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Marine Miocene deposits in the Maaseik well 49W/220 in eastern Belgium: biostratigraphy by means of various microfossil groups.

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Abstract

A micropalaeontological analysis (foraminifera, ostracoda and *bolboforma*) has been undertaken for the interval between 299.7 and 201.5m of the Maaseik borehole. This interval includes marine glauconitic sands, which are generally not or not strongly decalcified. Independent from each other, the observed taxa of the different microfossil groups indicate a Late (range down to Middle) Miocene age for the interval. On the base of the biozonations of the various microfossil groups, some correlations can be presented with Late Miocene deposits of other areas in Belgium (Antwerp and Campine area), and of other places in NW Europe.

Introduction.

In 1980, at the initiative of the Belgian Geological Survey, a reconnaissance borehole was carried out in the industry zone Jagersborg, about 5 km to the northwest of the town of Maaseik. The Lambert coordinates of the drilling site are X 246 636 and Y 200 835 (Fig. 1, location map).

The topographic reference height Z is +33,14 m TAW. The upper 30 m was strongly destructively cored (10 cm core diameter). A core description and stratigraphic interpretation by Vandenberghe, Laga and Vandormael (1981) is kept in the files of the Geological Survey (K.B.I.N.) under the numbers 49/W-0220 (VIII,b). As this borehole is one of the few cored wells to the north of the Feldbiss and Heersheide faults in Belgium, and close to the Dutch stratigraphic nomenclature tradition, it was decided to publish the stratigraphic results of the marine Miocene part.

Lithostratigraphy

Generally, the Deurne Sands Member of the Diest Formation (De Meuter, 1980) contains grey green medium fine fossiliferous, glauconitic and loose sands. Typical whitisch bioturbation spots occur with a dark contour of glauconite. Dispersed nests of Bryozoa, Bivalvia and Brachiopoda are observed. At the base occurs a poorly developed gravel with dark small flint pebbles, small bone fragments and rare shark teeth. The Deurne Sands Member is part of the mainly non-fossiliferous Diest Formation with locally preserved micro- and macrofossils (De Meuter, 1980). According to Vandenberghe et al. (1998) the Diest Formation constitutes a deeply incised lower (>50 m) sequence boundary with a high sedimentation rate. Below 198 m till total depth at 302 m, a fine slightly clayey, mica-rich, bioturbated glauconitic sand occurs, with shell debris and also complete preserved molluscs a.o. *Cardita, Pygocardia, Lingula* sometimes washed together in particular horizons. At 222-223 m occurs a calcareous sandstone layer. Small

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grain-size variations allow to further subdivide the sandy layer studied (Vandenberghe et al., in preparation).

Biostratigraphy of the marine Miocene

Foraminifera

In the studied marine interval, planktonic foraminifera occur as well as benthonic foraminifera. The collection of foraminifera is stored in the 'Instituut voor Aardwetenschappen' at Leuven. Under the numbers F12754 - F12782 and F13020 - F13046, planktonic foraminifera (interval -228.5 m to -201.5 m). The only discovered taxon is *Neogloboquadrina pachyderma* (Ehrenberg, 1861). Most of the individuals are dextrally coiled (Table 1).

De Meuter & Laga (1970) state that the change in the dominantly sinistrally or dextrally coiled specimens coïncides with the admitted Mio-Pliocene boundary in Belgium, defined by the resolutions of the Gent Symposium in 1961 between the Miocene Deurne Sands and the Pliocene Kattendijk Sands (1963). According to several authors (De Meuter & Laga, 1970), the coiling direction may be attributed to climatological oscillations: the temperature in the Pliocene deposits with sinistrally coiled specimens of *Neogloboquadrina pachyderma* is distinctly lower than the temperature of the Miocene deposits with dextrally coiled individuals. Since the paper of Bauch et al. (2003), however, we know that in fact two stocks of *Neogloboquadrina pachyderma* occur: one is 100% dextrally coiled and linked to warm water conditions and the other stock is dominantly sinistrally coiled (about 95%), which is explained by a different RNA, occuring in the colder water assemblages. We can accept that the studied marine deposits of the Maaseik borehole belong to the Upper Miocene. In the biostratigraphy of C. King (1983), the interval corresponds to the NSP16 *Neogloboquadrina* zone benthonic foraminifera.

