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Albian Foraminifera from Vértessomló Vst-8 borehole, Vértes Mountains (Hungary)

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(with 6 figures and 3 plates)

Abstract

The subject of this research is a rich and well-preserved foraminifera fauna of Albian age from Vértessomló Vst-8 borehole of Vértes Foreland (Transdanubian Range, Hungary). A fifty-meter section of the sequence contains a quantity of this diversified microfauna within the ~100 m thick Vértessomló Siltstone excavated by the borehole. The microfauna is dominated by foraminifera. The samples were dissolved in hydrogene peroxide and concentrated acetic acid. The fauna indicates Albian age but most of the species have wide stratigraphical distribution. *Tritaxia*, *Gavelinella*, *Favusella* are the dominant genera. Determination of 40 taxa, their statistical evaluation and their classification into morphogroups are given. The investigated sequence can be divided into three parts according to the ratio of calcareous/agglutinated forms, planktonic/benthic forms, inbenthic/ epibenthic forms and diversity. The lower part of the sequence was deposited in a weakly dysaerobic off-shore marine environment which contains *Orbitolina* redeposited from the platform of the Környe Limestone. The middle part of the sequence was formed in a planktonic foraminifera-rich (*Hedbergella*, *Favusella*), low energy off-shore environment with limited amount of nutrient and low/moderate degree of oxygen depletion (dysaerobic environment). On these results the upper part of the sequence can be described as a formation sedimented in a nutrient-rich dysaerobic (moderate degree of oxygen depletion) environment.
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Introduction

Former foraminifera investigations of the Vértessomló Siltstone Formation (Pelso Unit, Transdanubian Range) were carried out by I. BODROGI in 1970 but the studied material was derived from boreholes in the Tatabánya basin (see in FÜLÖP 1975). Since the investigations did not contain quantitative evaluation, descriptions and scanning electron microscopic observations the fulfilment of these modern examinations were timely. Getting results we can create a more precise reconstruction of the palaeoenvironment of the Vértes Foreland.

Orbitolinids studies of the Vértessomló Vst-8 borehole were accomplished by Á. GÖRÖG (GÖRÖG, 1993; 1996) forming a part of her investigations on Cretaceous

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orbitolinids from Hungary. Applying thin section observations GÖRÖG determined *Orbitolina (Mesorbitolina) texana* (ROEMER, 1849) and *Orbitolina* (*Mesorbitolina*) *subconcava* LEYMERIE, 1878 distributed from Late Aptian to Middle Albian and planktonic foraminifera *Favusella washitensis* (CARSEY, 1926) in the Early Albian.

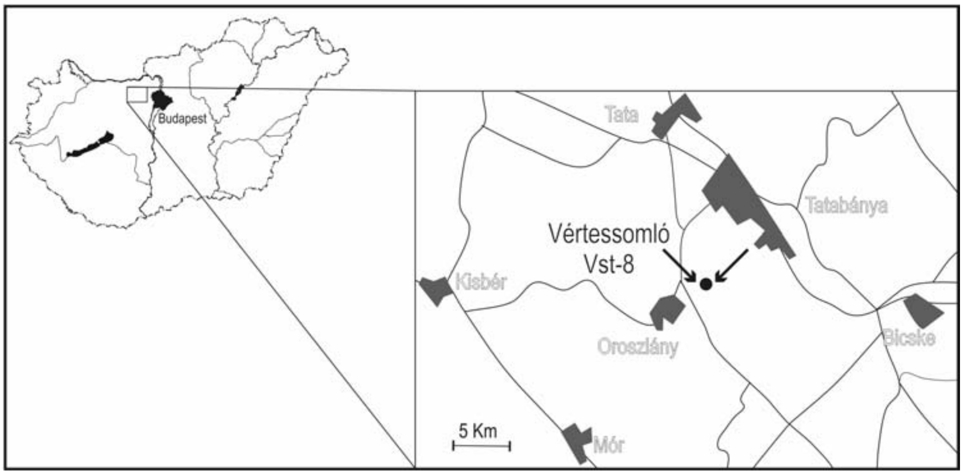

Fig. 1 Geographical location of the Vértessomló Vst-8 borehole

Geological setting

The investigated section of the Vértessomló Siltstone Formation is in the Vértessomló Vst-8 borehole which is located in the Vértes Foreland of the Transdanubian Range of the Pelso Unit. The borehole was drilled at the western slope of the Kálvária hill near Vértessomló in 1990 on behalf of the Hungarian Geological Institute (Fig. 1). The drilling opened up the following column: Middle Jurassic Tölgyhát Limestone Formation, Middle Cretaceous Tata Limestone Formation (with hiatus), Vértessomló Siltstone Formation (Fig. 2). This dark grey siltstone-marl formed in a semi-restricted weakly oxygenated basin in shallow bathyal depth. The formation interfingers with the Környe Limestone Formation of urgon facies to the west. The Környe Limestone was formed on a carbonate ramp at the edge of the basin. The stratigraphic peculiarity of the borehole sequence is facies change in 167 m depth where a 13 m thick Környe Limestone body is intercalated in the Vértessomló Siltstone. The intercalation of the Környe Limestone is a basin floor fan product (CSÁSZÁR, 2002; SZINGER, 2004).

