FORAMINIFERA AND STRATIGRAPHY OF THE VIBORG FORMATION IN SOFIENLUND, DENMARK

KAARE ULLEBERG

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A biostratigraphical treatment of the top of the Middle Oligocene Viborg Formation of Sofienlund (central Jylland) is made on the basis of Foraminifera. The sequence is divided into three zonules, on the basis of an essentially three-fold variation of 11 faunal groups, together with smaller variations of some of the species.

The fauna is dominated by benthonic calcareous species, of which at least 40 % is composed of the three species: *Turrilina alsatica, Nonion affine* and *Pullenia bulloides.* 112 species are documented of which 21 are treated systematically, including the most frequent species together with unidentified common specimens. Among *Gyroidinoides* spp., two unidentified species, *G. soldanii* forma 1 and *G?* sp. 1 are frequently met. The three species *Guttulina frankei, Gyroidinoides soldanii* forma *girardanus* and *Cibicides aknerianus* show wide morphological variation.

Kaare Ulleberg, Norwegian Petroleum Directorate, Lagårdsveien 80, N–4000 Stavanger, Norway, July, 13th, 1974.

Preliminary remarks on the sediments and foraminifers of the 27 m sequence of the uppermost part of the Middle Oligocene Viborg Formation in Sofienlund have been made by Christensen & Ulleberg (1973). The part of the formation examined is a sticky clay sequence; the Viborg Clay member (Christensen & Ulleberg, 1974), containing pyrite, some mica and locally some lenses of silt. The investigation is based upon two sections, 1 and 2, from which 28 and 9 samples have been examined respectively. Fig. 1 shows the vertical depth of samples below the top of the formation.

The sequence is overlain transgressively by the Upper Oligocene Sofienlund Formation. Its lower limit has not been observed because of the restricted range of the boring equipment. Christensen & Ulleberg (1973) referred the sequence to a Middle Oligocene age, and biostratigraphically to the *Turrilina alsatica* zone. Furthermore, they state that the foraminiferal fauna consists mainly of calcareous benthonic tests, where *Turrilina alsatica, Nonion affine* and *Pullenia bulloides* dominate. They divided the fauna into the following 11 groups on the basis of stability of species composition: Agglutinated tests, Porcelaineous tests, *"Dentalina"*-like tests, Nodosariacea,

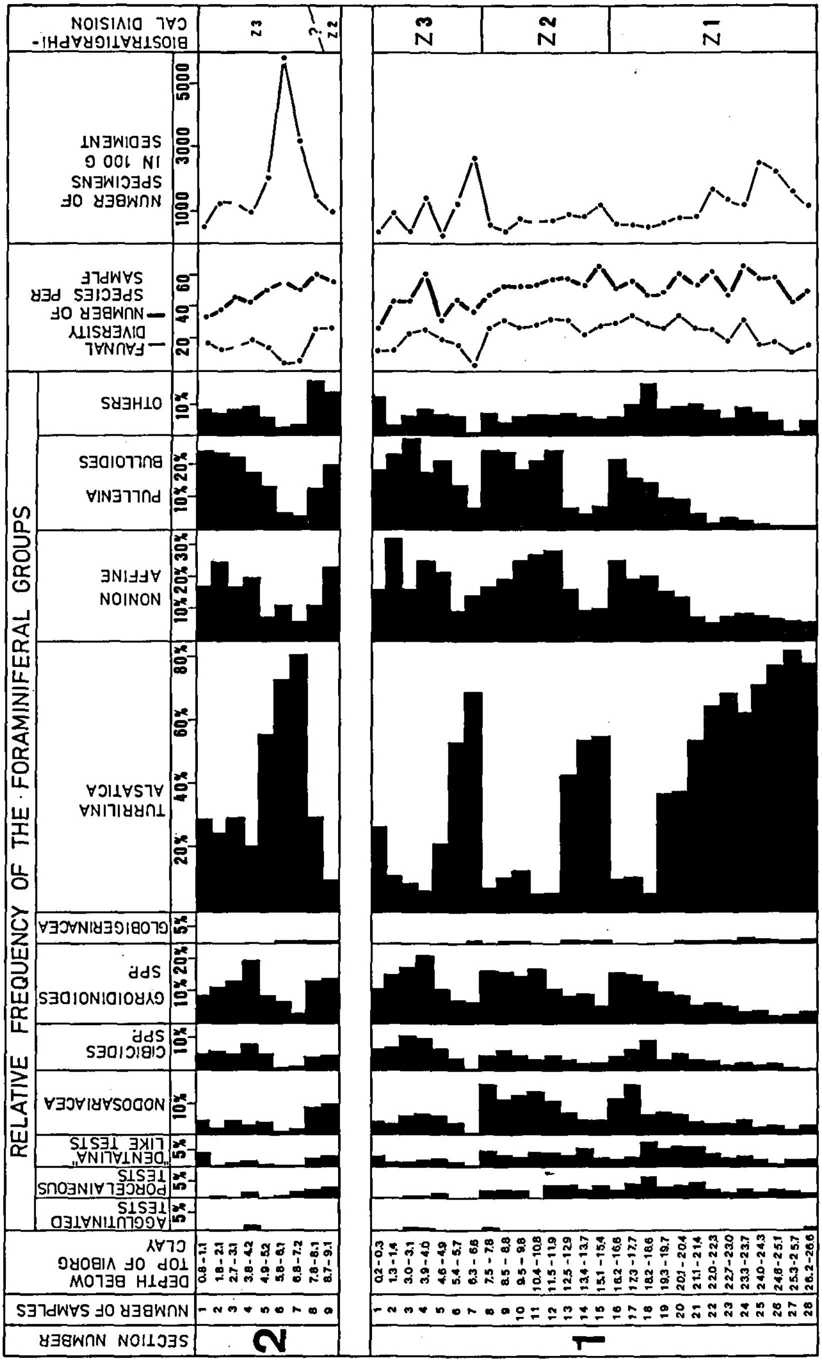

Fig. 1. Distribution chart for Section 1 & 2, Viborg Clay of Sofienlund.

Cibicides spp., *Gyroidinoides* spp., Globigerinacea, *Turrilina alsatica, Nonion affine, Pullenia bulloides* and "Others", and these are the basis of the stratigraphic interpretation presented in this paper.

Palaeoecologically, the Viborg Clay in the Sofienlund area probably represents environments comparable to the present-day outer continental shelf area. See Christensen and Ulleberg (1973) for description of locality, methods and the 11 foraminiferal groups. The present Sections 1 and 2 are identical with their Boring 1 and excavation section, and Boring 2 respectively.

The Foraminiferal fauna

Fig. 1 shows, for each sample examined, the relative frequency of the 11 foraminiferal groups, the faunal diversity, as defined by Walton (1964), and the number of species and specimens in each sample, i.e. in 100 g sediment.

The foraminiferal fauna consists almost exclusively of calcareous benthonic tests. The representation of planktonic specimens is very low, usually less than 0.5 ‰, whereas agglutinated tests are more or less missing (Fig. 1). The fauna is dominated by three species, *Turrilina alsatica, Nonion affine* and *Pullenia bulloides.* Less common, but still well represented in the fauna are: *Quinqueloculina impressa, Glandulina aequalis, G. dimorpha, Stilostomella hirsuta, S. longiscata, Epistominella oveyi, Eponides pygmeus, Cibicides aknerianus, C. telegdi, Pullenia quinqueloba, Alabamina tangentialis, Gyroidinoides* cf. *angustiumbilicata, G. soldanii* forma *girardanus, G. soldanii* forma 1. *G?* sp. 1 and *Ceratobulimina contraria.* These species are observed more or less in all samples. Their relative frequency usually exceeds 1 ‰, but only some of them may exceed 5 ‰ of the fauna.

In total, 112 species and varieties of foraminifers have been observed in the present material. They are all listed below with reference to the 11 foraminiferal groups. Species marked with * are treated in the systematic part.

AGGLUTINATED TESTS: *Spiroplectammina deperdita* (d'Orbigny), *Martinottiella* münsteri (Cushman).
PORCELAINEOUS TESTS: *Cyclogyra involvens* (Reuss), *Spiroloculina dorsata* Reuss, **Quinqueloculina impressa* Reuss, *Q. ludwigi* Reuss, *Q. triangularis* d'Orbigny, *Pyrgo inornata* (d'Orbigny), **Sigmoilina tenuis* (Czjzek), *Triloculina tricarinata* d'Orbigny, *T.* aff. *turgida* Reuss, *Miliolinella enoplostoma* (Reuss), *Scutuloris oblongus* (Montagu).
»DENTALINA«-LIKE TESTS: *Nodosaria? anomala* (Reuss), *N. cf. calomorpha,* Reuss, *Dentalina? acuticauda* (Reuss), *D. approximata* (Reuss), *D. emaciata,* Reuss, *D. intermittens* (Roemer), *D. oligosphaerica* Reuss, *D. pauperata* d'Orbigny, *D? retrorsa* (Reuss), *D. soluta* Reuss, **Stilostomella adolphina* (d'Orbigny), **S. hirsuta* (d'Orbigny), **S. longiscata* (d'Orbigny), *S. pyrula* (d'Orbigny), **S. spinescens* (Reuss), *S.* sp. 1.
NODOSARIACEA: *Frondicularia budensis* (Hantken), *Lagena? apiculata* (Reuss).

L? globosa (Montagu), *L. hexagona* (Williamson), *L. hispida* Reuss, *L. hystrix* Reuss, *L. hystrix longicolla* Matthes, *L. isabella* (d'Orbigny), *L. laevis* (Montagu), *L. rivata* Matthes, *L. striata* (d'Orbigny), *L. tenuis* (Bornemann), *L.* sp. 1, *Lenticulina arcuata* (d'Orbigny), *L. articulata,* (Reuss), *L. conferta* (Reuss), *L. convergens* (Bornemann), *L. crepidula* (Fichtel & Moll), *L. deformis* (Reuss), *L.* cf. *hauerina* (d'Orbigny), *L.* ex. gr. *incompta* (Reuss), *L.* ex. gr. *inornata* (d'Orbigny), *L.* sp. 1, *L.* sp. 2, *Globulina inaequalis* Reuss, *G. minuta* (Roemer), *G. münsteri* (Reuss), *G. rotundata* (Bornemann), **Guttulina frankei* Cushman & Ozawa, *G. irregularis* (d'Orbigny), *Paradentalina* sp. 1, *Pseudopolymorphina obscura* (Roemer), *P. subcylindrica* (Hantken), *Pyrulina cylindroides* (Roemer), *P. fusiformis* (Roemer), **Glandulina aequalis* Reuss, *G. dimorpha* (Bornemann), *G. laevigata* (d'Orbigny), *G. ozawai* Cushman, *G.* sp. 1, *Fissurina* cf. *castanea* (Flint), *F. modesta* (Matthes), *F.* sp. 1, *Parafissurina lateralis* (Cushman), *P.* sp. 1,
CIBICIDES SSP.: **Cibicides aknerianus* (d'Orbigny), *C. amphisyliensis* (Andreae), **C. telegdi* Grossheide & Trunkó, *C. ungerianus* (d'Orbigny).
GYROIDINOIDES SSP.: **Gyroidinoides* cf. *angustiumbilicata* (Ten Dam), **G. soldanii* forma *girardanus* (Reuss), **G. soldanii* forma 1, **G. octocamerata* (Cushman & Hanna), **G?* sp. 1.
GLOBIGERINACEA: *Pseudohastigerina wilcoxensis* (Cushman & Ponton) (reworked), *Acarinina* sp. 1, *Globigerina* cf. *officinalis* Subbotina, *G. ouachitaensis* (Howe & Wallace), *G. praebulloides* Blow, *G. angiporoides* Hornibrook.
TURRILINA ALSATICA: **Turrilina alsatica* Andreae.
NONION AFFINE: **Nonion affine* (Reuss).
PULLENIA BULLOIDES: **Pullenia bulloides* (d'Orbigny).
OTHERS: *Buliminella carteri* Bhatia, *Bulimina alsatica* Cushman & Parker, *B. aksuatica* (Morozova), *Uvigerina gracilis* forma *tenuistriata* (Reuss), *U. rugosa* Terquem, **Epistominella oveyi* (Bhatia), *Pararotalia fallax* (Steuer), **Eponides pygmeus* (Hantken, *E. umbonatus* (Reuss), *Cassidulina carapitana* Hedberg, *Globocassidulina oblonga* (Reuss), *Chilostomella ovoidea* Reuss, *Quadrimorphina petrolei* (Andreae), *Astrononion perfossum* (Clodius), *Nonionella jacksonensis* Cushman, *N. lobsannensis* (Andreae), *Pullenia quinqueloba* (Reuss), *Alabamina tangentialis* (Clodius), **Ceratobulimina contraria* (Reuss), *Robertina declivis* (Reuss).

Only 21 species are treated systematically, i.e. those which are more or less well represented in the material, the problematic specimens, and some because of their great morphological variation. Some introductory remarks are given concerning the systematic treatment of each species. The "dimension" of the tests does not refer to statistical calculations but to approximate values of a mean-sized test. Smallest and largest specimens are measured in species showing great variation in size. The following abbreviations are used for the measured dimensions of the test: L (length), B (width), D (thickness), H(height) and Ø (diameter). These units are as used, described, and illustrated by Kümmerle (1963, p. 24, fig. 1).

The relative frequency of the species in each sample is presented in the chart of Fig. 2, except for the three dominant ones, which are shown in Fig. 1.

In order to make the list of synonyms as short as possible, only more recent references and the original one are given. A more detailed list may be found in some of the recent references, especially in Hausmann (1964).