Table 1. Number of sinistrally- and dextrally coiled individuals of Neogloboquadrina pachyderma in the studied interval of the Maaseik well (after Dr. H. Hooyberghs)

DEPTH (m)	SINISTRALLY COILED	DEXTRALLY COILED
201,5		1
206,15		1
206,55		3
209,5		
211,5	1	1
225,5		
227,5	2	7
228,5	3	6

The quantitative distribution of the benthonic foraminifera, recorded from the interval -288,5 to -201,5 m in the Maaseik borehole is given in Table 2. Specimens less than 1% are not indicated, although

Plate 1: Foraminifera

Fig. 1.	*Spiroplectammina deperdita* (D' Orbigny, 1846)	-227,5 m	X 85
Fig. 2.	*Siphotextularia sculpturata* (Cushman & Ten Dam, 1947)	-201,5 m	X 26
Fig. 3.	*Siphotextularia sculpturata* (Cushman & Ten Dam, 1947)	-201,5 m	X 40
Fig. 4.	*Textularia abbreviata* (D' Orbigny, 1846)	-227,5 m	X 53
Fig. 5.	*Nodosaria longicauda* (D' Orbigny, 1826):	-227,5 m	X 67
Fig. 6.	*Lagena elongata* (Ehrenberg, 1844)	-227,5 m	X 56
Fig. 7.	*Lagena hispida* (Reuss, 1863)	-227,5 m	X 140
Fig. 8.	*Lagena pulchra* (Clodius, 1922)	-227,5 m	X 125
Fig. 9.	*Lagena tenuis* (Bornemann, 1855)	-227,5 m	X 103
Fig. 10.	*Lagena hexagona* (Williamson, 1848)	-227,5 m	X 135
Fig. 11.	*Globulina gibba* (D' Orbigny, 1826)	-227,5 m	X 133

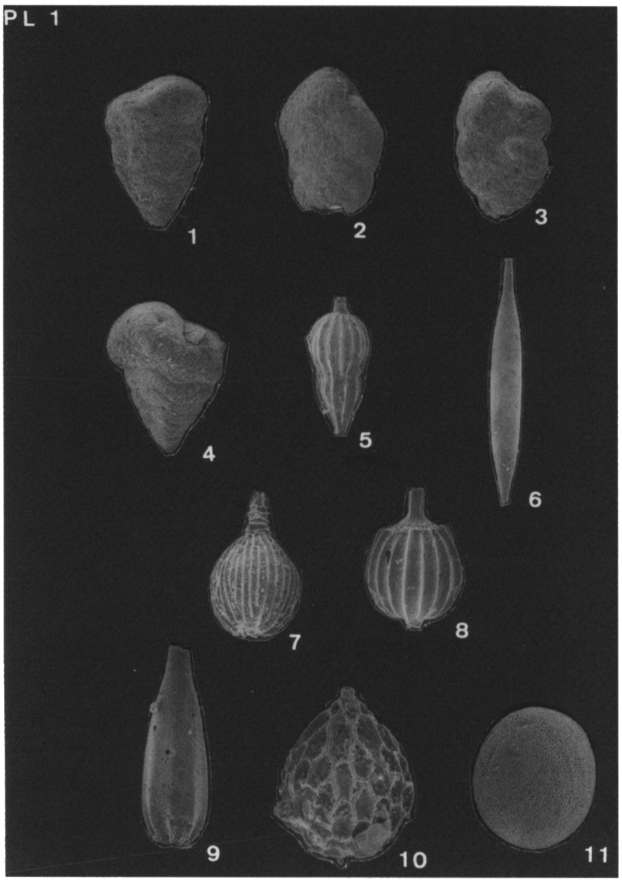

Table II: Quantitative distribution of benthonic foraminifera in the studied interval of the Maaseik well (after Dr. H. Hooyberghs)