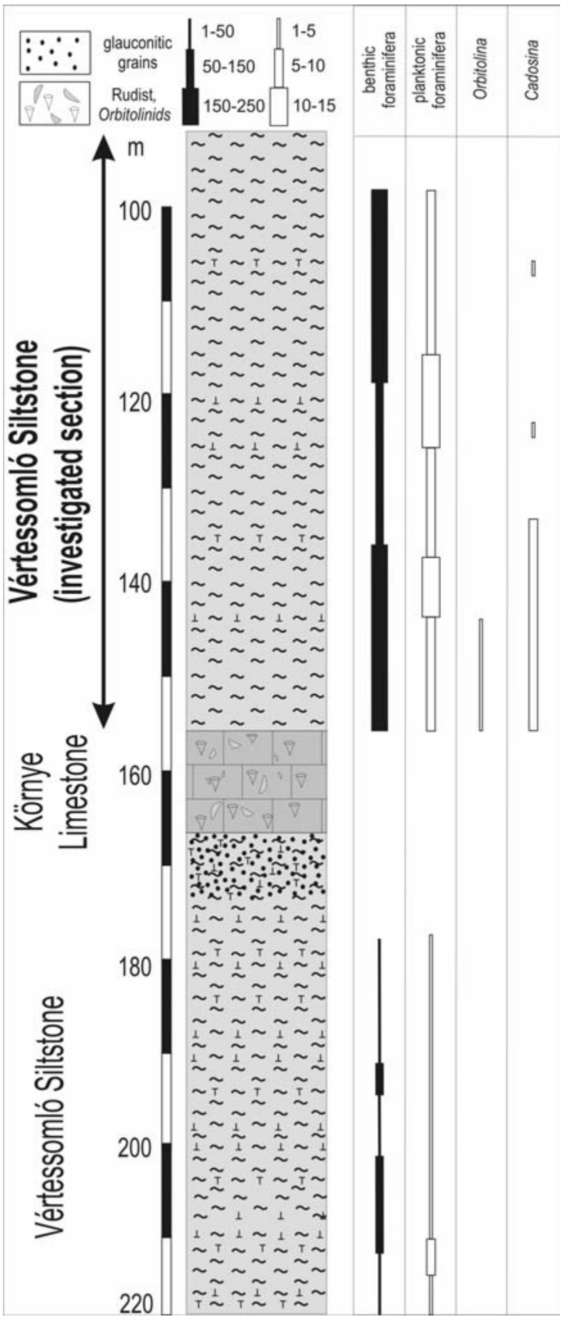

Fig. 2 Distribution of the microfauna in the Vértessomló Siltstone based on the thin sections. The arrow indicates the upper part (97—154 m) of the Vértessomló Siltstone sequence which was the subject of the detailed microfauna investigation.

Material and methods

There were 75 samples of the core observed. The samples were collected approximately in every 2 m. The clayey-silty ones were dissolved in hydrogen peroxide and then washed while the more carbonatic ones were dissolved in concentrated acetic acid and washed in a similar way to LETHIERS & CRASQUIN-SOLEAU (1988). To get more information about the microfauna and the microfacies thin section investigations were carried out. The detailed microfauna investigation was achieved on the upper part of the Vértessomló Siltstone (above the intercalation of the Környe Limestone, between 97–154 m) because there was well-preserved and rich foraminifera fauna only in this part of the sequence (38 samples). The identification and illustration of the microfauna were made by scanning electron microscopic observations. In each case when this method was unfeasible the determination was supported with normal thin section investigation and polarizing microscopic observations of the isolated specimens in transmitted light.

Microfauna studies

Thin section investigations

On the basis of the microscopic observation of 38 thin sections there are the following biogenic constituents of the siltstone in order of increasing frequency: echinoderm skeletal fragments, mollusc shell fragments, agglutinated foraminifers, calcareous (benthic and planktonic) foraminifers, *Cadosina*, siliceous sponge spicules, *Orbitolina*, coralline algae.

In addition to the foraminifers *Cadosina* were reliable tools of the stratigraphic and palaeoenvironmental determination. It was possible to determine three *Cadosina*: *Cadosina gigantea* BORZA, 1969 (Pl. 3, Fig. 17), *Cadosina oraviensis* BORZA, 1969 (Pl. 3, Fig. 18) and *Cadosina* sp. The two first mentioned species are Albian forms (BORZA, 1969).

Isolated forms

Microfossils and bioclasts (with exception of the foraminifera)

In addition to the foraminifers there are shark teeth (Pl. 3, Fig. 9), fish teeth (Pl. 3, Fig. 10), glauconitic grains, siliceous sponge spicules and pellets in the washing residue. According to SCHINDEWOLF (1967) and WIEDENMAYER (1994) the sponge spicules investigated here can be classified into two types. The round forms with short neck represent the Criccorhabd-shapes of the Diactine type (Pl. 3, Fig. 7). The bean-like forms can be classified into the groups of Rhax-shapes of the Anactine type (Pl. 3, Fig. 8).

Results of the investigation of foraminifera

As it was verified by the thin section examination the Vértessomló Siltstone contains well preserved foraminifers of the required quantity only in the upper part of the sequence (above the intercalation of the Környe Limestone, between 97–154 m). The quantitative distribution of the characteristic taxa represented in the samples along the sequence is shown in Fig. 3.