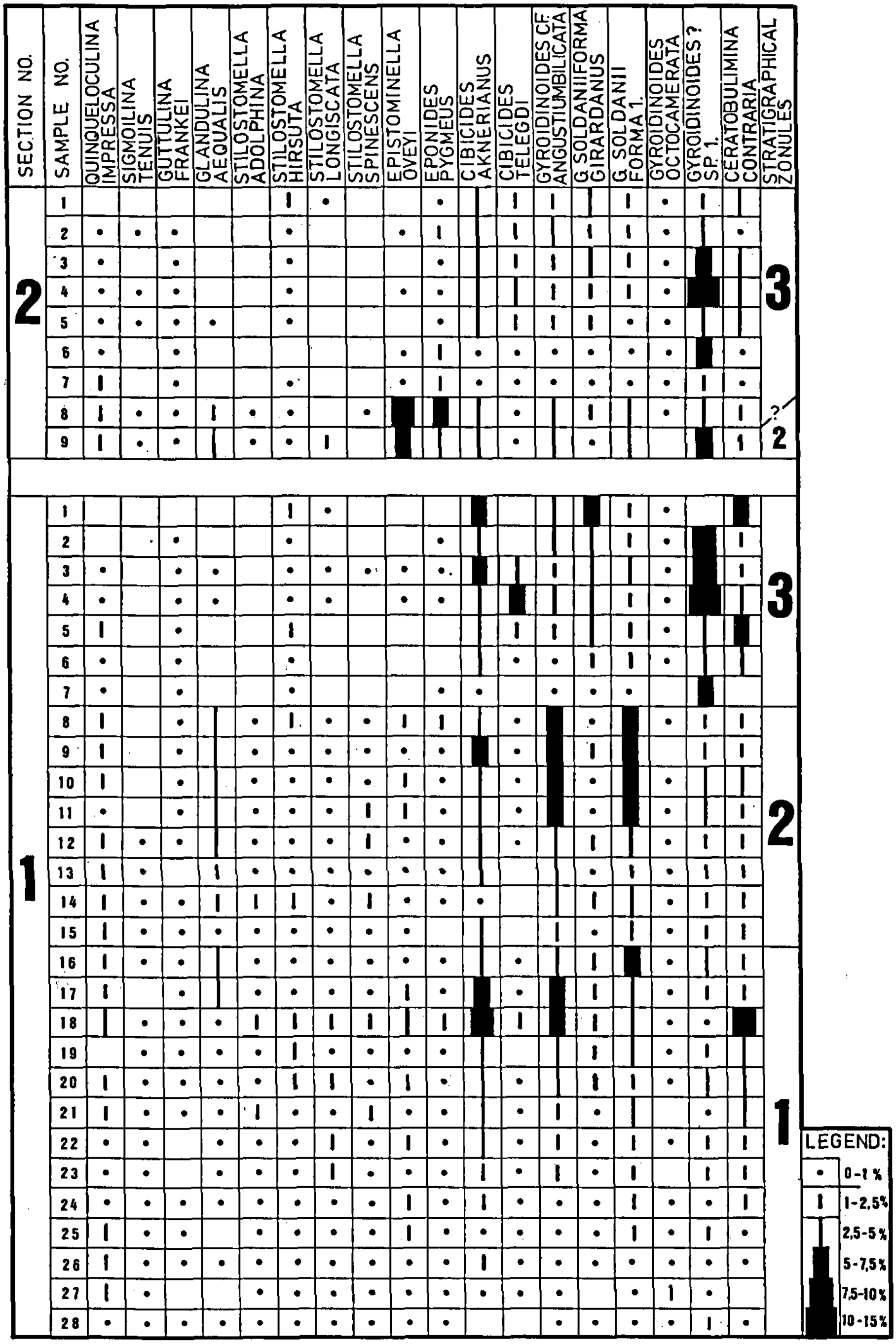

Fig. 2. The relative frequency of the described species of the Viborg Clay in Sofienlund. (See Fig. 1 for the frequency of *Turrilina alsatica, Nonion affine* and *Pullenia bulloides).*

TERTIARY EPOCHS		PALAEOCENE					EOCENE					OLIGOCENE					MIOCENE					PLIOCENE				
TERTIARY NORTH SEA AREA		BELGIUM	HOLLAND	ENGLAND	GERMANY	DENMARK	BELGIUM	HOLLAND	ENGLAND	GERMANY	DENMARK	BELGIUM	HOLLAND	ENGLAND	GERMANY	DENMARK	BELGIUM	HOLLAND	ENGLAND	GERMANY	DENMARK	BELGIUM	HOLLAND	ENGLAND	GERMANY	DENMARK
QUINQUELOCULINA IMPRESSA	L						4		7			24		25												
	M											26			27	31										
	U						13 14 15		17	18 19 20					+											
SIGMOILINA TENUIS	L																									
	M										12	26			27	31		38		39						
	U						13 14 15	13 14					+		+	35										
GUTTULINA FRANKEI	L																									
	M											26			27	31										
	U						15								+											
GLANDULINA AEQUALIS	L											23														
	M											26 28 29			27	31										
	U																									
TURRILINA ALSATICA	L									8																
	M											26			27	31										
	U									20						34 35										
STILOSTOMELLA ADOLPHINA	L																									
	M										12		+		27	31										
	U										22															
STILOSTOMELLA HIRSUTA	L																									
	M											26	+		27	31										
	U										22															
STILOSTOMELLA LONGISCATA	L							4	7	+																
	M				+					+		26	+		27	31		38		39						
	U				1+		15	14		18 20 21	22				33	34										
STILOSTOMELLA SPINESCENS	L							4																		
	M									+		26			27	31										
	U									+																
EPISTOMINELLA OVEYI	L						2 3	3													40					
	M						10					26		30	27	31				39	41 42					
	U						13 14			20						34 35					43					
EPONIDES PYGMEUS	L									+? 19?				25												
	M									+		26			27	31										
	U						14? 15?	+?	16? 17?	18? 20?	22				33	35										
CIBICIDES AKNERIANUS	L											23		25												
	M												+		27	31		+								
	U												+		33			+								
CIBICIDES TELEGDI	L																									
	M															31										
	U														+	35										
NONION AFFINE	L						2 4 5	2 3 4	7	+ 8		23		25						38	40					44
	M						10 11	10		+		26 27 28 29	+		27	31	+	+ 36 37		38 39	41 42					
	U						13 14 15	13	17	+			+		33	34 35				+	43					
PULLENIA BULLOIDES	L																			36			+			
	M											26	+		27	31	+	+ 36 37 38		38 39			+			
	U									18 20 21	22		+		+ 33	34 35		+			43		45			
GYROIDINOIDES ANGUSTIUMBILICATA	L							4	7	+																
	M															31										
	U		+							+ 20																
G. SOLDANII F. GIRARDANUS	L									+ 8																
	M									+		26	+		27	31										
	U							+		18 20 21			+		+											
GYROIDINOIDES OCTOCAMERATA	L		+			+	2 3 5	3																		
	M				+		10 11									31										
	U				+		13 14 15																			
CERATOBULIMINA CONTRARIA	L																									44
	M											26	+		27	31	+?	+			41 42					
	U									+		32	+		+	35		+								

The distribution of the systematically treated species in Tertiary deposits in NW Europe (i.e. around the North Sea Basin) is presented in Fig. 3.

Quinqueloculina impressa Reuss (Pl. 6, Figs. 1–2)

1851. *Quinqueloculina impressa* Reuss, p. 87, pl. 7, fig. 59.
1958. *Q. impressa* Reuss – Batjes, p. 103, pl. 1, fig. 13.
1961. *Q. impressa* Reuss – Kaasschieter, p. 151, pl. 3, fig. 4–6.
1962. *Q. impressa* Reuss – Kiesel, p. 17, pl. 2, fig. 4.
1964. *Q. impressa impressa* Reuss – Hausmann, p. 328, pl. 2, fig. 4.
1964. *Q. impressa cognata* Bornemann – Hausmann, p. 329, pl. 2, fig. 5.

Type stratum: Septarian Clay, Hermsdorf (Germany).
Remarks: All specimens show a smooth surface. No coating by grains as reported by Kaasschieter (1961) has been observed. Both subspecies described by Hausmann (1964) occur in the material, but because of heavy fragmentation and a strong secondary pyritic effect, they have not been separated and are dealt with under the same species. A distinct bifid tooth may be seen in the aperture (Pl. 6, Fig. 2).

Dimensions: L: 0.30 mm., B: 0.175 mm., D: 0.15 mm.

Sigmoilina tenuis (Czjzek) – (Pl. 6, Fig. 5 & Pl. 9, Fig. 1)

1848. *Quinqueloculina tenuis* Czjzek, p. 149, pl. 13, fig. 31–34.
1958. *Sigmoilina tenuis* (Czjzek) – Batjes, p. 106.
1960. »*S*«. *tenuis* (Czjzek) – Barker, pl. 10, fig. 7, 8, 11.
1961. *S. tenuis* (Czjzek) – Kaasschieter, p. 157, pl. 4, fig. 9, 10.
1962. *S. tenuis* (Czjzek) – Kiesel, p. 20, pl. 2, fig. 8.
1962. *S. tenuis* (Czjzek) – Indans, p. 38, pl. 2, fig. 8.
1964. *S. tenuis* (Czjzek) – Hausmann, p. 331, pl. 2, fig. 8.
1969. *S. tenuis* (Czjzek) – Voorthuysen & Toering, p. 106, pl. 7, fig. 14.

Fig. 3. The distribution of the described species in Tertiary deposits in NW Europe, plotted with reference to lithological units and to their chronostratigraphic position in Lower (L), Middle (M), and Upper (U) parts of the Tertiary epochs. The following numbers are used for lithological units: 1 (Heller Schichten), 2 (Sands of Mons-en Pévèle), 3 (Lower Panisel beds), 4 (Clays of Ieper), 5 (Clays of Roubaix), 6 (Clays of Ronq), 7 (London Clay), 8 (Zerbener Schichten), 9 (Mahlpfuhler Schichten), 10 (Sands of Aalter), 11 (Sands of Brüssel), 12 (Lillebælt Clay), 13 (Sands of Lede), 14 (Sands of Wemmel), 15 (Clays of Asse), 16 (Upper Bracklesham beds), 17 (Barton beds), 18 (Obere Sernoer Schichten), 19 (Untere Schönewalder Schichten), 20 (Obere Schönewalder Schichten), 21 (Latdorf Schichten), 22 (Søvind Marl), 23 (Lower Tongeren beds), 24 (Upper Tongeren beds), 25 (Brockenhurst beds), 26 (Boom Clay), 27 (Septarian Clay), 28 (Nucula Clay), 29 (Berg Sand), 30 (Hamstead Corbula beds), 31 (Viborg Clay), 32 (Sand of Voort), 33 (Kasseler Meeressand), 34 (Vejle Fjord Formation), 35 (Sofienlund Formation), 36 (Sable d'Edegem), 37 (Sable d'Anvers), 38 (Hemmoor), 39 (Reinbek), 40 (Klintinghoved Formation), 41 (Arnum Formation), 42 (Hodde Formation), 43 (Gram Formation), 44 (Sæd Formation), and 45 (Sables de Kallo). Record of species with no lithological reference is marked by +.

Type stratum: Badener Tegel (Tortonian), Baden (Vienna Basin).

Remarks: Only the two youngest chambers have a smooth surface. The inner whorls are covered by a granular mass, which in the SEM was shown to consist of spicules and tests of coccoliths (Pl. 9, Fig. 1).

Dimensions: L: 0.40 mm., B: 0.18 mm., D: 0.07 mm.

Guttulina frankei Gushman & Ozawa (Pl. 1, Figs. 1–6)

1930. *Guttulina frankei* Cushman & Ozawa, p. 28, pl. 4, fig. la–c.
1958. *G. problema* d'Orbigny var. *frankei* Cushman & Ozawa – Batjes, p. 121, pl. 4, fig. 11.
1961. *G. problema* d'Orbigny – Kaasschieter, p. 181, pl. 8, fig. 1 (not pl. 7, fig. 30–32).
1962. *G. frankei* Cushman & Ozawa – Kiesel, p. 45, pl. 7, fig. 3.
1964. *G. frankei* Cushman & Ozawa – Hausmann, p. 359, pl. 5, fig. 11.

Type stratum: Middle Oligocene deposit, Söllingen (Germany).

Remarks: The illustrated specimens are arranged to show the wide variation of this species. They are all characterized by their more or less parallelogram-like outline, acute and pointed initial and apertural parts, and subtriangular, more or less rounded cross section.

Among the illustrated specimens, Pl. 1, Figs. 2a–b shows a typical *G. frankei.* One part of the variation is illustrated in Pl. 1, Fig. 3 to Fig. 6. Here, the width (B) of the tests decreases compared to the length (L) of the tests. The gradual variation ends in the almost oval test of Pl. 1, Fig. 6 where the arrangement of chambers, the acute initial and apertural ends, and the subtriangular cross section are maintained more or less intact. The others pattern of variation is shown in Pl. 1, Figs. la–b. Here, the parallelogram-like outline has become somewhat less obvious. It is due to the more rounded initial end which is still pointed. The other characters remain more or less intact.

Some writers (Batjes, 1958; Kaasschieter, 1961; Grossheide & Trunkó, 1965) have assumed that this species falls within the range of variation of *G. problema.* However, typical specimens of the latter species were not observed in the present material. It is assumed that it differs from *G. frankei* mainly in showing a distinct, rounded initial part and strongly elevated chambers separated by deeply depressed sutures. *G. frankei* closely resembles *G. irregularis.* The latter differs in its broadly rounded initial end, giving oval to subdeltoidal tests.

Dimensions: L: 0.65 mm., B: 0.45 mm. (Pl. 1, Fig. 2). (The relationship L:B has an observed range of 1.3–2.2).

Glandulina aequalis Reuss – (Pl. 1, Figs. 7–9)

1863. *Glandulina aequalis* Reuss, p. 48, pl. 3, fig. 28.
1958. *G. aequalis* Reuss – Batjes, p. 123, pl. 4, fig. 5,6.
1964. *G. aequalis* Reuss – Hausmann, p. 365, pl. 6, fig. 5.

Type stratum: Septarian Clay (Oligocene), Offenbach (Germany).

Remarks: Both microspheric and macrospheric generations are represented in the present material. The former (Pl. 1, Fig. 9) is characterized by an acute initial part with a biserial arrangement of chambers which ends uniserially in the younger part. No initial spine is observed. The latter varies in outline from almost cylindrical (Pl. 1, Fig. 7) to distinctly oval (Pl. 1, Fig. 8), and the arrangement of chambers is strictly uniserial.

G. dimorpha differs from *G. aequalis* in possessing a fusiform outline and an irregular arrangement of chambers.

Dimensions: L: 0.31 mm., Ø: 0.18 mm.

Turrilina alsatica Andreae – (Pl. 6, Figs. 3–4)

1884. *Turrilina alsatica* Andreae, p. 120, pl. 8, fig. 18a–c.
1958. *T. alsatica* Andreae – Batjes, p. 125, pl. 4, fig. 15.
1960. *T. alsatica* Andreae – Ellermann, p. 669, pl. 53, fig. 5.
1962. *T. alsatica* Andreae – Kiesel, p. 52, pl. 8, fig. 2.
1964. *T. alsatica* Andreae – Hausmann, p. 371, pl. 6, fig. 16.
1970. *T. alsatica* Andreae – Kiesel, p. 255, pl. 12, fig. 6.

