSTRATIGRAPHY

THE BOOM FORMATION

The Boom clay is a banded gray silty clay or clayey silt. The bands, caused by rhythmic changes in silt, organic material and lime percentages, have been numbered by VANDENBERGHE (1978) (see fig. 2).
In the Rupel type area, the Boom Formation can be subdivided into three members: the Belsele Clay Member, the Terhagen Clay Member and the Putte Clay Member. In the sections studied in this contribution we recognize only the Terhagen Clay Member and the Putte Clay Member.

a) The Terhagen Clay Member

This member contains a gray clay which is less silty than the underlying Belsele Clay Member. It composes the middle part of the Boom Formation. We recognize it in the lower part of the clay pit at Kruibeke (fig. 2, samples K1 to K19). Here it is exposed along 7 meters. Several dark

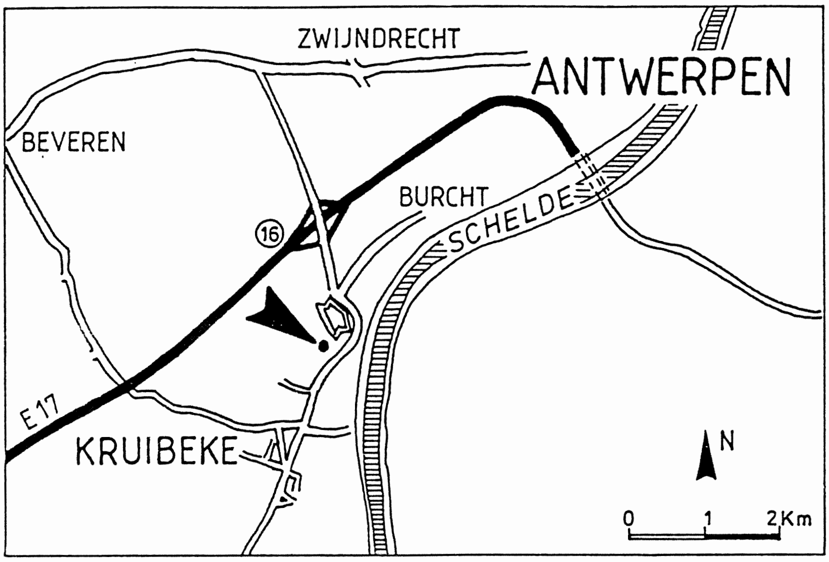

Fig. 1 : Location map of the quarry at Kruibeke.

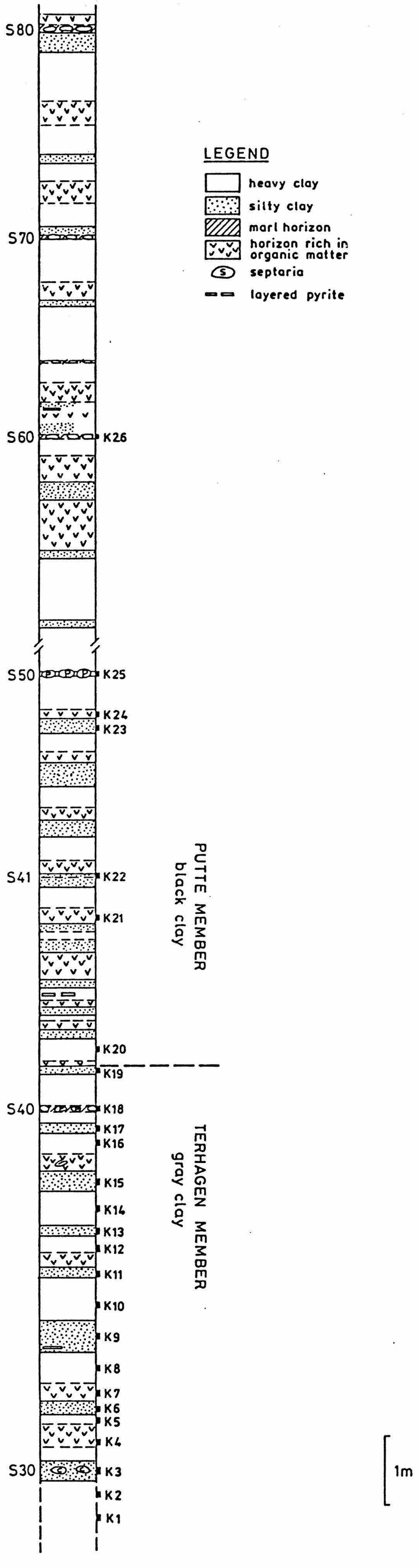

Fig. 2 : Lithological log of the Boom Formation at Kruibeke. (N. VANDENBERGHE, 1978)

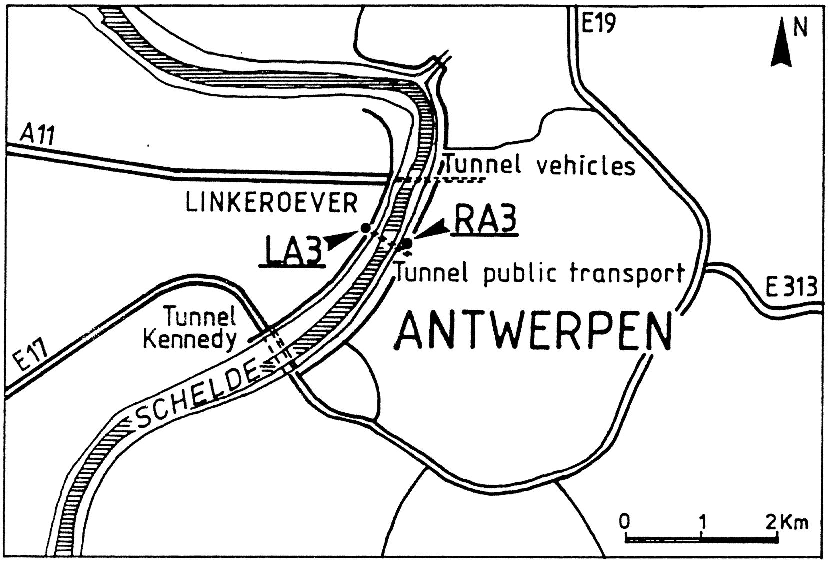

Fig. 3 : Location map of the wells near to Antwerp.

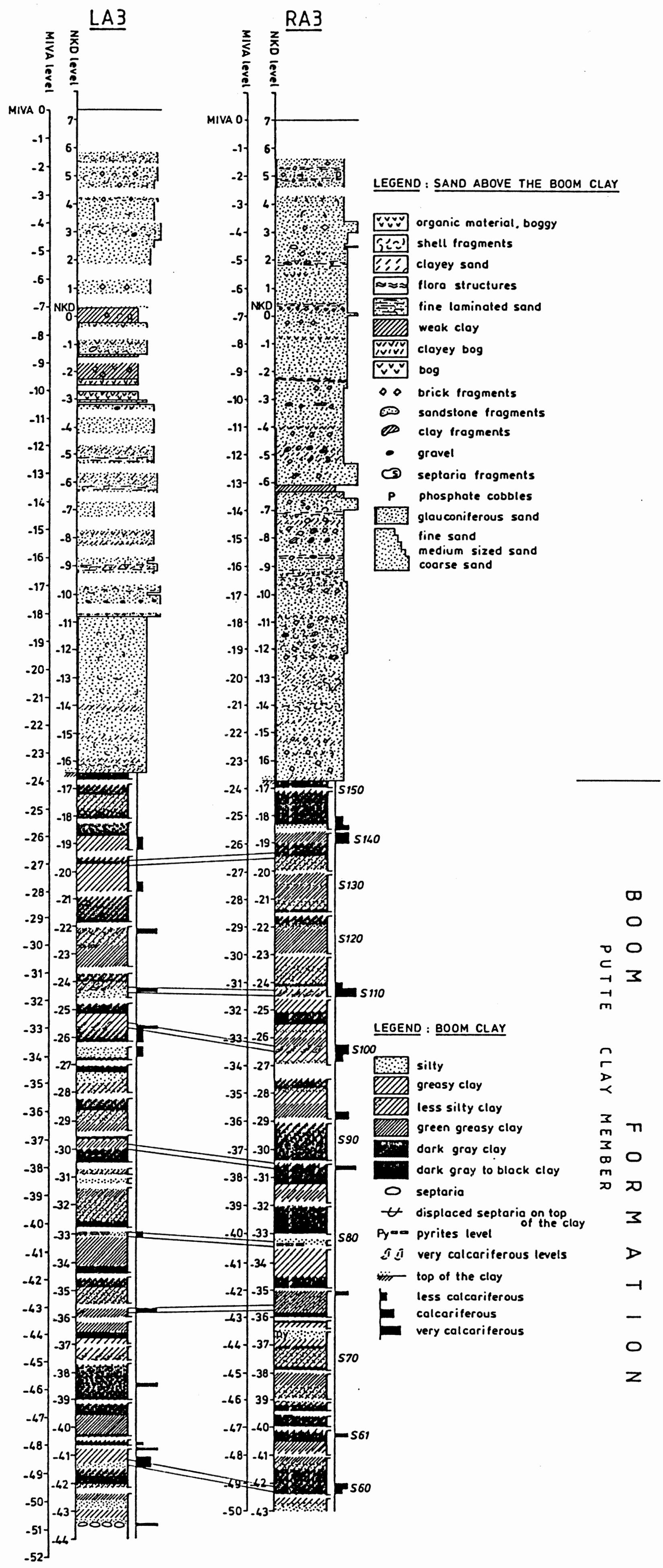

Fig. 4 : Logs of the wells LA 3 (= 28W - 627) and RA 3 (= 28 W - 626)

colored levels contain organic material. The lower part is particularly calcareous.

b) The Putte Clay Member

This upper member is characterized by alternating dark coloured levels with a lot of organic material and silty hirizons. Generally the Putte Clay is darker gray than the Terhagen Clay. In the Kruibeke quarry, it is exposed along 17 m.
The part of the Boom Formation in the wells at Antwerp (LA3 and R13, fig. 4) belongs to the upper part of the Putte Clay Member. The S80-S150 interval is not exposed in any outcrop. It overlies the part of the Putte Clay Member exposed at Kruibeke and is 16 m thick in the wells. A few samples from this material are calcareous and contain some planktonic foraminifera.

III. BIOSTRATIGRAPHY

Tables 1 and 2 show the distribution of the planktonic foraminifera in the studied sections.
The lower part of the Kruibeke section is characterized by the frequent occurrence of species as Globigerina ampliapertura, Globigerina fariasi, Globigerina winkleri, Globigerina tapuriensis, but especially by the presence of Globorotalia opima opima, which appears in Zone P19 in the standard zonation of BLOW (1969, 1979). Higher up, the associations differ by the sudden occurrence of Globigerinita martini and Globigerina woodi. On top of the section, we found species as Globoquadrina altispira globularis and Globoquadrina baroemoenensis. We know from previous works that this level can be situated in Zone P21. The Kruibeke section corresponds to the interval P19/P20 - base of P21 in the standard zonation.
The associations recorded from the wells at Antwerp show affinities with the upper part of the Putte Clay Member at Kruibeke by the presence of e.g. Globigerinita martini. However we did not find zonal markers to put this interval in a specific biozone. We know from the lithological column that the S80-S150 interval overlies the part of the Putte Clay Member at Kruibeke and we accept that it still belongs to Zone P21. In any case we didn't find species that should indicate a younger biostratigraphical position of this part of the Putte Clay Member.

IV. CHRONOSTRATIGRAPHICAL CONCLUSIONS

The P19/P20-P21 interval we found in the Kruibeke section and Zone P21 in the wells at Antwerp form part of the Rupelian, which is the global stage for the Lower and Middle Oligocene. In previous works (HOOYBERGHS, 1976-1983) we also described the presence of Zone P18 in the underlying Belsele Clay Member. The Rupelian in Belgium comprises thus the interval P18-P21. The top of the Oligocene, Zone P22, has

BOOM FORMATION

TERHAGEN CLAY MEMBER (samples 1–19) · PUTTE CLAY MEMBER (samples 20–26)

TAXA \ SAMPLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Globorotalia (T.) clemenciae	•	•	•	•	•	•	•									•										
Globorotalia (T.) gemma	•	•			•	•	•																			
Globorotalia (T.) increbescens		•	•															•							•	
Globorotalia (T.) opima nana		•																								
Globorotalia (T.) opima opima			•		•																					
Globorotalia (T.) permicra	•		•																							
Globigerina ampliapertura	•	•	•	•	•	•												•								
Globigerina angiporoides						•	•											•						•	•	•
Globigerina angustiumbilicata	•	•	•		•	•	•									•		•							•	•
Globigerina ciperoensis	•		•			•												•								
Globigerina crypthomphala	•	•																								
Globigerina eocaena	•	•	•	•	•	•	•									•										
Globigerina fariasi	•	•	•	•	•	•	•											•								
Globigerina linaperta	•	•			•																					
Globigerina officinalis	•	•	•	•	•	•	•									•		•							•	•
Globigerina ouachitaensis	•	•	•	•	•	•	•									•	•	•								•
Globigerina praebulloides leroyi	•	•	•	•	•	•	•									•		•						•	•	•
Globigerina praebulloides occlusa	•	•	•	•	•	•	•	•								•		•						•	•	•
Globigerina praebulloides praebulloides	•	•	•	•	•	•	•									•		•						•	•	•
Globigerina praeturritillina	•	•	•																							
Globigerina tapuriensis	•	•	•			•																				
Globigerina tripartita																								•	•	•
Globigerina winkleri	•	•	•	•	•	•																				
Globigerina woodi connecta																								•		
Globigerina yeguaensis	•																									
Globoquadrina altispira globularis																										•
Globoquadrina baroemoenensis																										•
Globigerinita martini martini																								•	•	•
Globigerinita martini scandretti																								•	•	•
Globigerinita pera																								•	•	
Globigerinita unicava primitiva	•	•	•	•	•	•	•											•						•	•	
Globigerinita unicava unicava	•	•	•																					•	•	

BIOSTRATIGRAPHY: P.19 – P.20 – P.21

Table 1 : Distribution of planktonic foraminifera in the Boom Formation at Kruibeke.

Table 2: Distribution of planktonic foraminifera in wells RA3 and LA3.