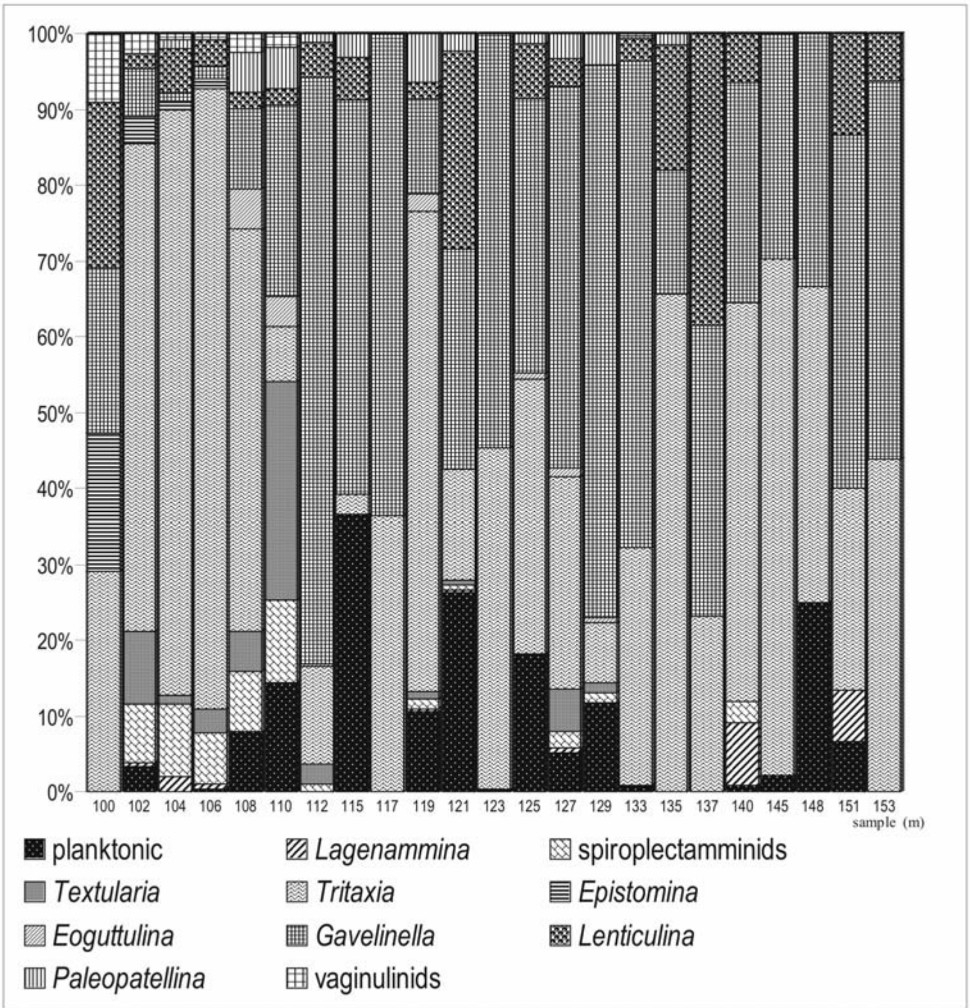

Fig. 3 Distribution and abundance of the characteristic taxa normalised to 100 %.

Fig. 4 presents the ratio of planktonic/benthic, agglutinated/calcareous and inbenthic/epibenthic forms.