Type stratum: Septarian Clay (Middle Oligocene), Barr (Germany).

Remarks: Small specimens are often difficult to distinguish morphologically from the Eocene species *T. brevispira* Ten Dam. Hansen (1972) stated that these species can be distinguished from each other only by their wall structure, which in the Sofienlund specimens is radiate.

Dimensions: L: (0.15–0.40) mm., Ø: (0.113–0.188) mm.

Stilostomella adolphina (d'Orbigny) – (Pl. 2, Fig. 1 & Pl. 6, Fig. 7)

1846. *Dentalina adolphina* d'Orbigny, p. 51, pl. 2, fig. 18–20.
1942. *D. adolphina* d'Orbigny – Ten Dam & Reinhold, p. 59.
1951. *Nodogenerina adolphina* (d'Orbigny) – Marks, p. 54.

Type stratum: Marl (Miocene), Baden area (Vienna Basin).

Remarks: The test is always more or less fragmented. The number of specimens is calculated by counting initial ends. This species differs from *S. spinescens* in showing more elevated and rounded chambers, which are separated by broader and deeper sutural areas (Pl. 6, Fig. 7 contra Fig. 8).

Dimensions: L: 0.825 mm., Ø: 0.15 mm. (An 8-chambered broken test).

Stilostomella hirsuta (d'Orbigny) – (Pl. 2, Figs. 5–6)

1826. *Nodosaria hirsuta* d'Orbigny, p. 252, no. 7.
1846. *N. hispida* d'Orbigny – d' Orbigny, p. 35, pl. 1, fig. 24, 25.
1923. *N. hispida* d'Orbigny – Cushman, p. 92, pl. 16, fig. 6.
1951. *Nodogenerina hirsuta* (Soldanii) – Marks, p. 56, pl. 7, fig. 7.
1958. *Siphonodosaria hirsuta* (d'Orbigny) – Batjes, p. 120, pl. 3, fig. 12.
1960. *Amphicoryna hirsuta* (d'Orbigny) – Barker, pl. 63, fig. 16, not fig. 10–15.
1964. *Stilostomella hirsuta* (d'Orbigny) – Hausmann, p. 381, pl. 3, fig. 12.

Type stratum: Adriatic Sea (Recent).

Remarks: The number of chambers varies from two to five. Two and four chambered specimens are most frequently met.

Dimensions: L: 1.40 mm., Ø: 0.275 mm. (4-chambered specimen).

Stilostomella longiscata (d'Orbigny) – (Pl. 2, Figs. 3–4)

1846. *Nodosaria longiscata* d'Orbigny, p. 32, pl. 1, fig. 10–12.
1851. *N. ewaldi* Reuss – Reuss, p. 58, pl. 3, fig. 2.
1951. *N. longiscata* d'Orbigny – Friese, p. 25, pl. 11, fig. 26–30.
1958. *N. ewaldi* Reuss – Batjes, p. 117.
1959. *N. longiscata* d'Orbigny – Larsen & Dinesen, p. 67.
1962. *N. ewaldi* Reuss – Kiesel, p. 23, pl. 3, fig. 7.
1962. *N. ewaldi* Reuss – Bettenstaedt, et al., p. 389, pl. 57, fig. 3, tabl. 22.
1963. *N. ewaldi* Reuss – Kümmerle, p. 30, pl. 2, fig. 5.
1964. *Stilostomella longiscata* (d'Orbigny) – Hausmann, p. 380, pl. 3, fig. 11.
1968. *S? longiscata* (d'Orbigny) – Schickor, p. 135, pl. 1, fig. 19.
1969. *Nodosaria ewaldi* Reuss – Voorthuysen & Toering, p. 107, pl. 8, fig. 5.

Type stratum: Marl (Miocene), Baden area (Vienna Basin).

Remarks: Only one unbroken test of a small specimen observed (Pl. 2, Fig. 3). The frequency of *S. longiscata* is calculated by counting the number of apertural tubes.

Dimensions: L: 1.05 mm., Ø: 0.05 mm. (The illustrated unbroken specimen).

Stilostomella spinescens (Reuss) – (Pl. 2, Fig. 2 & Pl. 6, Fig. 8)

1851. *Dentalina spinescens* Reuss, p. 62, pl. 3, fig. 10.
1958. *Nodosaria spinescens* (Reuss) – Batjes, p. 116, pl. 3, fig. 13.
1962. *Stilostomella spinescens* (Reuss) – Kiesel, p. 59, pl. 9, fig. 4.
1964. *S. spinescens* (Reuss) – Hausmann, p. 381, pl. 3, fig. 13, 14.
1970. *S. spinescens* (Reuss) – Kiesel, p. 271, pl. 14, fig. 2.

Type stratum: Septarian Clay, Hermsdorf (Germany).

Remarks: No unbroken specimens observed. Both macrospheric and microspheric generations are represented, as described by Hausmann (1964).

Dimensions: L: 1.09 mm., Ø: 0.17 mm. (The illustrated specimen of Pl. 2, Fig. 2).

Epistominella oveyi (Bhatia) – (Pl. 1, Figs. 10a–b & Pl. 6, Figs. 6a–b)

1955. *Pseudoparella oveyi* Bhatia, p. 684, pl. 66, fig. 29, textfig. 7.
1958. *P. oveyi* Bhatia – Batjes, p. 158, pl. 8, fig. 10.
1959. *P.* sp. – Larsen & Dinesen, p. 83, pl. 6, fig. 7.
1961. *Epistominella oveyi* (Bhatia) – Kaasschieter, p. 229, pl. 15, fig. 1.
1970. *E. oveyi* (Bhatia) – Kiesel, p. 299.

Type stratum: Hamstead Corbula beds (Middle Oligocene), Hamstead Hill (England).

Remarks: The specimens are all characterized by small size and glassy appearence. They differ from the listed synonyms in showing a distinct, convex spiral side (Pl. 6,

Fig. 6b). No conical spiral side observed. Kaasschieter (1961) reported great variation in the convexity of the spiral side, and conical specimens were very scarce in his material.

The chamber sutures on the spiral side are limbate, straight and run obliquely backwards, more or less tangential to the earlier spiral suture. Cursory observations in the sieve fraction 0.1–0.06 mm indicated that the representation of *E. oveyi* may be underestimated. It was very frequently encountered in this finer fraction, and is probably one of the dominant species.

Dimensions: D: 0.225 mm., H: 0.10 mm.

Eponides pygmeus (Hantken) – (Pl. 1, Figs. 11a–b & Pl. 6, Figs. 9a–b)

1875. *Pulvinulina pygmea* Hantken, p. 78, pl. 10, fig. 8a, b.
?1915. *Truncatulina pygmea* (Hantken) – Cushman, p. 38, fig. 41.
?1955. *Eponides cf. E. pygmeus* (Hantken) – Bhatia, p. 683, pl. 67, fig. 7a–c.
1958. *E. pygmeus* (Hantken) – Batjes, p. 146, pl. 7, fig. 11.
?1961. *Cibicides pygmeus* (Hantken) – Kaasschieter, p. 219, pl. 14, fig. 1.
1963. *Eponides pygmeus* (Hantken) – Kümmerle, p. 49, pl. 7, fig. 9a–c.
1964. *E. pygmeus* (Hantken) – Hausmann, p. 387, pl. 7, fig. 16.
?1970. *Cibicides pygmeus* (Hantken) – Kiesel, p. 307, pl. 20, fig. 2.

Type stratum: Clavulina szaboi-beds (Oligocene), Budapest area (Hungary).

Remarks: It is characterized by its small size, glassy appearance, and large number of whorls on the spiral side, usually 4 to 4½. The number of chambers in the youngest whorl is 6 to 7. The umbilicus if often filled with a glassy mass.

It is very doubtful whether the species described by Cushman (1915), Bhatia (1955), Kaasschieter (1961), or Kiesel (1970) are identical to the specimens observed in the Sofienlund material. These »synonyms« all lack the high number of whorls on the spiral side, and even the inner whorls are not visible. The development of »*Cibicides*«–aperture in adult specimens (Kaasschieter, 1961) is not observed.

The species is probably under-represented in the material for the same reason as *Epistominella oveyi.*

Dimensions: L: 0.20 mm., H: 0.10 mm.

Cibicides aknerianus (d'Orbigny) – (Pl. 3, Figs. 1–6, Pl. 4, Figs. 1–5 & Pl. 7, Figs. 1–2)

1846. *Rotalina akneriana* d'Orbigny, p. 156, pl. 8, fig. 13–15.
1942. *Cibicides aknerianus* (d'Orbigny) – Ten Dam & Reinhold, p. 99, pl. 8, fig. 7.
pars 1949. *C. tallahattensis* Bandy, p. 110, pl. 20, fig. 5.
1955. *C. aknerianus* (d'Orbigny) – Bhatia, p. 685, pl. 67, fig. 5a–c.
1958. *C. lobatulus* (Walker & Jacob) – Batjes, p. 153, pl. 9, fig. 8, *not* fig. 7.
1963. *C. aknerianus* (d'Orbigny) – Kümmerle, p. 55, pl. 9, fig. 3a–c.

Type stratum: Sticky clay (Tertiary), Nussdorf area (Vienna Basin).

Remarks: A great number of tests of this species occur in the material, representing all transitions from small (young) to large (adult) specimens. They are all characterized by a convex umbilical side, usually showing 8½ chambers, and a flat (small specimens) to concave (large specimens) spiral side, where only the chambers of the youngest whorl are visible. The inner whorls are covered by coarse hyaline material (not granular as in *C. ungerianus).* Other characteristics are a gradual increase in chamber size, and regular curved sutures.

The smallest specimens (Pl. 3, Figs. 1–4) have a hyaline filling in the umbilicus. It is restricted like a knob in the smallest tests (Pl. 3, Figs. 1–2), but become more diffuse in the larger ones (Pl. 3, Figs. 3–4). The small specimens are also characterized by limbate sutures flush with the surface. The sutures become threadlike and somewhat depressed only in the youngest part, particularly on the umbilical side, and this represents the initiation of a lobulate periphery. The older part of the periphery remains non-lobulate with an imperforate, thickened rim. The flat spiral side may have a small convex central area due to the covering of the inner whorls. The surface of these small tests is smooth, finely perforated on the umbilical side and coarsely perforated on the spiral side. *C. tallahattensis* shows close morphological resemblance to these small specimens of *C. aknerianus.*

The growth of the test (Pl. 3, Figs. 5–6 & Pl. 4, Figs. 1–3) gives rise to increasingly inflated chambers. At the same time, the coarse perforation on the spiral side gradually spreads onto the umbilical side (Pl. 3, Figs. 5–6, Pl. 4, Figs. 1–2 & Pl. 7, Fig. 1a), and finally covers the whole test (Pl. 4, Figs. 3–5 & Pl. 7, Fig. 2a). Thus the tests gradually develop a more lobulate periphery, more deeply depressed sutures (most clearly seen on the umbilical side), a more open umbilicus (resulting in the disappearance of the hyaline filling), a partly involute umbilical side, and a more or less concave spiral side.

The largest tests (Pl. 4, Figs. 4–5 & Pl. 7, Figs. 2a–b) represent the typical *C. aknerianus* with strong convex and partly involute umbilical side and coarse perforation. These *C. aknerianus* – affinities are also discernible in the younger parts of the smaller specimens, whereas in their older parts the characteristics of the smaller specimens are seen, such as limbate undepressed sutures, hyaline filling of umbilicus, and thickened imperforate peripheral rim. The smaller specimens show some affinity to *C. tenellus* (Reuss) because of the distinct hyaline filling of the umbilicus. However, the latter species is distinguished by a greater number of chambers in the final whorl (usually 12), distinct depressed sutures and by all chambers being visible on the spiral side. Compared with *C. lobatulus* (Walker & Jacob), Kümmerle (1963) assumed that these species may be separated by their test-thickness : test-height (D:H) ratio. Grossheide & Trunkó (1965) assumed that the *C. aknerianus* falls within the range of variation of *C. lobatulus.* In the Sofienlund material, the test-height of larger specimens is approximately half the test-thickness.

Concerning the frequency of the different forms of *C. aknerianus* in the present material, smallest and largest specimens are rare, whereas tests of mean size are most frequent.

Dimensions: D: (0.174–0.64) mm., H: (0.095–0.37) mm.

Cibicides telegdi Grossheide & Trunkó – (Pl. 2, Figs. 9a, b, & Pl. 7, Figs. 3,4)

1965. *Cibicides telegdi* Grossheide & Trunkó, p. 157, pl. 14, fig. 10a–c.

Type stratum: Upper Oligocene deposits, Doberg (Germany).

Remarks: The outlines and sizes of the tests are more or less constant. The large number of chambers in the final whorl, the almost straight and obliquely directed sutures and the large hyaline filling of the umbilicus are characteristic features.

The specimens of the Sofienlund material differ from the holotype in possessing fewer chambers in the final whorl. Usually 10 to 12 chambers occur, compared with 12 to 15 described by Grossheide & Trunkó (1965). Furthermore, the spiral side, having all chambers visible, does not have any opaque covering of the inner whorls. Some specimens, however, have a cover of milk-like calcite, especially along the spiral suture. This is assumed to be of secondary origin and is probably a weathering effect.

Dimensions: D: 0.225 mm., H: 0.11 mm.

Nonion affine (Reuss) – (Pl. 1, Fig. 12 & Pl. 9, Fig. 2)

1851. *Nonionina affinis* Reuss, p. 72, pl. 5, fig. 32a–b.
1958. *Nonion affine* (Reuss) – Batjes, p. 140, pl. 6, fig. 12.
1959. *N. umbilicatulum* (Walker & Jacob) – Larsen & Dinesen, p. 88, pl. 8, fig. 4.
1962. *N. affine* (Reuss) – Kiesel, p. 65, pl. 9, fig. 14.
1962. *N. affine* (Reuss) – Indans, p. 53, pl. 7, fig. 7.
1962. *N. affine* (Reuss) – Bettenstaedt, et al., p. 367, pl. 53, fig. 17a, b, tabl. 21.
1963. *N. umbilicatulum* (Walker & Jacob) – Kümmerle, p. 45, pl. 6, fig. 7a, b.
1964. *N. affine* (Reuss) – Hausmann, p. 367, pl. 6, fig. 10.
1964. *N. affine* (Reuss) – Smith, p. 41, pl. 4, fig. 1a, b.
1965. *N. affine* (Reuss) – Grossheide & Trunkó, p. 130.
1969. *Melonis affine* (Reuss) – Voorthuysen & Toering, p. 107, pl. 6, fig. 6.
1970. *M. affine* (Reuss) – Kiesel, p. 283, pl. 15, fig. 7.

