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DEPOSITIONAL ENVIRONMENT OF THE OLIGOCENE RUPEL CLAY IN WELL GRASHOEK-1, PEEL REGION, THE NETHERLANDS

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ABSTRACT

Brouwer, J. (1977). Depositional environment of the Oligocene Rupel Clay in well Grashoek-1, Peel region, The Netherlands. Geol. Mijnbouw, 56, p. 25-30.

A continuously cored marine Oligocene Rupel Clay of the N.A.M. well Grashoek-1 (Peel region, the Netherlands) yielded a benthonic foraminiferal fauna indicative of a bathyal environment with a seadepth below 300-500 m.

INTRODUCTION

In 1971 the N.A.M. drilled the well Grashoek-1 in the Peel region of the Netherlands (see location map, fig. 1). In this well an almost continuous series of cores was taken over the Oligocene Rupel Clay.

For the purpose of determining the environment of deposition of this Rupel Clay a closely sampled series of core material was studied quantitatively and qualitatively on the presence of foraminifera and other microfossil remains.

In the following paragraphs we will discuss the method of investigation applied here, the interpretation of the environment of deposition and our conclusions. A bibliography and check list of foraminiferal species are also given at the end of this article.

The author is indebted to his colleague, the late Dr. R.Lagaaij, for his constructive criticism and useful suggestions, and to the directors of Shell Internationale Petroleum Maatschappij and Nederlandse Aardolie Maatschappij for permission to publish this paper.

METHOD OF INVESTIGATION

Pieces of core material varying in dry weight from 70 to 340 grammes were collected at 1 m intervals or less. They were washed over a set of sieves, yielding three fractions of washresidue, i.e. 70–150 μ (fine), 150–420 μ (medium) and + 420 μ (coarse). These fine, medium and coarse fractions were then dried and weighed.

Next, the sieve fractions were investigated quantitatively for the presence of Foraminifera, Echinoidea, Mollusca, Ostracoda, Bryozoa, and fish remains consisting of teeth, otoliths or scales. In order to do this within a reasonable time, a sample splitter was used to obtain splits of residue in which between 100 and 200 specimens of both benthonic and planktonic foraminifera could be expected in the coarse and medium fractions.

The resulting specimen counts were then multiplied by the split factors for the purpose of calculating the number of foraminiferal specimens per gram of sediment in each sample.

The percentage occurrence of each benthonic foraminiferal species, as found in the coarse and medium fractions combined, is presented on a distribution chart (enclosure).

On this distribution chart the percentages are rounded off to whole figures, values of half a percent or a higher fraction being rounded off to one percent. Occurrences of less than half a percent are indicated by +. In most samples the percentages add up to approximately one hundred; in those, in which they do not, the balance consists of undetermined species. In those samples where the sum of the specimens in the coarse and medium fractions appeared to be less than one hundred, the occurrences are indicated by ×.

The specific determinations were accomplished with the aid of the literature listed in the bibliography. A check list of the identified species is appended.

The distribution chart moreover has been used to register the following statistical parameters:

– the percentage of agglutinated specimens in the total benthonic foraminiferal fauna > 150 μ;

1) Shell Internationale Petroleum Maatschappij B.V., The Hague.