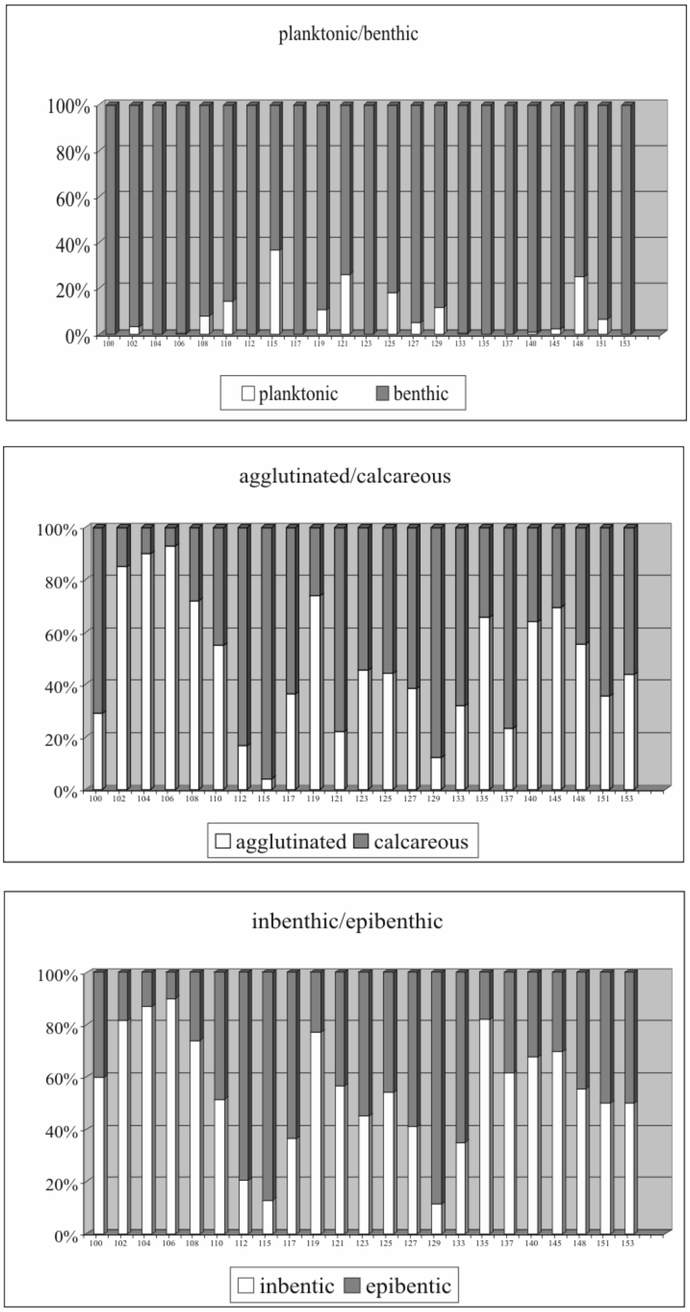

Fig. 4. Ratio of planktonic/benthic, agglutinated/calcareous, inbenthic/epibenthic forms.

In conclusion we used taxa that were the most abundant in the investigated formation and that were mentioned in standard works on the morphogroups (KOUTSOUKOS et al., 1990, TYSZKA, 1994, JONES & CHARNOCK, 1985).
On the basis of the present figures (Figs 4–5) it can be stated that:

- the sequence can be divided into three parts: upper (~112–100 m), middle (~135–112 m) and lower part (~153–135 m)
- the foraminifera are represented in large quantity in the middle and upper part
- the greatest diversity of the fauna can be found in the middle and upper part
- the quantitative distribution of the most abundant *Tritaxia* is heterogeneous in the sequence, while the *Gavelinella* which is the second in abundance is represented in the highest amount in the middle part of the sequence
- some forms (spiroplectamminids, *Textularia*, *Epistomina*, vaginulinids) occur only in the upper part of the sequence
- *Eoguttulina* and *Paleopatellina* are represented in the middle and upper part, while the *Lenticulina* occur in the whole sequence
- the rate of the agglutinated forms to the foraminifera fauna is about 75–85% in the upper part, 40% in the middle part and 60% in the lower part of the sequence
- the inbenthic rate of the forms to the whole foraminifera fauna is about 80–85% in the upper part, 55% in the middle part and 60% in the lower part of the sequence
- the rate of the planktonic forms to the foraminifera fauna never reaches 40% and its distribution is Gauss-curve like so it is the best represented in the middle part of the sequence

Life position, oxygen tolerance, feeding strategy

The interpretation of the ecological role of the foraminifers is based on the works of KOUTSOUKOS et al. (1990), TYSZKA (1994) and JONES & CHARNOCK (1985). According to KOUTSOUKOS et al. (1990) classification we can characterize the oxygen supply of the formation environment of the Vértessomló Siltstone as the following: the epipelagic planktonic forms (*Hedbergella*, *Favusella*) suggest low/moderate degree of oxygen depletion ("dysaerobic" condition: >0,1–1,0 ml/l); the occurance of some calcareous forms (*Gavelinella*, *Nodosaria*, *Vaginulina*) verifies low/moderate degree of oxygen depletion of the sea bottom ("dysaerobic" condition: >0,5–1,0 ml/l); the appearance of the *Textularia* and *Tritaxia* proves moderate degree of oxygen depletion of the sea bottom ("dysaerobic" condition: >0,1–0,5 ml/l).

As a result of KOUTSOUKOS et al. (1990) research the low diversity, the high dominance and the varied size are the characteristics of the "dysaerobic-quasi aerobic" environment.

In compliance with KOUTSOUKOS et al. (1990) paper the most abundant constituents of the samples, *Gavelinella*, *Tritaxia* and *Textularia*, can be classified into two morphogroups.