TAXA	DEPTH (m)							
	201,5	206,15	206,55	209,5	211,5	225,5	227,5	228,5
Spiroplectammina deperdita (D'ORBIGNY, 1846)				3				
Siphotextularia sculpturata (CUSMAN & TEN DAM, 1947)	1							
Textularia abbreviata (D'ORBIGNY, 1846)					1		2	
Nodosaria pyrula (D'ORBIGNY , 1826)	3	1	4		2	14	6	6
Nodosaria longicauda (D'ORBIGNY, 1826)	3	6	2	4	3		4	
Dentalina perigrina (REUSS,1846)			1					
Lagena tenuis (BORNEMANN, 1855)				2		1	1	1
Lagena hexagona (WILLIAMSON, 1848)		3	8	3	2	2	1	1
Lagena pulchra (CLODIUS, 1922)	5	3	8	2	5	2	2	5
Globulina gibba (D'ORBIGNY, 1826)	20	10	12	19	13	7	6	4
Globulina tuberculata (D'ORBIGNY, 1846)	5	1		4	8	6		2
Guttulina austriaca (D'ORBIGNY, 1846)	1	1						
Pseudopolymorphina subnodosa (REUSS,1861)					2			
Pyrulina fusiformis (ROEMER,1838)					2			2
Glandulina laevigata (D'ORBIGNY, 1826)	8	2	2	2	8	1		4
Fissurina orbignyana (SEGUENZA , 1826)		1	1	2		1		
Fissurina laevigata (REUSS, 185O)		1					1	1
Bolivina imporcata (CUSHMAN & RENZ, 1944)	2	1		1				
Globobulimina auriculata (BAILEY, 1851)	3	2	2	1	1		5	
Uvigerina hosiusi deurnensis (DE MEUTER & LAGA, 1977)		2	1				2	6
Trifarina angulosa (WILLIAMSON, 1858)	1	19	9	1	3	2	7	6
Rosalina globularis (D'ORBIGNY, 1826)		1	1					
Cancris auriculus (FICHTEL & MOLL, 1803)					2	11	6	6
Elphidium antonium (D'ORBIGNY, 1846)		4	1		2	2		4
Cibicides lobatulus (WALKER & JACOB, 1798)	4	9	9	4	11	1	5	5
Cibicides ungerianus (D'ORBIGNY , 1846)	22	18	20	36	21	39	27	30
Florilus boueanum (D'ORBIGNY, 1846)	22	15	19	16	13	7	24	12
Nonionella turgida (WILLIAMSON, 1858)					1	4	1	3
Hanzawaia boueanum (D'ORBIGNY, 1846)								2

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some of them also have been figured. The deeper interval is -distinctly less calcareous and contains sporadic individuals of *Polymorphinidae*. For the systematics of the taxa, we mainly refer to the publication of De Meuter (1980).

The samples were washed on a sieve of 75 μ. For each sample, 100 individuals were counted. The fauna observed can be correlated with the *Uvigerina hosiusi deurnensis-Elphidium antonium* assemblage zone

Plate 2. Foraminifera

Fig. 1.	*Globulina gibba* (D' Orbigny, 1826)	-227,5 m	X 115
Fig. 2.	*Pseudopolymorphina subnodosa* (Reuss, 1861)	-227,5 m	X 48
Fig. 3.	*Glandulina laevigata* (D' Orbigny, 1826)	-211,5 m	X 138
Fig. 4.	*Fissurina orbignyana* (Seguenza, 1826)	-227,5 m	X 340
Fig. 5.	*Bulimina elongata* (D' Orbigny, 1826)	-227,5 m	X 126
Fig. 6.	*Bolivina imporcata* (Cushman & Renz, 1944)	-227,5 m	X 133
Fig. 7.	*Uvigerina hosiusi deurnensis* (De Meuter & Laga, 1977)	-227,5 m	X 107
Fig. 8.	*Uvigerina hosiusi* deurnensis (De Meuter & Laga, 1977)	-227,5 m	X 123
Fig. 9.	*Trifarina angulosa* (Williamson, 1858)	-227,5 m	X 133