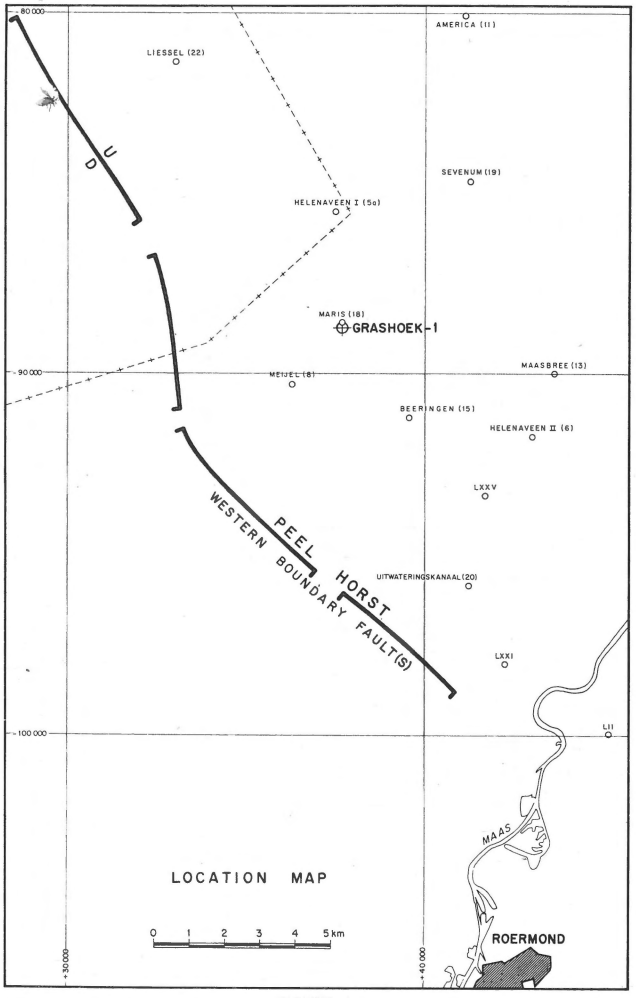


FIGURE 1

– the number of benthonic + planktonic foraminifera per gram of sediment, calculated by dividing the dry weight of the sample in grammes on the foraminiferal specimen counts fractions > 150 μ X split factors. In the same column the wavy areas represent the planktonic fraction of the foraminiferal number;
– the number of foraminifera per gram of sediment, taking into account the foraminiferal specimen counts of all fractions; the numbers thus obtained are indicated in a separate column;
– weight percentage of the three residues combined versus the dry weight of sample.

The occurrences of other microfossil remains are noted in still another column.

ENVIRONMENTAL INTERPRETATION

The environment of deposition, as indicated by the benthonic foraminiferal fauna, has been calculated by utilizing statistical information regarding the environmental distribution of benthonic foraminifera, stored in a Data Bank.

For the interpretation of the depositional environment of the Rupel Clay the statistical data of the following species, occurring with 5% or more in any of the presently studied samples, have been used:

Ammodiscus incertus aucts
\+ *Cyclammina placenta* (Reuss)
\+ *Karreriella siphonella* (Reuss)
\+ *Recurvoides deformis* (Andreae)
\+ *Reophax variabilis* Herrmann
Saccammina sphaerica M. Sars
\+ *Spiroplectammina carinata* (D'Orbigny) + var. *deperdita* (D'Orbigny)
\+ *Alabamina tangentialis* (Clodius)
\+ *Asterigerinoides gürichi* (Franke)
\+ *Brizalina beyrichi* (Reuss)
\+ *Cassidulina carapitana* Hedberg
\+ *Ceratobulimina contraria* (Reuss)
Chilostomella cylindroides Reuss
Gyroidina soldanii D'Orbigny
\+ *Heterolepa dutemplei* (D'Orbigny)
\+ *Heterolepa ungeriana* (D'Orbigny)
Hoeglundina elegans (D'Orbigny)
Lenticulina spp.
\+ *Nodosaria consobrina* (D'Orbigny)
\+ *Nodosaria longiscata* D'Orbigny
\+ *Nodosaria soluta* (Reuss)
Melonis affinis (Reuss)
Oridorsalis umbonatus (Reuss)
\+ *Plectofrondicularia seminuda* (Reuss)
Pullenia bulloides (D'Orbigny)
\+ *Siphonodosaria adolphina* (D'Orbigny)
\+ *Siphonodosaria verneuili* (D'Orbigny)
Sphaeroidina bulloides D'Orbigny
\+ *Trifarina oligocaenica* (Andreae)
\+ *Uvigerina gracilis* Reuss

For the species marked +, which are for the major part extinct nowadays, statistical data of closely related Recent species, or else calculated data derived from co-occurrences with Recent species, have been applied.