Type stratum: Septarian Clay, Berlin area (Germany).

Remarks: Large specimens show a well-developed ring around the open umbilicus (Pl. 9, Fig. 2). In smaller specimens the umbilicus is more or less closed by a hyaline mass, which often covers most of the umbilical area. Weathered tests show closed umbilicus, limbate and often slightly elevated sutures.

Dimensions: L: (0.185–0.475) mm., B: (0.150–0.385) mm., D: (0.085–0.185) mm.

Pullenia bulloides (d'Orbigny) – (Pl. 7, Fig. 5)

1826. *Nonionina bulloides* d'Orbigny, p. 293, no. 2.
1846. *N. bulloides* d'Orbigny – d'Orbigny, p. 107, pl. 5, fig. 9–10.
1914. *Pullenia sphæroides* (d'Orbigny) – Cushman, p. 20, pl. 11, fig. 2.
1924. *P. sphaeroides* (d'Orbigny) – Cushman, p. 40, pl. 8, fig. 3, 4.
1958. *P. bulloides* (d'Orbigny) – Batjes, p. 139, pl. 6, fig. 9.
1962. *P. sphaeroides* (d'Orbigny) – Kiesel, p. 66, pl. 9, fig. 17.
1964. *P. bulloides* (d'Orbigny) – Hausmann, p. 394, pl. 7, fig. 10a, b.
1964. *P. bulloides* (d'Orbigny) – Smith, p. 40.
1968. *P. bulloides* (d'Orbigny) – Schickor, p. 168, pl. 5, fig. 9, 10.
1970. *P. sphaeroides* (d'Orbigny) – Kiesel, p. 280, pl. 15, fig. 1.

Type stratum: Sticky clay (Tertiary), Nussdorf area (Vienna Basin).

Remarks: The axial section varies from circular to broadly elliptical. The number of visible chambers is 4 to 5½.

Dimensions: L: (0.15–0.41) mm., B: (0.13–0.375) mm., D: (0.11–0.375) mm.

Gyroidinoides cf. angustiumbilicata (Ten Dam)
Pl. 2, Figs. 8a,b, Pl. 7, Figs. 6. 7 & Pl. 9, Fig. 4)

1944. *Gyroidina angustiumbilicata* Ten Dam, p. 117, pl. 4, fig. 7.
1961. *G. angustiumbilicata* Ten Dam – Kaasschieter, p. 212, pl. 12, fig. 4.
1968. *G. angustiumbilicata* Ten Dam – Schickor, p. 170.
pars 1970. *G. angustiumbilicata* Ten Dam – Kiesel, p. 290, pl. 16, fig. 5.

Type stratum: Marl (Paleocene), Deep Bore »America«, Peel area (Holland).

Remarks: The specimens are biconvex, the umbilical side being more convex than the spiral one. The number of chambers in the last whorl is 8 to 8½. The specimens are differentiated from the listed synonyms by the distinct convex spiral side and by limbate sutures which are flush with the surface. In large specimens the two youngest sutures may be slightly depressed. In small specimens, the depressed umbilical area is often filled by a glassy mass. In large specimens, a narrow open umbilicus may be seen. It is partly filled by a fine-grained material.

The aperture is a typical »*Gyroidinoides*« aperture, i. e. an extraumbilical-umbilical slit with a thickened rim as a lip. Along the base of the apertural slit, a granular glassy mass may be observed in large specimens, which in the SEM (Pl. 9, Fig. 4) is an area of small conical spines.

The Sofienlund specimens differ from the specimens described by Kiesel (1970) in that they possess a narrow rounded periphery and curved sutures on the spiral side.

Dimensions: D: (0.21–0.40) mm., H: (0.11–0.21) mm.

Gyroidinoides soldanii forma girardanus (Reuss) –
(Pl. 5, Figs. 1–5 & Pl. 7, Figs. 8,9)

1851. *Rotalia girardana* Reuss, p. 73, pl. 5, fig. 34.
1958. *Gyroidina soldanii* d'Orbigny var. *girardana* (Reuss) – Batjes, p. 147, pl. 7, fig. 12.
1962. *G. soldanii girardana* (Reuss) – Kiesel, p. 69, pl. 10, fig. 7.
1962. *G. soldanii girardana* (Reuss) – Bettenstaedt, et al., p. 372, pl. 53, fig. 12a, b, tabl. 21.
1962. *Gyroidinoides girardanus* (Reuss) – Lühr, p. 144, pl. 5, fig. 10a–c, pl. 9, fig. 3.
1964. *Gyroidina soldanii girardana* (Reuss) – Hausmann, p. 384, pl. 7, fig. 7.
1965. *G. girardana* (Reuss) – Spiegler, p. 473, pl. 22, fig. 7.
1970. *Gyroidinoides girardanus* (Reuss) – Kiesel, p. 288, pl. 16, fig. 2.

Type stratum: Septarian Clay, Berlin area (Germany).

Remarks: The figures of Pl. 5 show the variation from small to large tests. They all have in common the main characters of the typical *Gyroidina soldanii* d'Orbigny: plano-convex test, open umbilicus and acute periphery. The form *girardanus* differs from *G. soldanii* by a stronger convex umbilical side. Hausmann (1964) assumed the ration D:H is about 1.8 in *G. soldanii,* whereas it is less than 1.64, usually around 1.3 in the *girardanus* form. In the Sofienlund material, this ratio varies from 1.6 in small specimens to about 1.4 in large specimens.

The specimens are referred to the genus *Gyroidinoides* because of the extraumbilical-umbilical apertural slit, extending at least ¾ of the distance from the umbilicus to the periphery. Furthermore, umbilical flaps from younger chambers are often seen in the open umbilicus in large specimens (Pl. 7, Fig. 9a). In smaller specimens, the middle part of the apertural slit is often broadened into the central area of the apertural face (Pl. 5, Figs. 1b & Pl. 7, Fig. 8). This often coincides with a secondary filling of the umbilical connection with the apertural slit, resulting superficially in an extraumbilical situation for the aperture. The chamber sutures on the spiral side differ from the sutures of the listed synonyms in running obliquely backwards, resulting in a close resemblance to *Gyroidina altiformis* (R. E. & K. C. Stewart). The latter is distinguished by greater number of chambers in the last whorl, usually 10 to 11, and by its slithtly rounded periphery.

Dimensions: D: (0.18–0.57) mm., H: (0.13–0.39) mm.

Gyroidinoides soldanii forma 1 – (Pl. 8, Figs. 1–2 & Pl. 9, Fig. 3)

Description: The test is plano-convex, the umbilical side is strongly convex and the spiral side is plane, or convex in a few specimens. Periphery is rounded, non-lobulate in small tests, slightly lobulate in large specimens especially in the youngest part.

The umbilical side shows 6 to 8 chambers which are separated by radiate to slightly curved sutures. In large specimens the youngest sutures are depressed. In the older part, and in small specimens, the sutures are flush with surface. The umbilical area is depressed with closed umbilicus.

The spiral side, which is plane in small specimens and convex in large specimens, has all whorls and chambers visible. The number of chambers in the last whorl varies from 6 to 7 in small tests, and from 8 to 9 in large tests. The chamber sutures are radiate, flush with the surface; The two youngest are somewhat depressed in large specimens. The aperture is an extraumbilical-umbilical slit along the base of the last chamber, and does not cross the periphery. It has developed a thickened rim (Pl. 9, Fig. 3), which in some specimens continues in a small flap in the umbilical area. The surface in smooth and very finely perforated.

Remarks: From the outline of the tests these specimens are referred to the *Gyroidinoides soldanii* – group. On the strong convex umbilical side especially, they are much like *G. soldanii* forma *girardanus*. The ratio D:H of the tests varies from approximately 1.3 to 1.5. This form differs from *G. soldanii* forma *girardanus* by its closed umbilicus and the distinctly rounded periphery.

Specimens with a convex spiral side (Pl. 8, Fig. 2) show a close resemblance to *G. mamillata* (Andreae) but differ in possessing a closed umbilicus, rounded periphery and less convexity of the spiral side.

Dimensions: D: (0.19–0.29) mm., H: (0.14–0.225) mm.

Gyroidinoides octocamerata (Cushman & Hanna) – (Pl. 8, Figs. 3,4 & Pl. 9, Fig. 5)

1927. *Gyroidina soldanii* var. *octocamerata* Cushman & Hanna, p. 223, pl. 14, fig. 1.
1949. *Valvulineria octocamerata* (Cushman & Hanna) – Bandy, p. 84, pl. 13, fig. 1.
1961. *Gyroidina octocamerata* Cushman & Hanna – Kasschieter, p. 212, pl. 13, fig. 2.
1962. *Gyroidinoides soldanii octocameratus* (Cushman & Hanna) – Hillebrandt, p. 108, pl. 9, fig. 6a–c.
1970. *G. octocamerata* (Cushman & Hanna) – Hansen, p. 106, pl. 13, fig. 1–3.

Type stratum: Eocene deposit, north of Coalinga (California).

Remarks: The trochospiral tests are more or less plano-convex, with a strongly rounded periphery. The convex umbilical side has 7 chambers, which are separated by depressed and slightly curved sutures. The umbilical area is depressed with a narrow open umbilicus. The spiral side is flat, having 8 chambers in the final whorl. The chamber sutures are depressed and strongly curved. The broadly rounded periphery is lobulate. The aperture is an extraumbilical-umbilical slit, running from umbilicus to periphery along the base of the last chamber; it has developed a distinct lip which, in some specimens, continues in a small umbilical flap, partly covering the umbilicus. (Pl. 9, Fig. 5).

Compared with the other species of *Gyroidinoides* in the present material, this species is characterized and separated by its increased chamber-size, elevated chamber, and distinctly depressed sutures.

Dimensions: D: 0.25 mm. H: 0.13 mm.

Gyroidinoides? sp. 1 – (Pl. 2, Fig. 7 & Pl. 8, Figs. 5,6)

Description: Test low trochospiral, biconvex with broadly rounded periphery. The umbilical side is more convex than the spiral side, involute, showing 7 to 8½ chambers separated by slightly limbate and faintly curved sutures flush with the surface. The umbilical area is broadly and slightly depressed, often partly filled by glassy material. The umbilicus is completely or partially completely closed. The almost plane spiral side is evolute, having all chambers visible. It usually shows 8½ chambers in the final whorl. Chamber sutures are slightly limbate and curved. They may be depressed especially in the youngest part.

The aperture is a low slit, running from umbilicus to periphery along the base of the last chamber. In some tests the aperture crosses the periphery, so that it may be seen on the spiral side as an opening at the base of the youngest chamber at the oldest part of the periphery, but it never extends along the spiral sutures. The aperture is covered by a distinct lip. The surface is smooth with a relative coarse perforation on both sides. Wall structure is granulate.

Remarks: The specimens show great affinity to small specimens of *G.* cf. *angustiumbilicata,* but differ in showing a more rounded periphery, slight difference in degree of convexity between the two sides of the test, and coarser perforation of the test. The coarse perforation, closed umbilicus, and the low trochospiral (almost »plane«-spiral) outline, make the reference to the genus *Gyroidinoides* very doubtful. The specimens also show great affinity to the genus *Anomalina* but the apertural extension along the spiral suture is missing.

Dimensions: D: 0.25 mm., H: 0.13 mm.

Ceratobulimina contraria (Reuss) – (Pl. 8, Fig. 7 & Pl. 9, Fig. 6)

1851. *Rotalina contraria* Reuss, p. 76, pl. 5, fig. 37.
1958. *Ceratobulimina contraria* (Reuss) – Batjes, p. 160, pl. 10, fig. 4.
1962. *C. contraria* (Reuss) – Bettenstaedt, et al., p. 375, pl. 54, fig. 10–12, tabl. 21.
1962. *C. contraria* (Reuss) – Kiesel, p. 76, pl. 12, fig. 1.
1964. *C. contraria* (Reuss) – Hausmann, p. 393, pl. 7, fig. 15.

1965. *C. contraria* (Reuss) – Spiegler, p. 475, pl. 22, fig. 15.
1970. *C. (Ceratobulimina) contraria* (Reuss) – Kiesel, p. 318, pl. 21, fig. 3.

Type stratum: Septarian Clay, Hermsdorf (Germany).

Remarks: Large specimens show teeth in the apertural depression, as observed by Batjes (1958) (Pl. 9, Fig. 6).

Dimensions: D: (0.19–0.45) mm., H: (0.125–0.275) mm.

Faunal and stratigraphical discussions

As mentioned above, the faunal species composition throughout the examined sequence is very uniform. However, some faunal variations, caused by varying representation between the 11 foraminiferal groups and in some of the registered species, have been observed. Looking at Fig. 1, the variations between the most frequent groups (*Turrilina alsatica, Nonion affine, Pullenia bulloides, Gyroidinoides* spp., Nordosariacea, and partly *Cibicides* spp.) may be characterized as a more or less three-fold repeated fluctuation, where *Turrilina alsatica* varies reciprocally to the other groups. A biostratigraphical classification of the examined sequence into three zonules, Z 1, Z 2, and Z 3, is suggested on this basis (Fig. 1). The classification is also supported by variation in faunal diversity and in slight variations of some of the register species. The shorter section, no. 2 (Fig. 1) supports this subdivision, although only one of the repeated variations is found. It is referred to the uppermost zonule of Section 1, because of its contact with the superimposed Sofienlund Formation and by the common faunal variation, which differs slightly from the underlying zonules (see later). The biostratigraphical classification, based on gradual variations in the fauna, makes distinct separation of the zonules impossible, so that only their approximate thickness may be given.

In the following, a faunal description of the zonules together with the observed variation in species representation is given.