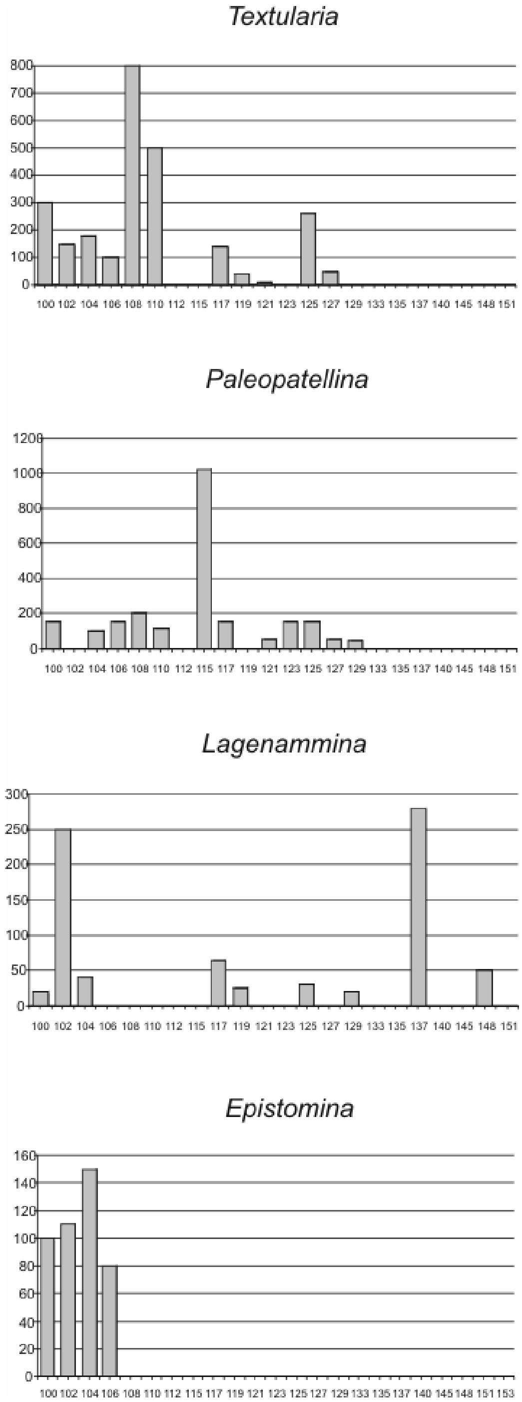

Fig. 5a. Distribution and abundance of characteristic taxa.

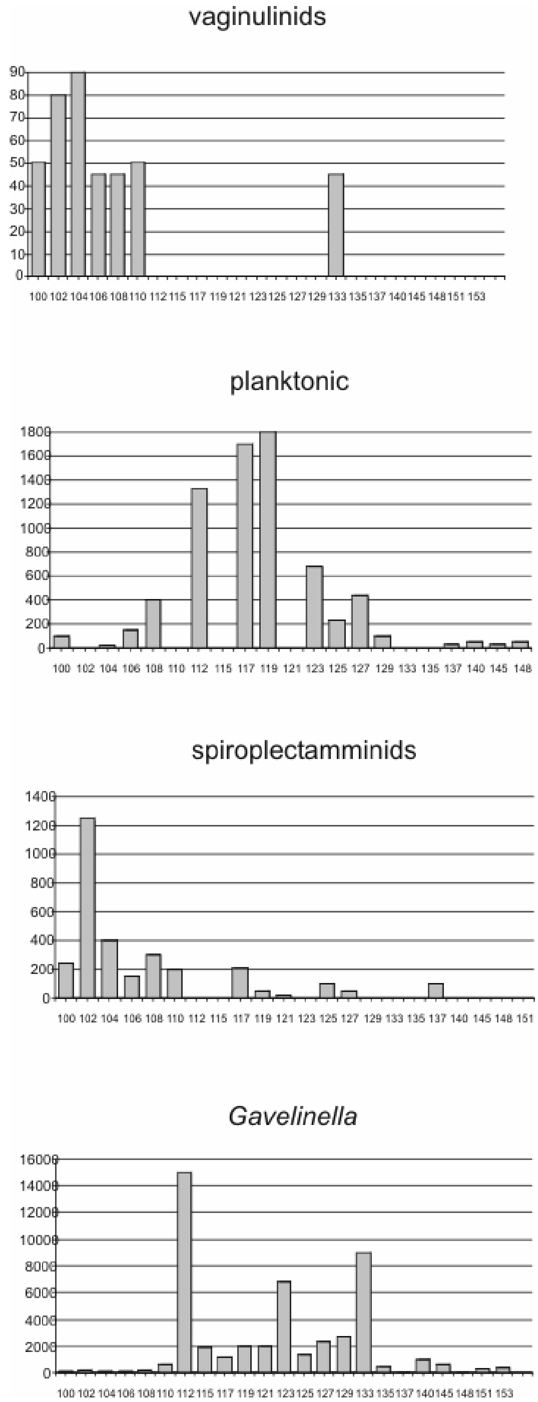

Fig. 5b. Distribution and abundance of characteristic taxa.

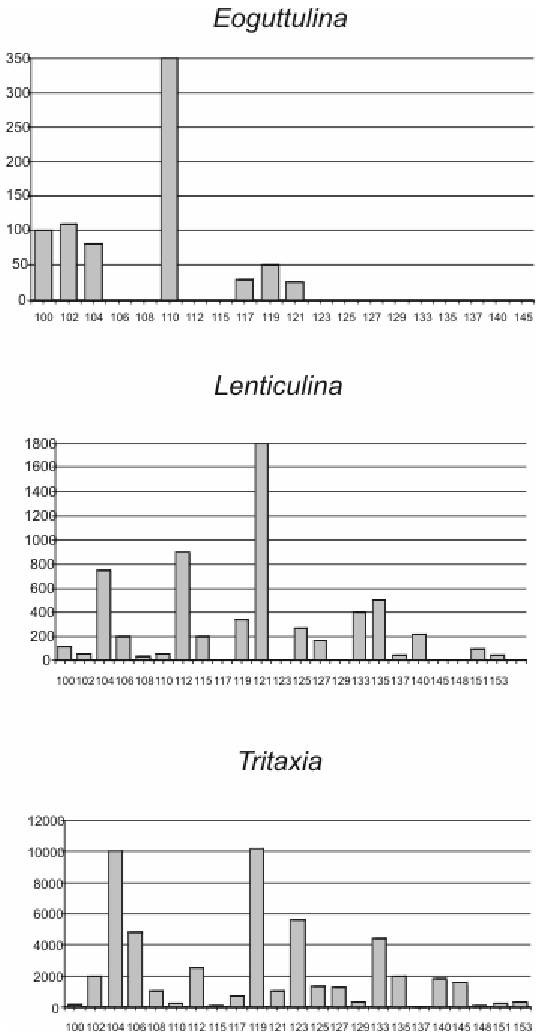

Fig. 5c. Distribution and abundance of characteristic taxa.