The sea-depth ranges resulting from these calculations have been plotted in a separate column on the distribution chart.

RESULTS AND DISCUSSION

The information brought together on the distribution chart leads to the following remarks regarding the Rupel Clay cores in the well Grashoek-1:

320–322m: clay, rich in glauconite, pyrite, and fish remains. Very poor benthonic fauna.
322–326 m: no core material
326–358 m: clay, with a few sandy intercalations, rich in

glauconite and pyrite. Well developed bathyal benthonic foraminiferal fauna, indicating an average sea depth below 500 and 700 m. Occasionally a poor, nondiagnostic planktonic fauna, never exceeding 18% of total fauna.

358–399 m: (no cores between 365–369 and 379–386 m) clay, with some thicker sand layers at 371–372 m and 381–386 m. At places rich in pyrite and fish remains. In general barren or with rather poor benthonic faunas, except for a thin band with a fairly rich *Brizalina beyrichi – Gyroidina soldanii* fauna at 376–376.1 m. The benthonic elements indicate in general a *bathyal* environment of deposition below 500–700 m.

399-406.8 m: clay, with pyrite. Well-developed benthonic foraminiferal fauna. Predominantly *bathyal* below 300 and 500 m.

406.8–411 m: clay, practically barren.

411–417 m: sand, underlying the Rupel Clay, with a very poor benthonic fauna at 417 m, not really different in composition from the ones above.

Throughout the whole section reworked Cretaceous foraminifera are occasionally present.

A comparison of some statistical parameters with Recent and Pleistocene samples taken at sea depths between 500 and 2,000 m in the Gulf of Guinea (B r o u w e r, 1973) shows some interesting differences:

	Number of samples	averages				
		Foraminifera per gram of sediment		Percent plankt. of total fauna	Benth. Foram. p. gr. of sed.	Weight residue in percent of dry sample
		> 150 μ	> 70 μ		> 150 μ	
Grashoek-1						
320-322 m	2	< 1	7	0	< 1	14
326-358 m	29	16	160	2	16	4
358-399 m	35	2	22	0	2	3
399-406.8 m	8	8	93	0	8	1
406.8-411 m	2	< 1	< 1	0	< 1	46
411-417 m	6	1	13	0	< 1	67
Guinea	28	1,000	7,500	68	160	5

Striking is the virtual absence of planktonics in the Rupel Clay considering its depth of deposition. This could be due to restricting environmental conditions in the surface waters. But also the number of benthonic foraminifera per gram of sediment is very low. This suggests an environment in which either conditions on the sea floor were restrictive for benthonic life, or otherwise, sediment was laid down at a rather rapid rate.

A restriction to benthonic life is also borne out by the relative paucity in species, if for example compared with foraminiferal faunas from Oligocene bathyal and abyssal sediments in the Caribbean, Indo-Pacific or Mediterranean regions.

In conclusion it is of interest to note that the sea depth interpreted for the Rupel Clay in well Grashoek-1 falls rather well in line with those found by B o e k s c h o t e n (1963, 1967), from a study of the malaco-fauna in the Rupel Clay of St. Niklaas-Waas (Belgium), Winterswijk and Ootmarsum. The depths concluded at for these localities are indicated on figure 2, together with the one found for Grashoek, whereby attention should be drawn to the fact that this well apparently has been drilled in the area of the thickest development of the Rupel Clay, as can be concluded from the base map from K e i z e r & L e t s c h (1963).

ANNOTATED LIST OF BENTHONIC FORAMINIFERA

Agglutinated:

Ammobaculites hockleyensis Cushman & Applin
Ammobaculites hockleyensis Cushman & Applin, 1926, p. 163, pl. VI, fig. 2a, b.
Ammobaculites hockleyensis Cushman & Applin – Ellisor, 1933, p. 1319, pl. VII, fig. 11.

Ammobaculites humboldti (Reuss)
Spirolina humboldti Reuss, 1851, p. 65, pl. III, fig. 17, 18.