LA3 24,4	RA3 47,2	RA3 33,9	RA3 31,5	RA3 12,1	SAMPLE DEPTH (m) / TAXA
	●	●	●		*Globigerina angiporoides* HORNIBROOK 1965
●	●	●	●		*Globigerina officinalis* SUBBOTINA 1953
●	●	●			*Globigerina ouachitaensis* HOWE & WALLACE 1932
●	●	●	●	●	*Globigerina praebulloides leroyi* BLOW & BANNER 1962
●	●	●	●		*Globigerina praebulloides occlusa* BLOW & BANNER 1962
	●	●	●		*Globigerina praebulloides praebulloides* BLOW 1959
●		●	●		*Globorotaloides suteri* BOLLI 1957
	●	●	●		*Globigerinita martini martini* BLOW & BANNER 1962
		●			*Globigerinita martini scandretti* BLOW & BANNER 1962
	●	●			*Globigerinita unicava primitiva* BLOW & BANNER 1962

been described by HOOYBERGHS (1983) from the Voort Sands Formation, which belongs to the "Neochattian" in Germany.

V. ACKNOWLEDGEMENTS

Sincere thanks are due to the Belgian Geological Survey (Brussels) for permission the study of some samples from the wells at Antwerp.
The author thanks also K. WOUTERS (K.B.I.N., Brussels) for photographing the specimens.

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PLATE I

Fig. 1: Globorotalia (Turborotalia) clemeniae
BERMUDEZ, 1961 Sample K1
umbilical side x 165

Fig. 2: Globorotalia (Turborotalia) clemeniae
BERMUDEZ, 1961 K1
spiral side x 150

Fig. 3: Globorotalia (Turborotalia) clemeniae
BERMUDEZ, 1961 K1
side-view x 165

Fig. 4: Globorotalia (Turborotalia) clemeniae
BERMUDEZ, 1961 K1
umbilical side x 170

Fig. 5: Globorotalia (Turborotalia) gemma
JENKINS, 1966 K1
umbilical side x 280

Fig. 6: Globorotalia (Turborotalia) gemma
JENKINS, 1966 K1
spiral side x 230

Fig. 7: Globorotalia (Turborotalia) gemma
JENKINS, 1966 K1
side view x 215

Fig. 8: Globorotalia (Turborotalia) gemma
JENKINS, 1966 K1
umbilical side x 230

Fig. 9: Globorotalia (Turborotalia) increbescens
(BANDY, 1949) K2
umbilical side x 200

Fig. 10: Globorotalia (Turborotalia) increbescens
(BANDY, 1949) K2
spiral side x 170

Fig. 11: Globorotalia (Turborotalia) increbescens
(BANDY, 1949) K3
side-view x 165

Fig. 12: Globorotalia (Turborotalia) increbescens
(BANDY, 1949) K3
umbilical side x 180

Fig. 13: Globorotalia (Turborotalia) opima nana
BOLLI, 1957 K2
umbilical side x 215

Fig. 14: Globorotalia (Turborotalia) opima opima
BOLLI, 1957 K3
umbilical side x 135

Fig. 15: Globorotalia (Turborotalia) opima opima
BOLLI, 1957 K3
spiral side x 125

Fig. 16: Globorotalia (Turborotalia) opima opima
BOLLI, 1957 K5
side-view x 155

Fig. 17: Globorotalia (Turborotalia) permicra
BLOW & BANNER, 1962 K1
umbilical side x 285

Fig. 18: Globorotalia (Turborotalia) permicra
BLOW & BANNER, 1962 K1
side-view x 265

Fig. 19: Globorotalia (Turborotalia) permicra
BLOW & BANNER, 1962 K1
spiral side x 290

Fig. 20: Globorotalia (Turborotalia) permicra
BLOW & BANNER, 1962 K1
umbilical side x 265

Plate I

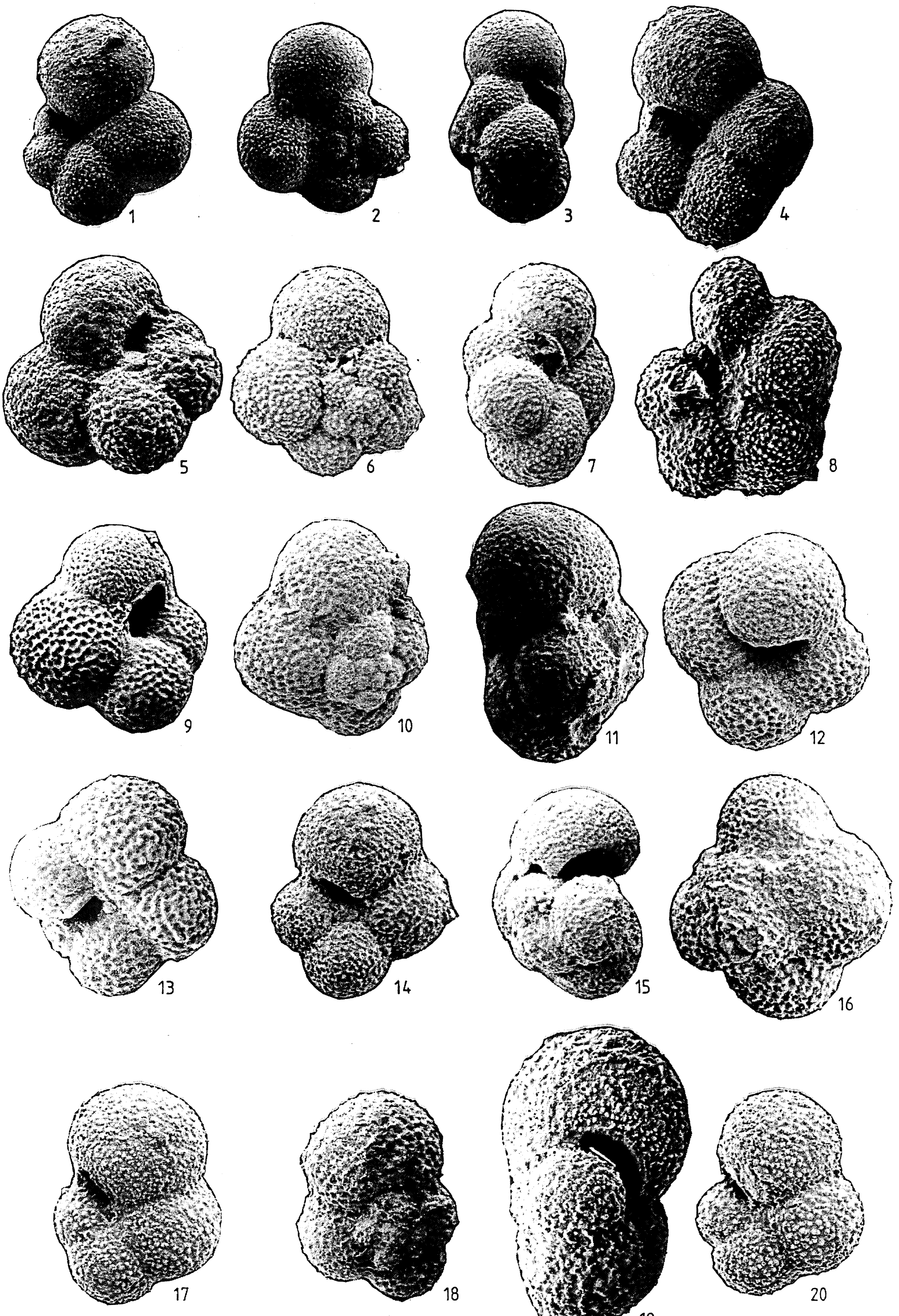


PLATE II

Fig. 1:	Globigerina ampliapertura BOLLI, 1957 umbilical side	x 170	Sample K1
Fig. 2:	Globigerina ampliapertura BOLLI, 1957 spiral side	x 165	K1
Fig. 3:	Globigerina ampliapertura BOLLI, 1957 side-view	x 215	K1
Fig. 4:	Globigerina ampliapertura BOLLI, 1957 umbilical side	x 150	K1
Fig. 5:	Globigerina angiporoides HORNIBROOK, 1965 umbilical side	x 125	K24
Fig. 6:	Globigerina angiporoides HORNIBROOK, 1965 spiral side	x 145	K24
Fig. 7:	Globigerina angiporoides HORNIBROOK, 1965 side-view	x 160	K24
Fig. 8:	Globigerina angiporoides HORNIBROOK, 1965 umbilical side	x 175	K24
Fig. 9:	Globigerina angustiumbilicata BOLLI, 1957 umbilical side	x 175	K1
Fig. 10:	Globigerina angustiumbilicata BOLLI, 1957 spiral side	x 200	K1
Fig. 11:	Globigerina angustiumbilicata BOLLI, 1957 side-view	x 240	K1
Fig. 12:	Globigerina angustiumbilicata BOLLI, 1957 umbilical side	x 225	K1
Fig. 13:	Globigerina ciperoensis BOLLI, 1957 umbilical side	x 125	K1
Fig. 14:	Globigerina ciperoensis BOLLI, 1957 spiral side	x 145	K1
Fig. 15:	Globigerina ciperoensis BOLLI, 1957 side-view	x 120	K1
Fig. 16:	Globigerina ciperoensis BOLLI, 1957 umbilical side	x 140	K1
Fig. 17:	Globigerina crypthomphala GLAESSHER, 1937 umbilical side	x 190	K1
Fig. 18:	Globigerina crypthomphala GLAESSHER, 1937 umbilical side	x 225	K1
Fig. 19:	Globigerina eocaena GÜMBEL, 1868 umbilical side	x 170	K1
Fig. 20:	Globigerina eocaena GÜMBEL, 1868 spiral side	x 160	K1

Plate II

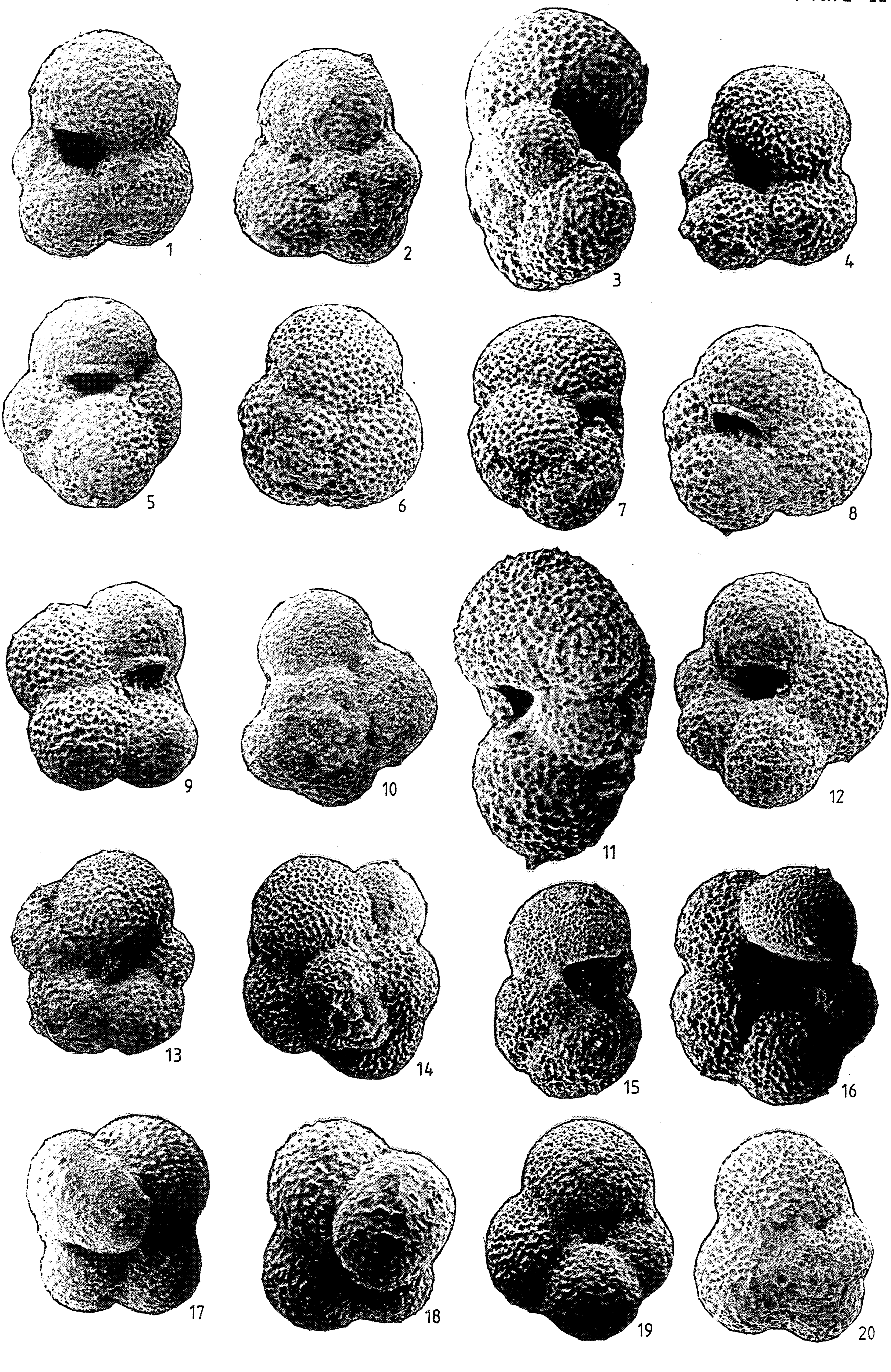


PLATE III

Fig. 1: Globigerina eocaena GÜMBEL, 1868 Sample K1
side-view x 160
Fig. 2: Globigerina eocaena GÜMBEL, 1868 K1
umbilical side x 145
Fig. 3: Globigerina fariasi BERMUDEZ, 1961 K1
umbilical side x 125
Fig. 4: Globigerina fariasi BERMUDEZ, 1961 K1
side-view x 180
Fig. 5: Globigerina fariasi BERMUDEZ, 1961 K1
spiral side x 120
Fig. 6: Globigerina fariasi BERMUDEZ, 1961 K1
umbilical side x 145
Fig. 7: Globigerina linaperta FINLAY, 1939 K1
umbilical side x 270
Fig. 8: Globigerina linaperta FINLAY, 1939 K2
side-view x 260
Fig. 9: Globigerina linaperta FINLAY, 1939 K5
umbilical side x 180
Fig. 10: Globigerina officinalis SUBBOTINA,
1953 K1
umbilical side x 205
Fig. 11: Globigerina officinalis SUBBOTINA,
1953 K1
spiral side x 285
Fig. 12: Globigerina officinalis SUBBOTINA,
1953 K1
side-view x 180
Fig. 13: Globigerina officinalis SUBBOTINA,
1953 K1
umbilical side x 240
Fig. 14: Globigerina ouachitaensis HOWE &
WALLACE, 1932 K1
umbilical side x 145
Fig. 15: Globigerina ouachitaensis HOWE &
WALLACE, 1932 K1
spiral side x 145
Fig. 16: Globigerina ouachitaensis HOWE &
WALLACE, 1932 K1
side-view x 150
Fig. 17: Globigerina ouachitaensis HOWE &
WALLACE, 1932 K1
umbilical side x 135
Fig. 18: Globigerina praebulloides leroyi
BLOW & BANNER, 1962 K1
umbilical side x 240
Fig. 19: Globigerina praebulloides leroyi
BLOW & BANNER, 1962 K1
spiral side x 270
Fig. 20: Globigerina praebulloides leroyi
BLOW & BANNER, 1962 K1
side-view x 245

