Bulletin de la Société belge de Géologie Bulletin van de Belgische Vereniging voor Geologie	99/3-4 99/3-4	pp. 275 - 300	Bruxelles 1990 Brussel 1990

PLANKTONIC FORAMINIFERAL BIOSTRATIGRAPHY AND PALAEOECOLOGICAL INTERPRETATION OF BENTHONIC FORAMINIFERAL POPULATIONS IN THE MONS-EN-PEVELE SANDS MEMBER OF THE IEPER FORMATION (EARLY EOCENE, YPRESIAN) AT MONT PANISEL

by

H.J.F. HOOYBERGHS [1]

ABSTRACT

Bio- and chronostratigraphical interpretation of twenty-five taxa of planktonic foraminifera found in the Mons-en-Pévèle Sands member of the Ieper Formation in the Mont Panisel well indicates correlation with the *triangularis* Zone subdivision of the North Sea Basin (Spiegler, 1986). Difficulties which are explained by an insufficient knowledge of the total stratigraphical range of different taxa arise in the international correlation.

The environment of deposition is defined as an inner shelf sea which gradually regressed, based on palaeoecological interpretation of forty-nine taxa of benthonic foraminifera.

RESUME

On propose une interprétation bio- et chronostratigraphique des vingt-cinq foraminifères planctoniques dans le Membre de Mons-en-Pévèle de la Formation d'Ypres, observé dans le sondage du Mont Panisel, S.E. de Mons. L'intervalle est situé dans la Zone à *triangularis* de la subdivision de Spiegler (1986) pour le bassin de la Mer du Nord. Il y a des difficultés dans la corrélation internationale, qu'on explique par une connaissance insuffisante de la distribution complète de plusieurs espèces.

On propose aussi une interprétation paléoécologique des quarante-neuf foraminifères benthiques. En utilisant plusieurs facteurs paléo-écologiques, le milieu de la sédimentation est défini comme une mer peu profonde qui régresse.

KEY WORDS

planktonic foraminifera, Lower Eocene, Ypresian benthonic foraminifera, palaeoecology, inner shelf.

MOTS CLES

foraminifères planctoniques, Eocène Inférieur, Yprésien, foraminifères benthiques, paléoécologie, mer peu profonde.

1. INTRODUCTION

Within the framework of the activities of the "Groupe de Contact du FNRS - Géologie des Sédiments Tertiaires de Belgique - Contactgroup "Geology of Tertiary Deposits in Belgium" a well was drilled by the Belgian Geological Survey in the type locality of the "Paniseliaan" (Dumont,

[1] K.U.Leuven, Instituut voor Aardwetenschappen - Redingenstraat 16bis - B-3000 Leuven.

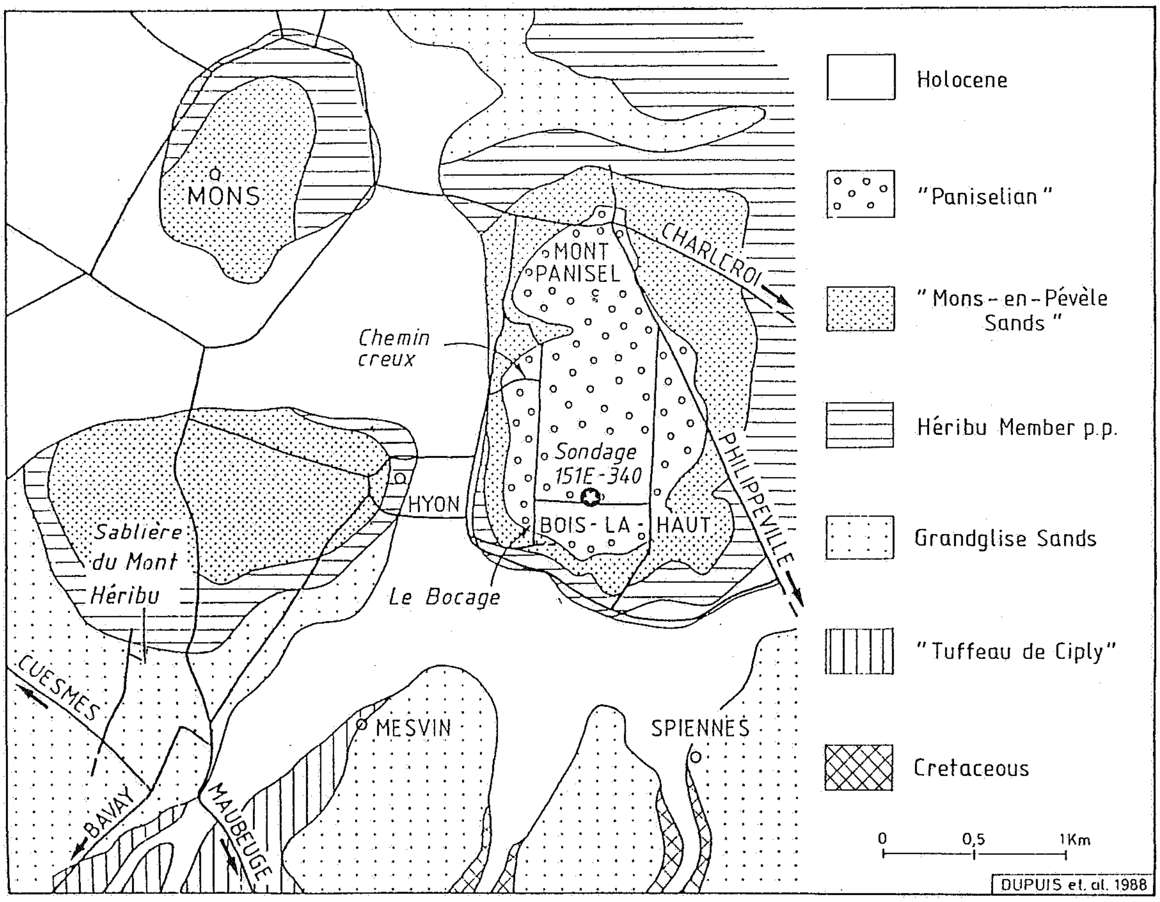

Figure 1 : location map of the well 151E-340.

1851) at Mont-Panisel, S.E. of Mons (Fig. 1, location-map). The aim of this well is a stratigraphical study of the "Paniselian" and the underlying Mons-en-Pévèle Sands Member of the Ieper Formation (see Steurbaut & Nolf, 1986). The first geological and geotechnical results have been described by Dupuis *et al.* (1988).

This contribution deals with the bio- and chronostratigraphical study of the planktonic foraminifera in a number of calcareous samples from the Mons-en-Pévèle Sands Member of the Ieper Formation in this well and with the paleoecological interpretation of the benthonic foraminiferal populations.

2. LITHOSTRATIGRAPHY

Figure 2 shows the log of the Mons-en-Pévèle Member in the Mont-Panisel well, between -65 and -17.5 m. The Mons-en-Pévèle Sands were defined by Ortlier & Chellonneix (1870). In the well they overlie the clayey sands of the Héribu Member which represents the basal sediments of the Ieper Formation (De Coninck, Geets & Willems, 1983). The Mons-en-Pévèle Sands are a lateral equivalent of the "Flanders Clay" or Roubaix and Aalbeke Clay Members (Steurbaut & Nolf, 1986), which constitute the largest part of the Ieper Formation. The Mons-en-Pévèle Member comprises alternating fine silty sands and silty clays, often rich in Nummulites (*N. planulatus*). A level at -30 m is especially glauconiferous. The calcimetric analyses show that mainly the interval between -52 and -35 m is calcareous, with a peak of nearly 40% at the -35 m level. This interval contains sufficient planktonic and benthonic foraminifera.

The Mons-en-Pévèle Sands Member is covered by clayey sands with sandstone layers of the Panisel Sands Member, which forms the top of the Ieper Formation.