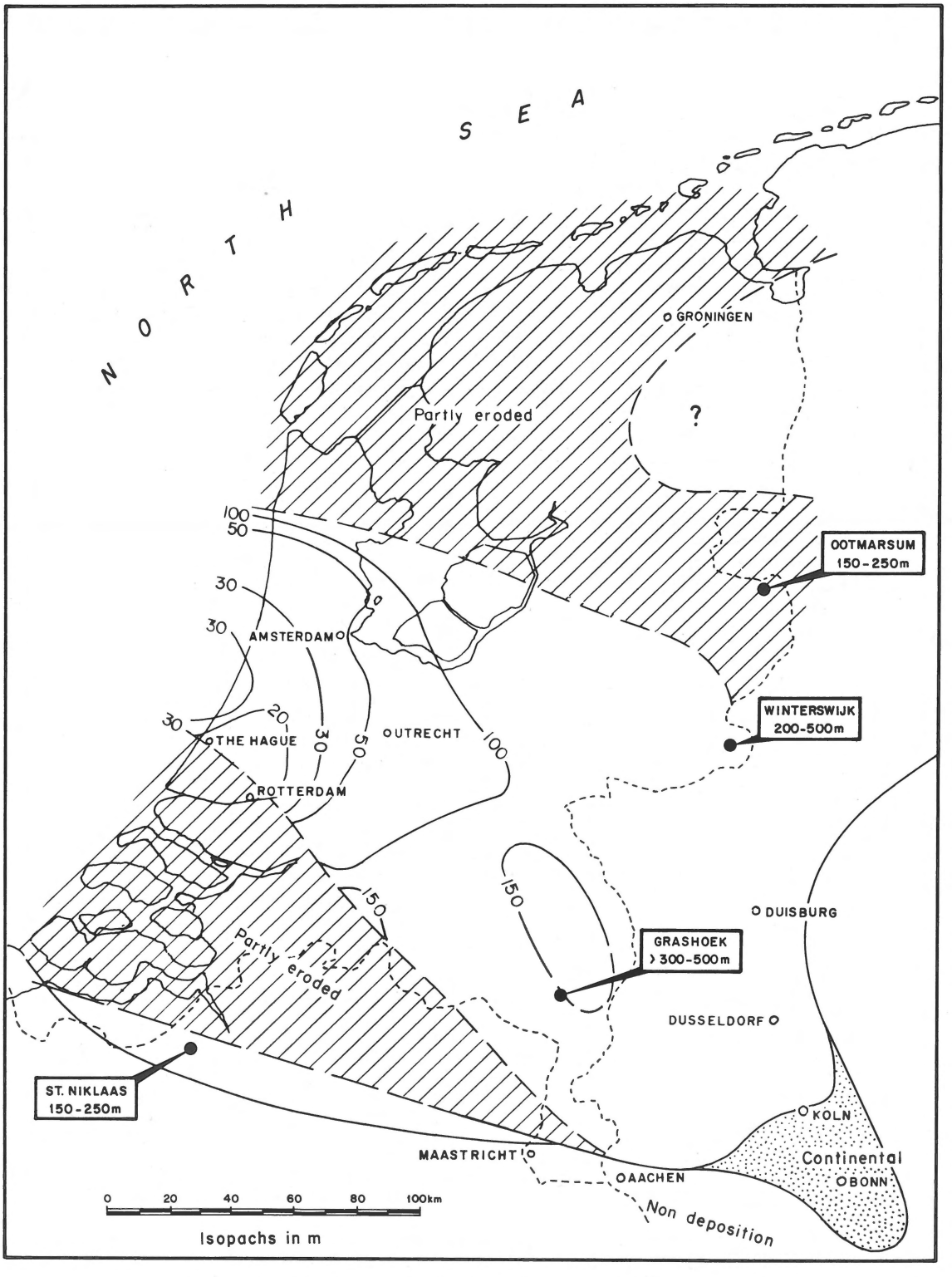
Ammodiscus incertus aucts.