CH-A (KOUTSOUKOS et al.): It is a small-scale active detritus feeder (grazing herbivore) shelf association/community living in the near surficial region of the sediment. The dominant members are *Gavelinella*.

AG-A (KOUTSOUKOS et al.): It is a detritus scavenger community living in the sediment. The dominant members are *Marssonella*, *Textularia* and *Tritaxia*.

On the basis of TYSZKA's research (TYSZKA, 1994) it was possible to subdivide the fauna into 9 morphogroups in accordance with identified foraminifers, their life position and nutrition mode (Fig. 6).

Life position type of the investigated foraminifera fauna was determined also with the help of the morphogroups set up by JONES & CHARNOCK (1985). The epibenthic

Gavelinella belong to the "B" morphogroup and the inbenthic *Textularia*, *Spiroplectammina* and *Tritaxia* pertain to the "C" morphogroup.

Planktonic forms (*Favusella*, *Hedbergella*) presented in the samples prove a shallower region of the deep off-shore environment (BODROGI 1989).

Dominance of the inbenthic forms suggests a nutrient-rich environment (CORLISS & CHAN, 1988). It is verified by recent analogy that the determining feature of the epibenthic/inbenthic ratio is not sea depth but distance from the shore that inflenced the range of the nutrient supply.

In the deeper marine region the agglutinated foraminifers prevail over the calcareous ones (DODD & STANTON, 1990).

morphogroup (TYSZKA, 1994)	life position	feeding strategy	genus
A-8 (agglutinated)	shallow to deep infaunal	detrital/bacterial scavengers	*Textularia, Lagenamminna*
C-1 (calcareous)	epifauna	primary weed fauna, grazing herbivores	*Epistomina*
C-3 (calcareous)	epifauna	primary weed fauna, grazing herbivores/ /detritivores	*Spirillina, Paleopatellina*
C-5 (calcareous)	shallow infauna	deposit feeders, grazing omnivores and/or bacterial/detrital scavengers	*Nodosaria*
C-6A (calcareous)	shallow infauna	active deposit feeders	*Astacolus*
C-6B (calcareous)	shallow to deep infauna	deposit feeders, grazing omnivores	*Vaginulina*
C-6C (calcareous)	shallow to deep infauna	active deposit feeders, grazing omnivores	*Marginulina*
C-7 (calcareous)	shallow to deep infauna	deposit feeders, grazing omnivores and/or bacterial/detrital scavengers	*Pseudonodosaria, Eoguttulina*
C-8 (calcareous)	shallow to deep infauna	active deposit feeders, grazing omnivores	*Lenticulina*

Fig. 6 Classification of the studied foraminifera according to TYSZKA's (1994) morphogroups, life position and feeding strategy

Microfacies and paleoecology

The investigated sequence can be divided into three parts according to their varied foraminifera association, the ratios of calcareous/agglutinated forms, planktonic/benthic forms, inbenthic/epibenthic forms and the diversity.

Lower part (~153–135 m)

The peculiar feature of this part is the presence of a quantity of *Cadosina* and *Orbitolina*. *Cadosina* suggests off-shore environment while the platform margin indicating *Orbitolina* was redeposited from the shallow marine platform of the Környe Limestone. In this section there is a smaller diversity of the foraminifera. The ratios of agglutinated/calcareous and inbenthic/epibenthic forms are not characteristic. The agglutinated inbenthic forms are the ~60% of the whole fauna. The weak (pre)dominance of the agglutinated forms (especially *Tritaxia*) suggests a moderate degree of oxygen depletion of the seafloor environment. The lower part of the sequence can be interpreted as sedimented in a weakly disaerobic off-shore marine environment which contains some amount of *Orbitolina* redeposited from the platform of the Környe Limestone.

Middle part (~135–112 m)

This part has the highest foraminifer diversity in the sequence. The characteristic features of this part are the sudden increase of the quantity of the calcareous epibenthic forms comparing to the lower part and the highest abundance of planktonic foraminifers and *Gavelinella*. Based on these results the middle part of the sequence can be interpreted as formed in a planktonic foraminifera-rich, low energy off-shore environment with limited amount of nutrient and low/moderate degree of oxygen depletion (disaerobic).

Upper part (~112–100 m)

The specific feature of this part is the dominance (75–85%) of the agglutinated inbenthic forms. Some taxa (spiroplectamminids, *Textularia, Epistomina,* vaginulinids) appear only in this section and the *Tritaxia* prevail over the foraminifera fauna. Based on these results the upper part of the sequence can be interpreted as a formation sedimented in a nutrient-rich dysaerobic (moderate degree of oxygen depletion) environment.