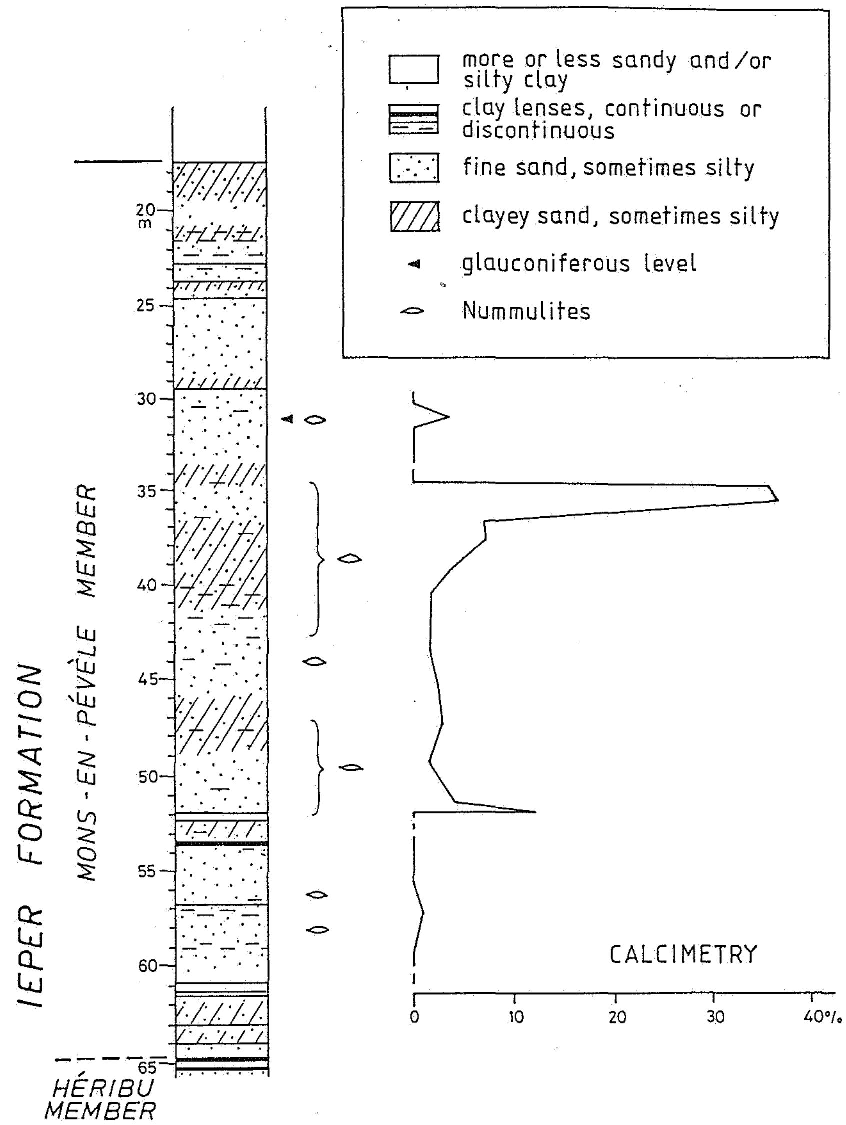

Figure 2 : development of the Mons-en-Pévèle Sands Member in the Panisel well (Modified after Dupuis *et al.*, 1988).

3. BIO- AND CHRONOSTRATIGRAPHY BY MEANS OF PLANKTONIC FORAMINIFERA

Twenty-five taxa of planktonic foraminifera have been observed in the samples from the Mons-en-Pévèle Sands Member. Table 1 shows the distribution of these taxa in the different samples.

Previous work on planktonic foraminifera from the Ieper Formation was carried out by Berggren (1969), Willems (1980) and Hooyberghs (1983).

Concerning the biostratigraphical correlation within the North Sea Basin, our associations of planktonic foraminifera can be situated in the *triangularis* Zone of Spiegler (1986). This interpretation is supported by the presence of taxa as *Globorotalia (Morozovella) aequa dolabrata, Globigerina (S.) triangularis triangularis, Globorotalia (Morozovella) lensiformis, Globorotalia (Acirinina) interposita, Globigerina (Muricoglobigerina) chascanona.* Concerning the international correlation with the standard zonation of Blow (1979), some problems concerning the total stratigraphical range of different arise as indicated by Blow. The knowledge of this total stratigraphical range has to be completed with more information from the distribution of the taxa in for instance the North Sea Basin. The same problem has recently been discussed by Berggren *et al.* (1988), who correct the correlation between the zonation of Blow (1979) and that of Berggren (1969) in the interval P6 to P10. The P8 interval of Blow corresponds to the zones P6-P7 of Berggren. It could be very helpful to us if Berggren were to publish a distribution chart with complete knowledge concerning the total stratigraphical range of the planktonic foraminifera in the Lower Eocene interval.

The *triangularis*-Zone of Spiegler (1986) is correlated with the P6a-P7 interval in the international zonation. It corresponds to the NP10-NP11 Zones for nannoplankton and is Lower Eocene in age.

4. DISTRIBUTION OF BENTHONIC FORAMINIFERA IN THE MONT PANISEL WELL AND PALAEOECOLOGICAL INTERPRETATION

Forty-nine taxa of benthonic foraminifera were observed in the calcareous samples. Table 2 shows the quantitative distribution of these taxa. The presence of extremely rare species (less than 1%) is indicated by :

- the dominance of the genus *Cibicides* in the whole section is noteworthy. In particular *C. tenellus* is abundant (57%) in sample 36.34

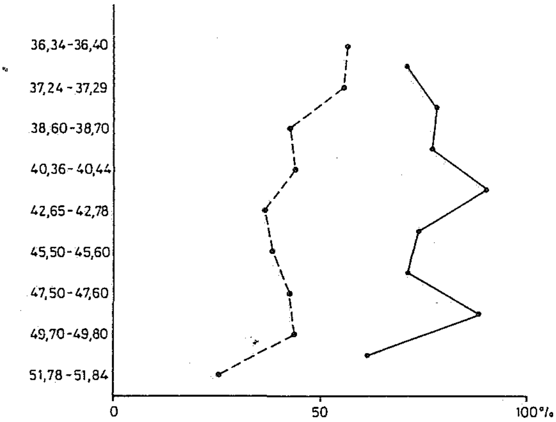

Figure 3 : similarities between the succeeding samples of the Mont-Panisel well ________ and percentage dominance in the different samples from the Mons-en-Pévèle Sands ---------

IEPER FORMATION – MONS-EN-PÉVÈLE MEMBER: 56,70 - 56,80	53,39 - 53,51	51,78 - 51,84	49,70 - 49,80	47,50 - 47,60	45,50 - 45,60	42,65 - 42,78	40,36 - 40,44	38,60 - 38,70	37,24 - 37,29	36,34 - 36,40	SAMPLES / TAXA
					●						*Chiloguembelina martini*
		●		●				●		●	*Globorotalia (Acarinina) cf. aspensis*
			●		●		●			●	*Globorotalia (Acarinina) camerata*
			●	●	●					●	*Globorotalia (Acarinina) interposita*
●		●	●	●	●				●	●	*Globorotalia (Acarinina) pentacamerata*
				●				●			*Globorotalia (Acarinina) wilcoxensis wilcoxensis*
			●	●	●						*Globorotalia (Globorotalia) palaeoscitula*
							●			●	*Globorotalia (Morozovella) aequa dolabrata*
			●	●			●	●			*Globorotalia (Morozovella) lensiformis*
				●	●						*Globorotalia (Turborotalia) chapmani*
					●						*Globorotalia (Turborotalia) griffinae*
				●	●						*Globorotalia (Turborotalia) perclara*
							●				*Globorotalia (Turborotalia) praecentralis*
●				●	●		●	●		●	*Globigerina (Muricoglobigerina) aquiensis*
				●	●		●	●		●	*Globigerina (Muricoglobigerina) chascanona*
●		●		●	●						*Globigerina (Muricoglobigerina) soldadoensis soldadoensis*
		●	●		●		●	●		●	*Globigerina (Subbotina) eocaena*
										●	*Globigerina (Subbotina) eocaenica*
				●			●	●		●	*Globigerina (Subbotina) hornibrooki finlay*
		●		●	●	●	●	●			*Globigerina (Subbotina) hornibrooki hornibrooki*
										●	*Globigerina (Subbotina) inaequispira*
				●	●					●	*Globigerina (Subbotina) linaperta*
		●	●	●			●		●		*Globigerina (Subbotina) patagonica*
							●	●		●	*Globigerina (Subbotina) triangularis triangularis*
					●						*Globigerinita taroubaensis*

Table 1 distribution of planktonic foraminifera in the Mons-en-Pévèle Member.

- 36.40 ; but also *C. proprius* (max. 21%), *C. acutimargo* (max. 12%) and *C. westi* (max. 10%) are important components of the populations. *Discorbis parisiensis* (max. 18%), *Eponides toulmini* (max. 19%) and *Nonion affine* (max. 5%) regulary take part in the associations. Striking is the' 18% frequency of *Discorbis perplexa* in sample 36.34 - 36.40, where it supersedes *Discorbis parisiensis.*

The frequency of *Textulariina* and *Miliolina* remains restricted, but, it is worth mentioning that in sample 36.34 - 36.40 the number of rare specimens, including several Miliolids, is distinctly greater.

We will try to build up a palaeocological interpretation of the populations using several lines of evidence. We also note that previous work on benthonic foraminifera from the Mons-en-Pévèle Sands has been carried out by Kaasschieter (1961), Moorkens & Verhoeve (1967) and Willems (1980).

4.1. Triangular plot of suborders

The three suborders of benthonic foraminifera *Textulariina, Miliolina* and *Rotaliina* are plotted in the triangular diagram, in which the field for the different possible ecological environment has been marked out by Murray (1973).

The frequencies of *Miliolina* and *Textulariina* are very restricted ; consequently the values for the different samples are situated at or near the *Rotaliina* corner. Those faunules can survive in hyposaline, hypersaline or normal marine marshes, in hypersaline lagoons and on the continental shelf.

4.2. Similarities

The method of Sanders (1960) measures the similarity between successive samples in a section. The total value of the lowest percentage of two common species in successive samples gives the similarity. The populations in the two samples are nearly identical when the total value is higher than 80. The associations differ progressively as the similarity index diminishes.

As shown in figure 3, the similarity index varies between 61 and 90%. Only two values are higher than 80 and reflect distinct homogenous associations. Most indices are situated in the 70 to 80% interval. The 61% factor in the lowest part of the sections indicates more pronounced differences between the first associations.