Cyclammina placenta (Reuss)
Nonionina placenta Reuss, 1851, p. 72, pl. V, fig. 33.
Cyclammina placenta (Reuss), 1936, P. 29, pl. IV, fig. 12a, b.

Dorothia nuttalli Cushman
Dorothia nuttalli Cushman, 1936, p. 29, pl. IV, fig. 12a, b.

Hormosina globulifera trinitatensis Cushman & Renz
Hormosina globulifera Brady var. *trinitatensis* Cushman & Renz, *1946, pl. I, fig. 15-19.*

Karreriella chilostoma (Reuss)
Textularia chilostoma Reuss, 1852, p. 18, figs. a, b.



Inferred depth of the Rupel Clay sea in Belgium and The Netherlands based on the malacofauna (BOEKSCHOTEN, 1963 & 1967) and on the benthonic Foraminifera in the well Grashoek-1 (this paper)

(Base map from KEIZER & LETSCH 1963, completed with other literature data, a.o. PFLUG 1958)

FIGURE 2

Karreriella siphonella (Reuss) var. *chilostoma* (Reuss), Batjes, 1958, pl. I, fig. 8.

Karreriella siphonella (Reuss)
Gaudryina siphonella Reuss, 1851, p. 78, pl. V, fig. 6-8.

Martinottiella muensteri (Cushman)
Listerella münsteri Cushman, 1936, p. 38, pl. VI, fig. 7.
Martinottiella sp., Batjes, 1958, pl. I, fig. 10.

Recurvoides deformis (Andreae)
Haplophragmium deforme Andreae, 1884, p. 197, pl. VIII, fig. 1.
Haplophragmoides latidorsatus (Bornemann), Batjes, p. 98, pl. I, fig. 1.

Reophax variabilis Herrmann
Reophax variabilis Herrmann, 1971, p. 286, pl. II, fig. 18-20.

Rhabdammina discreta Brady
Rhabdammina discreta Brady, 1884, p. 268, pl. XXII, p fig. 7-10.
Rhabdammina discreta Brady, Cushman & Renz, 1946, pl. 1, gif. 1.

Saccammina sphaerica M. Sars
Saccammina sphaerica M. Sars, Brady, 1884, p. 253, pl. XVIII, fig. 11-17.

Spiroplectammina carinata (D'Orbigny)
Textularia lacera Reuss, 1851, p. 84, pl. VI, fig. 52-53.
Textularia attenuata Reuss, 1851, p. 84, pl. VI, fig. 54.
Spiroplectammina carinata (D'Orbigny), Batjes, 1958, p. 98, pl. 1. fig. 2.

Spiroplectammina carinata deperdita (D'Orbigny)
Spiroplectammina carinata (D'Orbigny) var. *deperdita* (D'Orbigny), Batjes, 1958, p. 98, pl. I, fig. 3.

Textularia mayeriana D'Orbigny
Textularia mayeriana D'Orbigny, Grossheide & Trunkó, 1965, p. 52, pl. 3, fig. 2.

Calcareous:

Alabamina tangentialis (Clodius)
Alabamina tangentialis (Clodius), Batjes, 1958, p. 155, pl. VIII, fig. 7.

Asterigerinoides guerichi (Franke)
Asterigerina gürichi (Franke), Batjes, 1958, p. 159, pl. X, fig. 6, 7.

Astrononion perfossum (Clodius)
Nonion perfossum (Clodius), Batjes, 1958, p. 141, pl. VI, fig. 16.

Brizalina beyrichi (Reuss)
Bolivina beyrichi Reuss, Batjes, 1958, p. 131, pl. V, fig. 11.
Included in this species is the *var. melettica* (Andreae) (= *Bolivina bituminosa* Spandel) figured by Batjes on his pl. V, fig. 10, which occurs very abundantly in core 376 m of Grashoek-1).

Bulimina alsatica Cushman & Parker
Bulimina alsatica Cushman & Parker, Batjes, 1958, pl. IV, fig. 13a, b.

Cassidulina carapitana Hedberg
Cassadulina carapitana Hedberg, Batjes, 1958, p. 137, pl. VI, fig. 7.