Zonule 1 (Z 1): This consists of the lowermost part of the examined sequence (Section 1, no. 28 – no. 16). Its lower limit has not been found because of the restricted range of the boring equipment used. Vertical thickness is at least 10.4 m. *Turrilina alsatica* decreases strongly from about 80 % at the base to 5–10 % at the top. The other frequent groups, *Nonion affine, Pullenia bulloides, Gyroidinoides* spp., Nordosariacea, and *Cibicides* spp., all gradually increase in relative frequency, from 5 % to 26 %, 1 % to 21 %, 3 % to 15 %, 2 % to (12–15)%, and 1 % to (5–10)% respectively. The faunal diversity also increases, being approximately 15 at the base and rising to 30 or more in the upper part.

Nonionella lobsannensis is often met in this zone, where its maximum relative frequency, 2.5 %, is observed. This species is not usually represented in the samples from the two upper zonules, and if represented then it is by less than ½ %. Furthermore, the zonule is also characterized by a very small representation of the registered species. Other than the three dominant species, *Turrilina alsatica, Nonion affine* and *Pullenia bulloides,* only a few species are represented by more than 5 % of the fauna. These species, *Cibicides aknerianus, Gyroidinoides* cf. *angustiumbilicata, G. soldanii* forma 1, and *Ceratobulimina contraria,* have their strongest representation in the uppermost part of the zonule (Fig. 2). No divergence from the gradual variation throughout the zonule has been observed. All register species more or less increase from base to top of the zonule.

Zonule 2 (Z 2): The zone consists of the following samples: Section 1, no. 15 – no. 8, and Section 2, no. 9. Its vertical thickness is 8 to 9.5 m. The frequent foraminiferal groups show similar variations in relative frequencies as in Z 1, except for *Nonion affine* which has its maximum relative frequency in the middle part of the zone and decreases in the uppermost part.

Z 2 is characterized by lower frequency of *Turrilina alsatica* at the base than in the two other zonules, viz., about 55 % compared with 70 to 80 % in the other zonules. Furthermore, *Glandulina aequalis* has maximum relative frequency in this zonule of 4.2 %, but is usually represented with 1.5 % to 3.5 %. In the other zonules, it seldom exceeds ½ % of the fauna. As in Z. 1, only a few species may be represented by 5 % or more (Fig. 2). These "distinct" representations are all restricted to the upper part of the zone.

Zonule 3 (Z 3): This is the uppermost part of the examined sequence, consisting of the following samples: No. 7 to no. 1 in both sections. Its vertical thickness is approximately 7 m. The proximity to the surface, especially in Section 1 (see Christensen & Ulleberg, 1973, pl. 1) may give a strong and varied secondary weathering effect, resulting in the possibility of displaced faunas. It probably explains the small inconsistency in faunal variations between the two sections (Fig. 1). However, the same faunal variations of the most frequent groups are more or less equivalent in the two sections. Again, *Turrilina alsatica* has a maximum relative frequency at the base of the zonule, approximately (70–80 %), gradually decreasing to approximately 10 % in the middle part of the zonule, but increasing in the uppermost part. All other frequent groups are more or less reciprocal in their representation. They all increase upwards to the middle part and then in the uppermost part show a tendency to decrease.

Z 3 has a small faunal diversity, usually less than 20, particularly at the base of the zone, where a minimum of 4 was observed in sample no. 7 in Section 1 (Fig. 1). Furthermore, the zonule is characterized by poor representation of the following species, which are well represented in the two lower zonules: *Frondicularia budensis* is represented by one specimen in the complete zonule, whereas in Z 1 and Z 2 it occurs in every sample. Approximately the same proportions of *Stilostomella adolphina, S. longiscata, Glandulina aequalis* (see Fig. 2), and *G. dimorpha* occur. This might be explained by secondary pyritisation, because of the closeness to the surface. Since these species all have relatively large-chambered test, they are probably susceptible to corrosion and destruction. However, *Cibicides telegdi* has its greatest relative frequency in this zonule. It composes usually 2½ to 5½ % of the fauna, whereas in the lower zonules it seldom exceed 1 %. *Gyroidinoides?* sp. 1 is also well represented in this zonule (Fig. 2), with its maximum occurrence, 13.7 % throughout the whole examined sequence (Section 1, no. 4). In Section 2, the maximum relative frequency is observed in no. 4 (13.2 %), indicating that these two samples correspond roughly in stratigraphical terms.

The divergent faunal variation in the uppermost part of Z 3 compared with Z 1 and Z 2, may be explained, as this level represents the gradual variation to a new biostratigraphic zonule, perhaps to a new repeated variation. Sorgenfrei (1948) assumed that the boundary between Middle and Upper Oligocene at this locality (i.e. between Viborg Formation and Sofienlund Formation) indicates a new transgression. Christensen & Ulleberg (1973) stated that the boundary represents a break. Furthermore, they assumed that the Viborg Formation was deposited in environments like the present-day outer continental shelf area. Neither the sediments (Christensen, pers. com.) nor the foraminiferal fauna show any kind of regressional change in palaeoenvironments in the uppermost part of the sequence. Therefore, it is assumed that the boundary between the Viborg Formation and the Sofienlund Formation in this area represents a distinct hiatus during which erosion of the top of the Viborg Formation took place. The divergent variation in faunal composition in the uppermost part of Z 3 indicates the existence of a biozone which is not represented (or perhaps only by its basal part) in the clay to-day.

As mentioned earlier, the separation of the zonules is not distinct, because their junctions are gradual. In the present material, the fauna in sample no. 8 of Section 2 (Fig. 1) is regarded as a transition fauna between Z 2 and Z 3.

The three-fold faunal displacements are probably due mainly to variations in palaeoenvironments. Since no variation of planktonic foraminifers has been observed (Fig. 1), it is probable that no large scale variations in open marine conditions occurred. Sorgenfrei (1949) and Rasmussen (1961) stated that the Middle/Upper Oligocene boundary in Denmark is interrupted by changing conditions, probably of tectonic character. If tectonic events caused the repeated faunal zones in the Middle Oligocene sequence examined, they would also probably effect the sediments. It is noteworthy that no sedimentological variations have been observed (Christensen & Ulleberg, 1973, pl. 3; Christensen, pers. com.). It is therefore assumed that the environmental variations, which are very small, are probably very local and restricted to or within the Danish Oligocene Embayment. Because of the central situation of Sofienlund in the embayment, small variations in sea level could explain the faunal variations. This idea is also supported by the varying representation of *Pullenia bulloides*. According to Porkorny (1963), this species has experienced a "depth-migration" throught time and is quite common in shallow-water sediments of Miocene age, whereas today it is characteristic of deep-sea assemblages. In the present material, the inversely proportional representation of *Turrilina alsatica* and *Pullenia bulloides* could indicate slight gradual variations in sea level. Levels with high representation of *Turrilina alsatica* would probably indicate some deeper environments.

To summarise our discussion, the examined sequence of the Viborg Clay was probably deposited in environments like the present-day outer continental shelf area. The extremely sparse representation of planktonic specimens suggests that the palaeoenvironment of the "Viborg"-sea was a more or less strongly restricted (closed) shelf sea. Within this area, slight environmental variations occurred which did not effect the sedimentology. It is reduced that at least a three-fold variation took place, probably representing variation in depth which resulted in the three-fold displacement of the foraminiferal fauna described here.

Acknowledgements. The author wishes to thank Dr. R. W. Feyling-Hanssen (Aarhus), and the Norwegian Petroleum Directorate, who provided facilities for my investigation. I also express my thanks to Arne Dinesen (D.G.U.) for valuable suggestions and improvements of the manuscript, and for making the SEM-photos. Svend Meldgaard (Aarhus) made the photographs for the plates, and Ø. Strand (Norwegian Petroleum Directorate) drew the figures. Finally, I want to thank Dr. J. R. Wilson (Aarhus) and Dr. Alan Lord (University College London) who improved the English text.

Dansk sammendrag

I det foreliggende arbejde gives en beskrivelse af foraminiferfaunaen i en 27 m mægtig lagserie af det Mellem Oligocæne Viborg Ler fra den nu nedlagte teglværksgrav ved Sofienlund i Midtjylland. Lagserien opdeles biostratigrafisk i tre zonuler baseret på variationer i foraminiferfaunaens kvantitative sammensætning. Mindre faunistiske varationer i artssammensætningen er også observeret.

Foraminiferfaunaen domineres af bentoniske kalkskaller. *Turrilina alsatica, Nonion affine* og *Pullenia bulloides* udgør tilsammen minimum 40 % af foraminiferfaunaen.

I det foreliggende materiale er der observeret 112 foraminiferformer. Heraf er 21 former behandlet i en systematisk del omfattende de hyppigste arter, samt nogle hyppige ikke-bestemte arter og arter med stor morfologisk variation. *Gyroidinoides soldanii* forma 1 og G? sp. 1 er to ikke-bestemte arter som er almindelige i materialet. Arterne *Guttulina frankei*, *Gyroidinoides soldanii* forma *girardanus* og *Cibicides akerianus* viser store morfologiske variationer.

References

Andreae, A., 1884: Beitrag zur Kenntnis des Elsässer Tertiärs. *Abh. geol. Spec. Karte Els-Lothr.* **2,** 1–239.

Bandy, O. L.: 1949: Eocene and Oligocene Foraminifera from Little Stave Creek, Clarke County, Alabama. *Bull. Amer. Paleont.* **32,** 1–207.

Barker, R. W., 1960: Taxonomic Notes on the Species Figured by H. B. Brady in his Report on the Foraminifera Dredged by H. M. S. Challenger During the Years 1873–1876. *Soc. Econ. Paleont. Mineral., Spec. Publ.* **9,** 1–238.

Batjes, D. A. J., 1958: Foraminifera of the Oligocene of Belgium. *Inst. roy. Sci. nat. Belgique* **143,** 1–188.

Bettenstaedt, F., Fahrion, H., Hiltermann, H., Wick, W., 1962: Tertiär Norddeutschland. *In:* Arbeitskreis deutcher Mikropaläontologen: *Leitfossilien der Mikropaläontologie.* 339–378, Berlin: Borntraeger.

Bhatia, S. B., 1955: The foraminiferal fauna of the Late Paleogene sediments of the Isle of Wight, England. *J. Paleont.* **29,** 665–693.

Christensen, L. and Ulleberg, K., 1973: Sedimentology and micropalaeontology of the Middle Oligocene sequence at Sofienlund, Denmark. *Bull. geol. Soc. Denmark* **22,** 283–305.

Christensen, L. and Ulleberg, K., 1974: Sediments and foraminifers of the Middle Oligocene Viborg Formation, Denmark. *Bull. geol. Soc. Denmark* **23,** 109–117.

Cushman, J. A., 1914: A Monograph of the Foraminifera of the North Pacific Ocean. Part IV. Chilostomellidæ, Globigerinidæ, Nummulitidæ. *U. S. natl Mus., Bull.* **71,** 1–43.

Cushman, J. A., 1915: A Monograph of the Foraminifera of the North Pacific Ocean. Part V. Rataliidae. *U. S. natl Mus., Bull.* **71,** 1–81.

Cushman, J. A., 1923: The Foraminifera of the Atlantic Ocean. Part 4. Lagenidae. *U. S. natl Mus., Bull.* **104,** 1–178.

Cushman, J. A., 1924: The Foraminifera of the Atlantic Ocean. Part 5. Chilostomellidae and Globigerinidae. *U. S. natl Mus., Bull.* **104,** 1–45.

Cushman, J. A. and Hanna, G. D., 1927: Foraminifera from the Eocene near Coalinga, California. *Proc. Calif. Acad. Sci.* (4) **8,** 205–229.

Cushman, J. A. and Ozawa, Y., 1930: A monograph of the foraminiferal family Polymorphinidae recent and fossil. *U. S. natl Mus., Proc.* **77,** 1–185.

Czjzek, J., 1848: Beitrag zur Kenntnis der fossilen Foraminiferen des Wiener Beckens. *Haidinger naturwiss. Abh.* **2,** 137–150.

Ellermann, C., 1960: Foraminiferen aus dem Oligozän des Schachtes Kapellen (Niederrhein) mit Variationsstatistik von Elphidium subnodosum Roemer. *Geol. Jahrb.* **77,** 645–710.

Friese, H., 1951: Zur Foraminiferen-Fauna der Meeresmolasse des unteren Inngebietes. *Abh. geol. Dienst Berlin, N. F.* **227,** 1–52.

Grossheide, K., and Trunkó, L., 1965: Die Foraminiferen des Doberges bei Bünde und von Astrup mit Beiträgen zur Geologie dieser Profile (Oligozän, NW-Deutschland). *Beih. geol. Jahrb.* **60**, 1–213.

Hansen, H. J., 1970: Danian Foraminifera from Nûgssuaq, West Greenland. *Meddr Grønland* **193** (2), 1–132.

Hansen, H. J., 1972: Two species of Foraminifera of the genus Turrilina with different wall structure. *Lethaia* **5**, 39–46.

Hantken, M. V., 1875: Die Fauna der Clavulina-Szabou-Schichten. *Mitt. Jahrb. kgl. ungar. geol. Anst.* **4**, 1–94.

Hausmann, H. E., 1964: Foraminiferenfauna und Feinstratigraphie des mitteloligozänen Septarientones im Raum zwischen Magdeburg und Dessau – Teil 1: Die Foraminiferenfauna. *Hercynia, N. F.* **1**, 333–419.

Hillebrandt, A., v.: Das Paläozän und seine Foraminiferenfauna im Becken von Reichenhall und Salzburg. *Abh. bayer. Akad. Wiss., N. F.* **108**, 9–182.

Indans, J., 1962: Foraminiferen-Faunen aus dem Miozän des Niederrheingebietes. *Fortschr. Geol. Rheinld Westf.* **6**, 19–82.

Kaasschieter, J. P. H., 1961: Foraminifera of the Eocene of Belgium. *Verh. k. belg. Inst. Naturw.* **147**, 1–271.

Kiesel, Y., 1962: Die oligozänen Foraminiferen der Tiefbohrung Dobbertin (Mecklenburg). Ein Beitrag zur Feinstratigraphie des mittel-deutschen Rupels. *Freiberger Forsch.-H.* (C) **122**, 1–123.

Kiesel, Y., 1970: Die Foraminiferenfauna der paläozänen und eozänen Schichtenfolge der Deutschen Demokratischen Republik. *Paläont. Abh.* (A) **4** (2) 163–394.

Kümmerle, E., 1963: Die Foraminiferenfauna des Kasseler Meeressandes (Oberoligozän) im Ahnetal bei Kassel. *Abh. hess. L.-Amt Bodenforsch.* **45**, 1–72.