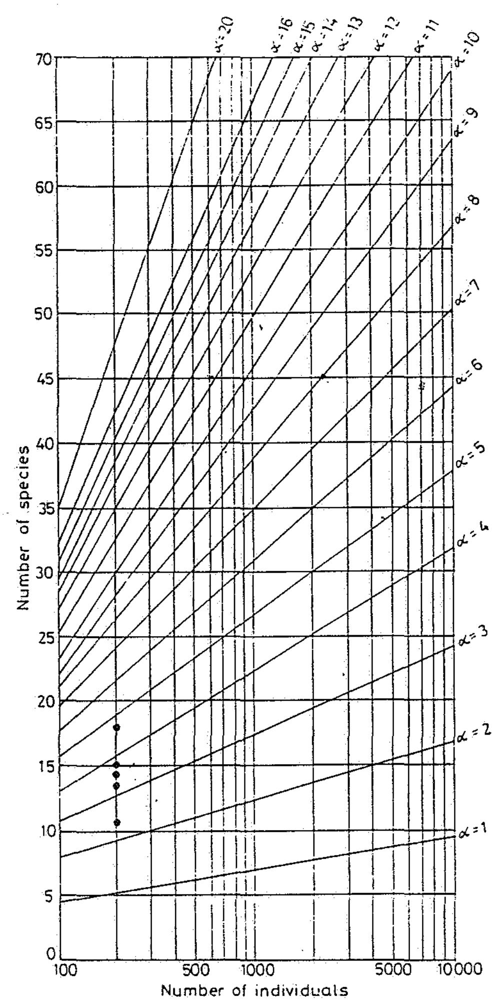

Figure 4 : Fisher α index in the Mons-en-Pévèle Sands at the Mont-Panisel.

4.3. Diversity index or Fisher α index

The diversity index or Fisher α index gives the relationship between the number of individuals and the number of species in a population in the base-graph constructed by Fisher, Corbett & Williams (1943).

Wright & Murray (1972) and Murray (1973) gave the interpretation of the different environments corresponding to the various α values. Figure 4 show the α values in the Mons-en-Pévèle Sands. They vary between 2.5 and 4.8. The posible ecological environments are hypersaline marshes or lagoons and hypersaline and nearshore shelf seas.

4.4. Dominance index (Wright, 1972)

Figure 5 gives the number of species in 80% of the populations from the different samples (dominance index). The fairly constant value in the greatest part of the section reflects a nearly stable environment with restricted fluctuations of the sea level. Only in the upper part of the

59,50 – 59,60	56,70 – 56,80	53,39 – 53,51	51,78 – 51,84	49,70 – 49,80	47,50 – 47,60	45,50 – 45,60	42,65 – 42,78	40,36 – 40,44	38,60 – 38,70	37,24 – 37,29	36,34 – 36,40	33,50 – 33,60	31,38 – 31,40	SAMPLES / TAXA
				•	1		•							*Textularia agglutinans* D'ORBIGNY, 1839
											•			*Quinqueloculina carinata* D'ORBIGNY, 1850
											1			*Quinqueloculina ludwigi* REUSS, 1866
											•			*Quinqueloculina seminula* (LINNE, 1758)
											•			*Spiroloculina bicarinata* D'ORBIGNY, 1850
											1			*Spiroloculina tricarinata* TERQUEM, 1882
										•	•			*Spiroloculina tricarinata* var. *belgica* KAASSCHIETER, 1961
											•			*Triloculina angularis* D'ORBIGNY, 1850
											•			*Triloculina gibba* D'ORBIGNY, 1846
											•			*Triloculina trigonula* (LAMARCK, 1804)
				•			•							*Lenticulina* sp.
				•				1	•		•			*Lagena globosa* (MONTAGU, 1803)
			•	•		•		•		•	•			*Lagena hexagona* (WILLIAMSON, 1848)
							•	•			•	•		*Lagena striata* (D'ORBIGNY, 1839)
						•	•				1			*Fissurina laevigata* (REUSS, 1850)
				•		1	•			•	•			*Fissurina orbignyana* SEGUENZA, 1862
			1	2	1		1	1	1	2	•	•		*Guttulina lactea* (WALKER & JACOB, 1798)
				•			•			•	•			*Guttulina pulchella* (D'ORBIGNY, 1839)
			•				•				•	•	•	*Globulina gibba* (D'ORBIGNY, 1846)
				•	1		•	•		2	•			*Globulina gravida* (TERQUEM, 1878)
	•		•				1	•	1	2	•			*Bulimina parisiensis* KAASSCHIETER ? 1961
			1	•				•		1	2			*Bulimina pulchella* (TERQUEM, 1882)
											•			*Reussella elongata* D'ORBIGNY, 1839
											•			*Reussella terquemi* CUSHMAN, 1945
	•		2	1	1	4	•	•	1	•	1			*Bolivina anglica* CUSHMAN, 1936
				2		1		•			2			*Bolivina carinata* TERQUEM, 1882
						•				•	•			*Bolivina crenulata* CUSHMAN, 1936
	•		•	•			•	•			•			*Bolivina pulchra* TERQUEM, 1882
	•					1					•			*Loxostomum teretum* CUSHMAN, 1936
			•			1	1		1		•			*Uvigerina garzaensis* CUSHMAN & SIEGFUS, 1939
			•	1		1	•	•	•	•	1			*Trifarina muralis* (TERQUEM, 1882)
				•										*Trifarina wilcoxensis* (CUSHMAN & PONTON, 1932)
	•		2	3	2	5	3	4		2	•			*Nonion affine* (REUSS, 1851)
	•					1	•	•	•		•			*Nonion scaphum* (FICHTEL & MOLL, 1798)
			1			2		•			•			*Nonionella spissa* CUSHMAN, 1949
	•		18	8	10	11	9	4	18	12	4			*Discorbis parisiensis* (D'ORBIGNY, 1865)
			2	•	1			1	1	•	18			*Discorbis perplexa* LE CALVEZ, 1949
	•		19	2	3	16	7	12	5	9	1			*Eponides toulmini* BROTZEN, 1948
				•		1	•		•		•			*Cancris subconicus* (TERQUEM, 1882)
	•		12	7	12	5	11	7	9	8	1	•	•	*Cibicides acutimargo* TEN DAM, 1944
			1		1		•		1		•			*Cibicides carinatus* (TERQUEM, 1882)
			1		1	•		1			•			*Cibicides lobatulus* (WALKER & JACOB, 1798)
•	•		6	21	16	6	19	13	7	5	7	•		*Cibicides proprius* (BROTZEN, 1948)
•	•		26	44	43	39	37	44	43	56	57	•	•	*Cibicides tenellus* (REUSS, 1850)
	•		9	7	7	5	10	10	6		•		•	*Cibicides westi* HOWE, 1939
	•		1	2		1		1						*Alabamina wolterstorffi* (FRANKE, 1925)
						•								*Siphonina lamarckana* CUSHMAN, 1927
	•		•	1				1	3	3	4			*Pararotalia armata* (D'ORBIGNY, 1826)
			•	3		2	1	2	3	•	1			*Elphidium laeve* (D'ORBIGNY, 1865)
			2	1	2	9		1	2		3			°/• planctonic foraminifera
									2		7			°/• ostracoda

• = rare

Table 2 Quantitative distribution of benthonic foraminifera in the Mons-en-Pévèle Member.

Mons-en-Pévèle Sands, does the decrease of the dominance index from 5 to 4 and sometimes 3 indicate a less stable and more marginal environment.

4.5. Percentage dominance

The percentage dominance (figure 3) corresponds to the percentages of the most abundant species in a sample. Walton (1964) notes that his percentage dominance increases with decreasing depth of the sea.

It varies from 26 in the lower part of the section to 57 in the upper part. It reflects more fluctuations of the sea level but the general trend shows a regressive cycle of the sea.

4.6. Palaeoecological significance of benthonic foraminifera from the Mons-en-Pévèle Sands Member

Several authors supply information about the influence of different (palaeo-)ecological factors on the composition of the benthonic foraminiferal associations. We can accept that this influence did not change significantly at generic level during the Tertiary.

We found useful information in Phleger (1960), Bandy (1960, 1964), Walton (1964), Wright & Murray (1972), Murray (1973), Wright (1972, 1973), Murray & Wright (1974) and Boltotskoy & Wright (1970). This information has already been worked up in Gerits, Hooyberghs & Voets (1981) and in Hooyberghs (1985, 1986a and 1986b).

The genus *Cibicides* is currently most abundant in temperate normal marine seas in a wide range of salinity. It is attached to all types of substrate such as algae and seagrass vegetation.

Discorbis likes a shallow inner shelf with subtropical - tropical conditions and a much seagrass and algae.

Eponides prefers a continental shelf or normal marine seas in a subtropical climate.

The environment in which *Nonion* dominates is a shelf of normal to hyposaline sea in different temperate conditions, but with oxygen rich waters.

Small smooth species of *Bolivina* prefer inner shelf conditions with normal salinity (32 - 36%).

Pararotalia likes shallow water conditions with much algae and seagrass and *Elphidium* dominates at an inner shelf depth with rather high salinities (35 - 50%) and in oxygen waters.

Guttulina occurs most frequently on an inner shelf and *Globulina* prefers temperate to subtropical waters in a normal marine sea.

Bulimina dominates in a muddy sediment in a near shore to bathyal environment with salinities between 32 and 36%.