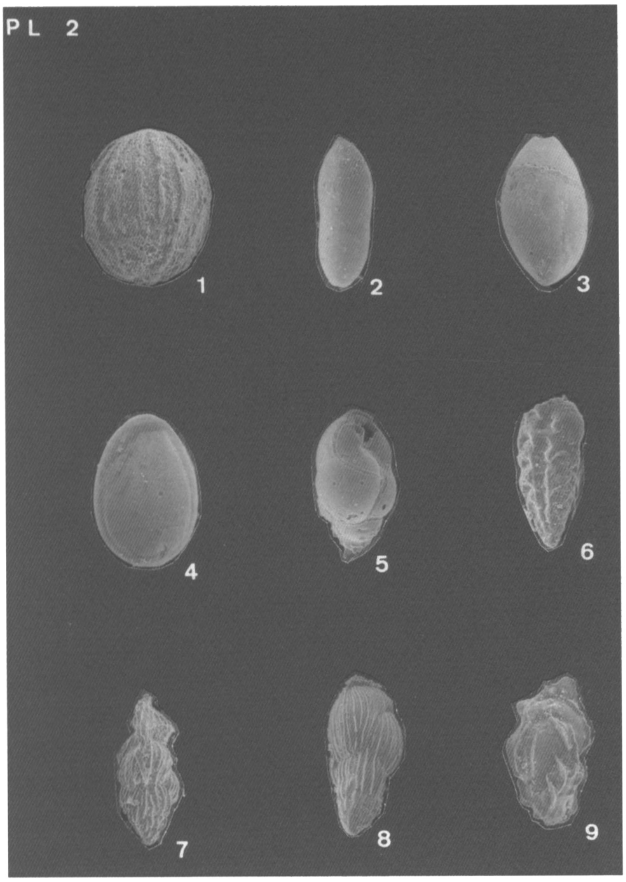
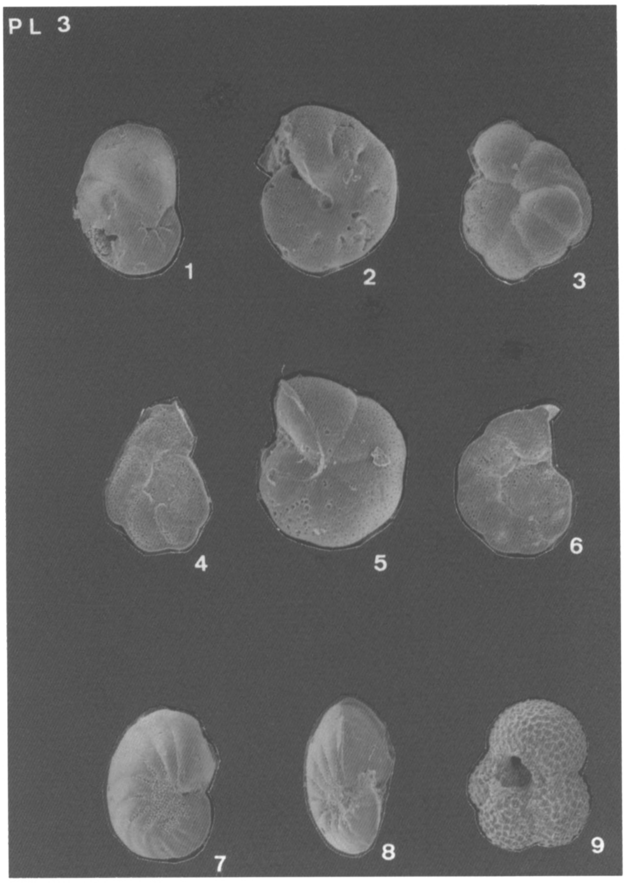