Larsen, G. & Dinesen, A., 1959: Vejle fjord formationen ved Brejning. Sedimenterne og foraminiferfaunaen (oligocæn-miocæn). *Danmarks geol. Unders. række 2,* **82**, 114 pp.

Lühr, H., 1962: Geologische und mikropaläontologische Untersuchungen im Alttertiär von Häring/Tirol. *Inaugural-Diss. Naturw. Fak., Ludwig-Maximilians-Univ.* München, 1–174.

Marks, P., 1951: A revision of the smaller Foraminifera from the Miocene of the Vienna Basin. *Contr. Cushman Found. Foram. Res.* **2**, 33–73.

Orbigny, A. de, 1826: Tableau méthodique de la classe des Céphalopodes. *An. Sci. nat. zool. Paris* **7**, 245–314.

Orbigny, A. de, 1846: *Foraminiferes fossiles du Bassin Tertiaire de Vienne.* 312 pp., Paris.

Pokorny, V., 1963: Principles of zoological Micropalaeontology, vol. 1. *Int. Ser. Monogr. Earth Sci.* 652 pp. Oxford: Pergamon.

Rasmussen, L. B., 1961: De miocæne formationer i Danmark. *Danmarks geol. Unders.* række 4, **4** (5), 45 pp.

Reuss, A. E., 1851: Über die fossilen Foraminiferen, und Entomostraceen der Septarienthone der Umgegend von Berlin. *Z. deutsch. geol. Ges.* **3**, 49–92.

Reuss, A. E., 1863: Beitrage zur Kenntnis der tertiären Foraminiferenfauna III. Die Foraminiferen des Septarienthones von Offenbach. IV. Die Foraminiferen des Septarienthones von Freuznach. *Sitz.-Ber. kais. Akad. Wiss., math.-nat. Cl.* **48**, 36–71.

Schickor, A., 1968: Biostratigraphische Untersuchungen im Paleozän und Eozän NW – Deutschland mit Kleinforaminiferen. *Münster Forsch. Geol. Paläont.* **7**, *1–253.*

Smith, B. P., 1964: Ecology of Benthonic Species. Recent Foraminifera off central America. *U. S. Geol. Surv. Prof. Paper* **429–B**, 1–55.

Sorgenfrei, Th., 1948: Excursion til Himmerland. *Meddr dansk geol. Foren.* **11**, 396–401.

Sorgenfrei, Th., 1949: Nyere undersøgelser over Fyns undergrund. *Meddr dansk geol. Foren.* **11**, 490–493.

Spiegler, D., 1965: Biostratigraphie des Rupels auf Grund von Foraminiferen im nördlichen Deutschland. *Geol. Jahrb.* **82**, 447–486.

Ten Dam, A. and Reinhold, Th., 1942: Die stratigraphische Gliederung des niederländischen Oligo-Miozäns nach Foraminiferen (mit Ausnahme von Süd-Limburg). *Med. Geol. Stichting* **C–V–2**, 1–106.

Ten Dam, A., 1944: Die stratigraphische Gliederung des niederlandischen Palaeozäns und Eozäns nach Foraminiferen (mit Ausnahme von Süd-Limburg). *Med. Geol. Stichting* **C–V–3**, 1–142.

Voorthuysen, J. H. van and Toering, K., 1969: Distribution quantitative des foraminifères néogènes et quaternaires aux environs d'Anvers. *Med. rijks geol. Dienst, N. S.* **20**, 93–123.

Walton, W. R., 1964: Recent Foraminiferal Ecology and Paleoecology. *In:* Imbrie, J. and Newell, N. (ed.): *Approaches to Paleoecology*, 151–237. New York: Wiley.

Plate 1

Fig. 1. *Guttulina frankei* Cushman & Ozawa; a, side view × 75, b, apertural view × 75.
Fig. 2. *Guttulina frankei* Cushman & Ozawa; a, side view × 75, b, apertural view × 75.
Fig. 3. *Guttulina frankei* Cushman & Ozawa; side view × 75.
Fig. 4. *Guttulina frankei* Cushman & Ozawa; side view × 75.
Fig. 5. *Guttulina frankei* Cushman & Ozawa; side view × 75.
Fig. 6. *Guttulina frankei* Cushman & Ozawa; side view × 75.
Fig. 7. *Glandulina aequalis* Reuss; side view × 75.
Fig. 8. *Glandulina aequalis* Reuss; side view × 75.
Fig. 9. *Glandulina aequalis* Reuss; side view ×75.
Fig. 10. *Epistominella oveyi* (Bhatia); a, spiral side × 120, b, umbilical side × 120.
Fig. 11. *Eponides pygmeus* (Hantken); a, spiral side × 120, b, umbilical side × 120.
Fig. 12. *Nonion affine* (Reuss); side view × 90.

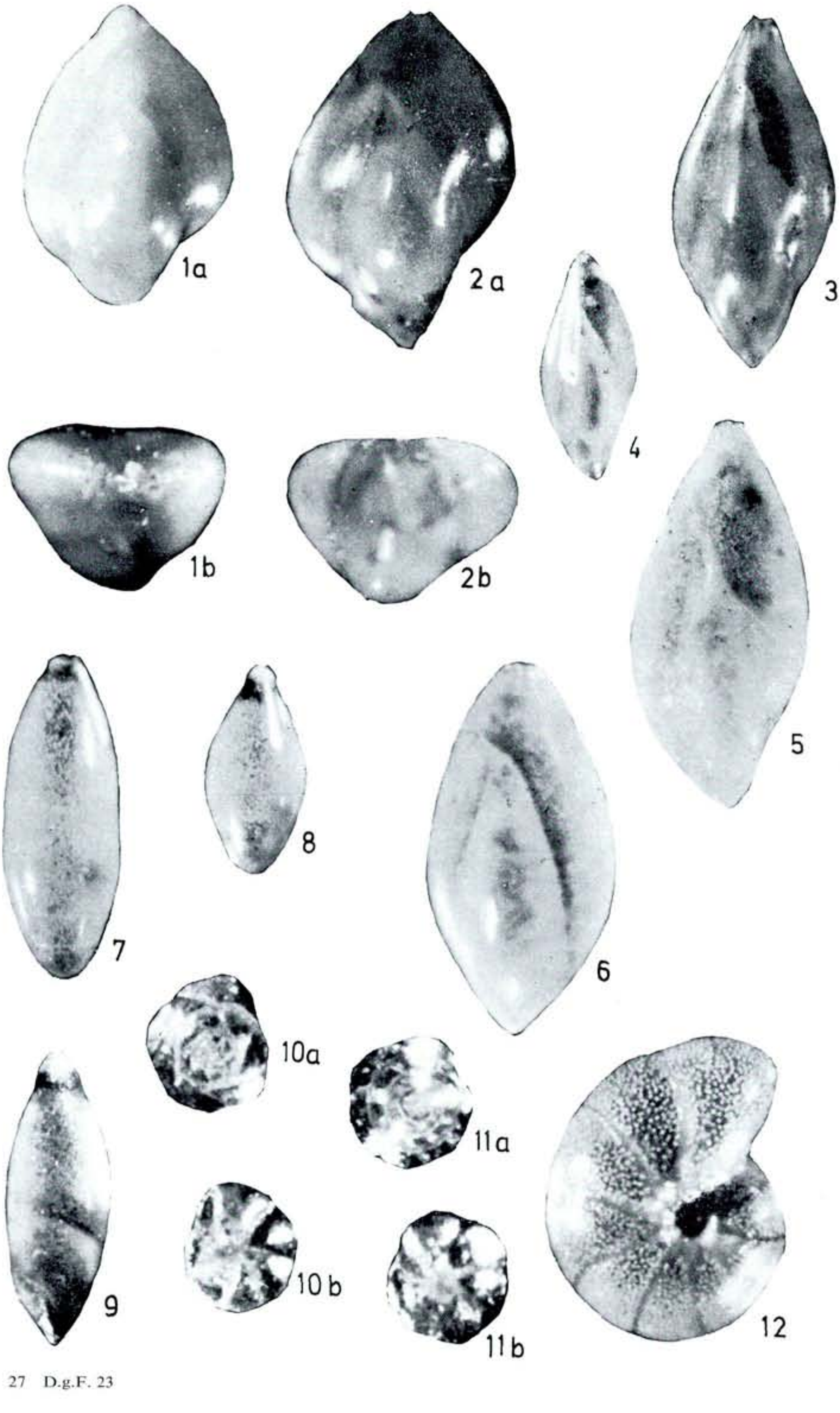
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Plate 2

Fig. 1. *Stilostomella adolphina* (d'Orbigny); side view × 90.
Fig. 2. *Stilostomella spinescens* (Reuss); side view × 75.
Fig. 3. *Stilostomella longiscata* (d'Orbigny); side view × 75.
Fig. 4. *Stilostomella longiscata* (d'Orbigny); side view × 75.
Fig. 5. *Stilostomella hirsuta* (d'Orbigny); side view × 75.
Fig. 6. *Stilostomella hirsuta* (d'Orbigny); side view × 75.
Fig. 7. *Gyroidinoides?* sp. 1; a, spiral side × 120, b, umbilical side × 120.
Fig. 8. *Gyroidinoides* cf. *angustiumbilicata* (Ten Dam); a, spiral side × 75, b, umbilical side × 75.
Fig. 9. *Cibicides telegdi* Grossheide & Trunko; a, spiral side × 90, b, umbilical side × 90.

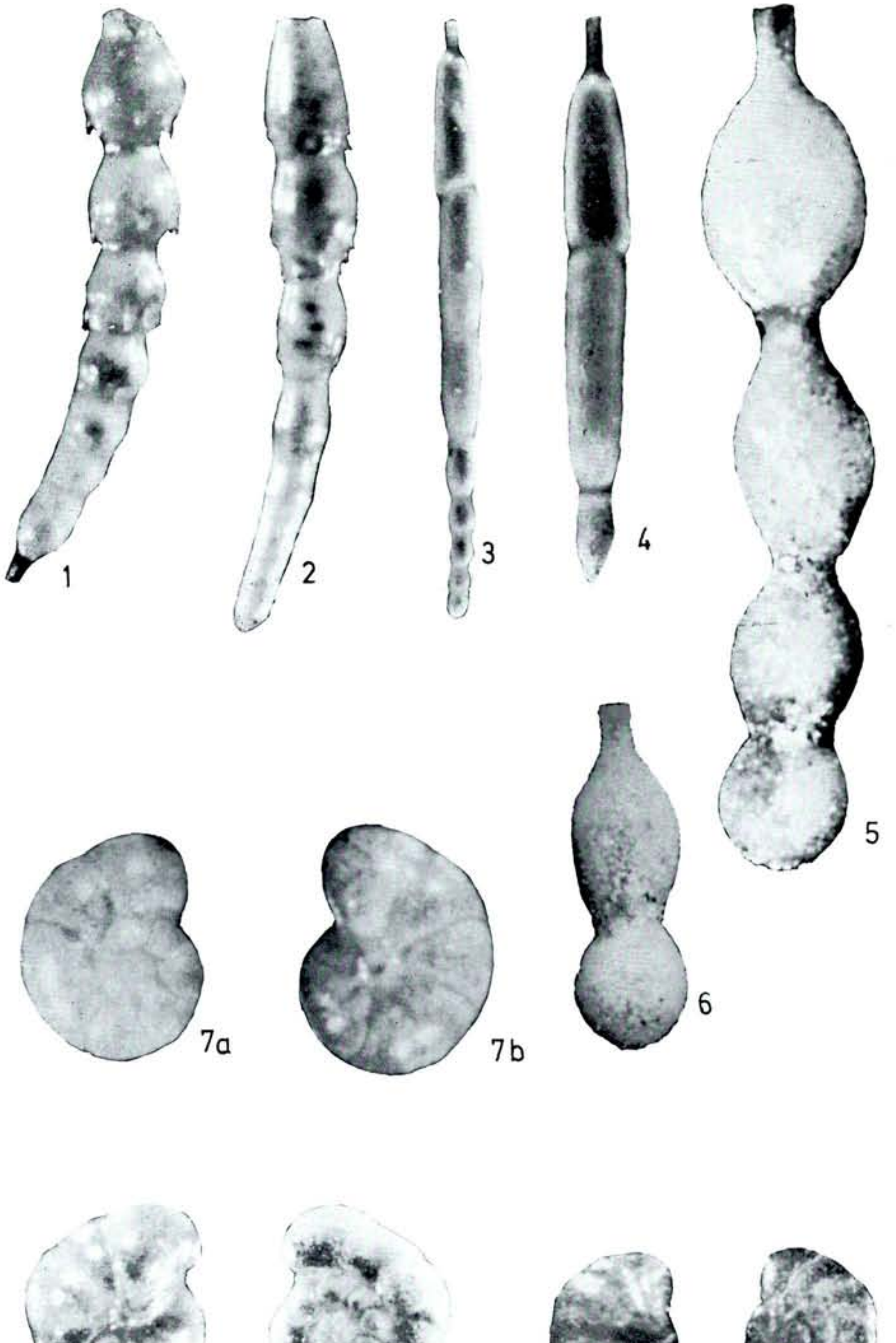
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Plate 3

Fig. 1. *Cibicides aknerianus* (d'Orbigny); a, spiral side × 105, b, peripheral view × 105, c, umbilical side × 105.
Fig. 2. *Cibicides aknerianus* (d' Orbigny); a, spiral side × 105, b, peripheral view × 105, c, umbilical side × 105.
Fig. 3. *Cibicides aknerianus* (d'Orbigny); a, spiral side × 105, b, peripheral view × 105, c, spiral side × 105.
Fig. 4. *Cibicides aknerianus* (d'Orbigny); a, spiral side × 105, b, peripheral view × 105, c, spiral side × 105.
Fig. 5. *Cibicides aknerianus* (d'Orbigny); a, spiral side × 90, b, peripheral view × 90, c, spiral side × 90.
Fig. 6. *Cibicides aknerianus* (d'Orbigny); a, spiral side × 90, b, peripheral view × 90, c, spiral side × 90.