The sudden appearance of *Miliolacea* in sample 36.34 - 36.40 reflects a changing salinity in a nearshore environmemt. *Quinqueloculina* especially does not tolerate salinities below 30%.

The presence of planktonic foraminifera indicates a connection with the open sea.

5. CONCLUSIONS

These observations suggest that the clayey and silty sands of the Mons-en-Pévèle Member accumulated in an inner shelf environment of an open sea. The temperature reached subtropical values and in the oxygen rich water seagrass and algae flourished. The sea level fluctuated but generally reflected a negative cycle of a regressing sea. Nearshore conditions are evident particularly in the upper part.

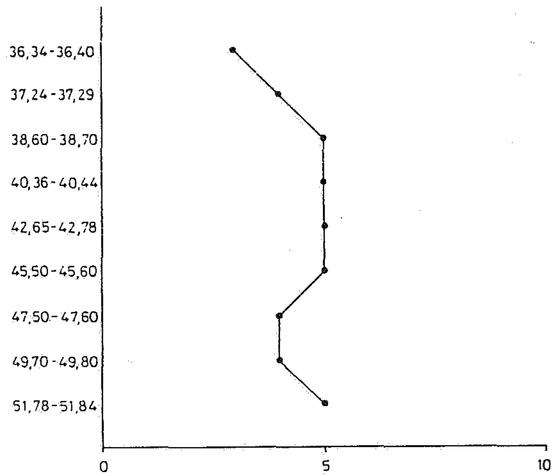

Figure 5 : dominance index in the diffferent samples from the Mons-en-Pévèle Sands at the Mont-Panisel.

ACKNOWLEDGMENTS

The author expresses his gratitude to the Director of the Belgian Geological Survey and to Dr Ch. Dupuis (Faculté Polytechnique de Mons) for providing the samples from the Panisel well. Special thanks are due to Dr K. Wouters (K.B.I.N., Brussels) for the photographs of the specimens.

REFERENCES

BANDY, O.L., 1960 - General correlations of foraminiferal structure with environment. *Int. Geol. Congress, Session Norden, 1960*, ***21***: 7-9.

BANDY, O.L., 1964 - General correlation of foraminiferal structure with environment. *In* : Imbrie & Newell : *Approaches to Palaeoecology*: 75-95.

BERGGREN, W.A., 1969 - Paleogene biostratigraphy and planktonic foraminifera of Northern Europe. *Proc. 1° Internat. Conf. Planktonic Microfossils Geneva 1967*, *1*: 121-160.

BERGGREN, W.A. & MILLER, K.G., 1988 - Paleogene tropical planktonic foraminiferal biostratigraphy and magnetobiochronology. *Micropal.*, ***34/4***: 362-380.

BLOW, W.A., 1979 - Cainozoic *Globigerinidae*. Text. part I and part II. ***I***, 752 p. ***II***: 754-1431, Brill Leiden.

DE CONINCK, J., GEETS, S. & WILLEMS, W., 1983 - The Mont-Héribu Member : base of the Ieper Formation in the Belgian Basins. *Tertiary Res.*, ***5/2***: 83-104.

DUMONT, A., 1851 - Note sur la position géologique de l'argile rupélienne et sur le synchronisme des formations tertiaires de la Belgique, de l'Angleterre et du nord de la France. *Bull. Acad. roy. Belgique, Cl. Sci.*, ***18/2***: 179-195.

DUPUIS, Ch., BRYCH, J., LAGA, P. & VANDENBERGHE, N., 1988 - Sondage stratigraphique du Mont Panisel : premiers résultats géologiques et géotechniques. *Bull. Soc. belge Géol.*, ***97***: 35-46.

FISHER, R.A., CORBET, A.S. & WILLIAMS, C.B., 1943 - The relation between the number of species and the number of individuals in a random sample of an animal population. *J. Animal. Ecol.*, ***12***: 42-58.

GERITS, M., HOOYBERGHS, H. & VOETS, R., 1981 - Quantitative distribution and palaeoecology of benthonic foraminifera recorded from some Eocene deposits in Belgium. *Belg. Geol. Survey, Prof. Paper*, ***1981/3***, 53 p.

HOOYBERGHS, H., 1983 - Contribution to the study of planktonic foraminifera in the Belgian Tertiary. *Aardk. Meded.*, ***2***, 131 p.

HOOYBERGHS, H., 1985 - Studies in Tertiary benthonic foraminifera in Belgium. *Belg. Geol. Surv., Prof. Paper*, ***1985/6***: 1-128.

HOOYBERGHS, H., 1986a - Quantitative distribution and palaeoecology of benthonic foraminifera in the Panisel and Lede Formations (Eocene) at Burst (Belgium). *Tertiary Res.*, ***7/4***: 145-155.

HOOYBERGHS, H., 1986b - Palaeocology of benthonic foraminifera from the Brussels Sands Formation (Middle Eocene) in Belgum. *Aardk. Meded.*, ***3***: 107-124.

KAASSCHIETER, J., 1961 - Foraminifera of the Eocene of Belgium. *Mem. Inst. roy. Sc. nat. Belgique.*, ***147***, 271 p.

MOORKENS, T. & VERHOEVE, D., 1967- Het fossielhoudend Ieperiaan van Merelbeke. *Natuurwet. Tijdschrift*, ***48***: 202-227.

MURRAY, J.W., 1973 - Distribution and ecology of living benthic foraminiferids. Heinemann Educational Books, 274 p.

MURRAY, J.W. & WRIGHT, C.A., 1974 - Palaeogene foraminiferida and palaeoecology, Hampshire and Paris Basins and the English Channel. *Spec. Papers Paleontology*, ***14***, 129 p.

ORTLIER, J. & CHELLONNEIX, E., 1870 - Etude géologique des collines tertiaires du département du Nord comparées avec celles de la Belgique. Lille, 288 p.

PHLEGER, F.B., 1960 - Ecology and distribution of Recent Foraminifera. Johns Hopkins, Baltimore, 297 p.

SANDERS, H.L., 1960 - Benthic studies in Buzzards Bay. II. The structure of the soft-bottom community. *Limnol. Oceanogr.*, ***5/2***: 138-151.

SPIEGLER, D., 1986 - Gliederung des northwestdeutschen Tertiärs (Paläogen und Neogen) auf grund von planktonische Foraminifera. *In* : Nordwestdeutschland im Tertiär Teil 1, *Beitr. Reg. Geol. Erde*, ***18***: 213-299.

STEURBAUT, E. & NOLF, D., 1986 - Revision of Ypresian stratigraphy of belgium and northwestern France. *Meded. Werkgr. Tert. Kwart. Geol.*, ***23/4***: 115-172.

WALTON, W.R., 1980 - Recent Foraminiferal Ecology and Palaeoecology. *In* : Imbrie & Newell : *Approaches to Palaeoecology*, Wiley, 151-237.

WILLEMS, W., 1980 - De foraminiferen van de Ieper Formatie (Onder Eoceen) in het Noordzeebekken (biostratigrafie, paleoekologie, systematiek). *Unpublished Thesis Gent*, 222 p.

WRIGHT, C.A., 1972 - Foraminiferids from the London Clay at Lower Swannick and the palaeoecological interpretation. *Proc. Geol. Assoc.*, ***83/3***: 337-347.

WRIGHT, C.A., 1973 - Foraminiferids from the Lutetian at Ronquerolles (Val d'Oise) and their palaeoecological interpretation. *Revue Micropal.*, ***16/2***: 147-157.

WRIGHT, C.A. & MURRAY, J.W., 1972 - Comparisons of Modern and Paleogene Foraminiferid distribution and their environmental implications. *Mém. B.R.G.M.*, ***79***: 87-96.

Manuscript received on 24 April 1990 and accepted for publication on 30 January 1991.

PLATE I

Figure 1 : *Chiloguembelina martini* (Pijpers, 1933 - X 220.

Figure 2 : *Globorotalia (Acarinina)* cf. *aspensis* (Colom, 1954). - X 150.

Figure 3 : *Globorotalia (Acarinina)* cf. *aspensis* (Colom, 1954). - X 160.

Figure 4 : *Globorotalia (Acarinina)* cf. *aspensis* (Colom, 1954). - X 245.

Figure 5 : *Globorotalia (Acarinina)* cf. *aspensis* (Colom, 1954). - X 120.

Figure 6 : *Globorotalia (Acarinina)* cf. *aspensis* (Colom, 1954). - X 175.

Figure 7 : *Globorotalia camerata* (Khalilov, 1956) - X 175.

Figure 8 : *Globorotalia camerata* (Khalilov, 1956) - X 170.

Figure 9 : *Globorotalia camerata* (Khalilov, 1956) - X 170.

Figure 10 : *Globorotalia camerata* (Khalilov, 1956) - X 145.

Figure 11 : *Globorotalia (Acarinia) interposita* (Subbotina, 1953) - X 200.

Figure 12 : *Globorotalia (Acarinia) interposita* (Subbotina, 1953) - X 195.

Figure 13 : *Globorotalia (Acarinia) interposita* (Subbotina, 1953) - X 280.

Figure 14 : *Globorotalia (Acarinia) interposita* (Subbotina, 1953) - X 185.

Figure 15 : *Globorotalia (Acarinia) pentacamerata* (Subbotina, 1947) - X 190.