Plate 3. Foraminifera

Fig.	1. *Cancris auriculus* (Fichtell & Moll, 1803)	-227,5 m	X 88
Fig. 2.	*Elphidium antonium* (D' Orbigny, 1846)	-227,5 m	X 156
Fig. 3.	*Cicides lobatulus* (Walker & Jacob, 1798), Umbilical side	-227,5 m	X 73
Fig. 4.	*Cibicides lobatulus* (Walker & Jacob, 1798), Spiral side	-227,5 m	X 78
Fig. 5.	*Cibicides ungerianus* (D' Orbigny, 1846), Umbilical side	-227,5 m	X 125
Fig. 6.	*Cibicides ungerianus* (D' Orbigny, 1846), Spiral side	-227,5 m	X 98
Fig. 7.	*Florilus boueanum* (D' Orbigny, 1846), Lateral side	-227,5 m	X 67
Fig. 8.	*Florilus boueanum* (D' Orbigny, 1846), Front side	-227,5 m	X 76
Fig. 9.	*Globigerina pachyderma* (Ehrenberg, 1861)	-201,5 m	X 150



of De Meuter & Laga (1976), by the presence of the index taxa. In the correlation chart of Dopert, Laga & De Meuter (1979), the association fits in the BFN3 *Uvigerina hosiusi deurnensis-Elphidium antonium* assemblage zone, which can be correlated with lower part of the (FC 2) *Siphotextularia sculpturata- Uvigeri-*

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Table III: Ditribution of ostracoda in the studied interval of the Maaseik well (after Dr. K. Wouters)

TAXA	DEPTH (m)								
	201,5	205,5	209,5	211,5	214,5	225,5	227,5	228,5	235,5
Bonnyannella sp. 1 (n. sp. in thesis)						X	X	X	
Bythocypris arquata (MÜNSTER, 1830)			X	X		X			
Callistocythere sp. indet.				X					
Callistocythere sp. 1 indet.			X						
Callistocythere sp. 2 indet.					X				
Cytherella sp. indet.			X	X					X
Cytherella pilgeri (BASSIOUNI, 1962)		X		X					
Cytheridea hoerstgenensis (BASSIOUNI, 1962)		X							
Eucytheridea lienenklausi (KUIPER, 1918)		X							
Eucytheridea sp. indet. juv.					X				
Flexus sp. 1 (n. sp. in thesis)					X				
Kuiperiana latissima (BRADY, 1878)		X		X					
Leptocythere sp. indet.							X		
Loxoconcha variolata (BRADY, 1878)						X			
Loxoconcha sp. 1 (n. sp. in thesis)		X							
Muellerina latimarginata (SPEYER, 1863)					X	X			
Neocytherideis sp.			X						
Pontocythere lithodomoides (BOSQUET, 1852)		X	X						
Propontocypris propinqua (BRADY, 1878)			X						
Schizocythere hollandica (TRIEBEL,1950)			X						
Thaerocythere sp. 1 (n. sp. in thesis)	X	X				X		X	
Xestoleberis sp. indet. juv.		X							

na hosiusi assemblage zone in the Netherlands (Breda Formation). This association has also been observed in the Gram Formation in Denmark (Hooyberghs & Moorkens (in preparation). In the biozonation of C. King (1983), the association belongs to the NSB13 zone, with the significant presence of *Siphotextularia sculpturata*.

As far as the palaeoecology concerns, we can say that the marine sediments reflect an open marine continental shelf deposit of normal salinity, with a higher temperature than in the Pliocene deposits.

Ostracoda

Table 3 shows the distribution of ostracoda in the studied interval of the Maaseik borehole. The observed taxa can be correlated with the association of the Deurne Sands in the Antwerp area. Especially the presence of *Thaerocythere sp. 1, Loxochoncha variolata* (Brady, 1878) and *Propontocypris propinqua* (Brady,

1878) is significant. Those taxa seem not to occur in other Miocene deposits or in Pliocene deposits of the Antwerp area. Also the other taxa indicate a Miocene rather than a Pliocene age. Interesting is the occurrence of *Callistocythere* sp. 1 and 2 and *Leptocythere* sp. as none of those three species occur in the Deurne Sands, nor in other Miocene deposits in Belgium. This may indicate an other palaeo environment, namely a shallow, relatively quite marine environment, characterized by the presence of algae (Athersuch, J.& al., 1989).

