Upper Albian agglutinated foraminifera from two wells in Northeast Germany

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ABSTRACT
We examined agglutinated foraminifera in Upper Albian sediments from two cored wells in distinctly different palaeogeographic settings in NE Germany. The southern well E Daehre 4/83 was influenced by high rates of terrigenous flux from the Bohemian Massif. The benthic foraminiferal assemblages from this well are characterised by high percentages of agglutinated foraminifera (average of about 30%), low faunal density (maximum 300 individual/g sediment), and higher abundance of organically cemented forms such as Rhizammina, Ammodiscus, Glomospira, Haplophragmoides and Trochammina. The northern well Gt Waren 1/81 was situated at the flank of a pelagic high and was largely sheltered from terrigenous flux. Agglutinated foraminifera make up only approximately 15% of the benthic assemblages, the faunal density reaches 1000 individuals/gram sediment and calcareous cemented forms including Spiroplectinata, Falsogaudryinella, Tritaxia, Dorothia, Arenobulimina and Eggerellina dominate the agglutinated assemblages. Since the palaeobathymetric positions of the two wells were not significantly different, the main factors causing the differences in the assemblage composition of agglutinated foraminifera may be differences in primary productivity and terrigenous flux.

INTRODUCTION
Agglutinated foraminiferal assemblages of mid-Cretaceous Boreal shelf seas often contain unusually high numbers of "primitive" organically cemented forms including ammodiscids, astrorhizids, lituolids and trochoaminids. These assemblages have no real analogues, since modern shelf assemblages are completely dominated by calcareous benthic foraminifera (i.e., Elphidium, Ammonia). Lower Cretaceous assemblages have high numbers of lagenids and epistominids, and Upper Cretaceous benthic assemblages of the Boreal chalk seas almost completely lack "primitive" agglutinated forms. Several environmental constraints were proposed to explain these unusual agglutinated assemblages, which superficially resemble deep-water faunas: (1) influence of cold arctic water masses (Kemper, 1987), (2) oxygen deficiency under warm, saline water masses (Kuhnt & Wiedmann, 1995), (3) high fluxes of terrigenous sediment (Prokoph et al., 1999).

The material available from two equivalent stratigraphic sections of two wells in distinct palaeogeographic and palaeoceanographic positions offers the opportunity to test some aspects of these hypotheses. The Waren site, situated at the southern margin of the Pompeckj High, was sheltered from terrigenous supply and influenced by intrabasinal upwelling along the submarine high. The Daehre site, situated closer to the southern border of the North German Basin, was influenced by terrigenous supply from the Bohemian Massif and probably occasionally experienced restricted circulation, which may have resulted in a reduced primary productivity. The main palaeoenvironmental differences between the two studied wells were: (1) a significantly higher terrigenous flux in the southern well E Daehre 4/83 (palaeogeographic position close to the coastline of the Bohemian Massif, higher sedimentation rates); (2) a higher marine palaeoproductivity in the northern well Gt Waren 1/81 (palaeogeographic position close to the Pompeckj High, which probably caused intrabasinal upwelling, higher accumulation rates of planktic carbonate producers and primary consumers, presence of calcareous benthic foraminifera indicating enhanced carbon flux (Prokopf et al., 1999). The purpose of this study is to test how far the quantitative assemblage composition of agglutinated foraminifera reflects these palaeoenvironmental differences, and under which environmental conditions "primitive" organically cemented agglutinated foraminifera preferably occurred.

MATERIAL AND METHODS

Upper Albian to Lower Cenomanian sedimentary successions were recovered during drilling in Northeast Germany within a depth range of 1000-1460 m below surface. The locations and co-ordinates of wells are shown in Figure 1. The Upper Albian sediments were deposited within the eastern part of the epicontinental North German Basin, bordered by the Rhenish-Bohemian Massif to the south and connected with the North Sea Basin to the north (Best et al., 1989). The submarine Pompeckj High bordering the basin to the North may have somewhat limited the open marine circulation into the basin (Diener, 1966). The North German Basin was superimposed on the late Carboniferous Variscan foredeep basin (Betz et al., 1987). Main transgressions into the basin occurred from the western Lower Saxony Basin in the Middle Albian, Late Albian and Early Cenomanian, leading to a continuous pelagic connection from England to the Russian Platform in the Cenomanian. A short regressive phase is documented at the Albian-Cenomanian boundary (Frieg & Kemper, 1989).