Figure 16 : *Globorotalia (Acarinia) pentacamerata* (Subbotina, 1947) - X 185.

Figure 17 : *Globorotalia (Acarinia) pentacamerata* (Subbotina, 1947) - X 310.

Figure 18 : *Globorotalia (Acarinia) pentacamerata* (Subbotina, 1947) - X 210.

Figure 19 : *Globorotalia (Acarinia) pentacamerata* (Subbotina, 1947) - X 225.

Figure 20 : *Globorotalia (Acarinia) wilcoxensis* Cushman & Potton, 1932 - X 215.

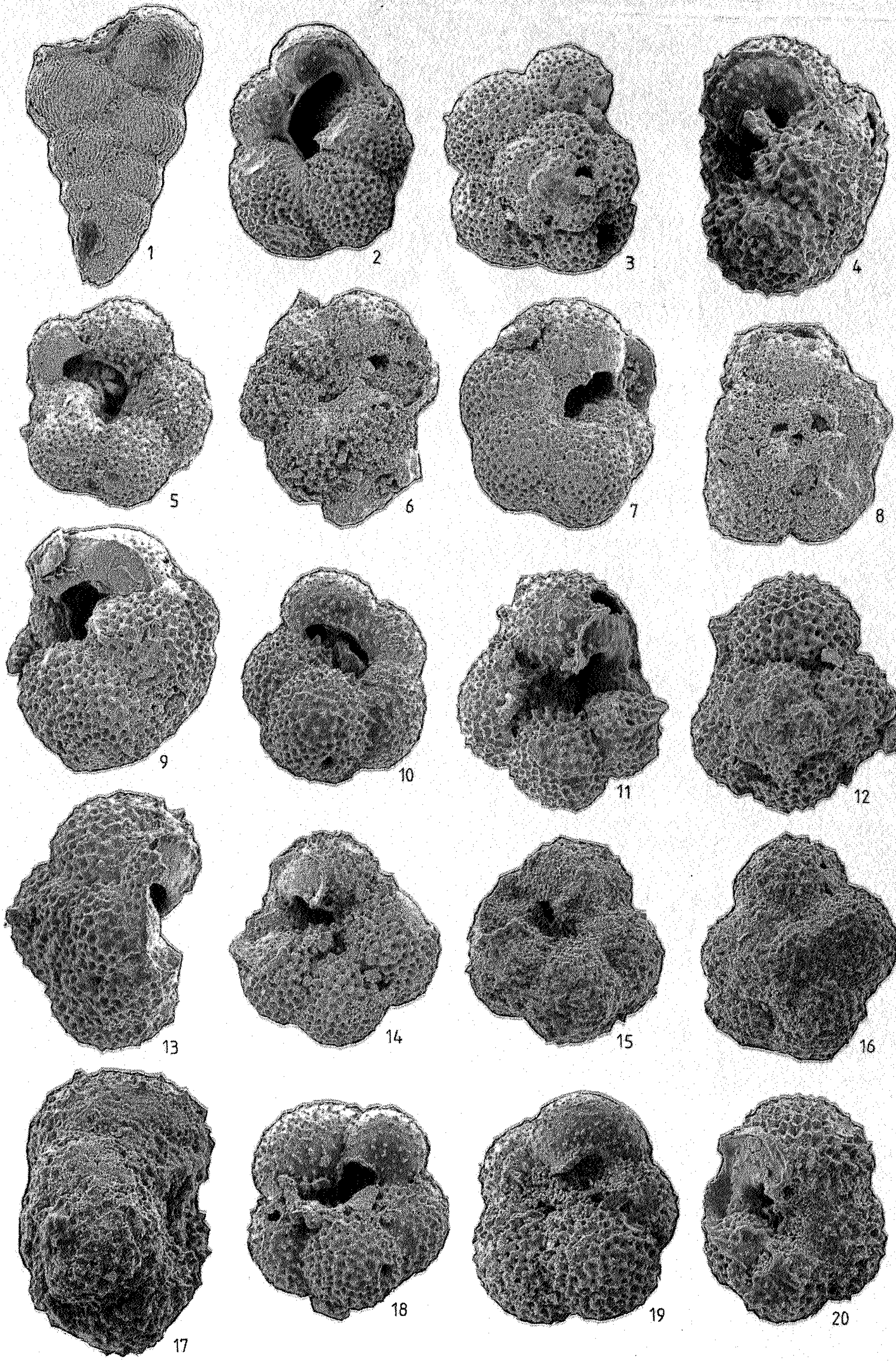
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

PLATE II

Figure 1 : *Globorotalia (Acarinia) wilcoxensis* Cushman & Potton, 1932 - X 305.

Figure 2 : *Globorotalia (Acarinia) wilcoxensis* Cushman & Potton, 1932 - X 270.

Figure 3 : *Globorotalia (Globorotalia) palaeoscitula* Spiegler, 1986 - X 225.

Figure 4 : *Globorotalia (Globorotalia) palaeoscitula* Spiegler, 1986 - X 225.

Figure 5 : *Globorotalia (Morozovella) aequa dolabrata* Jenkins, 1965 - X 200.

Figure 6 : *Globorotalia (Morovozella) aequa dolabrata* Jenkins, 1965 - X 200.

Figure 7 : *Globorotalia (Morovozella) lensiformis* Subbotina, 1953 - X 195.

Figure 8 : *Globorotalia (Morovozella) lensiformis* Subbotina, 1953 - X 245.

Figure 9 : *Globorotalia (Morovozella) lensiformis* Subbotina, 1953 - X 275.

Figure 10 : *Globorotalia (Morovozella) lensiformis* Subbotina, 1953 - X 275.

Figure 11 : *Globorotalia (Turborotalia) chapmani* Parr *sensu* Berggren, Olsson & Reyment, 1967 - X 400.

Figure 12 : *Globorotalia (Turborotalia) chapmani* Parr *sensu* Berggren, Olsson & Reyment, 1967 - X 380.

Figure 13 : *Globorotalia (Turborotalia) griffinae* Blow, 1979 - X 170.

Figure 14 : *Globorotalia (Turborotalia) perclara* Loeblich & Tappan, 1957 - X 225.

Figure 15 : *Globorotalia (Turborotalia) perclara* Loeblich & Tappan, 1957 - X 290.

Figure 16 : *Globorotalia (Turborotalia) perclara* Loeblich & Tappan, 1957 - X 300.

Figure 17 : *Globorotalia (Turborotalia) perclara* Loeblich & Tappan, 1957 - X 235.

Figure 18 : *Globorotalia (Turborotalia) praecentralis* Blow, 1979 - X 300.

Figure 19 : *Globorotalia (Muricoglobigerina) aquiensis* Loeblich & Tappan, 1957 - X 165.

Figure 20 : *Globorotalia (Muricoglobigerina) aquiensis* Loeblich & Tappan, 1957 - X 195.