Plate III

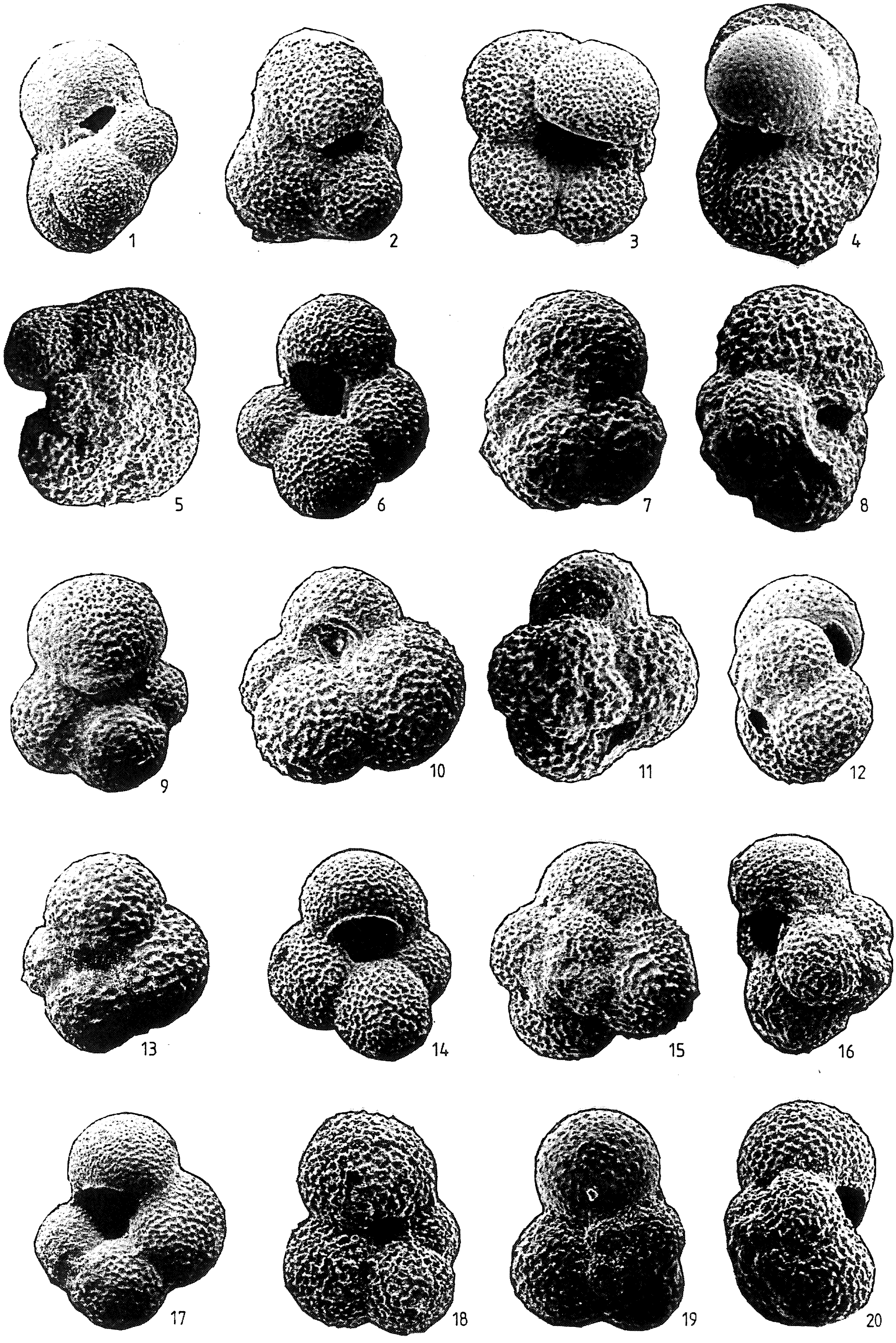


PLATE IV

Fig. 1:	Globigerina praebulloides leroyi BLOW & BANNER, 1962 umbilical side	Sample x 205	K1
Fig. 2:	Globigerina praebulloides occlusa BLOW & BANNER, 1962 umbilical side	x 190	K1
Fig. 3:	Globigerina praebulloides occlusa BLOW & BANNER, 1962 spiral side	x 170	K1
Fig. 4:	Globigerina praebulloides occlusa BLOW & BANNER, 1962 side-view	x 185	K1
Fig. 5:	Globigerina praebulloides occlusa BLOW & BANNER, 1962 umbilical side	x 190	K1
Fig. 6:	Globigerina praebulloides praebulloides BLOW, 1959 umbilical side	x 160	K1
Fig. 7:	Globigerina praebulloides occlusa BLOW & BANNER, 1962 spiral side	x 180	K1
Fig. 8:	Globigerina praebulloides occlusa BLOW & BANNER, 1962 side-view	x 170	K1
Fig. 9:	Globigerina praebulloides occlusa BLOW & BANNER, 1962 umbilical side	x 160	K1
Fig. 10:	Globigerina praeturritillina BLOW & BANNER, 1962 umbilical side	x 165	K1
Fig. 11:	Globigerina praeturritillina BLOW & BANNER, 1962 side-view	x 165	K1
Fig. 12:	Globigerina praeturritillina BLOW & BANNER, 1962 spiral side	x 200	K3
Fig. 13:	Globigerina praeturritillina BLOW & BANNER, 1962 umbilical side	x 210	K3
Fig. 14:	Globigerina tapuriensis BLOW & BANNER, 1962 umbilical side	x 210	K1
Fig. 15:	Globigerina tapuriensis BLOW & BANNER, 1962 side-view	x 200	K1
Fig. 16:	Globigerina tapuriensis BLOW & BANNER, 1962 umbilical side	x 165	K2
Fig. 17:	Globigerina tripartita KOCH, 1926 umbilical side	x 140	K24
Fig. 18:	Globigerina tripartita KOCH, 1926 spiral side	x 195	K24
Fig. 19:	Globigerina tripartita KOCH, 1926 side-view	x 230	K25
Fig. 20:	Globigerina tripartita KOCH, 1926 umbilical side	x 150	K25

Plate IV

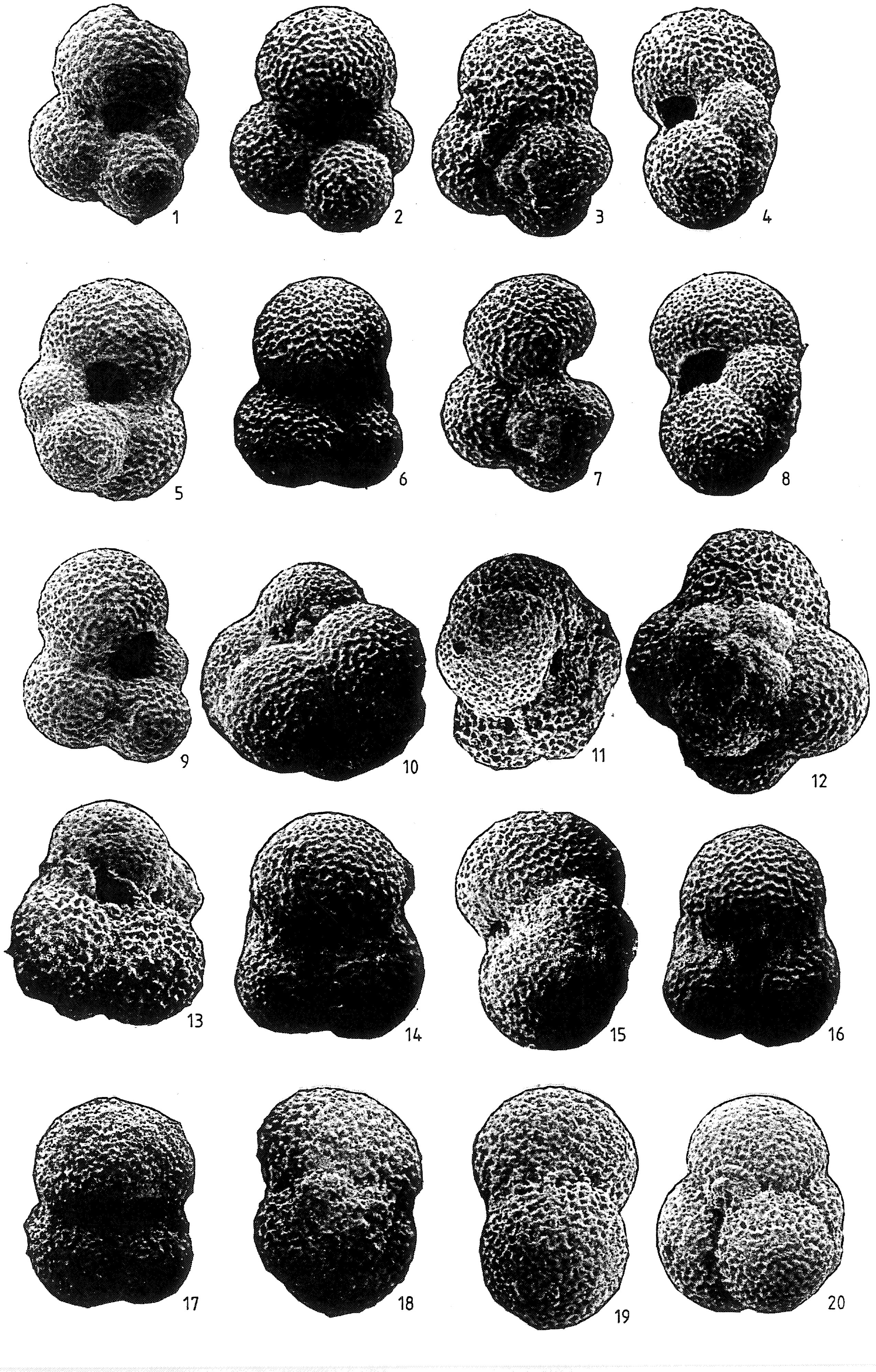


PLATE V

Fig. 1:	Globigerina winkleri BERMUDEZ, 1960		Sample K1
	umbilical side	x 180	
Fig. 2:	Globigerina winkleri BERMUDEZ, 1960		K1
	spiral side	x 205	
Fig. 3:	Globigerina winkleri BERMUDEZ, 1960		K1
	side-view	x 175	
Fig. 4:	Globigerina winkleri BERMUDEZ, 1960		K1
	umbilical side	x 165	
Fig. 5:	Globigerina woodi connecta JENKINS, 1964		K24
	umbilical side	x 150	
Fig. 6:	Globigerina woodi connecta JENKINS, 1964		K24
	umbilical side	x 190	
Fig. 7:	Globigerina yeguaensis WEINZIER & APPLIN, 1929		K1
	umbilical side	x 185	
Fig. 8:	Globigerina yeguaensis WEINZIER & APPLIN, 1929		K1
	spiral side	x 190	
Fig. 9:	Globigerina yeguaensis WEINZIER & APPLIN, 1929		K1
	side-view	x 195	
Fig. 10:	Globigerina yeguaensis WEINZIER & APPLIN, 1929		K1
	umbilical side	x 180	
Fig. 11:	Globoquadrina altispira globularis BERMUDEZ, 1961		K26
	umbilical side	x 110	
Fig. 12:	Globoquadrina altispira globularis BERMUDEZ, 1961		K26
	umbilical side	x 165	
Fig. 13:	Globoquadrina baroemoenensis (LE ROY, 1939)		K26
	umbilical side	x 185	
Fig. 14:	Globoquadrina baroemoenensis (LE ROY, 1939)		K26
	side-view	x 160	
Fig. 15:	Globigerinita martini martini BLOW & BANNER, 1962		K25
	umbilical side	x 145	
Fig. 16:	Globigerinita martini martini BLOW & BANNER, 1962		K25
	side-view	x 175	
Fig. 17:	Globigerinita martini martini BLOW & BANNER, 1962		K25
	spiral side	x 165	
Fig. 18:	Globigerinita martini martini BLOW & BANNER, 1962		K25
	umbilical side	x 145	
Fig. 19:	Globigerinita martini scandretti BLOW & BANNER, 1962		K25
	umbilical side	x 215	
Fig. 20:	Globigerinita martini scandretti BLOW & BANNER, 1962		K25
	side-view	x 190	