Caucasina elongata (D'Orbigny)
Bulimina elongata D'Orbigny, Batjes, 1958, p. 126, pl. IV, fig. 16, 17.

Ceratobulimina contraria (Reuss)
Ceratobulimina contraria (Reuss), Batjes, 1958, p. 160, pl. X, fig. 4.

Chilostomella cylindroides Reuss
Chilostomella cylindroides Reuss, Batjes, 1958, p. 138, pl. VI, fig. 13.

Chrysalogonium? multilineata (Bornemann)
Nodosaria emaciata (Reuss) var. *multilineata* (Bornemann), Batjes, 1958, pl. III, fig. 21.

Cibicides oligocenicus Samoilova
Cibicides lobatulus (Walker & Jacob) var., Batjes, 1958, pl. IX, fig. 8.
Cibicides oligocenicus Samoilova, Schutzkaja, 1963, pl. IV, fig. 1, 2.

Dentalina communis D'Orbigny
Dentalina communis D'Orbigny, Kiesel, 1962, p. 25, pl. III, fig. 11.

Ehrenbergina variabilis Trunkó
Ehrenbergina variabilis Trunkó, Grossheide & Trunkó, 1965, p. 124, pl. 13, fig. 1.

Elphidium inflatum (Reuss)
Elphidium inflatum (Reuss), Batjes, 1958, p. 164, pl. XII, fig. 1.

Florilus boueanus (D'Orbigny)
Nonion boueanum (D'Orbigny), Batjes, 1958, p. 143, pl. VII, fig. 6, 7.

Glandulina laevigata (D'Orbigny)
Glandulina laevigata (D'Orbigny), Batjes, 1958, p. 123, pl. IV, fig. 7, 8.

Globocassidulina sp.indet.
Cassidulina oblonga Andreae (not Reuss), 1884, p. 156, pl. X, fig. 32.
Cassidulina subglobosa Brady var., Batjes, 1958, p. 137, pl. VI, fig. 10.

Guttulina problema D'Orbigny
Guttulina problema D'Orbigny, Batjes, 1958, p. 121, pl. IV, fig. 10-12.

Gyroidina soldanii D'Orbigny
Gyroidina soldanii D'Orbigny, Batjes, 1958, p. 147, pl. VII, fig. 12-15.

Hanzawaia crassa (Luczkowska)
Cibicides boueanus (D'Orbigny) var. *crassus* Luczkowska, 1955, p. 127, pl. X, fig. 3a-c.
Hanzawaia boueana (D'Orbigny), Batjes, 1958, p. 154, pl. VIII, fig. 5.

Heterolepa dutemplei (D'Orbigny)
Cibicides dutemplei (D'Orbigny), Batjes 1958, p. 150, pl. IX, fig. 9-11.

Heterolepa praecincta Franzenau
Heterolepa praecincta Franzenau, 1884, p. 216, pl. V, fig. 4, 6, 10.

Heterolepa ungeriana (D'Orbigny)
Cibicides ungerianus (D'Orbigny), Batjes, 1958, p. 152. pl. IX, fig. 6.

Hoeglundina elegans (D'Orbigny)
Epistomina elegans (D'Orbigny), Batjes, 1958, p. 155, pl. X, fig. 2.

Lagena s.l.
In this group we combine various species belonging to the genera *Lagena*, *Fissurina* and *Oolina*.

Lenticulina spp.
Practically all specimens belong to unornamented species.

Melonis affinis (Reuss)
Nonion affine (Reuss), Batjes, 1958, p. 140, pl. VI, fig. 12.

Miliolidae
Only a few miliolids are present; a specific determination has not been attempted.

Nodosaria consobrina (D'Orbigny)
Nodosaria consobrina D'Orbigny, Reuss, 1863, p. 45, pl. II, fig. 19-23.

Nodosaria longiscata D'Orbigny
Nodosaria exilis Neugeboren, Andreae, 1884, p. 201, p. X, fig. 18-20.