Plate II

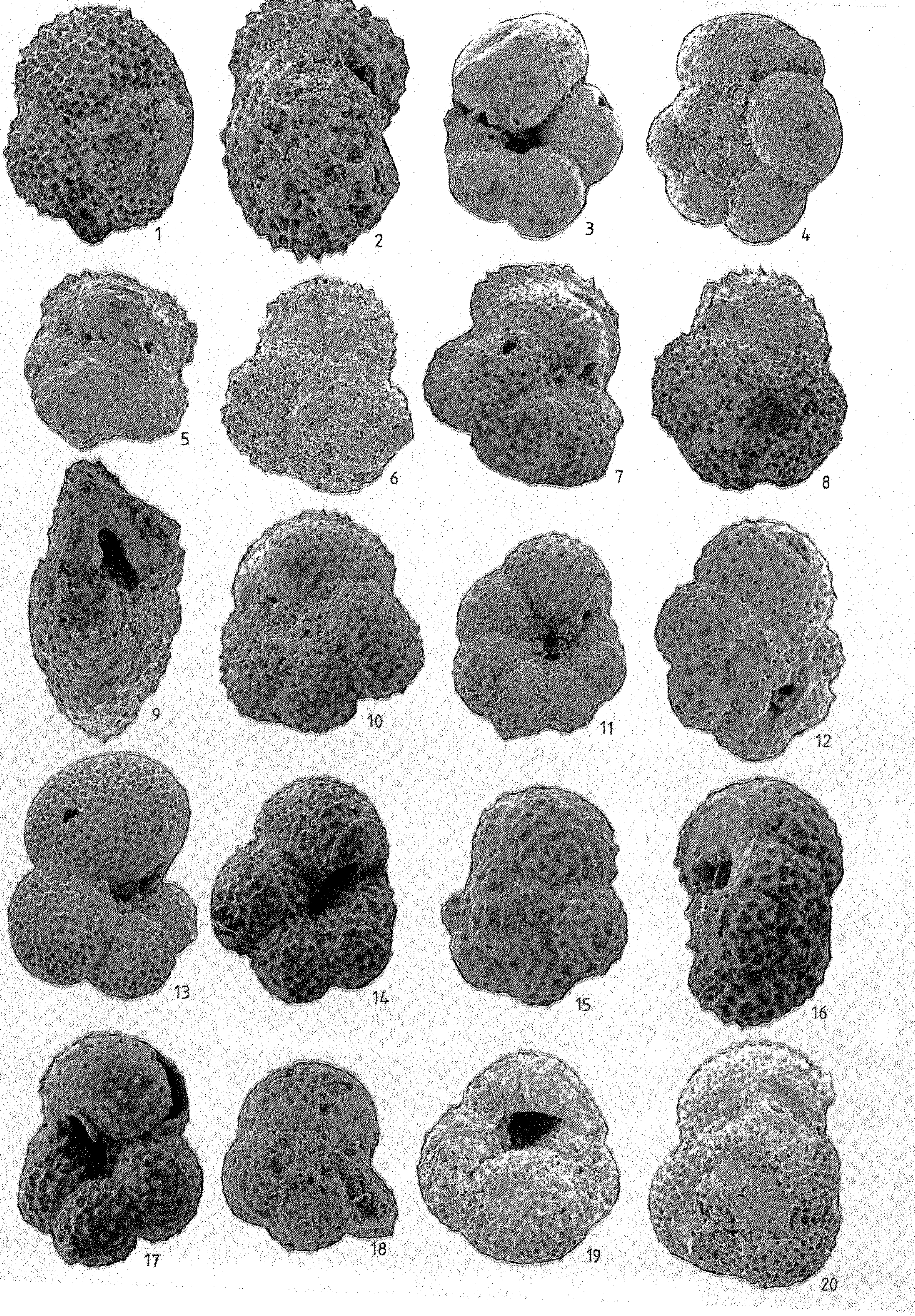

PLATE III

Figure 1 : *Globorotalia (Muricoglobigerina) aquiensis* Loeblich & Tappan, 1957 - X 200.

Figure 2 : *Globorotalia (Muricoglobigerina) chascanona* Loeblich & Tappan, 1957 - X 160.

Figure 3 : *Globorotalia (Muricoglobigerina) chascanona* Loeblich & Tappan, 1957 - X 180.

Figure 4 : *Globorotalia (Muricoglobigerina) chascanona* Loeblich & Tappan, 1957 - X 185.

Figure 5 : *Globorotalia (Muricoglobigerina) chascanona* Loeblich & Tappan, 1957 - X 195.

Figure 6 : *Globorotalia (Muricoglobigerina) chascanona* Loeblich & Tappan, 1957 - X 210.

Figure 7 : *Globorotalia (Muricoglobigerina) soldadoensis* (Brönnimann, 1952) - X 225.

Figure 8 : *Globorotalia (Muricoglobigerina) soldadoensis* (Brönnimann, 1952) - X 200.

Figure 9 : *Globorotalia (Muricoglobigerina) soldadoensis* (Brönnimann, 1952) - X 195.

Figure 10 : *Globorotalia (Muricoglobigerina) soldadoensis* (Brönnimann, 1952) - X 200.

Figure 11 : *Globorotalia (Muricoglobigerina) soldadoensis* (Brönnimann, 1952) - X 225.

Figure 12 : *Globorotalia (Subbotina) inaequispira* Subbotina, 1953 - X 240.

Figure 13 : *Globorotalia (Subbotina) eocaena* Gümbel, 1870 - X 195.

Figure 14 : *Globorotalia (Subbotina) eocaena* Gümbel, 1870 - X 215.

Figure 15 : *Globorotalia (Subbotina) eocaena* Gümbel, 1870 - X 186.

Figure 16 : *Globorotalia (Subbotina) eocaena* Gümbel, 1870 - X 175.

Figure 17 : *Globorotalia (Subbotina) eocaena* Gümbel, 1870 - X 325.

Figure 18 : *Globorotalia (Subbotina) eocaena* Terquem, 1882 - X 185.

Figure 19 : *Globorotalia (Subbotina) hornibrooki finlayi* (Brönnimann, 1952) - X 225.

Figure 20 : *Globorotalia (Subbotina) hornibrooki finlayi* (Brönnimann, 1952) - X 195.

Plate III

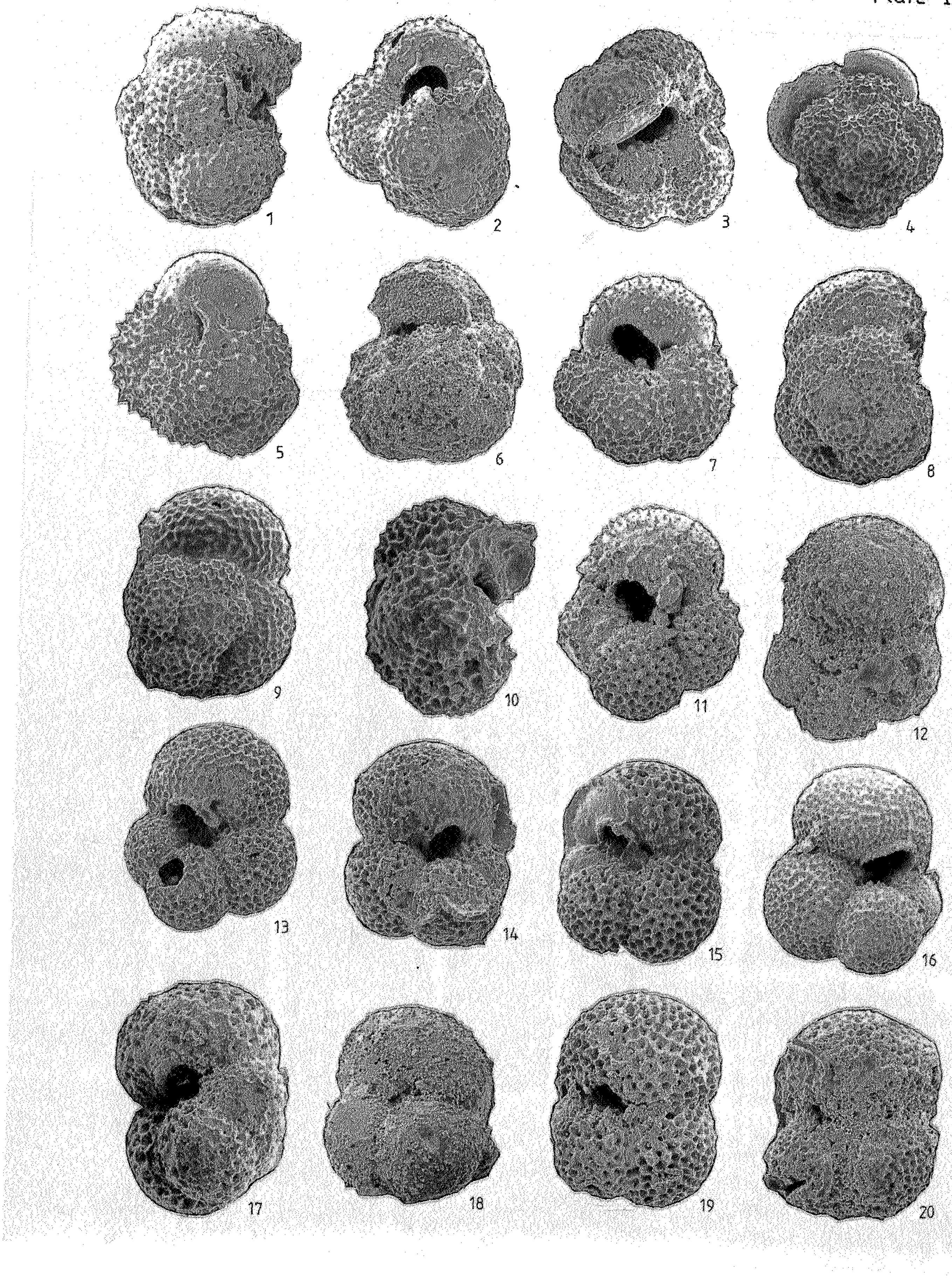

PLATE IV

Figure 1 : *Globorotalia (Subbotina) hornibrooki finlayi* (Brönnimann, 1952) - X 280.

Figure 2 : *Globorotalia (Subbotina) hornibrooki hornibrooki* (Brönnimann, 1952) - X 250.

Figure 3 : *Globorotalia (Subbotina) hornibrooki hornibrooki* (Brönnimann, 1952) - X 250.

Figure 4 : *Globorotalia (Subbotina) hornibrooki hornibrooki* (Brönnimann, 1952) - X 245.

Figure 5 : *Globorotalia (Subbotina) linaperta* Finlay, 1939 - X 215.

Figure 6 : *Globorotalia (Subbotina) linaperta* Finlay, 1939 - X 180.

Figure 7 : *Globorotalia (Subbotina) linaperta* Finlay, 1939 - X 200.

Figure 8 : *Globorotalia (Subbotina) patagonica* Todd & Knicker, 1952 - X 175.

Figure 9 : *Globorotalia (Subbotina) patagonica* Todd & Knicker, 1952 - X 265.

Figure 10 : *Globorotalia (Subbotina) patagonica* Todd & Knicker, 1952 - X 265.

Figure 11 : *Globorotalia (Subbotina) triangularis triangularis* White, 1928 - X 200.

Figure 12 : *Globorotalia (Subbotina) triangularis triangularis* White, 1928 - X 280.

Figure 13 : *Globorotalia (Subbotina) triangularis triangularis* White, 1928 - X 250.

Figure 14 : *Globorotalia (Subbotina) triangularis triangularis* White, 1928 - X 185.