Plate V

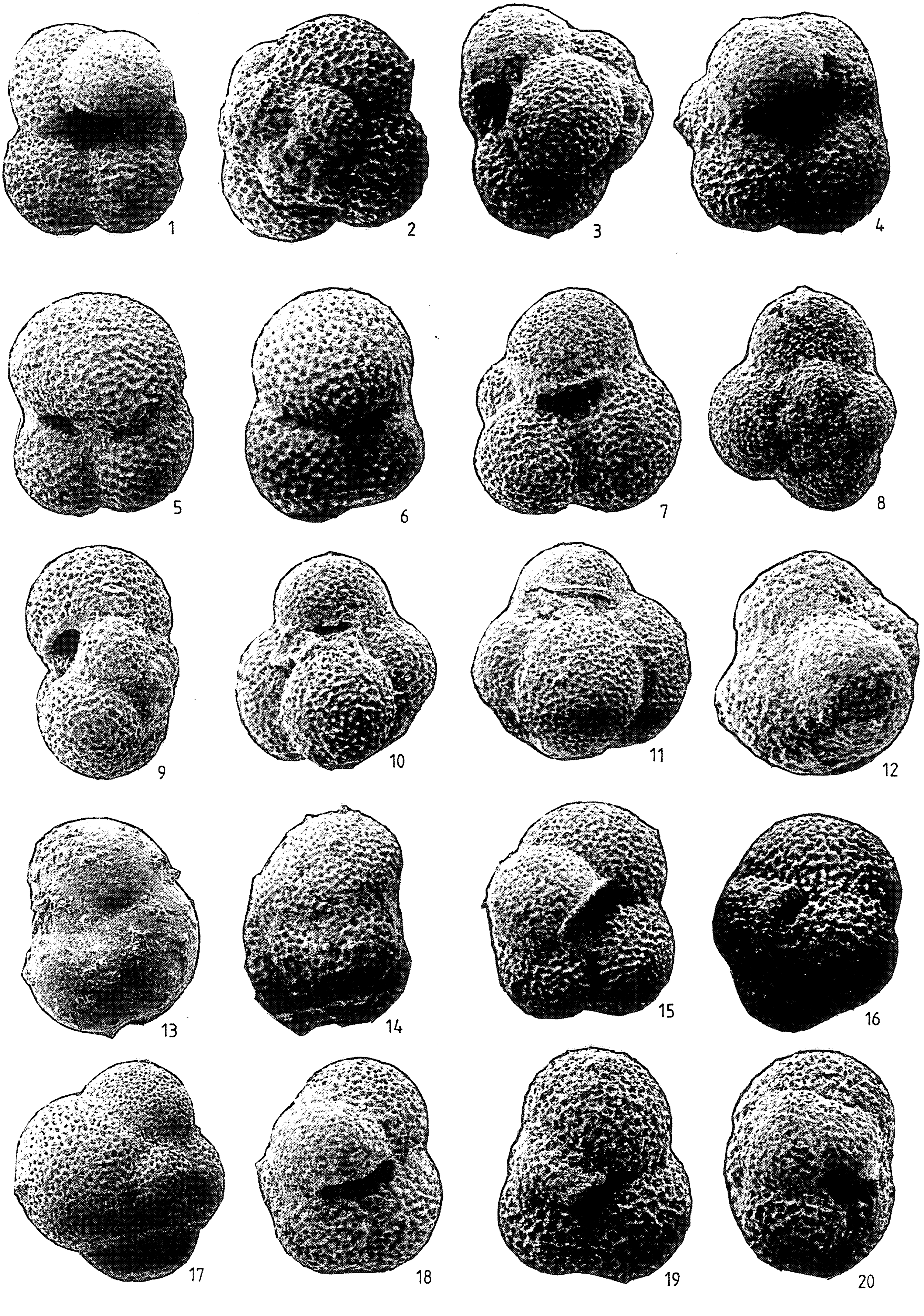
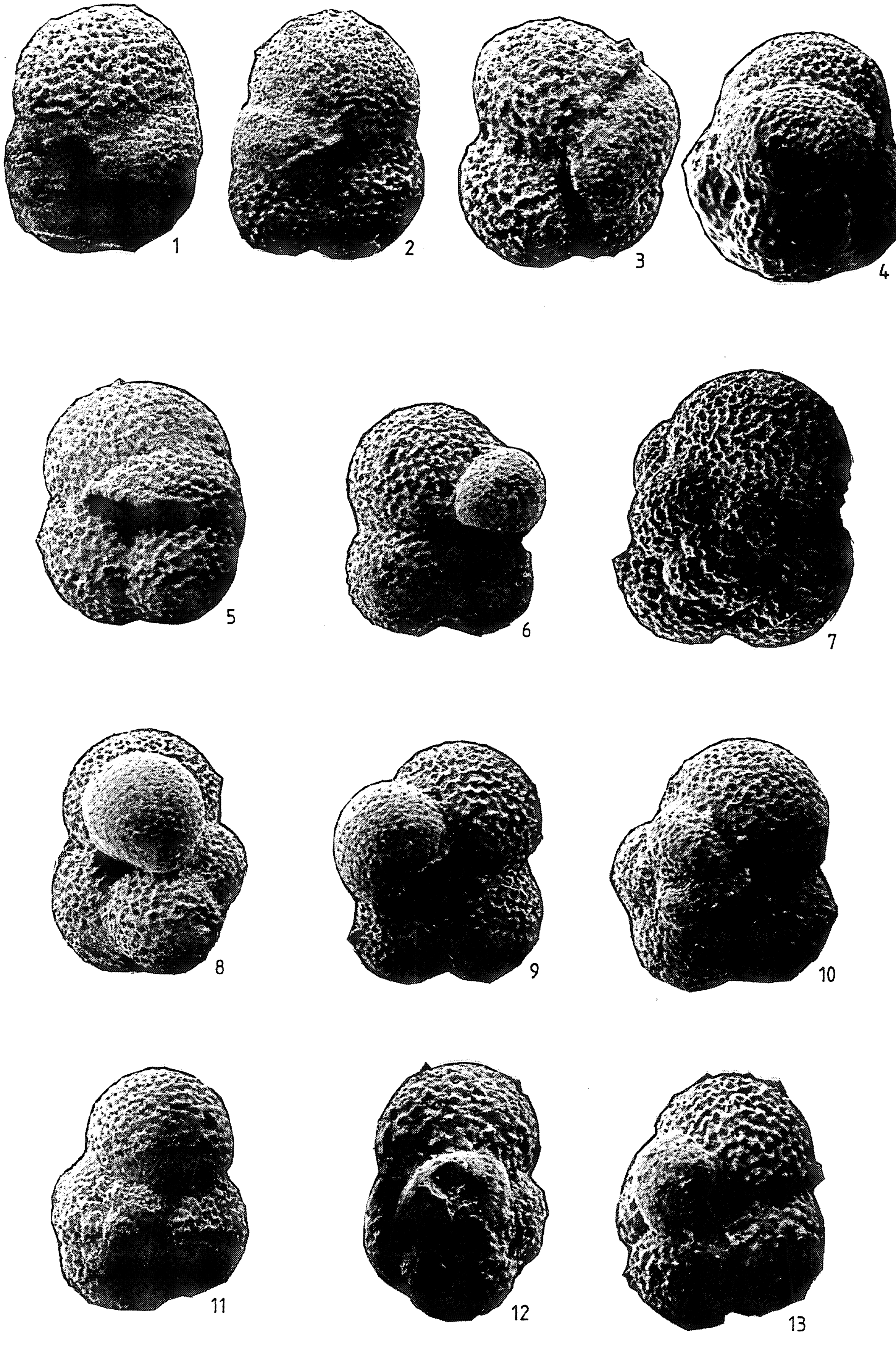


PLATE VI

Fig. 1:	Globigerinita martini scandretti BLOW & BANNER, 1962	Sample	K25
	umbilical side	x 210	
Fig. 2:	Globigerinita martini scandretti BLOW & BANNER, 1962	Sample	K25
	umbilical side	x 145	
Fig. 3:	Globigerinita pera (TODD, 1957)		K24
	umbilical side	x 205	
Fig. 4:	Globigerinita pera (TODD, 1957)		K24
	umbilical side	x 170	
Fig. 5:	Globigerinita pera (TODD, 1957)		K24
	umbilical side	x 165	
Fig. 6:	Globigerinita unicava primitiva BLOW & BANNER, 1962		K1
	umbilical side	x 175	
Fig. 7:	Globigerinita unicava primitiva BLOW & BANNER, 1962		K1
	spiral side	x 190	
Fig. 8:	Globigerinita unicava primitiva BLOW & BANNER, 1962		K1
	side-view	x 170	
Fig. 9:	Globigerinita unicava primitiva BLOW & BANNER, 1962		K1
	umbilical side	x 175	
Fig. 10:	Globigerinita unicava unicava (BOLLI, LOEBLICH & TAPPAN, 1957)		K1
	umbilical side	x 180	
Fig. 11:	Globigerinita unicava unicava (BOLLI, LOEBLICH & TAPPAN, 1957)		K1
	spiral side	x 205	
Fig. 12:	Globigerinita unicava unicava (BOLLI, LOEBLICH & TAPPAN, 1957)		K1
	side-view	x 210	
Fig. 13:	Globigerinita unicava unicava (BOLLI, LOEBLICH & TAPPAN, 1957)		K1
	umbilical side	x 215	

Plate VI



BENTHONIC FORAMINIFERAL ASSOCIATIONS OF THE BOOM FORMATION (OLIGOCENE) IN THE REGION OF BOOM (N. BELGIUM)

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ABSTRACT

The benthonic foraminiferal associations of three outcrops of the Boom Formation located near Boom, south of Antwerp, have been studied in a principal component analysis.
The association pattern can be described by seven varimax rotated factors. The lower deposits of the Belsele Clay Member and the Terhagen Clay Mamber are characteristic by alternating high scores mainly of factors 1 and 2, less by factors 3 and 4. The upper Putte Clay Member deposits show alternating high scores on factors 5, 6 and 7. The alternation of the values of the factor scores is not related to the alternating silty and clayey sequence of the sediments studied. The dominating benthonic foraminiferal taxa, together with the varying abundance of planktonic specimens, indicate a middle shelf environment for the deposits of the Belsele and Terhagen Clay Members, which deepens to an outer shelf environment during the deposition of the Putte Clay Member.

I. INTRODUCTION

The Boom Formation, exposed in brickyards along a broad cuesta front south of the city of Antwerp, is lithologically characterized by repeated alternations of silty and clayey layers and by continuous thin lime bands. Profiles at Sint-Niklaas, Tielrode and Terhagen have been described and sampled by VANDENBERGHE and HOOYBERGHS (fig. 1, location map).
The Boom Formation can be subdivided into the Belsele Clay, Terhagen Clay and Putte Clay Members (profiles in fig. 2 of VANDENBERGHE, 1974). Chronostratigraphically the Boom Formation is Rupelian (Oligocene) in age and is assigned to planktonic foraminiferal zones P.18-P.21 (HOOYBERGHS, 1983).
The benthonic foraminifera were identified according to the work of BATJES (1958). Some decalcified samples contained no foraminiferal fauna. The frequencies of the species within each fossiliferous sample were determined from counts of a hundred individuals. The different species associations were compared by means of a principal components analysis. The association patterns found were graphed and combined with the lithological sequence of the profiles. Based on the frequencies of the taxa, the palaeoecology of the deposits was estimated according to the ecological data of similar taxa in the modern seas.

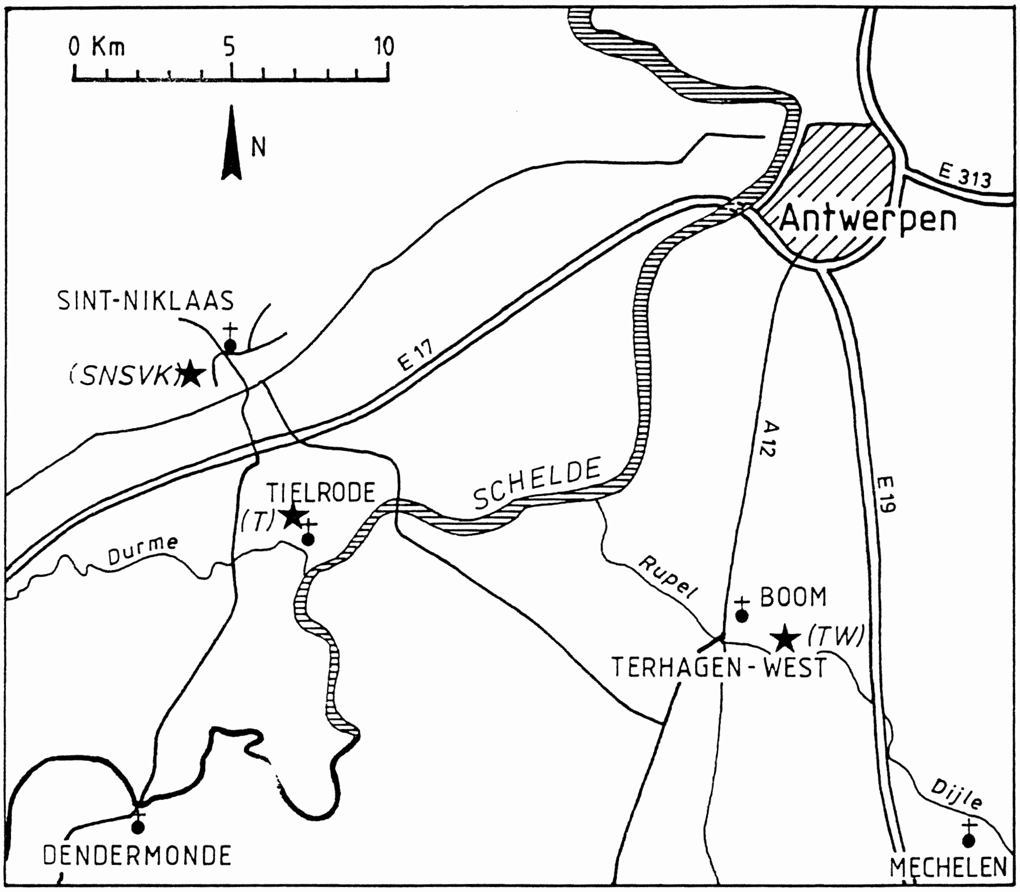


Fig. 1 : Location map of the studied quarries. (★)

II. LITHOSTRATIGRAPHY

The Boom Formation

The Boom clay is a banded gray silty clay or clayey silt. The bands, caused by rhythmic changes in silt, organic material, and lime percentages, have been numbered by VANDENBERGHE (1978). The type area of the formation lies along the Rupel river between Rumst and Boom and along the Scheldt river between Temse and Antwerp.
In the Rupel area, the Boom Formation can be subdivided into three members: the Belsele Clay Member, the Terhagen Clay Member and the Putte Clay Member (VANDENBERGHE, 1988). This work is a paleontological study of outcrops at Sint-Niklaas, Tielrode and Terhagen, each exposing one or more of these members.

a. The Belsele Clay Member
The name refers to the locality Belsele, near Sint-Niklaas. The Belsele Clay Member is exposed in the Scheerders-Van Kerkhoven quarry (S.V.K.). This member, which has rather silty sediments, especially in its lower part, composes the lower part of the Boom Clay. Its upward limit is defined by the first septaria level (S.10) or limestone band. In the silt horizons we observed several gully-like structures which we interpret to be caused by undulation of the sea water. This member is about 13 m in the Sint-Niklaas quarry, and 7 m thick in Tielrode.

b. The Terhagen Member
This name refers to the locality Terhagen between Boom and Rumst, where this member is exposed in the Landuyt and De Beukelaar quarries. The Terhagen Clay Member, which is gray and less silty than the Belsele Clay Member, composes the middle part of the Boom Formation. We observed several dark-colored levels with organic material. The lower part is particularly calcareous. The upper limit of the Terhagen Clay Member is placed between bands 31 and 32. It is about 24 m thick in Terhagen quarry, 10 m thick in Tielrode quarry and 3 m thick in Sint-Niklaas quarry.

c. The Putte Clay Member
The name refers to the village of Putte, in the southern part of the province of Antwerp, where the member is exposed. This member is characterized by alternating dark-colored levels with a lot of organic material and silty horizons. Generally the Putte Clay is darker gray than the Terhagen Clay. The Putte Clay Member is covered by sediments of Pliocene, Miocene or Oligocene age. In Terhagen quarry, it is about 9 m thick.