The two studied wells (E Daehre 4/83 and Gt Waren 1/81) consist of alternating multicoloured marlstones and gray marly claystones. Lithology, chronostratigraphy and occurrences of stratigraphically important macrofauna are shown in Figure 2. A detailed lithologic description of the studied interval was given by Prokoph (1994).

The sample material examined in the study comprises 49 samples from the Upper Albian sequences of both wells. Samples (approximately 100 cc) were completely disintegrated in diluted buffered hydrogen peroxide or anionic tensides, washed over a 63 μm sieve and dried at 50°C. Residues were sieved (>125 μm, >630 μm) and randomly divided with a sample splitter. Assemblages of ~300 specimens per sample were picked, then sorted in slides, determined and counted. Scanning electron micrographs were made on a Camscan 44 at the GPI, University of Kiel, and on a Cambridge SEM at the University of Tubingen.

The age assignment was based on calcareous nannofossils from the *Effididius turrisellifilii* zone, which indicate a late Albian age according to Sissingh (1977). The biostratigraphic correlation of Albian sediments in Northeast Germany was based on inoccu-
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ramids: Inoceramus anglicus and Birostrina sulcata (Troeger, 1981), planktic foraminifera: Hedbergella infracretacea, Globigerinelloides bentonensis and Schackoina cenomana (Prokoph, 1994), mass occurrence of aucellines: Aucellina gryphaeoides ('bivalve maxima A-H') and mass occurrence of Neohibolites minimus ('belemnite maximum'). The first occurrence of Eiffellithus turrisseiffelii and Globigerinelloides bentonensis are used as markers for the boundary between the early Late and the latest Albian in the infracretacea, Globigerinelloides bentonensis and Schackoina cenomana (Prokoph, 1994), mass occurrence of aucellines: Aucellina gryphaeoides ('bivalve maxima A-H') and mass occurrence of Neohibolites minimus ('belemnite maximum'). The first occurrence of Eiffellithus turrisseiffelii and Globigerinelloides bentonensis are used as markers for the boundary between the early Late and the latest Albian in the North German Basin (Prokoph, 1997).

RESULTS

Although calcareous benthic foraminifera generally dominate the assemblages, significant numbers of agglutinated foraminifera (up to 50%) are present in both sections (Figure 3). Tests are generally large (300-700 μm). Specimens of Spiroplectinata bettenstaedti are generally more than 1500 μm in length, and specimens of Dorothia gradata and Spiroplectinata annectens are more than 1000 μm in length. Forty-six taxa of agglutinated foraminifera were recognized in the Daehre (45) and Waren (37) samples. The abundance data of common taxa are given in Appendix 1. The average number of agglutinated foraminifera is 22 tests per gram of sediment in the Daehre samples and 26 tests per gram of sediment in the Waren samples.

Concurrent fluctuations in abundance were observed in both wells for the following taxa: Falsogaudryinella moesiana, Rhizammina indivisa, Heterantyx cretosa, Tritaxia tricarinata and Textularia spp. Distribution and abundance plots of selected taxa are presented in Appendix 2.

Assemblages

Five agglutinated assemblages were distinguished within the foraminiferal successions, based on the occurrences of stratigraphically important taxa (e.g., Heterantyx cretosa) and on changes in the abundances, of dominant taxa (e.g., Falsogaudryinella moesiana). The most common taxa are listed in Table 1 in decreasing order.

1. Glomospira charoides - Spiroplectinata bettenstaedti
Samples: F29-F18 & WF20-WF15
The highest occurrence of this assemblage is marked by the last occurrence of Spiroplectinata bettenstaedti. The abundance of agglutinated foraminifera in this interval is almost constant (representing approximately 35% of the assemblage). At the boundary between the early Late and the latest Albian, the only observed change within the agglutinated assemblage is the FO of Heterantyx cretosa (F19 & WF16), a characteristic form of the Upper Albian. This assemblage is dominated by organically cemented agglutinated foraminifera, which represent epifaunal suspension feeders such as Rhizammina and Rhabdammina, epifaunal deposit feeders such as Ammodiscus semi-

infaunal detritivores such as Haplophragmoides, Arenobulimina and Recurvirostra (Nagy et al., 1995).

2. Falsogaudryinella moesiana
Samples: F17-F11 & WF14-WF12
This assemblage is characterised by a significant increase in the abundance of calcareous cemented species, especially Falsogaudryinella moesiana, which reaches up to 60 specimens in one gram of sediment in the Waren samples. In the Daehre samples the peak of abundance of presumed infaunal species (e.g., Falsogaudryinella moesiana, Heterantyx cretosa) is combined with a decrease in the abundance of tubular, eroded, epifaunal morphotypes including Rhizammina and Rhabdammina. Tubular, coiled forms such as Glomospira, Ammodiscus and Spiroplectinata disappear within this interval.