Conclusion

Microfauna of the Vértessomló Siltstone Formation in the Vértessomló Vst-8 borehole show that the dominant forms are the foraminifera. They indicate Albian age but most of the species have wide stratigraphical distribution. *Tritaxia*, *Gavelinella*, *Favusella* are the most abundant species.

The investigated sequence can be divided into 3 parts according to their varied foraminifera association, the ratios of calcareous/agglutinated forms, planktonic/benthic forms, inbenthic/epibenthic forms and diversity. The lower part of the sequence can be interpreted as a formation sedimented in a weakly disaerobic off-shore marine environment which contains some amount of *Orbitolina* redeposited from the platform of the Környe Limestone. The middle part of the sequence could formed in a planktonic foraminifera-rich (*Hedbergella*, *Favusella*) low energy, off-shore environment with limited amount of nutrients and low/moderate degree of oxygen depletion (disaerobic). The upper part of the sequence can be described as a formation sedimented in a nutrient-rich disaerobic (moderate degree of oxygen depletion) environment.

Based on these results it can be stated that the foraminifera fauna denotes well that the Vértessomló Siltstone is created in a semi-restricted weakly oxygenated basin in shallow bathyal depth. The microfauna is a sensitive indicator of the fluctuating oxygen content of the water of this semi-restricted basin and the distance from the shore.

Acknowledgements

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Systematic description

After LOEBLICH & TAPPAN (1988).

Phylum Protista
Subphylum Sarcodina SCHMARDA, 1871
Class Rhizopodea VON SIEBOLD, 1845
Subclassis Lobosia CARPENTER, 1861
Ordo Foraminiferida EICHWALD, 1830
Subordo Textulariina DELAGE & HÉROUARD, 1896
Superfamilia Astrorhizacea BRADY, 1881
Familia Saccamminidae BRADY, 1884
Subfamilia Saccamminidae BRADY, 1884
Genus *Lagenammina* LOEBLICH & TAPPAN, 1985

Lagenammina grzybowskii (SCHUBERT, 1901)
(Plate 1, Figure 1–2)

1951 *Proteonina difflugiformis* (BRADY, 1879) – BARTENSTEIN & BRAND, p. 265, pl. 1, fig. 3.
1965 *Proteonina* sp. cf. P. *ampullacea* (BRADY, 1881) – NEAGU, p. 3, pl. 1, fig. 11.
1988 *Lagenammina grzybowskii* (SCHUBERT, 1901) – KAMINSKI, GRADSTEIN & BERGGREN, p. 182, pl. 2, fig. 7.

Description: flask-shaped, coarse test, with elongated neck; wide aperture; grained agglutinated wall; rough surface.
Distribution: Albian (Romania), Early Maastrichtian (Trinidad)

Superfamilia Hippocrepinacea RHUMBLER, 1895
Familia Ammodiscidae REUSS, 1862
Subfamilia Ammovertellinae SAIDOVA, 1981
Genus *Glomospira* RZEHAK, 1885

Glomospira sp.
(Plate 1, Figure 3)

Description: small test, irregularly coiled tubular chamber; aperture at the end of the tube; finely agglutinated wall.
Distribution: Albian (Hungary)

Superfamilia Spiroplectamminacea CUSHMAN, 1927
Familia Spiroplectamminidae CUSHMAN, 1927
Subfamilia Spiroplectammininae CUSHMAN, 1927
Genus *Spiroplectammina* CUSHMAN, 1927

Spiroplectammina sp. 1
(Plate 1, Figure 4)

Description: elongated, narrow test with sharp, finely depressed edges; early stage: short and narrow test, the first 4–5 chambers are planispirally coiled; later stage: biserial alternating chambers; a low arched aperture at the inner margin of the final chamber; agglutinated wall.
Distribution: Albian (Hungary)

Spiroplectammina sp. 2
(Plate 1, Figure 5)

Description: short and depressed, narrow test with sharp edges; early stage: short and wide test, the first 4–5 chambers planispirally coiled; later stage: biserial alternating chambers; a low arched aperture at the inner margin of the final chamber; agglutinated wall.
Distribution: Albian (Hungary)

Superfamilia Verneuilinacea CUSHMAN, 1911
Familia Verneuilinidae CUSHMAN, 1911
Subfamilia Spiroplectinatinae CUSHMAN, 1928
Genus *Spiroplectinata* CUSHMAN, 1927

Spiroplectinata complanata (REUSS, 1860)
(Plate 1, Figure 6–8)

1863 *Proporus Schultzei* m. – REUSS, p. 80, pl. 9, fig. 10.
1994 *Spiroplectinata complanata* (REUSS, 1860) – MEYN & VESPERMANN, p. 76, pl. 3, fig. 10–15.