Bolboforma

The *Bolboforma* specimens were picked under the binocular from the same washed residue used to study the foraminifera. However, they are much more smaller than foraminifera. *Bolboforma*s are enriched in the sediment fractions smaller than 200 μ.

In the Maaseik well, *Bolboforma* specimens are well preserved and common to abundant in samples between -201.50 to -228.50 m belonging to the Upper Miocene and rare in the samples of the Middle Miocene between -237.50 to -298.70 m. Nine *Bolboforma* taxa were observed. Their abundance shown in the range chart (Table 4) is based on semi-quantitative estimates as follows: A = abundant: > 25 specimens; C = common : 6-25 specimens; R = rare: 2-5 specimens; T = trace : 1 specimen, and contamination = (?).

Four Neogene *Bolboforma* zones have been recognized in the investigated interval: the *B. metzmacheri Zone, B. capsula* zone, *B. compressipinosa* zone, and the *B. badenensis* zone. These zones are established in Spiegler and Von Daniels (1991), updated in Spiegler (1999).

The *Bolboforma* metzmacheri Zone (-201.50 to -227.70 m) contains five *Bolboforma* taxa : *B. metzmacheri, B. metzmacheri ornata, B. clodiusi, B. deformis* and *B. laevis*. In the upper part of the section down to sample -206.55 m, *B. metzmacheri* and *B. metzmacheri ornata* are common and *B. clodiusi* and *B. laevis* are rare, but the latter two were common to abundant in the lower part of the section together with only single specimens of *B. metzmacheri.* In sample -228.50 m one specimen of *Boboforma capsula* occurs together with *B. clodiusi, B. deformis, and B. laevis*, determining the Upper Miocene *B. metzmacheri* zone and the *B. capsula* zone at 9.7 Ma (Spiegler, 1999). The following sample -234.50m contains only one poor preserved *Bolboforma metzmacheri* (contamination?).

In the samples - 237.50 and - 246.50 m *Bolboforma compressispinosa* and *B. furcata* occured together with single *B. deformis* and *B. clodiusi* (contamination too?) *B. compressispinosa* is the index fossil for the *B. compressispinosa* zone (11.7 - 11.9 Ma) of the upper part of the Middle Miocene.

The last occurrence (LO) of *Bolboforma* badenensis, the zone fossil of the B. badenensis zone, is observed in sample -259.50 m. Therefore, the boundary between the *B. badenensis* zone and the *B. compressispinosa* zone lies in the well between -246,50 and -259,50m. Comparing the *Bolboforma* associations of the Maaseik well with the high-resolution *Bolboforma* biostratigraphy of the North Atlantic (Spiegler, 1999), the record seems to be not complete. Only the following events dated in the Nort Atlantic are also observed in the well and allowed correlation and age determination: the LO of *B. capsula* which lies in the North Atlantic at 9.7 Ma and in the Maaseik well at -228.50m. The total range of *B. compressispiniosa* oc-

Plate 4 : Ostracoda

Fig. a & b:	*Thaerocythere sp.*
Fig. c:	*Propontocypris propinqua* (BRADY, 1878)
Fig. d:	*Loxoconcha variolata* (BRADY, 1878)