3. Heterantyx cretosa
Samples: F10-F9 & WF11-WF8
The base of the assemblage is marked by a bivalve maximum and the top by the last occurrence of Heterantyx cretosa. Foraminiferal abundance significantly increases at the base of this interval, especially for planktonic foraminifera, which show abundance values several times higher than average. Some organically cemented agglutinated genera disappear within this interval in the Waren section (e.g., Haplophragmoides, Ammodiscus, Glomospira) but the abundance of these genera increases at the Daehre site. These changes in foraminiferal distribution may indicate a change to more open marine conditions in the Waren area.

4. Arenobulimina macfadyeni
Samples: F8-F5 & WF7-WF4
This assemblage consists of agglutinated organically cemented foraminifera. Arenobulimina macfadyeni, the most common species within this interval, has very constant abundance values, while other species show fluctuations in abundance. Agglutinated foraminiferal abundance reaches 50% of the benthic foraminiferal assemblage in the Daehre section, but at the top of the section the total number of foraminifera decreases. The number of agglutinated specimens per gram of sediment in Waren is generally very low. The genera with calcareous cement are almost absent, and only Falsogaudryinella moesiana and F. alta occur in low numbers.

5. Ammodiscus cretaceus
Samples: F4-F1 & WF3-WF1
This assemblage is characterised by the common occurrence of Ammodiscus cretaceus, although the assemblages from the Daehre and Waren sections show significant differences. The Daehre samples are almost barren of benthic foraminifera. Only agglutinated foraminifera with organic cement are present in low numbers within this impoverished assemblage (e.g., Rhizammina, Glomospira, Trochammina). The position of the Waren site seems to provide more
favorable conditions for benthic foraminifera. The occurrence of *Rhizammina indivisa*, *Spiroplectinata complana* and *S. annectens* in the upper part of this site is significant, although the abundance of agglutinated foraminifera decreases towards the top of the interval within the Waren section.

**DISCUSSION**

Assemblages from the lower part of the Daehre section are diverse and contain a significant proportion of agglutinated foraminifera. Infaunal and semi-infaunal morphotypes including *Pseudobolivina*, *Verneulinoides*, *Bulbobaculites*, *Spiroplectammina* and *Recurvoides* indicate fairly well-oxygenated conditions with a redox boundary situated well below the sediment water interface (Kuhnt, 1995; Nagy et al., 1995). Epifaunal suspension and detritus feeders including *Ammodiscus*, *Rhizammina*, *Rhabdammina* and *Glomospira* are also common. Assemblages from the upper part of the section probably experienced periodically dysoxic conditions, as shown by the dominance of opportunistic forms including *Scherochorella*, *Psammosphaera*, *Textularia*, *Ammodiscus* and *Haplophragmoides*, which probably indicate oxygen-deficient conditions at the sea floor (Kuhnt, 1995;
<table>
<thead>
<tr>
<th>Daehre assemblages</th>
<th>Agglutinated foraminifera with organic cement</th>
<th>Agglutinated foraminifera with calcareous cement</th>
<th>Waren assemblages</th>
<th>Agglutinated foraminifera with organic cement</th>
<th>Agglutinated foraminifera with calcareous cement</th>
</tr>
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<tbody>
<tr>
<td>– Spiroplectinata bettenstaedti</td>
<td>samples: F18-F29</td>
<td>depth (m): 1394.7-1406.7</td>
<td>– Spiroplectinata bettenstaedti</td>
<td>samples: W15-W20</td>
<td>depth (m): 1079-1085</td>
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<tr>
<td>2. Falsogaudryinella moesiana</td>
<td>Glomospira charoides</td>
<td>Ammodiscus cretaceous</td>
<td>2. Falsogaudryinella moesiana</td>
<td>Glomospira charoides</td>
<td>Ammodiscus cretaceous</td>
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<tr>
<td>– Tritaxia tricarinata</td>
<td>samples: F9-F10</td>
<td>depth (m): 1385.7-1387.7</td>
<td>– Tritaxia tricarinata</td>
<td>samples: W12-W14</td>
<td>depth (m): 1076-1079</td>
</tr>
<tr>
<td>3. Heterantyx cretosa</td>
<td>Rhizammina indicata</td>
<td>Textularia chapmani</td>
<td>3. Heterantyx cretosa</td>
<td>Rhizammina indicata</td>
<td>Textularia chapmani</td>
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<td>– Tritaxia tricarinata</td>
<td>samples: F9-F10</td>
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<td>– Tritaxia tricarinata</td>
<td>samples: W12-W14</td>
<td>depth (m): 1076-1079</td>
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<td>4. Arenobulimina macfadyeni</td>
<td>Rhizammina indicata</td>
<td>Textularia chapmani</td>
<td>4. Arenobulimina macfadyeni</td>
<td>Rhizammina indicata</td>
<td>Textularia chapmani</td>
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<td>5. Ammodiscus cretaceous</td>
<td>Rhizammina indicata</td>
<td>Textularia chapmani</td>
<td>5. Ammodiscus cretaceous</td>
<td>Rhizammina indicata</td>
<td>Textularia chapmani</td>
</tr>
</tbody>
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Table 1. Late Albian agglutinated foraminiferal assemblages.
Kaminski et al., 1995). Intervals with high numbers of epifaunal suspension feeders including *Rhizammina* and *Rhabdammina* may indicate better oxygenated environments. Agglutinated foraminifera compose approximately 35-50% of the benthic assemblages. This comparatively high abundance may be related to the low organic carbon flux and high terrigenous flux at this site.