III. FORAMINIFERAL ASSOCIATIONS

a. Methods

Up to a hundred specimens of benthonic foraminifera were counted in the fifty fossiliferous samples studied. Planktonic foraminifera were not included in these counts. The results are given in table 1 (A,B,C). The associations of benthonic foraminifera could be compared throughout the outcrop sections. A principal component analysis of the numerical data was carried out in order to determinate the association structure. A similar factor analytic approach was used for the description of benthonic foraminiferal associations of the Oued Hammon Formation in Tunisia (DE MEUTER & SYMONS, 1973) and the Edegem Sands at Terhagen near Boom (SYMONS & DE MEUTER, 1974). The fluctuations of the associations in the profiles can be described by means of restricted number of varimax rotated factors, characterized by well-defined patterns. The results of this principal component analysis are shown in fig. 3.

b. Results

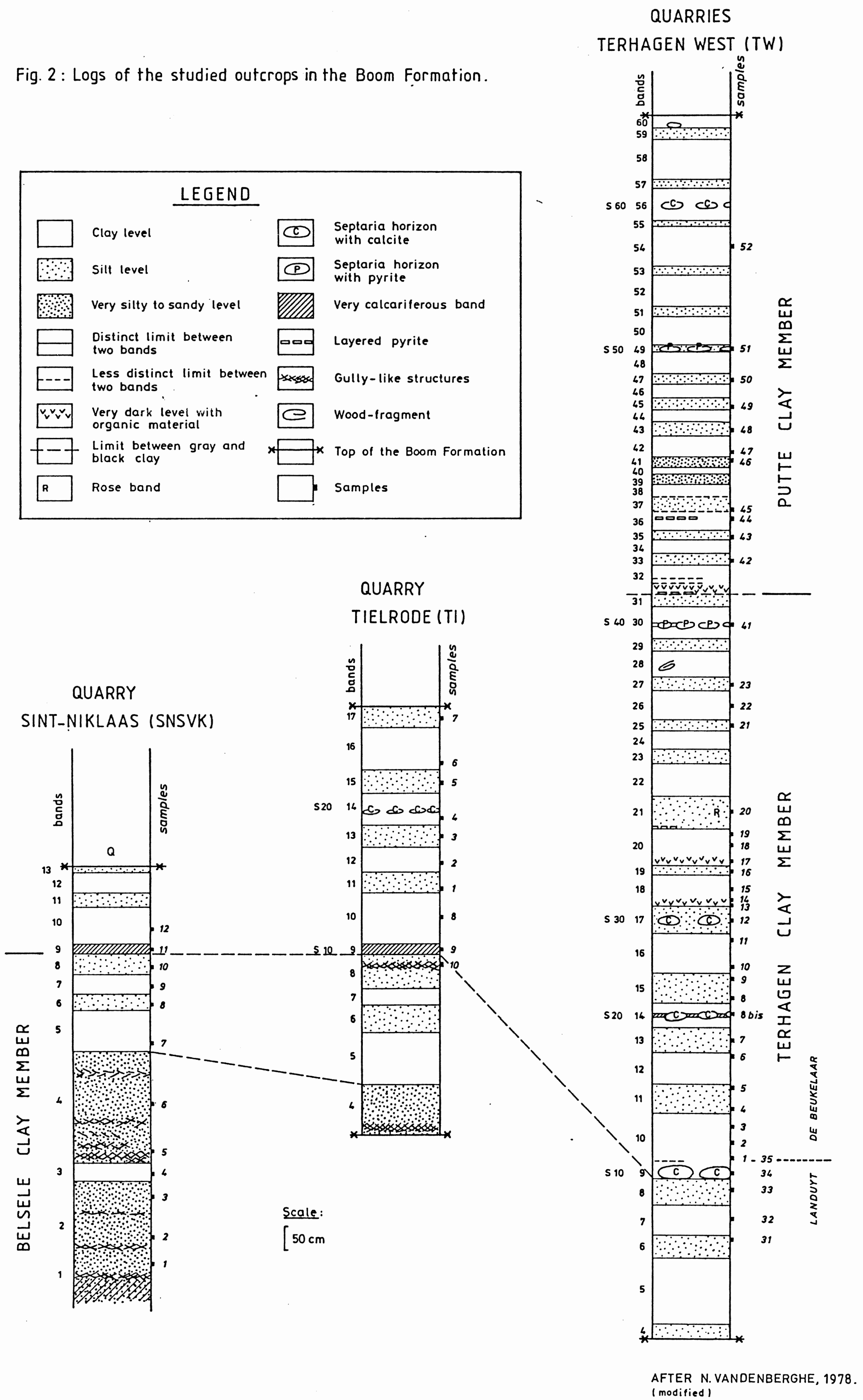
Seven uncorrelated reference variables, the varimax rotated factors, were determined from the principal component analysis. Each of these variables is characterized by an association of species in well-defined ratios. The "factor loadings" indicate the extent to which the samples contain a particular association. The most striking feature is the irregular fluctuation of the seven factors over the profiles. Most samples are characterized by one or two factors. Factors 1 and 2 which express respectively 38 % and 28 % of the global common variability, are especially important. Factor 1 has high frequencies of the species Sphaeroidina bulloides, Gyroidina soldanii, Heterolepa dutemplei, Melonis affinis, Globulina gibba, Globocassidulina oblonga, Dentalina emaciata and Eponides umbonatus. Sphaeroidina bulloides is the most frequent species.

Factor 2 is characterized by the species Trifarina gracilis, Heterolepa dutemplei, Cibicides tenellus, Gyroidina soldanii, Eponides pygmaeus and Globocassidulina oblonga. Trifarina gracilis is now clearly the most important species with a higher frequency than Sphaeroidina bulloides in factor 1.

The factors 3 and 4 can be considered as concerned with characteristics of factors 1 and 2; By the reduction in amounts of Sphaeroidina bulloides and Trifarina gracilis in these factors the species Heterolepa dutemplei and Globocassidulina oblonga acquire more weight.

The factors 5, 6 and 7 are each characterized by a separate association, including a great number of species of which one stands out above all others. The most

Fig. 2 : Logs of the studied outcrops in the Boom Formation.



A. BOOM FORMATION

OUTCROPS	SINT NIKLAAS (SNSVK)								TIELRODE (TI)								TERHAGEN WEST (TW)																							TERHAGEN WEST		
SAMPLES Nº	3	5	7	8	9	10	11	12	10	9	8	3	4	5	6	7	31	33	34	35	1	2	3	4	5	6	7	8b	8	9	10	11	12	13	14	15	16	18	41	43	46	51
Spiroplectammina carinata	3	3				3	2	1	5	1	2		1	1	7		1	1			5		1	1		1		1	1	2	3	3		2	5	3	3	1				
Spiroplectammina deperdita		1	2	1	2	5	1	1	1	3		1		1		3		5		1	2	2		1	4	1											2					
Spiroplectammina pectinata				1		4	3			2						1		1	1	1	3	3	2	1	1	1	1	3	2	5	4	3	12	2	2		4	6		1		
Textularia sp. cf. *T. gramen*		1			1	2	2					3								1			1						1				1									
Textularia spp.							2		3		1	1				1								2						1										1		
Siphotextularia labiata	6	5	4	2		3		1	3	1		3		5	5	1	3	1			5	1	2	1	3	1			1	3			8	1			3	1				
Karreriella chilostoma	1	1		1		1	1		1	1	1		1			1		1	4			1	2				1	1	1		1	1	1			1	1		1			
Karreriella siphonella	3	3	1			2	1			1	2							1	1		1			1					1		2		2			1						
Martinottiella communis	1														1																											
Quinqueloculina ackeriana									1	2		1		2		1														1							1					
Quinqueloculina juleana																											1															
Nodosaria ewaldi						1					1	1		2	3					1				2		2			1	1	8	6			12	4	1	5		31		22
Nodosaria hirsuta																												1	1	2	5		1	1	1		2			5		
Nodosaria longiscata			1		1		1				1				1			1						1										1								
Nodosaria spinescens																									1																	
Dentalina communis														1		1																										
Dentalina emaciata	1			1	1	1		1	1		3	2	4	4	3	2			1	1	1			1	1	2	3		1	1	2		1	1	2	1	2			4		22
Dentalina soluta						1	1						1	2	1							1			3																	
Dentalina sp. cf. *D. guttifera*					1											1			1		2	1	1						1									3		2		11
Dentalina spp. & *Nodosaria* spp.	1	6	2	2	1						1				7			1					1	1	4	6	6						1		1	2	3			4	1	2
Lagena hexagona																					●																					
Lagena hispida												1	1	1																		1		1								
Lagena isabella					2			1		2		1					1					1			2	1					1											
Lagena sulcata				1	1			1	1								1		1				1			1				2	1											
Lagena tenuis										1			2												2				1	2	2			1								
Lenticulina spp.	1	1		1	1		1				1			1	3				1	1						3									1					1		1
Palmula oblonga																									1																	
Planularia auricula																						1																				
Saracenaria boettcheri																																	1									
Globulina gibba	1	5	4	3	3	1		1	2	3	3	4	3	4	1	3		1	2			2		8	4	4	9				2		2	5	1	1	1	1	1			
Globulina punctata												1		3	2										1																	

B.

OUTCROPS	SINT NIKLAAS (SNSVK)								TIELRODE (TI)							
SAMPLES Nº	3	5	7	8	9	10	11	12	10	9	8	3	4	5	6	7
Guttulina frankei		1				1								2	1	
Guttulina irregularis		1				1	1		1			1		2		
Guttulina problema	3	3				3					2	3		1	4	2
Pyrulina cylindroides		2				2									1	
Pyrulina fusiformis					2			1		1		1	1	1		
Glandulina laevigata		1									1					
Oolina lagenoides									1							
Fissurina laevigata		1		3	1					3	1	1		1		
Turrilina alsatica	3		1	6			1					1				
Sphaeroidina bulloides	16	9	6	8	14	16	22	5	19	24	22	22	23	24	16	12
Bolivina beyrichi		1				1					1	4		2		3
Bolivina melettica	1				1											
Bulimina alsatica																
Bulimina elongata						1										
Trifarina gracilis	2	2	35	40	19	5	19	47	10	8	5	1	7			7
Epistominella oveyi																
Asterigerina gueruchi																
Protelphidium granosum							●									
Eponides pygmaeus				5		1			4	3	1	2	4	2	6	
Cibicides sp. cf. C. lobatulus		2			1				1	3	2	2	2	2	2	5
Cibicides sulzensis		2	2		2		5		1	1			5		2	2
Cibicides tenellus	11	2	10	5	8	2	1		1	1	1	5	4	4	6	5
Loxostomum minutissimum	3		4													
Loxostomum teretum		1														
Cassidulina neocarinata			4		3	3			1	1						
Globocassidulina oblonga	5	9	4	1	6	4	6	9	5	10	5	3	12	3	7	
Globocassidulina subglobosa		1			1											
Chilostomella cylindroides																
Quadrimorphina petrolei					2		1	3			1	1	1	5	2	19
Nonionella lobsannensis	2			1	1					1			3	4	1	2
Nonionella wemmelensis		1			1						1					2

OUTCROPS	TERHAGEN WEST (TW)																						
SAMPLES Nº	31	33	34	35	1	2	3	4	5	6	7	8b	8	9	10	11	12	13	14	15	16	18	41
Guttulina frankei			1					1									1					1	
Guttulina irregularis											2												
Guttulina problema			3			2		2	4	2				1			3		3	1	1	2	2
Pyrulina cylindroides	1		1								1									1			
Pyrulina fusiformis																							
Glandulina laevigata									1		1												
Oolina lagenoides																							
Fissurina laevigata	1					2			1	1				2		1							
Turrilina alsatica	2	6		1	1	1		1	4	3	1		1					8	8	8	6	8	40
Sphaeroidina bulloides	4	5	31	13	7	5	7	14	15	18	20	17	15	25	11	6	5	7	8	16	10	11	9
Bolivina beyrichi				3	1	3	1							2	3	3		4	3	1	1	1	
Bolivina melettica																							
Bulimina alsatica																							
Bulimina elongata																							
Trifarina gracilis	54	4	5	26	22	23	16	2	5	5	12	18	2	3	5	4	4	21	2	9	13	10	
Epistominella oveyi																							
Asterigerina gueruchi																							
Protelphidium granosum																							
Eponides pygmaeus	2	3	5	5		8	3	1	4	7	4	2	3	1	1	5	3	2	2	5	3	3	1
Cibicides sp. cf. C. lobatulus	2	3	2	1	3		4			4	1	2		2	1	2	2	2	2	1	3	1	1
Cibicides sulzensis		1	2		4	3	1	2	1	3		3	5	1	2	4		2	1	1			3
Cibicides tenellus	1	2	2	3	1	5	13	11	2	10	3	2	6	4	4	3	2	4	11	5	4	14	2
Loxostomum minutissimum						1		1														1	
Loxostomum teretum		1																					
Cassidulina neocarinata	5	5			2	3	2			3							2						
Globocassidulina oblonga	1	8	9	13	5	2	11	5	10	2	3	2	13	6	14	33	16	15	4	7	7	7	15
Globocassidulina subglobosa							2			1		1	2								1		
Chilostomella cylindroides																							
Quadrimorphina petrolei			1	1							2	2	1	4	10	1	2			3		3	1
Nonionella lobsannensis			1		1				2		3	1					4	1					
Nonionella wemmelensis										1			1										

OUTCROPS	TERHAGEN WEST		
SAMPLES Nº	43	46	51
Guttulina frankei	1		
Guttulina irregularis	1		
Guttulina problema			1
Pyrulina cylindroides			3
Pyrulina fusiformis			1
Glandulina laevigata			
Oolina lagenoides			
Fissurina laevigata			
Turrilina alsatica		34	9
Sphaeroidina bulloides	1	2	
Bolivina beyrichi	18	9	
Bolivina melettica	16	16	3
Bulimina alsatica			2
Bulimina elongata			
Trifarina gracilis	1	2	2
Epistominella oveyi			1
Asterigerina gueruchi			2
Protelphidium granosum			
Eponides pygmaeus		1	2
Cibicides sp. cf. C. lobatulus			2
Cibicides sulzensis			
Cibicides tenellus	1	2	
Loxostomum minutissimum			
Loxostomum teretum			
Cassidulina neocarinata			
Globocassidulina oblonga		16	
Globocassidulina subglobosa		5	2
Chilostomella cylindroides			2
Quadrimorphina petrolei			
Nonionella lobsannensis			1
Nonionella wemmelensis			

C.