Figure 15 : *Globorotalia taroubaensis* (Brönnimann, 1952) - X 310.

Plate IV

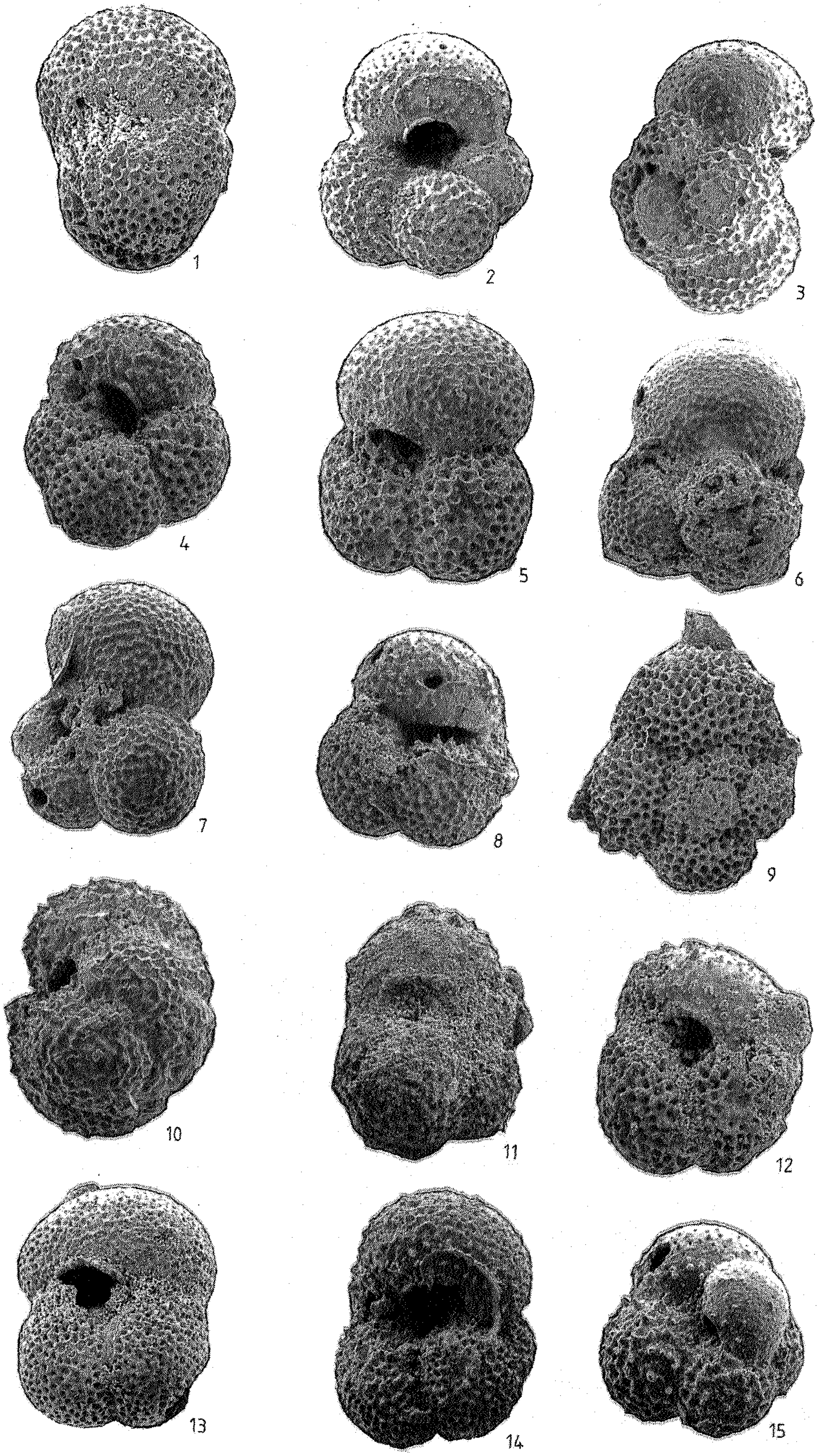

PLATE V

Figure 1 : *Textularia agglutinans* d'Orbigny, 1839 - X 150.

Figure 2 : *Textularia agglutinans* d'Orbigny, 1839 - X 220.

Figure 3 : *Quinqueloculina carinata* d'Orbigny, 1850 - X 95.

Figure 4 : *Quinqueloculina carinata* d'Orbigny, 1850 - X 120.

Figure 5 : *Quinqueloculina carinata* d'Orbigny, 1850 - X 130.

Figure 6 : *Quinqueloculina ludwigi* Reuss, 1866 - X 75.

Figure 7 : *Quinqueloculina ludwigi* Reuss, 1866 - X 95.

Figure 8 : *Quinqueloculina ludwigi* Reuss, 1866 - X 95.

Figure 9 : *Quinqueloculina seminula* (Linne, 1758) - X 150.

Figure 10 : *Spiroloculina bicarinata* d'Orbigny, 1850 - X 100.

Figure 11 : *Spiroloculina bicarinata* d'Orbigny, 1850 - X 115.

Figure 12 : *Spiroloculina bicarinata* d'Orbigny, 1850 - X 135.

Figure 13 : *Spiroloculina tricarinata* Terquem, 1882 - X 58.

Figure 14 : *Spiroloculina tricarinata* var. *belgica* Kaasschieter, 1961 - X 95.

Figure 15 : *Spiroloculina tricarinata* var. *belgica* Kaasschieter, 1961 - X 90.

Figure 16 : *Triloculina angularis* d'Orbigny, 1850 - X 95.

Figure 17 : *Triloculina angularis* d'Orbigny, 1850 - X 170.

Figure 18 : *Triloculina gribba* d'Orbigny, 1846 - X 65.

Figure 19 : *Triloculina trigonula* (Lamarck, 1804) - x 155.

Figure 20 : *Triloculina trigonula* (Lamarck, 1804) - x 210.

Plate V

PLATE VI

Figure 1 : *Triloculina trigonula* (Lamarck, 1804) - x 83.

Figure 2 : *Lenticulina* sp. - X 130.

Figure 3 : *Lagena globosa* (Montagu, 1803) - X 180.

Figure 4 : *Lagena hexagona* (Williamson, 1848) - X 180.

Figure 5 : *Lagena striata* (d'Orbigny, 1839) - X 180.

Figure 6 : *Fissurina laevigata* (Reuss, 1850) - X 270.

Figure 7 : *Fissurina orbignyana* Seguenza, 1862 - X 175.

Figure 8 : *Guttulina lactea* (Walker & Jacob, 1798) - X 200.

Figure 9 : *Guttulina pulchella* (d'Orbigny, 1839) - x 57.

Figure 10 : *Globulina gibba* (d'Orbigny, 1846) - X 140.

Figure 11 : *Globulina gravida* (Terquem, 1878) - X 170.

Figure 12 : *Bulimina parisiensis* Kaasschieter, 1961 - X 205.

Figure 13 : *Bulimina pulchella* (Terquem, 1882) - X 175.

Figure 14 : *Ruessella elongata* d'Orbigny, 1839 - X 190.

Figure 15 : *Ruessella terquemi* Cushman, 1945 - X 195.

Figure 16 : *Bolivina anglica* Cushman, 1936 - X 180.

Figure 17 : *Bolivina carinata* Terquem, 1882 - X 175.

Figure 18 : *Bolivina crenulata* Cushman, 1936 - X 145.

Figure 19 : *Bolivina pulchra* Terquem, 1892 - X 180.

Figure 20 : *Bolivina pulchra* Terquem, 1892 - X 135.