Agglutinated assemblages from the Waren section exhibit low diversity in some samples, dominance by infaunal morphotypes and fluctuations in abundance, but no remarkable decrease in faunal density. The presence of *Ammodiscus cretaceus*, *Glomospira charoides* and *G. gordialis*, in some intervals may indicate oxygen deficiency (Kuhnt, 1995). Intervals of increased diversity and abundance may indicate periods of better oxygenated conditions at the sea-floor. These intervals are also characterized by the reddish colour of the sediments. Agglutinated foraminifera constitute only 10-35% of the total foraminiferal assemblage, indicating open marine conditions with "normal" or increased primary productivity. Common occurrences of open marine calcareous species including *Gyroidinoides*, *Berthelina* and nodosariids imply pelagic environments (outer shelf to upper bathyal) (Moullade, 1984).

**CONCLUSIONS**

The agglutinated foraminiferal assemblages of the Darhe site generally indicate a well oxygenated, oligotrophic shelf environment with significant terrigenous flux. Occasional changes in abundance were probably caused by fluctuating terrigenous input from the Bohemian Massif. Agglutinated foraminiferal assemblages include a large portion of "primitive" forms with organic cement (*Rhizammina*, *Ammodiscus*, *Glomospira*, *Haplophragmoides* and *Trochammina*). Oxygen-depleted conditions at the sea floor only occurred during the deposition of the upper part of the section and were probably linked to a sea level rise.

The composition of the agglutinated foraminiferal assemblages of the Waren site implies open marine pelagic conditions. "Primitive" organically cemented are generally rare and mainly consist of epifaunal detritus feeding forms, that may have taken advantage of increased organic particle flux during periods of enhanced surface productivity. Agglutinated foraminifera with calcareous cement make up the largest part of the agglutinated assemblages and include suspension feeders (*Spiroplectinata*) and infaunal detritus feeders (*Falsogaudrytinella*, *Truitacea*, *Dorothia*, *Arenobulimina* and *Eggerellina*).

**ACKNOWLEDGMENTS**

Dr. Schneider (Geothermie Neubrandenburg GmbH) and Dr. Schretzenmayer (Erdöl/Erdgas Gommern GmbH) are thanked for permission to sample the core material. Dr. Ann Holbourn (Kiel) is thanked for correcting our manuscript. Mrs. Schultdt (Kiel) and Mr. Hüttemann (Tübingen) are thanked for photographic and SEM work. SEM photographs were taken on the Camscan 44 at the GfK Kiel and on a Cambridge SEM at the University of Tübingen.

**TAXONOMIC NOTES**

The agglutinated foraminifera classification used here follows the taxonomic classification of Loeblich on a revision proposed by Meyn & Vespermann (1994) and Rögl (1995).

*Ammobaculites subcretaceus* Cushman & Alexander, 1930

Pl. 2, Fig. 5


Coarse grained, agglutinated test with large, initial planispiral stage, followed by a short uniserial part with compressed chambers.

*Ammodiscus cretaceus* (Reuss, 1845)

Plate 1, Fig. 5

*Operculina cretacea* Reuss, 1845, p. 35, pl. 13, figs 64, 65a-b.

*Ammodiscus cretaceus* (Reuss).—Cushman, 1946, p. 17, pl. 1, fig. 35.—Hemleben & Tröster, 1984, p. 517, pl. 1, fig. 17.—Weidich, 1990, p. 82, pl. 1, fig. 15.—Reicherter et al., 1994, pl. 7, a, fig. a.—Holbourn & Kaminski, 1997, p. 35, pl. 4, figs 7-8.