OUTCROPS	SINT NIKLAAS (SNSVK)								TIELRODE (TI)								TERHAGEN WEST (TW)																							TERHAGEN WEST		
SAMPLES Nº	3	5	7	8	9	10	11	12	10	9	8	3	4	5	6	7	31	33	34	35	1	2	3	4	5	6	7	8b	8	9	10	11	12	13	14	15	16	18	41	43	46	51
Pullenia bulloides	1		3	1	1								1	1	1	1		2										2	3	2			2		2			1	1		5	3
Pullenia quinqueloba	1	1										1		1		1									1	1	1		3	1			1	1	1							
Alabamina tangentialis	11	3	2												1									1														1	7			1
Gyroidina soldanii	7	7	2	1	6	15	9	14	5	16	6	4	6	2	2	3	3	4	15	8	6	6	4	6	7	1	3	6	4		2	1	1		1	2	3	4	5	1	3	38
Oridorsalis umbonatus	1		1	2			1	1		1		1	1	1	2			1	1	1	2	1					1	1	2	3		2	1		1					1		
Svratkina perlata		2			1				1			2			1	1		1								1	1	1	3	1			2				1	1		2		
Heterolepa dutemplei	4	8	5	6	13	11	15	2	4	4	7	11	7	6	7	5	17	22	3	4	17	7	2	7	1	6	14	22	12	12	4	5	18	6	14	6	8	8	2	1		
Melonis affinis	10	13	2	5	3	4		1	2	4	4		3	7	2	9		3	2	7	5	7	4	4	3	4	4	9	6	6	9	6	8	6	2	2	4	3	2		1	
Ceratobulimina contraria	1	1				6	1	9		1	3	4	6		1			5		2	2	4	3	6	1		1	2	3	1	3			2	3	7	5	3				
Hoeglundina elegans																																										10
Robertina declivis												2																														
Number of planctonic taxa per 100 bentonic taxa	17	26	6	7	12	1	63	17	4	31	21	81	40	88	55	69		2	24	46	11	2	3	3	5	3	34	34	29	21	44	34	23	60	7	26	43	87	9	13	1	21

Table 1 (A-B-C): Distribution of benthonic foraminifera in the outcrops. (St. Niklaas, Tielrode and Terhagen)
(• : less than 1%)

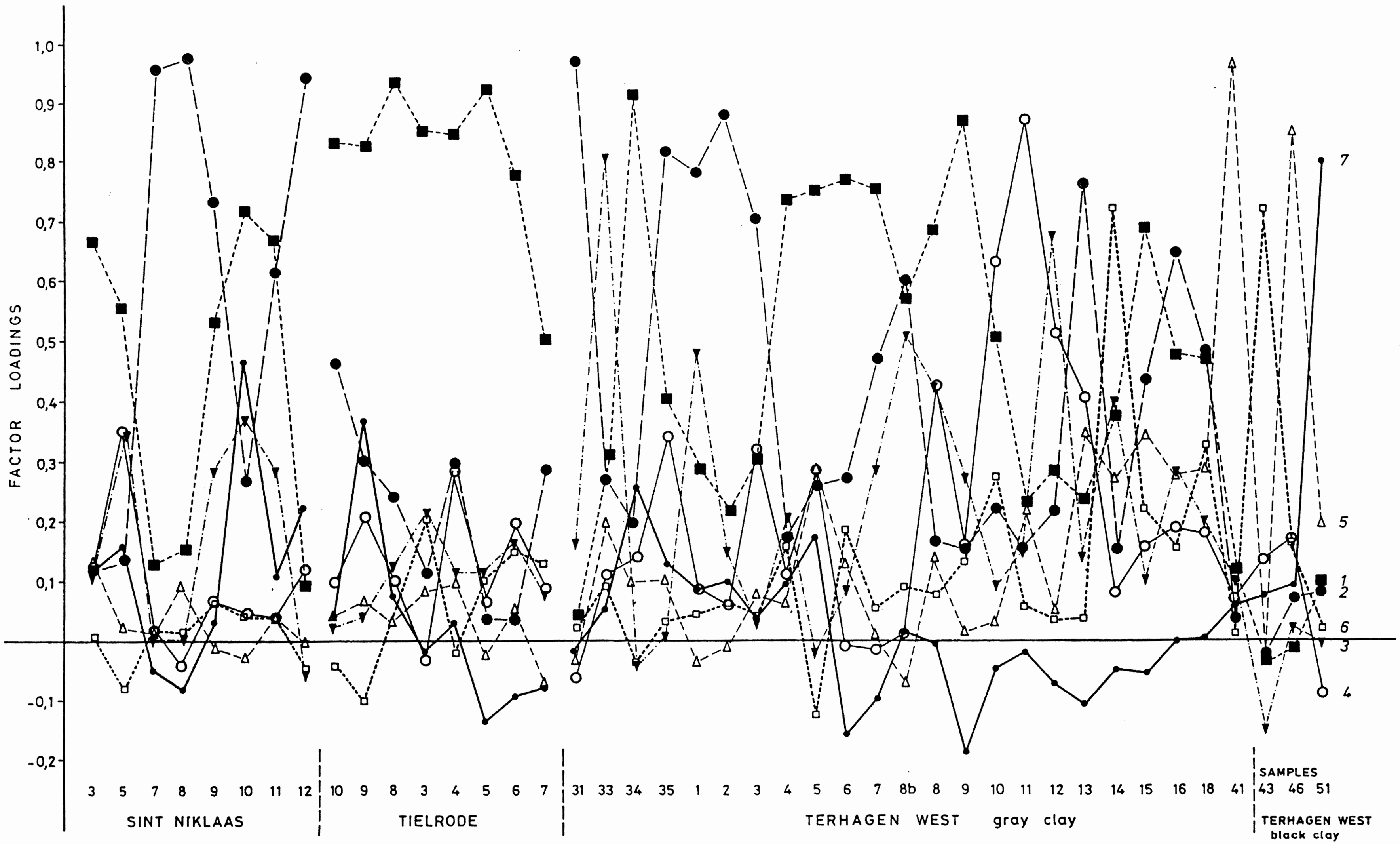


Fig. 3 : Loadings of seven varimax rotated factors characterizing the association patterns of the fossiliferous samples in the Boom Formation at Sint Niklaas, Tielrode and Terhagen.

important species of factor 5 is Turrilina alsatica, of factor 6 Nodosaria ewaldi and of factor 7 Gyroidina soldanii. In the factors 5, 6 and 7 some species become more frequent than in the first four factors, namely Bolivina beyrichi, Bolivina melettica and Hoeglundina elegans. In figure 3 the samples can be defined in two groups: the first described by the factors 1 and 2 and to a lesser extent by the factors 3 and 4; the second by high rates of factors 5, 6 and 7.

c. Comparison with the lithology

Comparison of the association pattern with the lithological data leads to several conclusions. A coarse division can be made into an underlying and an upperlying packet of samples. The first group includes the samples from Sint-Niklaas, Tielrode and the lower most samples from Terhagen-West (up to and including TW 18) and is characterized by high values of one or more factors 1, 2, 3 and 4. The uppermost samples TW 41, 43, 46 and 51 from Terhagen-West show alternating high scores on the factors 5, 6 and 7. This transition nearly coincides with the boundary between the underlying Terhagen Clay Member and the overlying Putte Clay Member.
The samples from the quarry Sint-Niklaas, Belsele Clay Member, have fluctuating high values of factors 1 and 2. However, there is no obvious relation with the alternating layers of more silty and more clayey sediments. Also, in the samples from Tielrode, the Terhagen Clay Member shows a high score on factor 1, whilst the corresponding samples from Terhagen-West (TW 31 - TW 12) have high values of both factors 1 and 2. The scores on factors 1 and 2 of Terhagen-West are more and more disturbed by higher values, first of factors 3 and 4 (from TW 10), and later of factors 5 and 6 (from TW 13). As noted above, factors 5 and 6 dominate in the sample TW 41, 43 and 46, followed by factor 7 in sample TW 51.
Finally a finer comparison of some samples with the corresponding silty or clayey composition of the sediment, reveals no evidence of correlation. The samples from Tielrode show a homogeneously high value of factor 1 but are typically characterized by alternating silty and clayey layers. On the other hand, the samples with the clayey layer from Terhagen-West (TW 13, 14 and 15) have totally different scores. In spite the difficulties of comparing sedimentology and foraminiferal associations, it is remarkable that there is in both cases a continuously alternating relationship of the variables. Furthermore, the numbers of planktonic specimens fluctuate independently of both benthonic foraminifera and lithology. In all cases we suppose a continuous change of ecological factors during the deposition of these sediments.

IV. PALAEOECOLOGICAL SIGNIFICANCE OF THE BENTHONIC FORAMINIFERA IN THE BOOM FORMATION

The composition of the benthonic foraminiferal populations is certainly influenced by different (palaeo-) ecological factors e.g. depth, temperature, salinity and bottom conditions. The information about the ecological influence on the distribution of benthonic foraminifera can be projected on generic level on fossil material at least down to the Cretaceous/Tertiary boundary. Several authors supply information about these influence. We especially consulted the work of PHLEGER (1960), BANDY (1960), MURRAY (1973), HAYNES (1981) and EDWARDS (1982) to interpret the palaeoecological significance of the benthonic foraminiferal genera occurring in the Boom Formation.

Agglutinated foraminifera occur on the abyssal plain of the sea as well as brackish, marginal marine environments. This group tolerates lower oxygen levels. In particular Textularia prefers normal marine conditions and a silty or sandy sea bottom at different depths and in wide range of temperature. Agglutinated foraminifera with more complex morphological features such as Siphotextularia and Karreriella (with siphonate aperture) occur preferably at greater depth. In a normal marine sea with a muddy sedimentation they occur most frequently between 100 and 150 m.

Miliolids, rarely represented in the Boom Formation by the genus Quinqueloculina, prefer a shallow sea with a characteristic carbonate environment, normal to hypersaline conditions and seaweed and seagrass with high turbulence or energy. They occur but rarely in deeper waters.

The Nodosariidae most frequently occur in a middle to inner neritic environment of a normal marine sea. Lagena prefers a muddy sedimentation on the continental shelf in cold to tropical temperatures. Lenticulina usually occurs from the outer shelf to bathyal depth with a muddy sedimentation in a normal marine sea. Globulina and Guttulina occur more frequently in an inner shelf area.

Fissurina survives in normal marine conditions with preference of a muddy sedimentation on the continental shelf and the globular Sphaeroidina occurs most frequently below 100 m under reduced current activity and on a fine-grained substrate.

Buliminidae occur in a wide depth range from shallow waters on the abyssal plain but are most abundant on the outer shelf and on the uppermost continental slope. Bolivina prefers a salinity of 32 to 36 per mile on a muddy bottom. It shows marked morphological trends: the shelf species are less ornamented and spinose species (represented by Bolivina beyrichi in the Boom Formation) occur more frequently at greater depth. This applies also to Trifarina (Trifarina gracilis).

Eponides prefers a shelf or bathyal depth in a normal marine sea.

The Cibicides group occurs most frequently in an inner shelf area of a normal marine sea with a sandy or

gravelly substrate, to which it is attached. The abundance of the species Cibicides lobatulus decreases with increasing distance from the shore and with increasing depth. At greater depth, the individuals are small, more symmetrical and they do not show a large degree of morphological variation.
Cassidulina and Gyroidina prefer a muddy sedimentation in a cold to temperate normal marine sea at shelf to bathyal depth. Nonionella too, likes a muddy sedimentation on the shelf or at bathyal depth in a normal marine sea but with temperate to subtropical conditions.
Hoeglundina, which we found especially in the Putte Clay Member, prefers a muddy sedimentation below 150 m in a normal marine sea.

V. CONCLUSIONS

The Boom Formation was accumulated in a normal marine sea. The Sphaeroidina bulloides, the Trifarina gracilis and the Heterolepa dutemplei - Globocassidulina oblonga associations reflect a central shelf environment (100 m) of clay deposition, while the Turrilina alsatica, the Nodosaria ewaldi and Gyroidina soldanii associations with Bolivina beyrichi, Bolivina melettica and Hoeglundina elegans indicate a deepening of the sea to an outer shelf environment (150 m) with accumulation of organic material under reduced current activity during the deposition of the Putte Clay Member. Although the occurrence of several taxa is distinctly influenced by the fine-grained sedimentation, we observed no distinct difference between the populations from silty and from clay levels. The temperature of the sea water probably did not reach subtropical values. The presence of a fairly high quantity of planktonic foraminifera indicates an open marine connection.