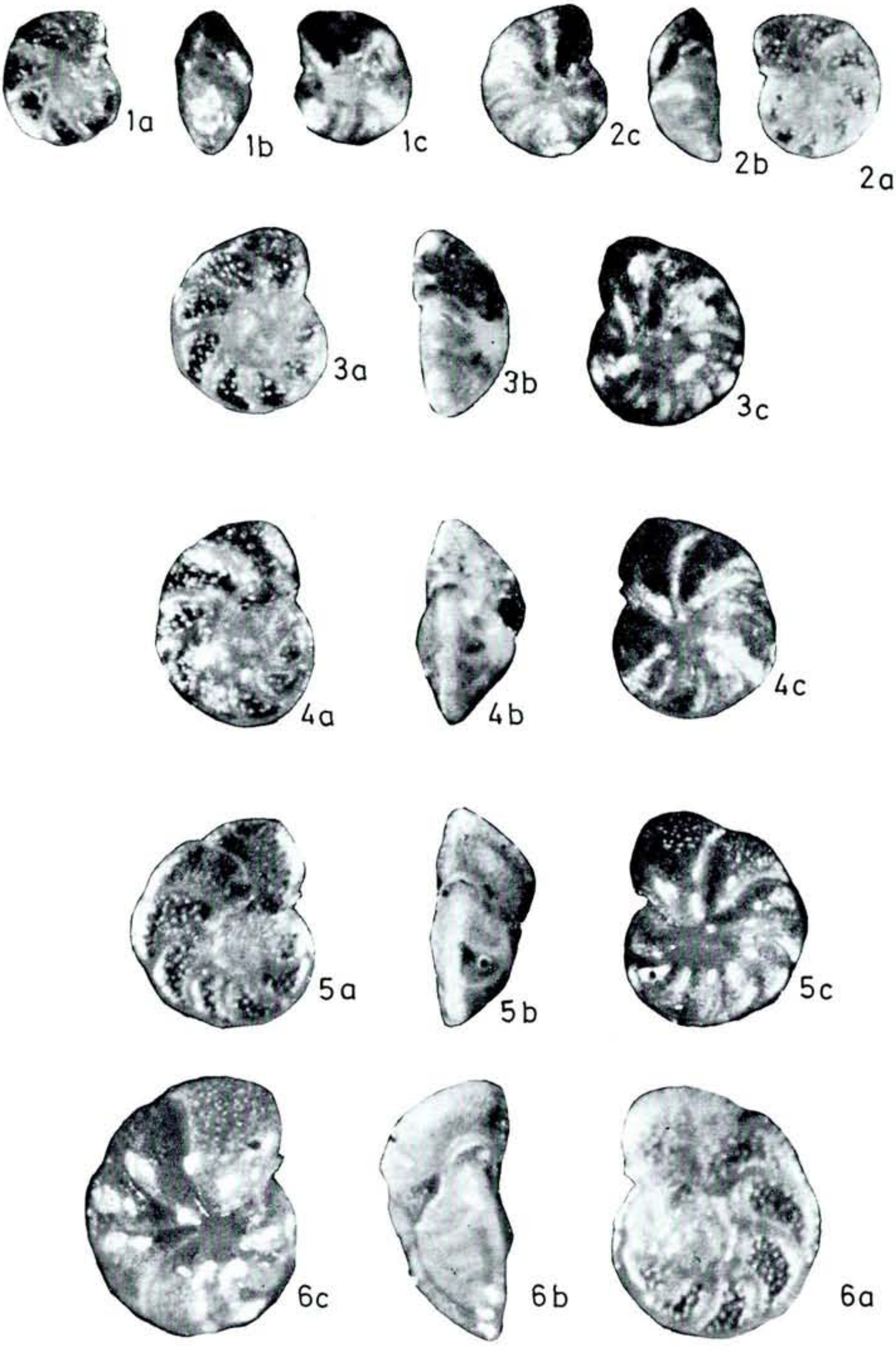
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Plate 4

Fig. 1. *Cibicides aknerianus* (d'Orbigny); a, spiral side × 75, b, peripheral view × 75, c, umbilical side × 75.
Fig. 2. *Cibicides aknerianus* (d'Orbigny); a, spiral side × 75, b, peripheral view × 75, c, umbilical side × 75.
Fig. 3. *Cibicides aknerianus* (d'Orbigny); a, spiral side × 75, b, peripheral view × 75, c, umbilical side × 75.
Fig. 4. *Cibicides aknerianus* (d'Orbigny); a, spiral side × 60, b, peripheral view ×60, c, umbilical side × 75.
Fig. 5. *Cibicides aknerianus* (d'Orbigny); a, spiral side × 60, b, peripheral view × 60, c, umbilical side × 75.

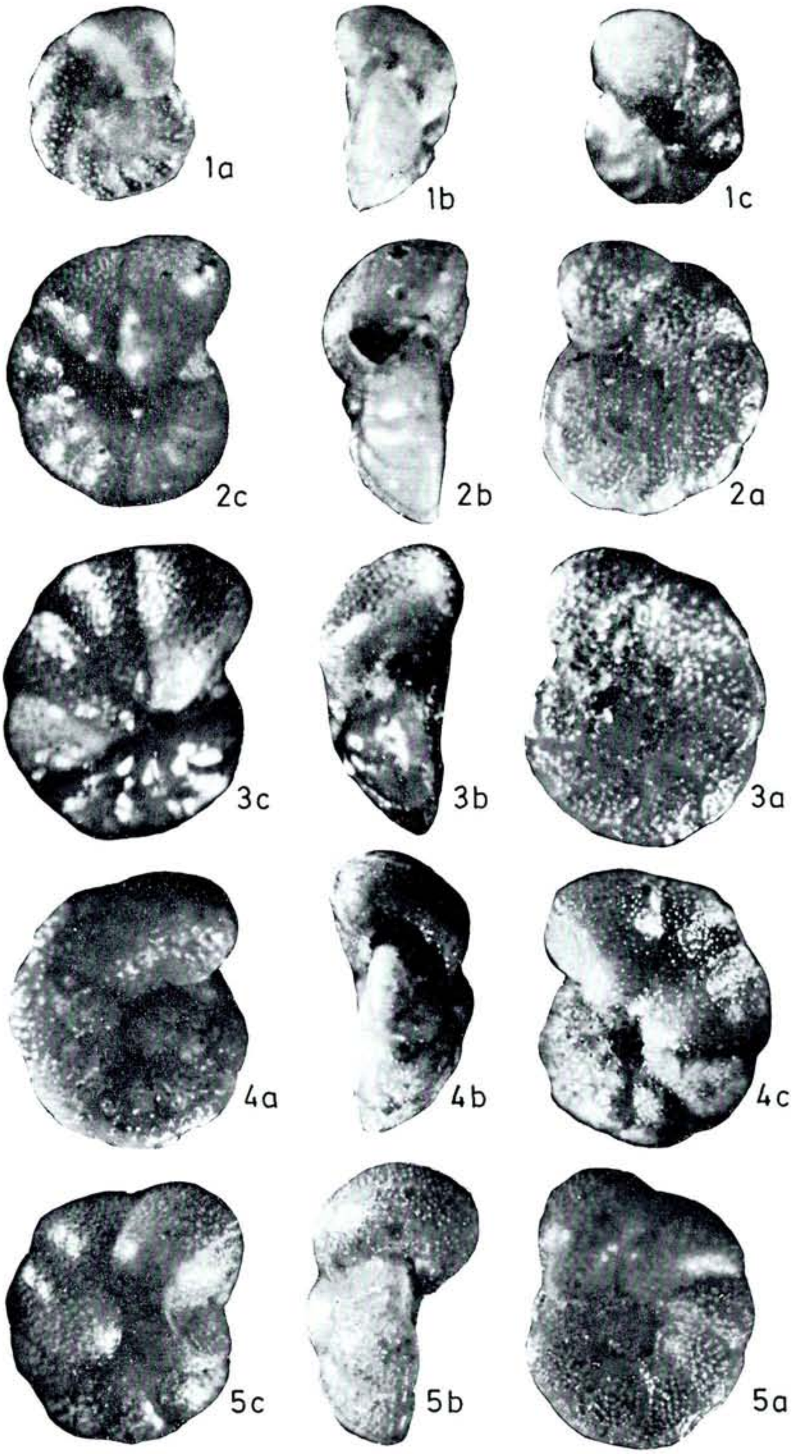
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Plate 5

Fig. 1. *Gyroidinoides soldanii* forma *girardanus* (Reuss); a, umbilical side × 105, b, peripheral view × 105, c, spiral side × 105.
Fig. 2. *Gyroidinoides soldanii* forma *girardanus* (Reuss); a, umbilical side × 105, b, peripheral view × 105, c, spiral side × 105.
Fig. 3. *Gyroidinoides soldanii* forma *girardanus* (Reuss); a, umbilical side × 90, b, peripheral view × 90, c, spiral side × 90.
Fig. 4. *Gyroidinoides soldanii* forma *girardanus* (Reuss); a, umbilical side × 90, b, peripheral view × 90, c, spiral side × 90.
Fig. 5. *Gyroidinoides soldanii* forma *girardanus* (Reuss); a, umbilical side × 75, b, peripheral view × 75, c, spiral side × 75.

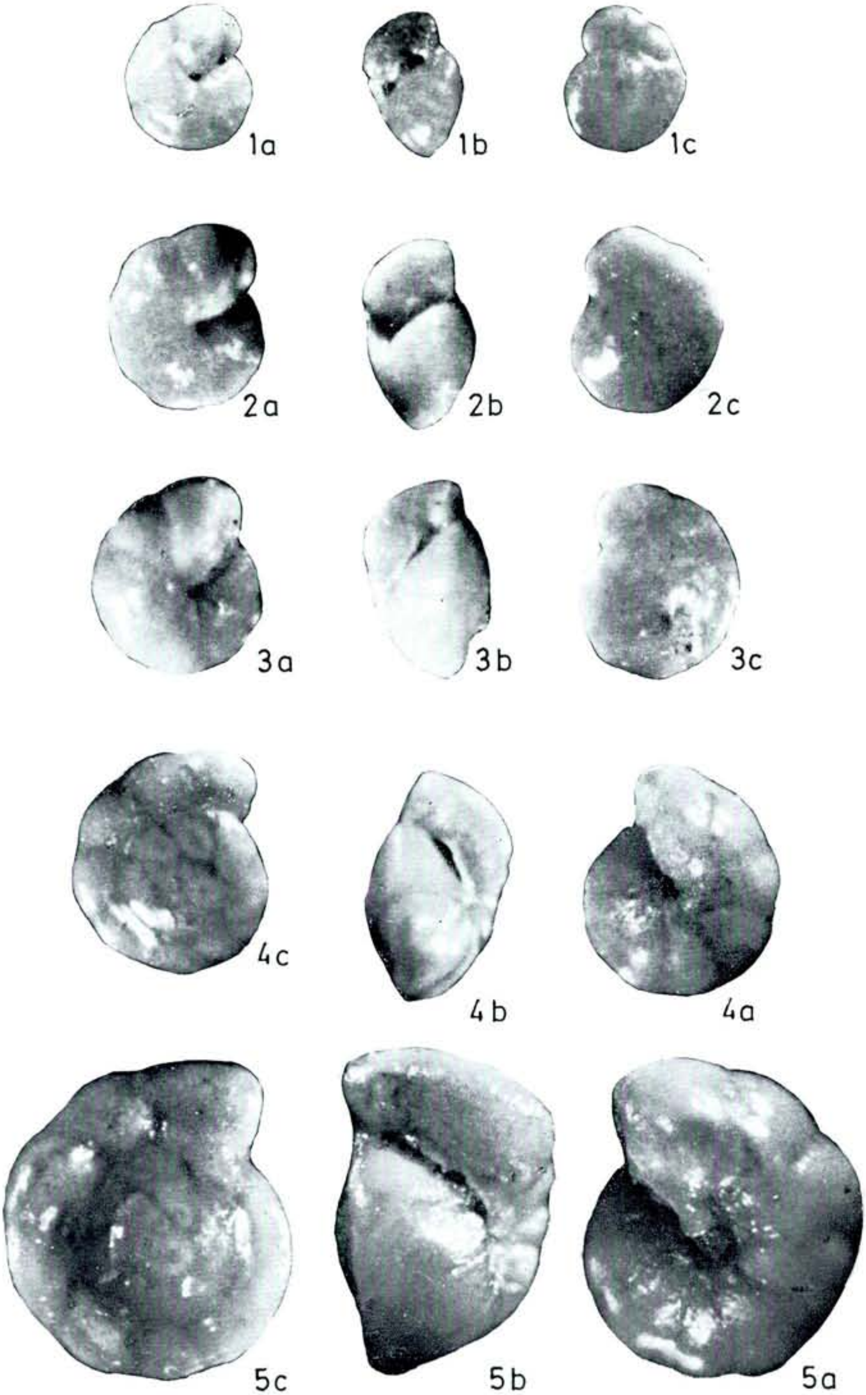
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Plate 6

Fig. 1. *Quinqueloculina impressa* Reuss; × 225.
Fig. 2. *Quinqueloculina impressa* Reuss; × 230.
Fig. 3. *Turrilina alsatica* Andreae; side view × 170.
Fig. 4. *Turrilina alsatica* Andreae; side view × 275.
Fig. 5. *Sigmoilina tenuis* (Cjzek); side view × 225.
Fig. 6. *Epistominella oveyi* (Bhatia); a, oblique umbilical view × 280, b, peripheral view × 280.
Fig. 7. *Stilostomella adolphina* (d'Orbigny); side view of three chambers × 115.
Fig. 8. *Stilostomella spinescens* (Reuss); side view of three chambers × 100.
Fig. 9. *Eponides pygmeus* (Hantken); a, umbilical side (slightly fragmented) × 285, b, peripheral view × 285.