Tubular test with relatively large proloculus; broad whorls in a regular planispiral coil, overlapping the previous ones; siliceous, homogeneous or finely agglutinated wall.

*Ammodiscus infimus* Franke, 1936

Plate 1, Figs 6-7

*Ammodiscus infimus* (Strickland).—Franke, 1936, p. 15, pl. 1, fig. 14a-b.—Ceroch & Nowak, 1984, pl. 1, fig. 11; pl. 5, fig. 13.—Weidich, 1990, p. 82, pl. 34, figs 1-3.—Reicherter et al., 1994, pl. 7a, figs g, h.—Holbourn & Kaminski, 1997, p. 35, pl. 4, figs 9-11.

Tubular, planispiral test with tendency to uncoil.

*Ammodiscus peruvianus* Berry, 1928

Plate 1, Fig. 8


*Arenobulimina chapmani* Cushman, 1936

Plate 3, Fig. 17

*Arenobulimina chapmani* Cushman, 1936, p. 26, pl. 4, fig. 7.—Neagu, 1965, p. 10, pl. 2, fig. 9.—Magniez-Jannin, 1975, p. 79, pl. 7, figs 9-18.—Carter & Hart, 1977, p. 15, pl. 1, fig. 4.—Barnard & Banner, 1981, p. 404, pl. 4, fig. 1, pl. 7, fig. 1.—Frieg & Price, 1982, p. 59, pl. 22, figs h, i, j, m.

Trophic spiral test, final whorl has five chambers and comprises more than half the length of the test, sutures between chambers depressed, arch-shaped
aperture, surrounded by a narrow lip; surface of the test rough, built of quartz grains with large amount of calcareous cement.

_Arenobulimina frankei_ Cushman, 1936 Plate 3, Fig. 14

_Arenobulimina frankei_ Cushman, 1936, p. 27, pl. 4, fig. 5a-b.—Gawor-Biedowa, 1969, p. 84, pl. 5, figs 4-5; pl. 7, figs 6, 7a-b, 8a-b; text-figs 5-6.—Price, 1977, p. 508, pl. 59, figs 5-6, 9.

Large, subconical, trochospiral test; last whorl increasing rapidly in width; chambers inflated, separated by slightly depressed sutures; interiomarginal arch-shaped aperture; coarse agglutinated wall with large amount of carbonate material.

_Arenobulimina ex gr. macfadyeni_ Cushman, 1936 Plate 3, Fig. 16

_Arenobulimina macfadyeni_ Cushman, 1936, p. 26, pl. 4, fig. 6a-b.—Neagu, 1965, p. 10, pl. 2, figs 7-8.—Magniez-Jannin, 1975, p. 78, pl. 7, figs 1-8.—Barnard & Banner, 1981, p. 402, pl. 2, fig. 4-7, pl. 6, figs 1-7.—Frig & Price, 1982, p. 61, pl. 2-2, figs k, l, n.—Weidich, 1990, p. 108, pl. 37, figs 1-2; pl. 38, figs 27-28.

In this group we included forms having subconical, trochospiral test, gradually increasing in width, inflated chambers, separated by slightly depressed sutures; interiomarginal arch-shaped aperture, smooth, fine-grained wall, mainly agglutinated quartz grains.

_Arenobulimina cf. obliqua_ Price, 1977 Plate 3, Fig. 15

_Arenobulimina cf. obliqua_ (d’Orbigny).—Price, 1977, p. 510, pl. 59, fig. 10.—Frig & Price, 1982, p. 53, pl. 2.1, fig. h.

Small, trochospiral test; last whorl comprises two-thirds of the length of the test, elongated chambers, usually indistinct sutures; interiomarginal arch-shaped aperture, smooth, fine-grained wall with large amount of carbonate material.

_Bigenerina sp._ Plate 2, Fig. 18

Biserial slightly twisted initial part, composed of five sets of chambers, followed by two sets of larger, globular chambers and finally short semi-uniserial part; fine-grained wall.

_Bulbobaculites problematicus_ (Neagu, 1962) Plate 2, Fig. 6

_Ammobaculites agglutinans_ (d’Orbigny) ssp. problematicus Neagu, 1962, p. 61, pl. 2, figs 22-24.

_Ammobaculites problematicus_ Neagu.—Geroch & Nowak, 1984, pl. 1, figs 17-18; pl. 6, fig. 23.