Plate VI

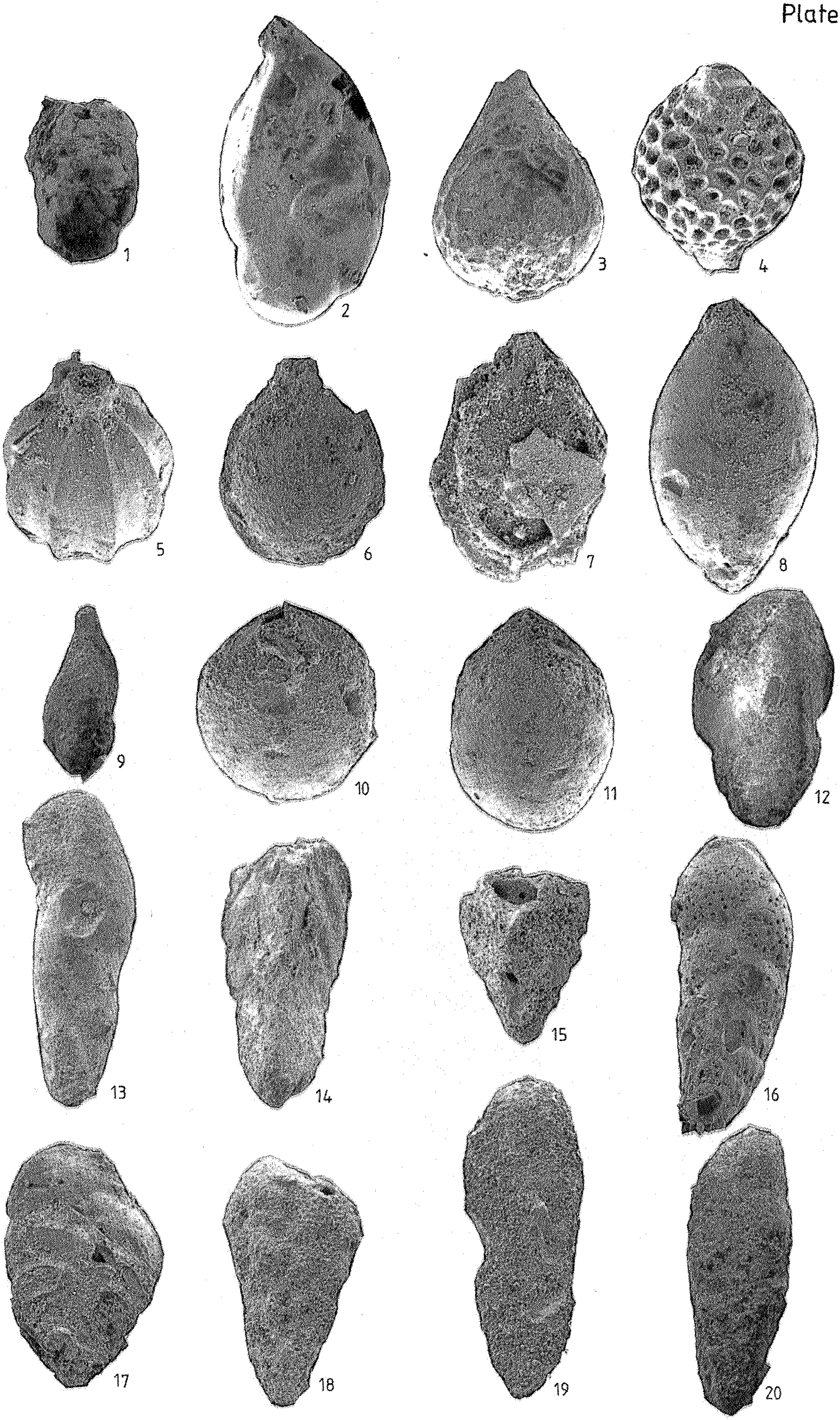

PLATE VII

Figure 1 : *Loxostomum teretum* Cushman, 1936 - X 190.

Figure 2 : *Uvigerina garzensis* Cushman & Siegfus, 1939 - X 180.

Figure 3 : *Uvigerina garzensis* Cushman & Siegfus, 1939 - X 165.

Figure 4 : *Trifarina muralis* (Terquem, 1882) - X 190.

Figure 5 : *Trifarina muralis* (Terquem, 1882) - X 215.

Figure 6 : *Trifarina wilcoxensis* (Cushman & Ponton, 1932) - X 190.

Figure 7 : *Nonion affinis* (Reuss, 1851) - X 105.

Figure 8 : *Nonion scaphus* (Fichtel & Moll, 1798) - X 105.

Figure 9 : *Nonion scaphus* (Fitchel & Moll, 1798) - X 160.

Figure 10 : *Nonionella spissa* Cushman, 1949 - X 155.

Figure 11 : *Nonionella spissa* Cushman, 1949 - X 165.

Figure 12 : *Nonionella spissa* Cushman, 1949 - X 185.

Figure 13 : *Discorbis parisiensis* (d'Orbigny, 1865) - X 190.

Figure 14 : *Discorbis parisiensis* (d'Orbigny, 1865) - X 175.

Figure 15 : *Discorbis perplexa* Le Calvez, 1949 - X 195.

Figure 16 : *Discorbis perplexa* Le Calvez, 1949 - X 170.

Figure 17 : *Eponides toulmini* Brontzen, 1948 - X 170.

Figure 18 : *Eponides toulmini* Brontzen, 1948 - X 160.

Figure 19 : *Cancris subconius* (Terquem, 1882) - X 97.

Figure 20 : *Cancris subconius* (Terquem, 1882) - X 140.

Plate VII

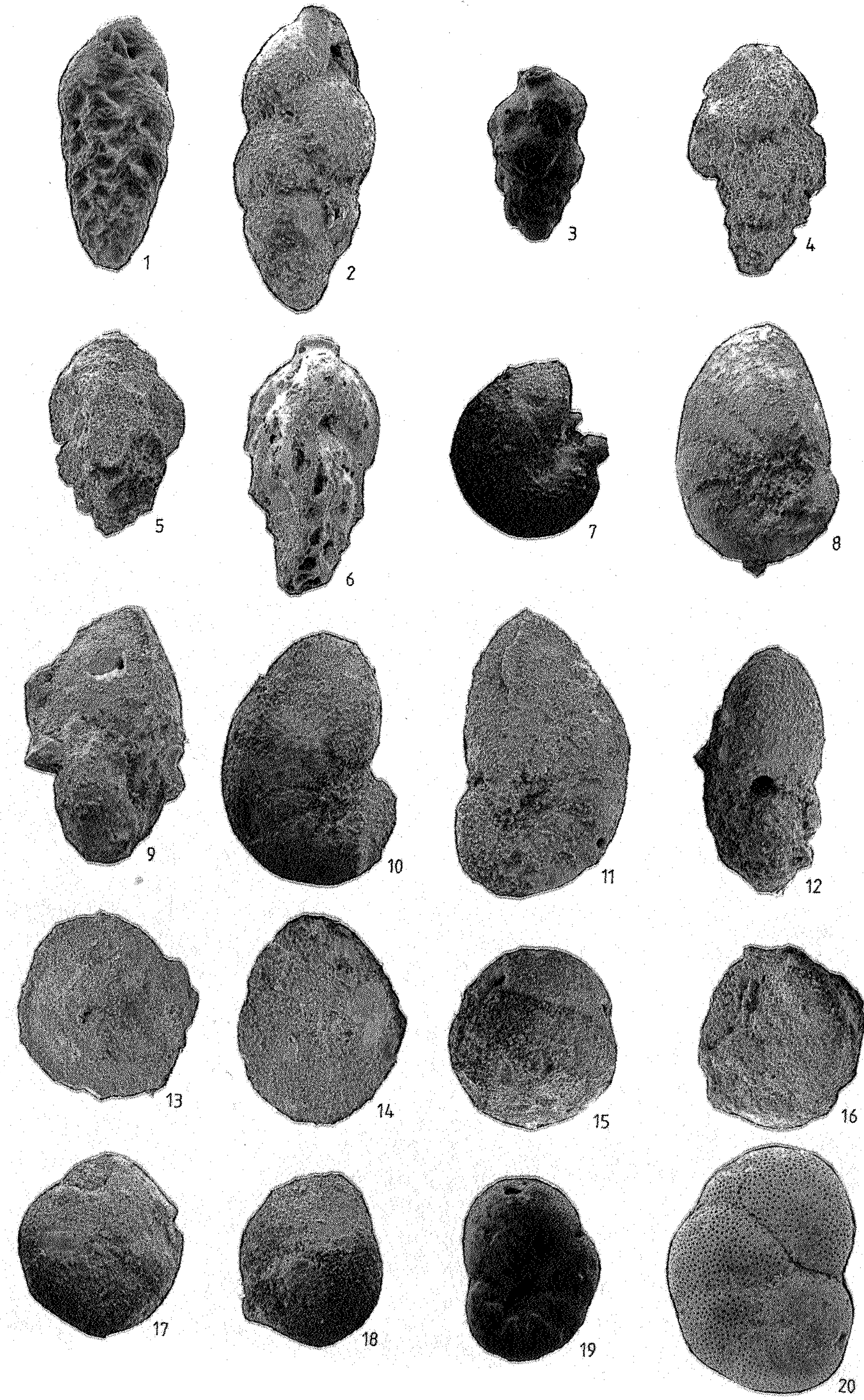

PLATE VIII

Figure 1 : *Cibicides acutimargo* Ten Dam, 1944 - X 75.

Figure 2 : *Cibicides acutimargo* Ten Dam, 1944 - X 85.

Figure 3 : *Cibicides carinatus* (Terquem, 1882) - X 90.

Figure 4 : *Cibicides carinatus* (Terquem, 1882) - X 115.

Figure 5 : *Cibicides lobatulus* (Walker & Jacob, 1798) - X 80.

Figure 6 : *Cibicides lobatulus* (Walker & Jacob, 1798) - X 85.

Figure 7 : *Cibicides proprius* (Brotzen, 1948) - X 100.

Figure 8 : *Cibicides proprius* (Brotzen, 1948) - X 100.

Figure 9 : *Cibicides tenellus* (Reuss, 1850) - X 240.

Figure 10 : *Cibicides tenellus* (Reuss, 1850) - X 170.

Figure 11 : *Cibicides westi* Howe, 1939 - X 165.

Figure 12 : *Cibicides westi* Howe, 1938 - X 210.

Figure 13 : *Cibicides westi* Howe, 1938 - X 210.

Figure 14 : *Alabamina wolterstorffi* (Franke, 1925) - X 140.

Figure 15 : *Alabamina wolterstorffi* (Franke, 1925) - X 190.

Figure 16 : *Siphonina lamarckana* Cushman, 1927 - X 175.

Figure 17 : *Pararotalia armata* (d'Orbigny, 1826) - X 175.

Figure 18 : *Pararotalia armata* (d'Orbigny, 1826) - X 185.

Figure 19 : *Elphidium laeve* (d'Orbigny, 1805) - X 165.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19