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PLATES I to V

Benthonic foraminifera from the Boom Formation

PLATE I

Fig. 1:	Spiroplectammina carinata (D'ORBIGNY, 1946)	Sample TW1	x 68
Fig. 2:	Spiroplectammina carinata (D'ORBIGNY, 1846)	Sample TW1	x 45
Fig. 3:	Spiroplectammina deperdita (D'ORBIGNY, 1846)	Sample TW1	x 35
Fig. 4:	Spiroplectammina deperdita (D'ORBIGNY, 1846)	Sample TW1	x 55
Fig. 5:	Spiroplectammina pectinata (REUSS, 1850)	Sample TW1	x 80
Fig. 6:	Spiroplectammina pectinata (REUSS, 1850)	Sample TW1	x 68
Fig. 7:	Textularia sp. cf. T. gramen (D'ORBIGNY, 1846)	Sample SNSVK11	x 48
Fig. 8:	Textularia sp. cf. T. gramen (D'ORBIGNY, 1846)	Sample TW8	x 72
Fig. 9:	Siphotextularia labiata (REUSS, 1861)	Sample TW1	x 35
Fig. 10:	Karreriella chilostoma (REUSS, 1852)	Sample TW1	x 83
Fig. 11:	Karreriella siphonella (REUSS, 1851)	Sample SNSVK11	x 36
Fig. 12:	Karreriella siphonella (REUSS, 1851)	Sample TW1	x 43
Fig. 13:	Martonotiella communis (D'ORBIGNY, 1826)	Sample SNSVK11	x 32
Fig. 14:	Quinqueloculina ackneriana D'ORBIGNY	Sample TW8	x100
Fig. 15:	Quinqueloculina ackneriana D'ORBIGNY	Sample TW8	x 85
Fig. 16:	Quinqueloculina juleana (D'ORBIGNY, 1846)	Sample TW7	x 97
Fig. 17:	Nodosaria ewaldi REUSS, 1851	Sample SNSVK11	x 37
Fig. 18:	Nodosaria ewaldi REUSS, 1851	Sample TW8	x 27
Fig. 19:	Nodosaria hirsuta D'ORBIGNY, 1826	Sample TI4	x 23
Fig. 20:	Nodosaria hirsuta D'ORBIGNY, 1826	Sample TW8	x 44
Fig. 21:	Nodosaria longiscata D'ORBIGNY, 1846	Sample TW8	x 49
Fig. 22:	Nodosaria spinescens (REUSS, 1851)	Sample TW43	x 38
Fig. 23:	Dentalina communis D'ORBIGNY, 1826	Sample TW8	x 57
Fig. 24:	Dentalina emaciata REUSS, 1851	Sample TI1	x 50

Pl. I

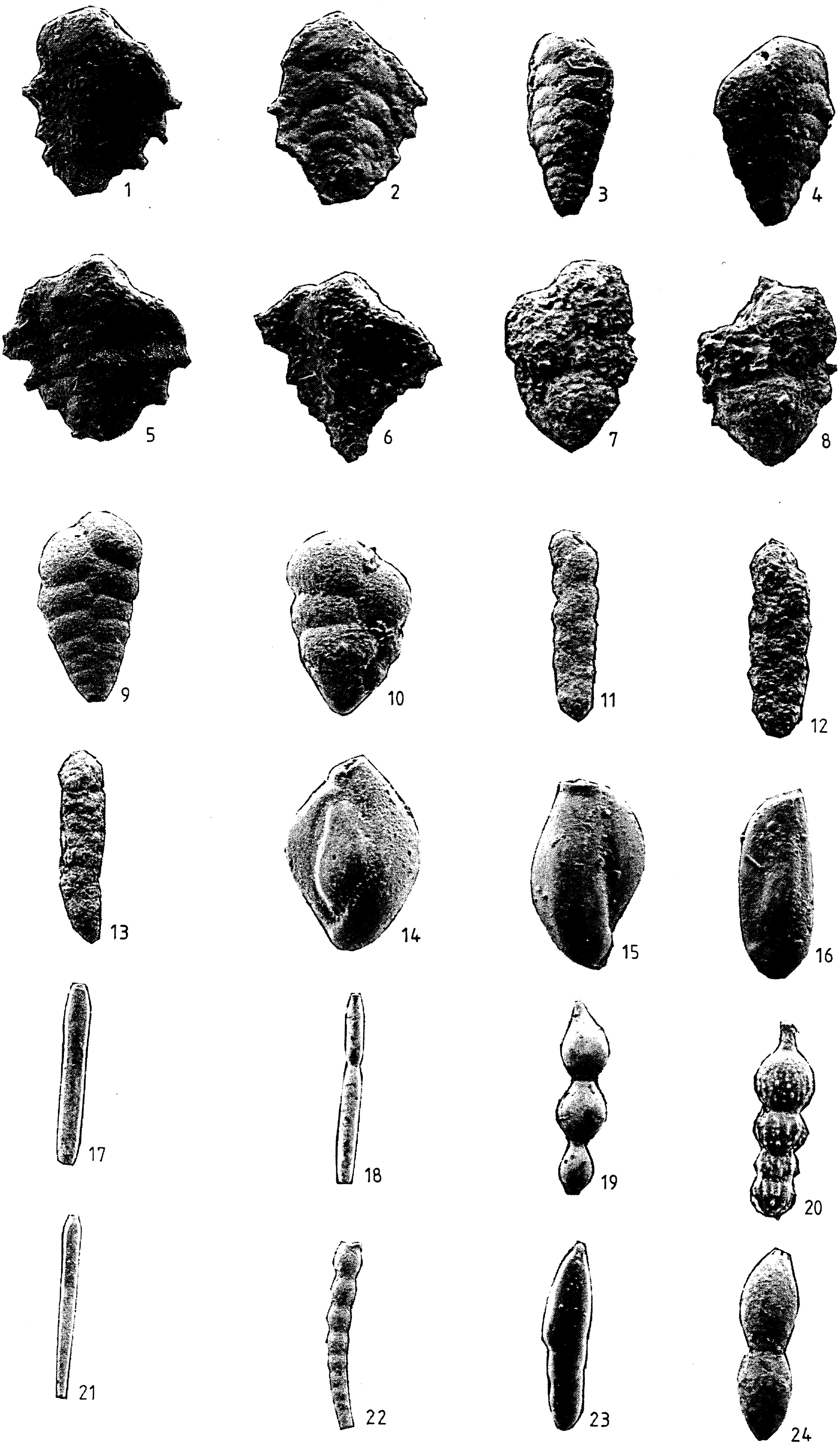

PLATE II

Fig. 1:	Dentalina emaciata REUSS, 1851	Sample TW7	x 50
Fig. 2:	Dentalina soluta REUSS, 1851	Sample TW1	x 20
Fig. 3:	Dentalina soluta REUSS, 1851	Sample TW8	x 47
Fig. 4:	Dentalina sp. cf. D. guttifera D'ORBIGNY, 1846	Sample TW1	x127
Fig. 5:	Dentalina sp. cf. D. guttifera D'ORBIGNY, 1846	Sample TW1	x 88
Fig. 6:	Lagena hexagona (WILLIAMSON, 1848)	Sample TW1	x145
Fig. 7:	Lagena hispida REUSS, 1858	Sample TI4	x160
Fig. 8:	Lagena hispida REUSS, 1858	Sample TW1	x160
Fig. 9:	Lagena isabella (D'ORBIGNY, 1839)	Sample TW1	x160
Fig. 10:	Lagena isabella (D'ORBIGNY, 1839)	Sample TW1	x188
Fig. 11:	Lagena sulcata (WALKER & JACOB, 1798)	Sample TW1	x160
Fig. 12:	Lagena sulcata (WALKER & JACOB, 1798)	Sample TW1	x160
Fig. 13:	Lagena tenuis (BORNEMANN, 1855)	Sample TW1	x 85
Fig. 14:	Lagena sp. cf. L. tenuis (BORNEMANN, 1855)	Sample TW5	x132
Fig. 15:	Lenticulina sp.	Sample TW1	x 64
Fig. 16:	Lenticulina sp.	Sample TW1	x 66
Fig. 17:	Palmula oblonga (ROEMER, 1838)	Sample TW51	x 17
Fig. 18:	Planularia auricula (ROEMER, 1838)	Sample TW1	x 13
Fig. 19:	Saracenaria boettcheri (REUSS, 1863)	Sample TW1	x 13
Fig. 20:	Saracenaria boettcheri (REUSS, 1863)	Sample TW12	x 34
Fig. 21:	Globulina gibba D'ORBIGNY, 1826	Sample TW1	x 95
Fig. 22:	Globulina gibba D'ORBIGNY, 1826	Sample TW1	x 83
Fig. 23:	Globulina punctata D'ORBIGNY, 1846	Sample TW1	x120
Fig. 24:	Globulina punctata D'ORBIGNY, 1846	Sample TW8	x110

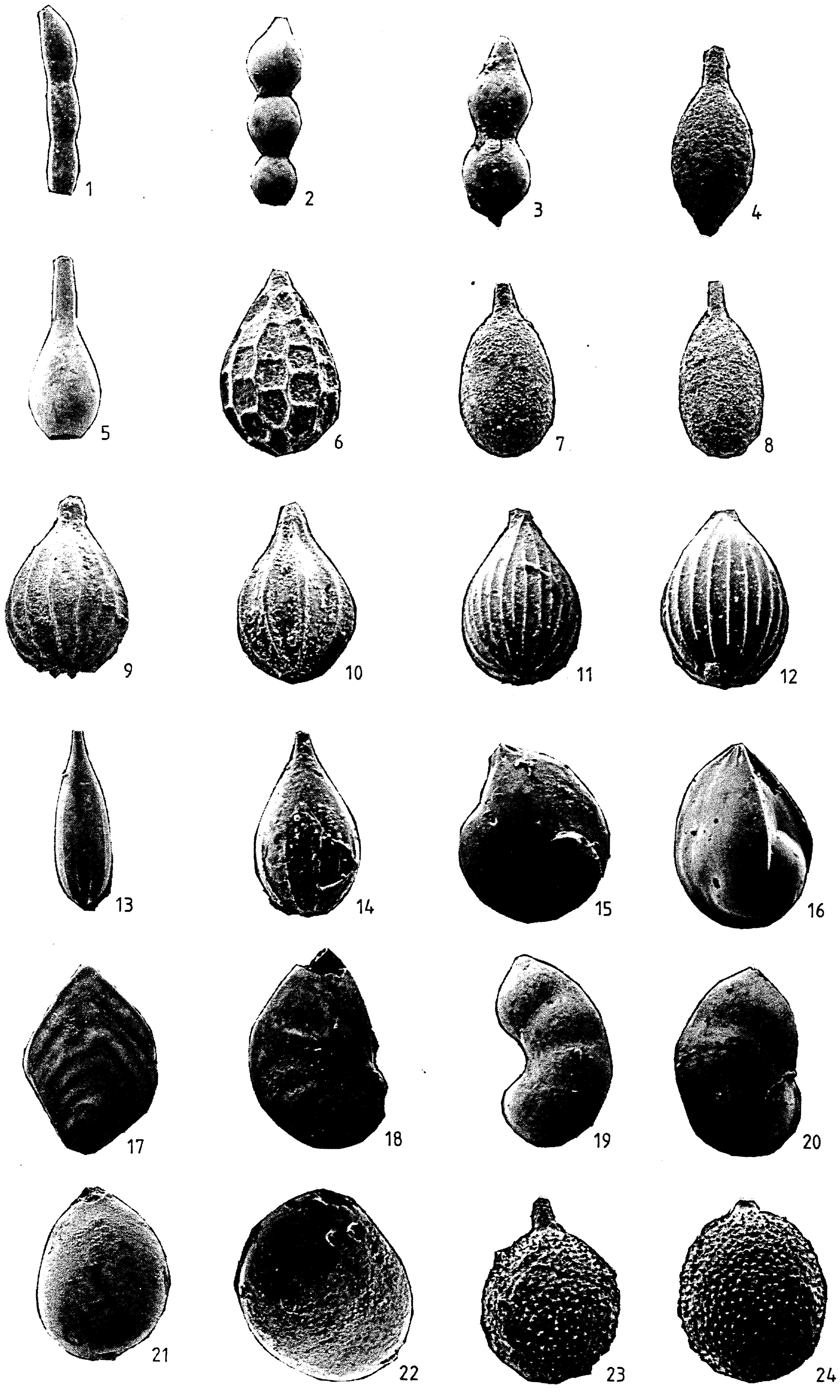
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PLATE III

Fig. 1:	Guttulina frankei	CUSHMAN & OZAWA, 1930	Sample TW1	x 60
Fig. 2:	Guttulina frankei	CUSHMAN & OZAWA, 1930	Sample TW8	x 88
Fig. 3:	Guttulina irregularis	(D'ORBIGNY, 1826)	Sample TW8	x 43
Fig. 4:	Guttulina irregularis	(D'ORBIGNY, 1826)	Sample TW8	x 60
Fig. 5:	Guttulina problema	(D'ORBIGNY, 1826)	Sample TW1	x 88
Fig. 6:	Guttulina problema	(D'ORBIGNY, 1826)	Sample TW1	x 83
Fig. 7:	Pyrulina cylindroidis	(ROEMER, 1838)	Sample SNSVK11	x110
Fig. 8:	Pyrulina cylindroidis	(ROEMER, 1838)	Sample TW1	x 54
Fig. 9:	Pyrulina fusiformis	(ROEMER, 1838)	Sample TW1	x 65
Fig. 10:	Glandulina laevigata	(D'ORBIGNY, 1826)	Sample TW1	x 34
Fig. 11:	Oolina lagenoides	(WILLIAMSON, 1838)	Sample TI10	x132
Fig. 12:	Fissurina laevigata	REUSS, 1850	Sample TW1	x213
Fig. 13:	Fissurina laevigata	REUSS, 1850	Sample TW1	x124
Fig. 14:	Turrilina alsatica	ANDREAE, 1884	Sample TW1	x188
Fig. 15:	Turrilina alsatica	ANDREAE, 1884	Sample TW1	x183
Fig. 16:	Sphaeroidina bulloides	D'ORBIGNY, 1826	Sample TW1	x 32
Fig. 17:	Bolivina beyrichi	REUSS, 1851	Sample TW1	x 45
Fig. 18:	Bolivina beyrichi	REUSS, 1851	Sample TW1	x 45
Fig. 19:	Bolivina melettica	ANDREAE, 1884	Sample TW46	x 44
Fig. 20:	Bolivina melettica	ANDREAE, 1884	Sample TW46	x 50
Fig. 21:	Bulimina alsatica	CUSHMAN & PARKER, 1937	Sample TW1	x124
Fig. 22:	Bulimina alsatica	CUSHMAN & PARKER, 1937	Sample TW51	x 80
Fig. 23:	Bulimina elongata	D'ORBIGNY, 1846	Sample TI1	x 80
Fig. 24:	Trifarina gracilis	(REUSS, 1851)	Sample SNSVK11	x 95