_Haplophragmium lucami_ Cushman & Hedberg.—Mouладe et al., 1988, p. 363, pl. 3, figs 1-6.

_Bulbobaculites problematicus_ (Neagu).—Kuhn & Kaminski, 1995, pp. 451-465, text-figs 5-5a; pl. 4, fig. a-h.—Bubik, 1995, p. 80, pl. 12, figs 2, 17.

_Caudamminia ovulum_ (Grzybowski, 1896)

_Reophax ovulum_ Grzybowski, 1896, p. 276, pl. 8, figs 19-21.

_Hormosina ovulum_ (Grzybowski).—Geroch, 1960, pl. 2, fig. 20.—Bubik, 1995, p. 82.

_Caudamminia crassa_ (Geroch, 1966)

_Hormosina ovulum_ crassa Geroch, 1966, p. 463, 6/19, 21-26; 7/21-23.—Weidich, 1990, p. 84, pl. 33, fig. 25.

_Hormosina crassa_ Geroch.—Kuhn, 1990, p. 314, pl. 2, fig. 5.—Bubik, 1995, p. 82, pl. 2, figs 12-13; cf. pl. 9, fig. 1.

_Caudamminia crassa_ (Geroch).—Holbourn & Kaminski, 1997, p. 38, pl. 7, figs 4-9.

_Caudamminia praecaudata_ (Hanzliková, 1973)

_Pelosina praecaudata_ Hanzliková, 1973, p. 137, pl. 2, fig. 9.

_Hormosina praecaudata_ (Hanzliková).—Weidich, 1990, p. 84, pl. 1, fig. 13; pl. 33, figs 21-24.

_Dorothia filiformis_ (Berthelin, 1880) Plate 4, Fig. 1

_Gaudryinopsis filiformis_ Berthelin, 1880, p. 25, pl. 1, fig. 8a-d.—Geroch, 1966, fig. 12 (11,12).—Haig, 1980, p. 120, pl. 8, figs 1-5; pl. 11, fig. 2.

_Dorothia filiformis_ (Berthelin).—Cushman, 1937, p. 73, pl. 8, figs 1-2.—Magniez-Jannin, 1975, p. 83, pl. 8, figs 1-2; text-fig. 34.—Weidich, 1990, p. 109, pl. 36, fig. 22.


Elongated, narrow test, triserial at first, becoming biserial; last chambers usually flattened; interiomarginal apertural slit on the last chamber; medium to fine-grained wall.

_Dorothy gradata_ (Berthelin, 1880) Plate 4, Figs 2-5

_Gaudryina gradata_ Berthelin, 1880, p. 24, pl. 1, fig. 6a-c.—Haig, 1980, p. 121, pl. 8, figs 17-18; pl. 11, fig. 1.

_Dorothy gradata_ (Berthelin).—Gawor-Biedowa, 1972, p. 29, pl. 2, fig. 7a-b.—Dalley, 1973, p. 48, pl. 3, fig. 13a-b.—Magniez-Jannin, 1975, p. 86, pl. 8, figs 3-6; text-fig. 38.


Elongated finely agglutinated test with initial triserial stage, triangular in section, then becoming biserial with inflated chambers; the aperture is an arch at the base of last chamber.

Most of the specimens from site M2-19 have compressed, flattened or curved tests such as in Plate 4, Figs 4 & 5.

_Eggerellina mariae_ Ten Dam, 1950 Plate 4, Figs 10-15

_Eggerellina mariae_ Ten Dam, 1950, p. 15, pl. 1, fig. 17a-e.—Magniez-Jannin, 1975, p. 94, pl. 6, figs 12-21.—Weidich, 1990, p. 112.

_Falsogaudryinella ex gr. moesiana_ (Neagu, 1965) Plate 3, Figs 9-13

In this group we lumped elongated, cone-shaped forms with tricarinate outline, unusually large last three chambers and a terminal, elongated, slit-like aperture.

We used a very broad concept for these forms, which include representatives of _Falsogaudryinella moesiana_ and _F. alta_. Specimens closely resembling _Falsogaudryinella subrotunda_ (Ten Dam, 1950) from the Upper Albian of the Netherlands are also included in the variability of our population.

_Glomospira charoides_ (Jones & Parker, 1860)
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Dorothy oxyconia (Reuss).—Trujillo, 1960, p. 309, pl. 44, fig. 5.—Sliter, 1968, p. 50, pl. 3, fig. 13.—Geroch & Nowak, 1984, pl. 4, fig. 14.