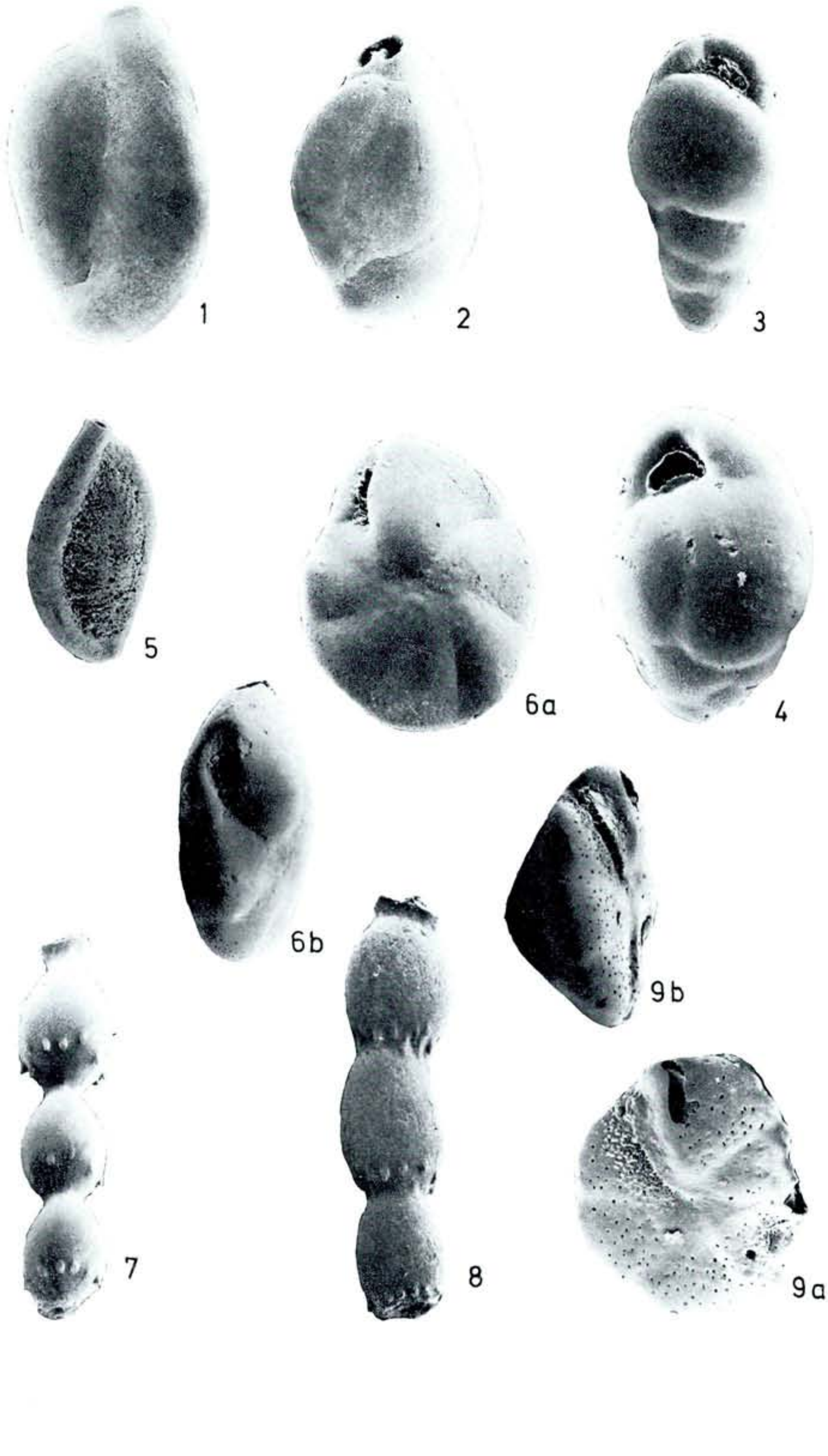
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Plate 7

Fig. 1. *Cibicides aknerianus* (d'Orbigny); a, umbilical side ×110, b, peripheral side × 110.
Fig. 2. *Cibicides aknerianus* (d'Orbigny); a, oblique umbilical view × 85, b, peripheral view × 115.
Fig. 3. *Cibicides telegdi* Grossheide & Trunkó; a, spiral side × 225, b, peripheral view × 225.
Fig. 4. *Cibicides telegdi* Grossheide & Trunkó; umbilical side × 220.
Fig. 5. *Pullenia bulloides* (d'Orbigny); peripheral view × 200.
Fig. 6. *Gyroidinoides* cf. *angustiumbilicata* (Ten Dam); umbilical side × 115.
Fig. 7. *Gyroidinoides* cf. *angustiumbilicata* (Ten Dam); peripheral view × 110.
Fig. 8. *Gyroidinoides soldanii* forma *girardanus* (Reuss); peripheral view × 230.
Fig. 9. *Gyroidinoides soldanii* forma *girardanus* (Reuss); a, oblique umbilical view × 85, b, peripheral view × 85.

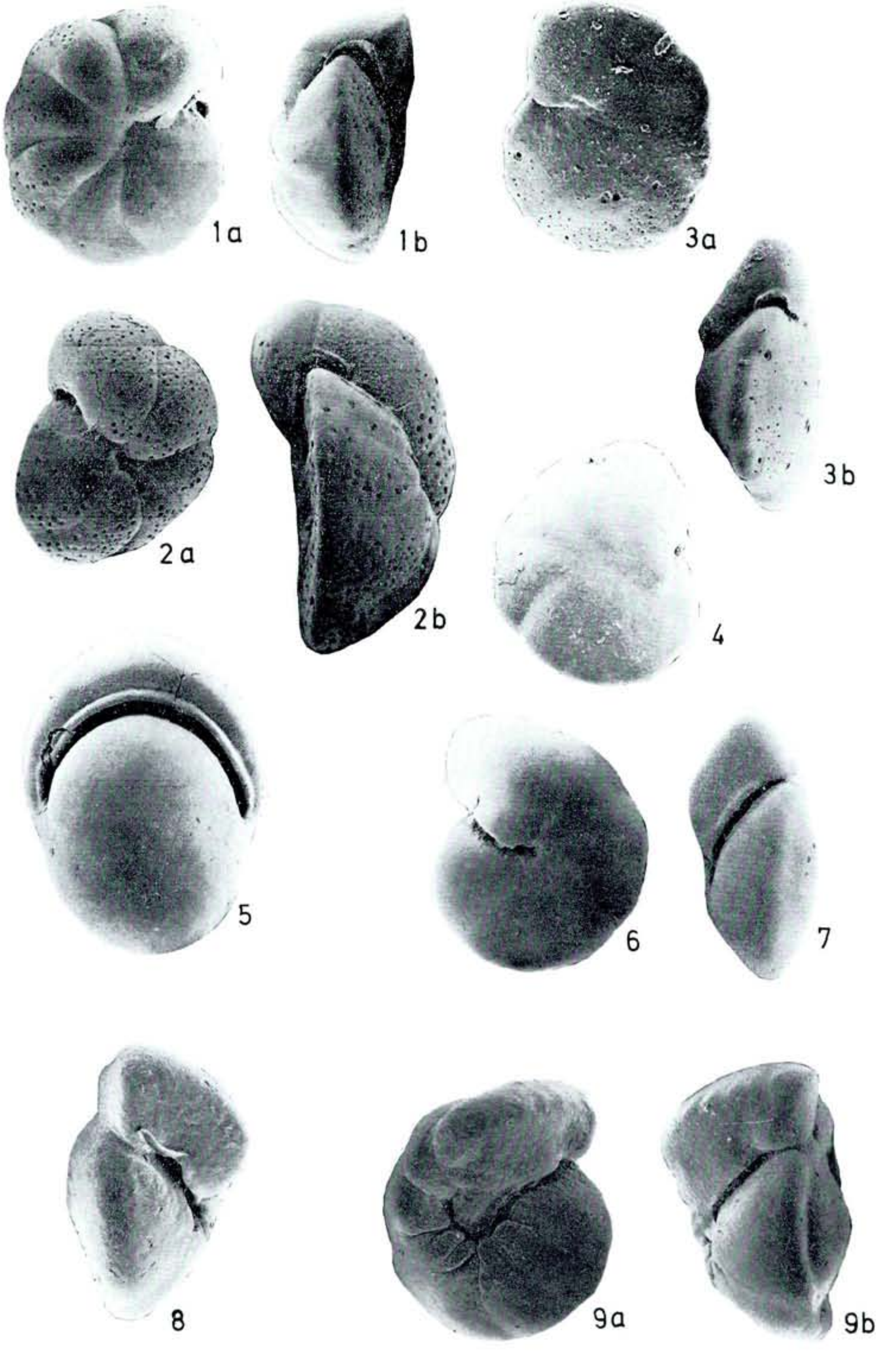
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Plate 8

Fig. 1. *Gyroidinoides soldanii* forma 1; a, peripheral view × 120, b, umbilical side × 120.

Fig. 2. *Gyroidinoides soldanii* forma 1; peripheral view × 170.

Fig. 3. *Gyroidinoides octocamerata* (Cushman & Hanna); a, umbilical side × 170, b, peripheral view × 180.

Fiig. 4. *Gyroidinoides octocamerata* (Cushman & Hanna); spiral side × 170.

Fig. 5. *Gyroidinoides?* sp. 1; a, umbilical side ×280, b, peripheral view × 280.

Fig. 6. *Gyroidinoides?* sp. 1; spiral side × 225.

Fig. 7. *Ceratobulimina contraria* (Reuss); a, peripheral view × 115, b, umbilical side × 115.

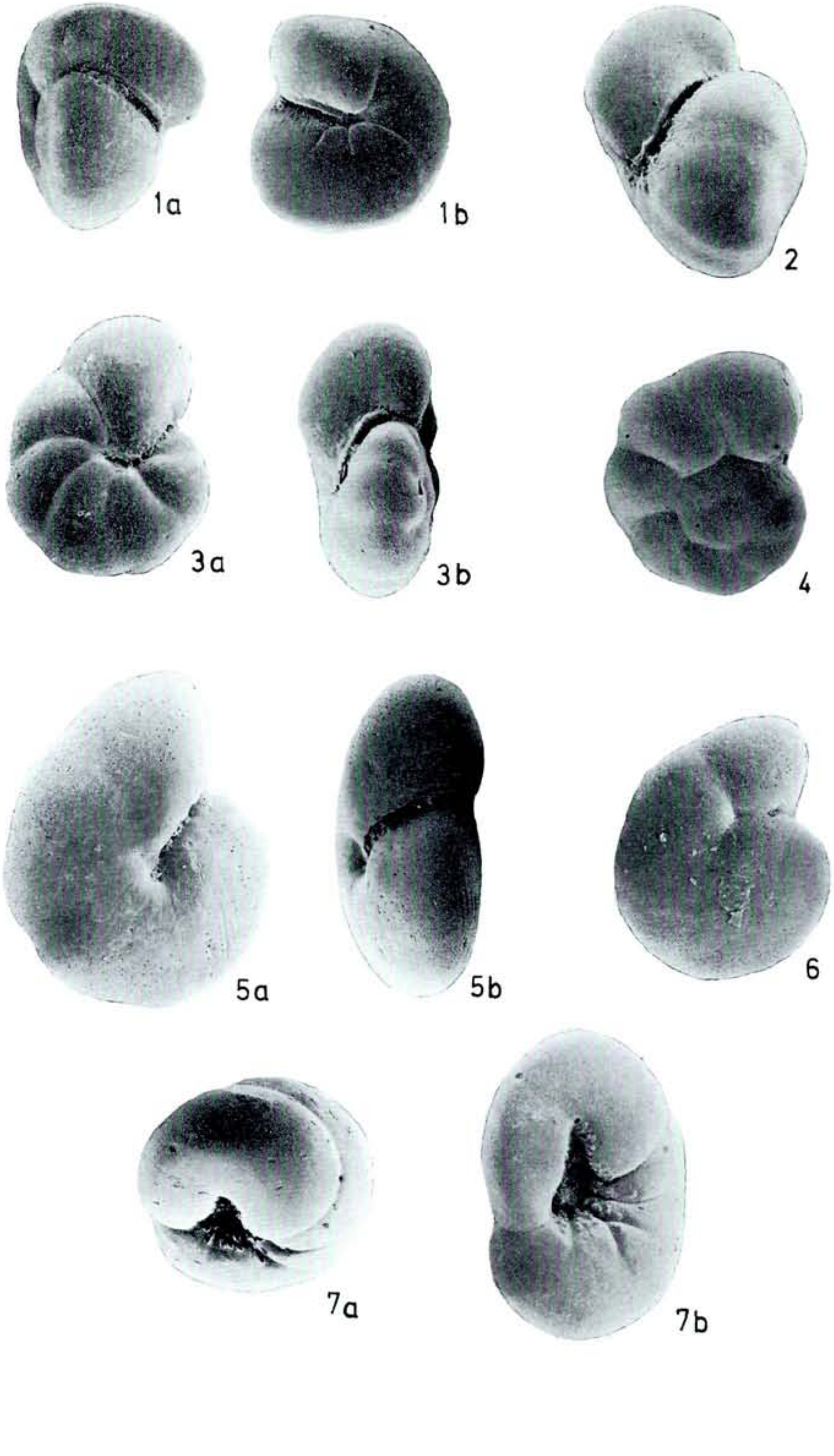
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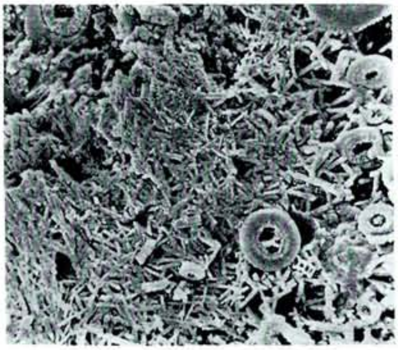
Plate 9

Fig. 1. *Sigmoilina tenuis* (Czjzek); granular "coating" of inner whorls × 1100.
Fig. 2. *Nonion affine* (Reuss); umbilicus × 255.
Fig. 3. *Gyroidinoides soldanii* forma 1; apertural lip × 335.
Fig. 4. *Gyroidinoides* cf. *angustiumbilicata* (Ten Dam); apertural slit × 340.
Fig. 5. *Gyroidinoides octocamerata* (Cushman & Hanna); umbilicus and umbilical area × 570.
Fig. 6. *Ceratobulimina contraria* (Reuss); aperture × 370.



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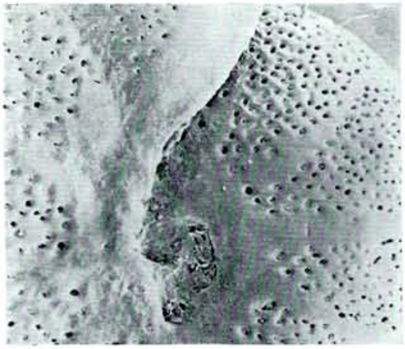

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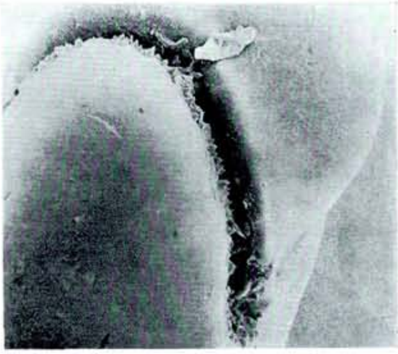

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