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PLATE IV

Fig. 1: Trifarina gracilis
(REUSS, 1851) Sample SNSVK11 x116
Fig. 2: Trifarina gracilis
(REUSS, 1851) Sample SNSVK11 x 98
Fig. 3: Epistominella oveyi
BHATIA, 1955 Sample TW51 x109
Fig. 4: Asterigerina guerichi
(FRANKE, 1912) Sample TW51 x109
Fig. 5: Asterigerina guerichi
(FRANKE, 1912) Sample TW51 x127
Fig. 6: Protelphidium granosum
(D'ORBIGNY, 1846) Sample SNSVK11 x128
Fig. 7: Eponides pygmaeus
(VON HANTKEN, 1875) Sample TI2 x200
Fig. 8: Eponides pygmaeus
(VON HANTKEN, 1875) Sample TI2 x248
Fig. 9: Cibicides sp. cf. C. lobatulus
(WALKER & JACOB, 1798) Sample TW1
x 40
Fig. 10: Cibicides sp. cf. C. lobatulus
(WALKER & JACOB, 1798) Sample TW1
x106
Fig. 11: Cibicides sulzensis
(HERRMANN, 1917) Sample SNSVK11 x120
Fig. 12: Cibicides sulzensis
(HERRMANN, 1917) Sample SNSVK11 x103
Fig. 13: Cibicides tenellus
(REUSS, 1865) Sample TW8 x112
Fig. 14: Cibicides tenellus
(REUSS, 1865) Sample TW8 x106
Fig. 15: Loxostomum minutissimum
(SPANDEL, 1909) Sample TW1 x103
Fig. 16: Loxostomum teretum
(CUSHMAN, 1936) Sample SNSVK5 x 83
Fig. 17: Cassidulina neocarinata
THALMAN, 1950 Sample TW1 x 98
Fig. 18: Cassidulina neocarinata
THALMAN, 1950 Sample TW1 x124
Fig. 19: Globocassidulina oblonga
(REUSS, 1850) Sample TW8 x206
Fig. 20: Globocassidulina oblonga
(REUSS, 1850) Sample TW8 x165
Fig. 21: Globocassidulina subglobosa
(BRADY, 1881) Sample SNSVK11 x120
Fig. 22: Chilostomella cylindroides
REUSS, 1851 Sample TW51 x 31
Fig. 23: Chilostomella cylindroides
REUSS, 1851 Sample TW8 x 50
Fig. 24: Quadrimorphina petrolei
(ANDREAE, 1884) Sample TW8 x112

Pl. IV

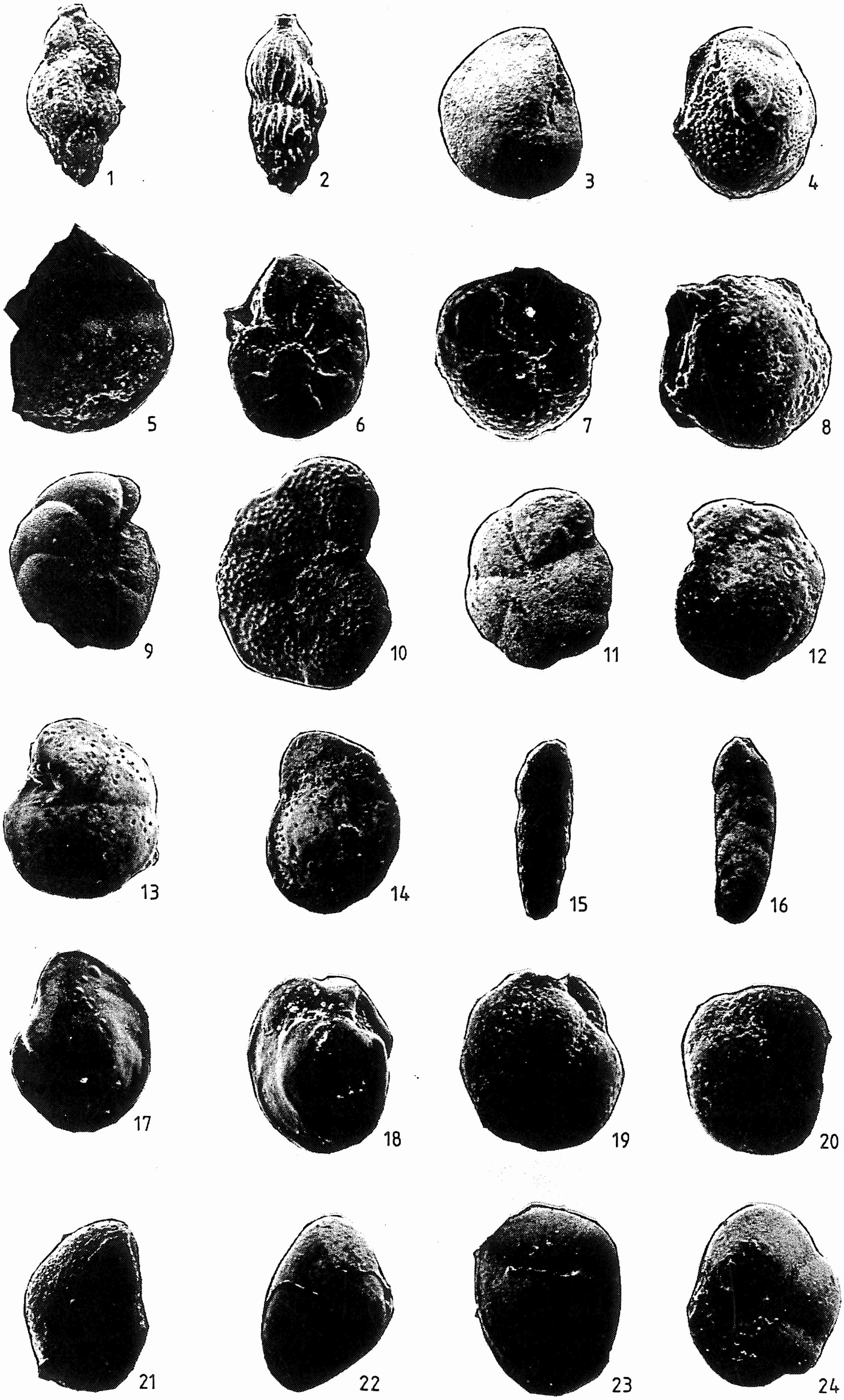
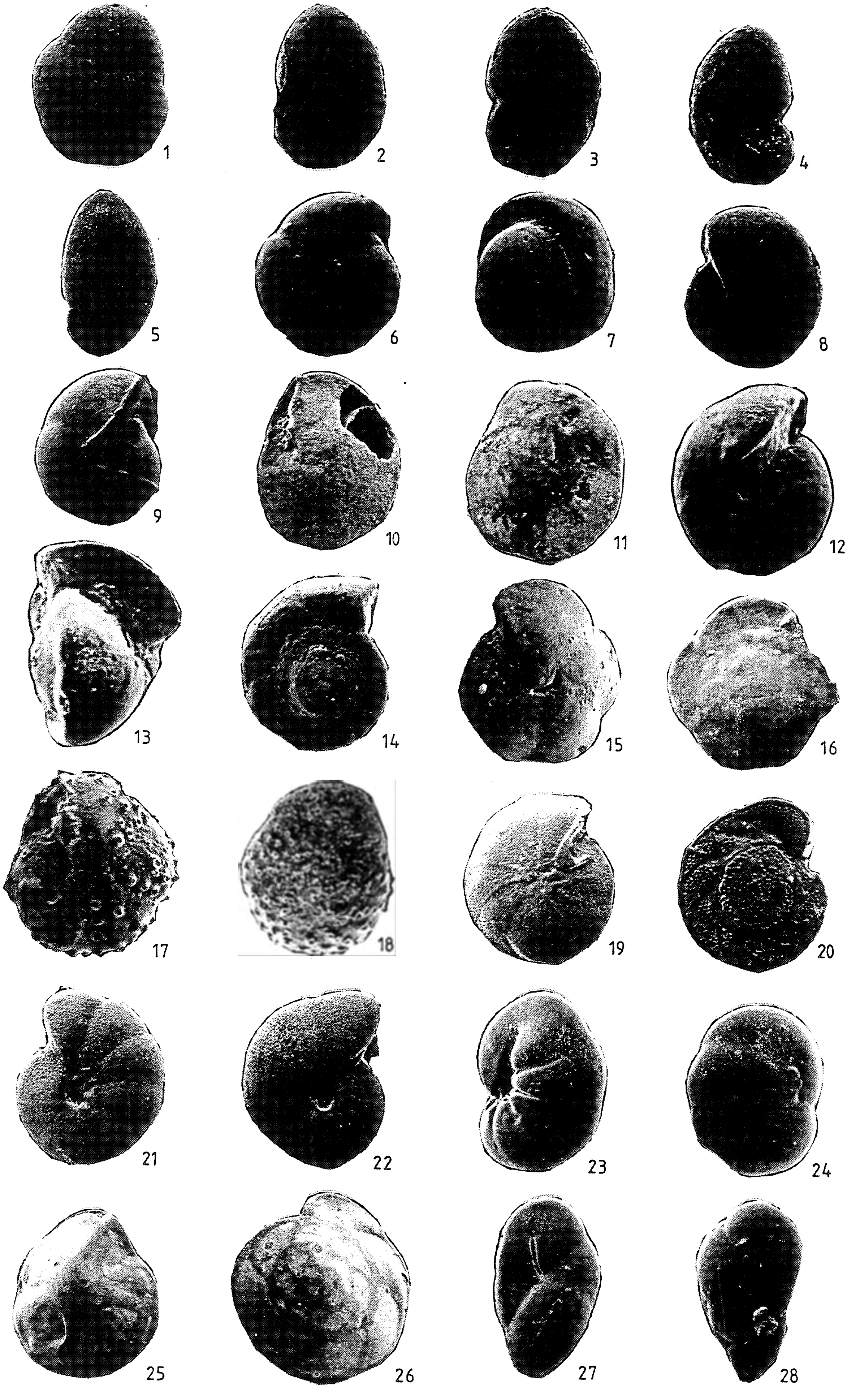


PLATE V

Fig. 1:	Quadrimorphina petrolei			
	(ANDREAE, 1884)	Sample	TW8	x 89
Fig. 2:	Nonionella lobsannensis			
	(ANDREAE, 1884)	Sample	TW8	x155
Fig. 3:	Nonionella lobsannensis			
	(ANDREAE, 1884)	Sample	TW8	x160
Fig. 4:	Nonionella wemmelensis			
	KAASSCHIETER, 1961	Sample	TW8	x138
Fig. 5:	Nonionella wemmelensis			
	KAASSCHIETER, 1961	Sample	TW8	x183
Fig. 6:	Pullenia bulloides			
	(D'ORBIGNY, 1846)	Sample	TW8	x107
Fig. 7:	Pullenia bulloides			
	(D'ORBIGNY, 1846)	Sample	TW8	x124
Fig. 8:	Pullenia quinqueloba			
	(REUSS, 1851)	Sample	TW8	x124
Fig. 9:	Pullenia quinqueloba			
	(REUSS, 1851)	Sample	TW8	x120
Fig. 10:	Alabamina tangentialis			
	(CLODIUS, 1922)	Sample	SNSVK3	x113
Fig. 11:	Alabamina tangentialis			
	(CLODIUS, 1922)	Sample	SNSVK3	x120
Fig. 12:	Gyroidina soldani			
	(D'ORBIGNY, 1826)	Sample	TW8	x 99
Fig. 13:	Gyroidina soldani			
	(D'ORBIGNY, 1826)	Sample	TW8	x 97
Fig. 14:	Gyroidina soldani			
	(D'ORBIGNY, 1826)	Sample	TW8	x 83
Fig. 15:	Oridorsalis umbonatus			
	(REUSS, 1851)	Sample	TW8	x 93
Fig. 16:	Oridorsalis umbonatus			
	(REUSS, 1851)	Sample	TW8	x 66
Fig. 17:	Svratkina perlata			
	(ANDREAE, 1884)	Sample	SNSVK8	x155
Fig. 18:	Svratkina perlata			
	(ANDREAE, 1884)	Sample	SNSVK8	x132
Fig. 19:	Heterolepa dutemplei			
	(D'ORBIGNY, 1846)	Sample	TW8	x 38
Fig. 20:	Heterolepa dutemplei			
	(D'ORBIGNY, 1846)	Sample	TW8	x 40
Fig. 21:	Melonis affinis			
	(REUSS, 1851)	Sample	TW8	x 88
Fig. 22:	Melonis affinis			
	(REUSS, 1851)	Sample	TW8	x 93
Fig. 23:	Ceratobulimina contrari			
	(REUSS, 1851)	Sample	TW8	x 93
Fig. 24:	Ceratobulimina contrari			
	(REUSS, 1851)	Sample	TW8	x 85
Fig. 25:	Hoeglundina elegans			
	(D'ORBIGNY, 1826)	Sample	TW51	x 69
Fig. 26:	Hoeglundina elegans			
	(D'ORBIGNY, 1826)	Sample	TW51	x 56
Fig. 27:	Robertina declivis			
	(REUSS, 1863)	Sample	TI3	x 75
Fig. 28:	Robertina declivis			
	(REUSS, 1863)	Sample	TI3	x 75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