Marssonella turris (d’Orbigny, 1839)
Plate 4, Figs 8-9
Textularia turris d’Orbigny, 1839, p. 46, pl. 4, figs 27-28.
Marssonella turris (d’Orbigny).—Barnard, 1963, p. 42, text-fig. 2a-b.

Dorothy turris (d’Orbigny).—Hanzliková, 1973, p. 161, pl. 6, figs 12-13.

? Marssonella ozawai Cushman, 1936, p. 43, pl. 4, fig. 10a-b.—Hart et al., 1989, p. 176, pl. 7.2, figs 8-9.

Strongly elongated, slender, conical test; initial trochospirally coiled part, composed of three to five chambers; biserial part composed of seven to eight sets of wide chambers; apertural surface flat or slightly depressed; elongated slit aperture, situated at the base of last chamber; fine-grained wall.

This form is very similar to Marssonella ozawai Cushman (1936), until an examination of the holotype is possible, we regard M. ozawai as a junior synonym of M. turris (d’Orbigny, 1839).

Psammophaera fusca Schulze, 1875
Psammophaera fusca Schulze, 1875, p. 113, pl. 2, fig. 8a-f.

Psammophaera fusca Schulze.—Weidich, 1990, p. 81, pl. 1, fig. 11, pl. 33, fig. 28.—Bender, 1985, p. 48, pl. 1, fig. 14.—Holbourn & Kaminski, 1997, p. 32, pl. 2, figs 4-5.

Unilocular, spherical test; coarse to medium grained agglutinated wall; apertures rarely visible.

Pseudobolivina spp.
Plate 2, Fig. 17
We included forms with distinct initial biseral part, followed by flattened and rounded chambers in a loose biseral series, gradually increasing in size; finely agglutinated wall.

Recovoides imperfectus Hanzliková, 1953
Plate 2, Fig. 3
Recovoides imperfectus Hanzliková, 1953, p. 9, fig. 1a-d.—Geroch & Nowak, 1984, pl. 2, fig. 19; pl. 6, fig. 1.—Bubik, 1995, p. 85, pl. 4, fig. 8; cf. 9; pl. 13, fig. 12.—Weidich, 1990, p. 89, pl. 5, figs 1-15; pl. 6, fig. 24; pl. 35, figs 13-14.

Recovoides sp.
Plate 2, Fig. 4
These forms are generally rare and diagnostically strongly compressed, some with radially elongated chambers; finely agglutinated wall; usually indeterminate aperture.

Rhabdammina spp.
Plate 1, Fig. 1
In this group we included all large, fairly straight, unbranched, tubular forms with a thick wall.

Rhizammina indivisa Brady, 1884
Plate 1, Fig. 2
Rhizammina indivisa Brady, 1884, p. 277, pl. 29, figs 5, 7.—Geroch, 1966, pl. 1, figs 1-7.—Weidich, 1990, p. 79, pl. 33, figs 4-6.

Test unbranching with usually thin, flattened and distorted wall.

Saccammina alexanderi (Loeblich & Tappan, 1950)
Proteomina alexanderi Loeblich & Tappan, 1950, p. 1, fig. 1a-b.

Saccammina alexanderi (Loeblich & Tappan).—Eicher & Worstell, 1970, p. 280, pl. 3, fig. 7.—Weidich, 1990, p. 81, pl. 2, fig. 7; pl. 34, figs 12-15.

Saccammina placenta (Grzybowski, 1898)
Reophax placenta Grzybowski, 1898, p. 276, pl. 10, figs 9-10.
Saccammina placenta (Grzybowski).—Geroch, 1960, p. 37, pl. 2, figs 1-6.—Gradstein & Berggren, 1981, p. 241, pl. 2, fig. 3.—Weidich, 1990, p. 81.

Saccammina sphærica Sars, 1872
Plate 1, Fig. 4

Scherochorella minuta (Tappan, 1940)
Plate 1, Fig. 13
Haplostiche DI Hecht, 1938, pl. 4a, figs 4-8.
Reophax minuta Tappan, 1940, p. 94, pl. 14, fig. 4a-b; 1943, p. 480, pl. 77, fig. 44-b.
Reophax minutus (Tappan).—Ten Dam, 1950, p. 6, pl. 1, fig. 3.—Bartenstein & Bettenstaedt, 1962, p. 282, pl. 39, fig. 16.—Weidich, 1990, p. 85, pl. 34, fig. 19.
Scherochorella minuta (Tappan, 1940).—Geroch & Kaminski, 1995, p. 119, pl. 1, fig. 3, text-fig. 4.