Nodosaria soluta (Reuss)
Nodosaria soluta (Reuss), Batjes, 1958, p. 114, pl. III, fig. 17, 18.

Nodosaria raphanistrum (Linné)
Nodosaria vertebralis (Batsch), Batjes, 1958, p. 115, pl. III, fig. 19.

Oridorsalis umbonatus (Reuss): *Eponides umbonatus (Reuss), Batjes, 1958, p. 146, pl. VII, fig. 10.*

Plectofrondicularia seminuda (Reuss): *Frondicularia seminuda* Reuss, Batjes, 1958, p. 112, pl. III, fig. 8.

Polymorphinidae
Specimens belonging to the genera *Globulina* and *Pyrulina* have been recorded under this heading.

Praeglobobulimina socialis (Bornemann)
Bulimina socialis Bornemann, Cushman & Parker, 1937, p. 36, pl. IV, fig. 1a-c. ag (g)
Pullenia bulloides (D'Orbigny)
Pullenia bulloides (D'Orbigny), Batjes, 1958, p. 139, pl. VI, fig. 9.
Pullenia quinqueloba (Reuss)
Pullenia quinqueloba (Reuss), Batjes, 1958, p. 139, pl. VI, fig. 8.
Pyrgo spp.
The specimens of *Pyrgo* are mainly of the globular type.
Quadrimorphina sp.indet.
Possibly this species has been confused with *Valvulineria petrolei* (Andreae), which also occurs in the Oligocene.
Ramulina? sp.
A number of single-chambered spinose forms, with tubular openings at two opposite sides, are possibly in part belonging to the genus *Ramulina*
Robertina germanica Cushman & Parker
Robertina germanica Cushman & Parker, 1938, p. 73, pl. XIII, fig. 2.
Rotaliatina bulimoides (Reuss)
Rotaliatina bulimoides (Reuss), Batjes, 1958, p. 148, pl. VIII, fig. 3, 4.
Sigmomorphina regularis (Roemer)
Sigmomorphina regularis (Roemer), Batjes, 1958, p. 125, pl. IV, fig. 2.
Siphonodosaria adolphina (D'Orbigny)
Dentalina adolphina D'Orbigny, 1846, p. 51, pl. II, fig. 18-20.
Siphonodosaria sp.indet.
Looks similar to *Siphonodosaria paucistriata* (Galloway & Morrey), except that the specimens from Grashoek have elongated chambers.
Siphonodosaria hirsuta (D'Orbigny)
Siphonodosaria hirsuta (D'Orbigny), Batjes, 1958, p. 120, pl. III, fig. 12.
Siphonodosaria verneuili (D'Orbigny)
Ellipsonodosaria verneuili (D'Orbigny), Cushman, 1929, p. 96, pl. XIV, fig. 1-3.
Sphaeroidina bulloides D'Orbigny
Sphaeroidina bulloides D'Orbigny, Batjes, 1959, p. 140, pl. VI, fig. 11.
Spiroloculina canaliculata D'Orbigny
Spiroloculina canaliculata D'Orbigny, Batjes, 1958, p. 106, pl. II, fig. 3.
Svratkina perlata (Andreae)
Alabamina perlata (Andreae), Batjes, 1958, p. 157, pl. VIII, fig. 8, 9.
Trifarina oligocaenica (Andreae)
Angulogerina gracilis (Reuss) var. *oligocaenica* (Andreae), Batjes, 1958, p. 135, pl. VI, fig. 3.
Turrilina alsatica Andreae
Turrilina alsatica Andreae, Batjes, 1958, p. 125, pl. IV, fig. 15.
Uvigerina gracilis Reuss
Angulogerina gracilis (Reuss), Batjes, 1958, p. 134, pl. VI, fig. 2.
Vaginulinopsis sublituus (Nuttall)
Cristellaria sublituus Nuttall, 1932, p. 11, pl. I, fig. 13, 14.
Valvulineria petrolei (Andreae)
Valvulineria petrolei (Andreae), Batjes, 1958, p. 146, pl. VIII, fig. 1.

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