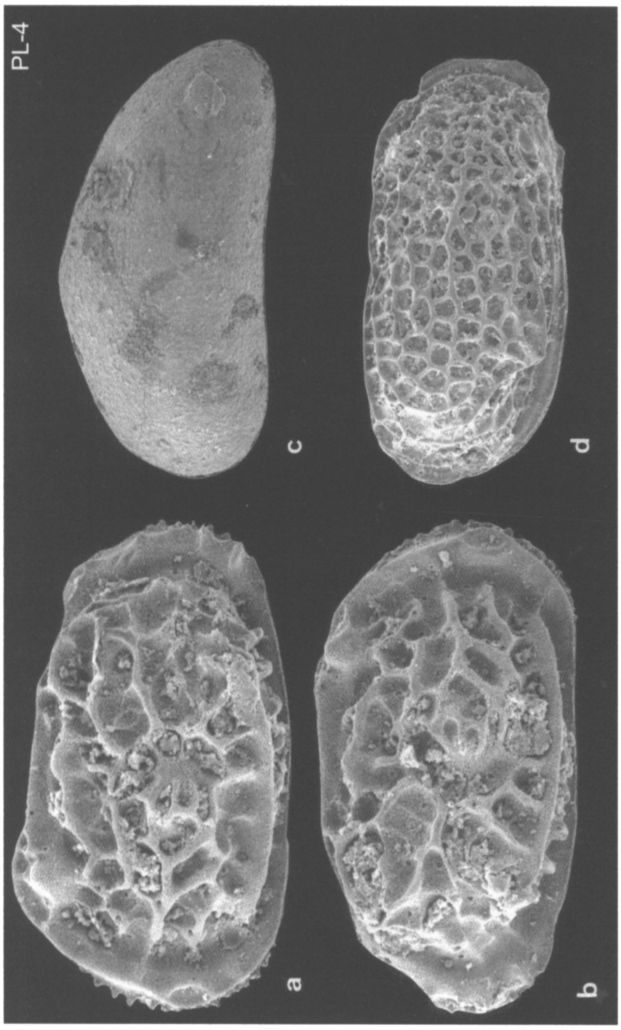

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Table IV : Distribution of Bolloforma in the interval between -299,7 & -201,5 of the Maaseik well (after Dr. D. Spiegler) (T: very rare; R: rare; C:common; A:abundant)

TAXA	DEPTH (m)													
	201,5	206,1	206,5	209,5	211,5	214,3	225,5	227,7	228,5	234,5	237,5	246,5	259,5	298,7	299,7
Bolboforma metzmacheri (CLODIUS)	C	C	R	T	T					T					
Bolboforma metz. Ornata (SPIEGLER)	R	C	C											(T)	
Bolboforma clodiusi (V.H DANIELS & SPIEGLER)	T	T	R	T		C	A	A	A			T			
Bolboforma deformis (SPIEGLER)		T	R				R	R	R		T	T			
Bolboforma laevis (V.H DANIELS & SPIEGLER)			T	C	A	A			T				T	T	
Bolboforma capsula (SPIEGLER)									T						
Bolboforma furcata (SPIEGLER)											C	R			
Bolboforma compressispinosa (SPIEGLER)											R	C			
Bolboforma badenensis (SZCZECHURA)													T	T	

Bolboforma - ZONES	upper *Bolboforma metzmacheri*	lower *Bolboforma metzmacheri*	*B. capsula?*	?	*Bolboforma compressispinosa*	*Bolboforma badenensis*
SERIES	Upper Miocene				?	Middle Miocene
AGE	> 7.7 Ma		9.7 Ma		> 11.7 Ma	> 11.9 Ma

cured between -237.50m and -246.70m and is dated with 11.7 - 11.9 Ma. The LO of *B. badenensis* is observed at -259.50m and is dated with 11.9 Ma.

In the record drilled by the Maaseik well, a hiatus of more than 2my between the Upper Miocene and the Middle Miocene is to observe, because parts of the *B. capsula* zone and the complete *B. subfragoris*-zone are missing.

The *Bolboforma* associations of the Maaseik well complete our knowledge about *Bolboforma* biostratigraphy of Belgium (Spiegler, 2001).

Conclusions.

The micropalaeontological analysis of marine deposits between -201.50 and -299.70 m in the Maaseik well allows us to recognize Upper Miocene down to Middle Miocene (Tortonian-Messinian) ages for these marine sediments. A stratigraphical hiatus occurs between the Middle and Upper Miocene, indicating two different transgression levels. It is possible to correlate these marine sands with the Antwerp area and with deposits in other countries in Northern Europe. The recognition of these marine Miocene deposits is important for a more detailed elaboration of the palaeogeographic map of the Miocene deposits in Belgium.

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