Spiroplectammina spp.
We included in this group all varieties of Spiroplectammina, which have elongated and flattened biserial test with small initial, planispiral part, no dentate outline and finely agglutinated wall.

Spiroplectinatana amnecienst (Parker & Jones, 1863)
Plate 3, Figs 1-3
Textularia amnecienst Parker & Jones, 1863, p. 92, text-fig. 1.
Spiroplectinatana amnecienst (Parker & Jones).—Ten Dam, 1950, p. 13, pl. 1, fig. 14.—Bartenstein & Bettenstaedt, 1962, p. 293, text-fig. 23.—Weidich, 1990, p. 104, pl. 11, figs 9-10; pl. 36, fig. 23.—Haig & Lynch, 1993, p. 347, pl. 2, figs 2-5.

Spiroplectinatana bettenstaedti Grabet, 1959
Plate 3, Fig. 5

Large, very elongated, narrow test; agglutinated material contains large amount of pyritic particles.

Probably a phylogenetic endmember of the Spiroplectinatana amnecienst – S. complana – S. bettenstaedti lineage.

Spiroplectinatana complana (Reuss, 1860)
Plate 3, Fig. 4
Proroporus complanatus Reuss, 1860, p. 231, pl. 12, fig. 5.
Spiroplectinatana complana (Reuss).—Grabet, 1959, p. 14, pl. 1, fig. 13; pl. 2, figs 39-41; pl. 3, figs 87-88.—Bartenstein & Bettenstaedt, 1962, p. 293, text-fig. 23; pl. 39, fig. 12.—Haig & Lynch, 1993, p. 347, pl. 2, figs 7, 13.
We follow the concept of Grabert (1959) and Bartenstein & Bettenstaedt (1962) who regard S. annectens and S. complanata as different species. This is in contrast to Ten Dam (1950), who regarded S. complanata as the megalospheric generation of S. annectens.

**Subreophax scalaris** (Grzybowski, 1896)
Plate 1, Fig. 14


*Subreophax scalaria* (Grzybowski).-- Kaminski et al., 1988, p. 187, pl. 2, figs 16-17.

*Subreophax scalaris* (Grzybowski).-- Kuhnt, 1990, p. 326, pl. 3, figs 4-5.

**Textularia chapmani** Lalicker, 1935
Plate 2, Figs 13-14


**Textularia ssp.**
Plate 2, Fig. 16

We included under this name all typical textulariid forms.

**Textulariopsis rioensis** (Carsey, 1926)
Plate 2, Fig. 15

*Textularia rioensis* Carsey, 1926, p. 24, pl. 7, fig. 2. -- Haig, 1981, pl. 1, figs 18-19. -- Weidich, 1990, p. 98, pl. 12, figs 18-19, 21; pl. 37, figs 11-14.


**Tritaxia pyramidata** Reuss, 1863
Plate 3, Figs 6-7


**Tritaxia tricarinata** (Reuss, 1845)
Plate 3, Fig. 8


**Trochammina ssp.**
Plate 2, Fig. 10

We included in this group all compressed forms with trochospiral, planoconvex test; with five to eight chambers in the last whorl, separated by slightly depressed suture.

**Verneuilinoides neocomiensis** (Mjatliuk, 1939)
Plate 2, Fig. 19


Elongated triserial arrangement of chambers throughout, about seven sets of chambers; interiomarginal arched aperture; finely agglutinated wall.

According to Mjatliuk (1939), *Verneuilinoides neocomiensis* has seven to ten sets of chambers. *Verneuilinoides subfiliformis* described by Bartenstein (1952), has twelve sets of chambers. According to Maync (1973), both species *V. neocomiensis* and *V. subfiliformis* are synonymous.

REFERENCES


TAXONOMY REFERENCES


Sliter, W.V. 1968. Upper Cretaceous foraminifera from southern California and northwestern Baja California, Mexico. University of Kansas Paleontological Contributions, 49 (7), 1-141.


## E. Deade 4/83

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<th>Sample</th>
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<th>Texlularia</th>
<th>Trocharnmina</th>
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## Gt Waren 1/81

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## Additional Information

- **Sample F1 to F25:** Various species of foraminifera found in different samples, including Arenobulimina, Texlularia, Trocharnmina, Pseudobolivina, Ammodiscus, and Haplophragmoides spp.
- **Sample F26 to F45:** Similar species distribution as above.
- **Note:** Data includes percentages and numbers for each species in each sample.
Appendix 2. Comparison of the distribution and abundance of the most common taxa (percentage from total agglutinated assemblage).

**E Daehre 4/83**

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