Description: elongated, narrow, thin and depressed test; short early 3–4 chambers planispirally coiled; later stage: biserial alternating chambers; inflated final chamber; a low arched aperture at the inner margin of the final chamber; agglutinated wall.
Distribution: Middle to Late Albian (Germany)

Superfamilia Verneuilinacea CUSHMAN, 1911
Familia Tritaxiidae PLOTNIKOVA, 1979
Genus *Tritaxia* REUSS, 1860

Tritaxia pyramidata REUSS, 1863
(Plate 1, Figure 9–10)

1863 *Tritaxia pyramidata* m. – REUSS, p. 32, pl. 1, fig. 9.
1965 *Tritaxia pyramidata* REUSS, 1863 – NEAGU, p. 5, pl. 1, fig. 9–10.
1975 *Tritaxia pyramidata* REUSS, 1863 – SIDÓ, pl. 1, fig. 2.
1979 *Tritaxia pyramidata* REUSS, 1863 – KAPTARENKO-CHERNOUSOVA, PLOTNIKOVA & LIPNIK p. 20, pl. 4, fig. 1.
1981 *Tritaxia pyramidata* REUSS, 1862 – JENKINS & MURRAY, p. 178, pl. 7.3, fig. 2–3.
1983 *Tritaxia pyramidata* REUSS, 1863 – MOULLADE, pl. 1, fig. 12.
1990 *Tritaxia pyramidata* REUSS, 1863 – Weidich, p. 105, pl. 12, fig. 23.
1994 *Tritaxia pyramidata* REUSS, 1863 – MEYN & VESPERMANN, p. 76, pl. 4, fig. 3–8.

Description: triserial, triangular test in cross-section; generally concave sides but may be straight; inflated chambers with depressed suture, rounded last chamber; circular and terminal aperture at the inner margin in the triserial stage; agglutinated wall.
Distribution: Early Cretaceous (Germany), Albian (Romania), Aptian to Early Cenomanian (Germany), Upper Albian to Early Cenomanian (England), Late Albian (Atlantic Ocean, DSDP).

Tritaxia tricarinata (REUSS, 1845)
(Plate 1, Figure 11)

1965 *Tritaxia tricarinata* (REUSS, 1845) – NEAGU, p. 6, pl. 1, fig. 17–18.
1981 *Tritaxia singularis* MAGNIEZ-JANNIN, 1975 – JENKINS & MURRAY, p. 178, pl. 7.3, fig. 2–3.
1983 *Tritaxia tricarinata* (REUSS, 1845) – MOULLADE, pl. 1, fig. 14.
1990 *Tritaxia tricarinata* (REUSS, 1845) – WEIDICH, p. 106, pl. 12, fig. 24.

Description: triserial test with sharp edges, triangular in cross-section; strongly concave sides; slightly inflated chambers with strongly depressed suture; circular and terminal aperture, at the inner margin in the triserial stage; agglutinated wall.
Distribution: Albian (Romania), Albian (England), Aptian to Late Cenoman (Germany), Late Albian (Atlantic Ocean, DSDP).

Superfamilia Ataxophragmacea SCHWAGER, 1877
Familia Orbitolinidae MARTIN, 1890
Genus *Orbitolina* D'ORBIGNY, 1850

Orbitolina (Mesorbitolina) texana (ROEMER, 1849)
(Plate 3, Figure 12)

1849 *Orbitulites Texanus* n. sp. – ROEMER, p. 392.
1969 *Orbitolina (Mesorbitolina) texana* (ROEMER) – MÉHES, pl. 3, fig. 4.
1996 *Orbitolina (Mesorbitolina) texana* (ROEMER, 1849) – GÖRÖG, p. 281, fig. 6.1.6/B–G.; 6.3.2/A–H.; 6.3.3.; 6.3.4.;6.3.6/C–E.; 6.4.5.; 6.4.6.; 6.4.9./A, B; 6.4.13/A–B., E_H.; 6.4.15/A–C; 6.4.17/A–O.

Remark: Orbitolina fauna of the present sample was studied and described in details by Á. GÖRÖG (GÖRÖG, 1996).

Superfamilia Textulariacea EHRENBERG, 1838
Familia Eggerellidae CUSHMAN, 1937
Subfamila Dorothiinae BALAKHMATOVA, 1972
Genus *Bannerella* Loeblich & TAPPAN, 1985

Bannerella sp.

Description: conical test, rounded in section, early stage: trochospirally enrolled, then reduce finally biserial; the last two biserial chambers are large and rounded, rapidly increasing in diameter; circular aperture at the inner side in the biserial stage; agglutinated wall.
Distribution: Albian (Hungary)

Genus *Dorothia* PLUMMER, 1931

Dorothia gradata (BERTHELIN, 1880)

1965 *Dorothia gradata* (BERTHELIN, 1880) – NEAGU, p. 8, pl. 2, fig. 23.
1975 *Dorothia gradata* (BERTHELIN, 1880) – SIDÓ, pl. 2, fig. 3.
1987 *Dorothia gradata* (BERTHELIN, 1880) – WILLIAMSON, p. 53, pl. 1, fig. 2.

Description: elongate test, rounded chambers, early stage: trochospiral, with four or more chambers by whorl, then reduced to biserial; aperture is at the inner side in the biserial stage; finely agglutinated wall.
Distribution: Albian (Romania), Late Albian (Newfoundland), Late Albian (Hungary), Albian to Cenomanian (Poland).

Dorothia oxycona (REUSS, 1860)
(Plate 1, Figure 12)

1975 *Dorothia (Marssonella) oxycona* (REUSS, 1860) – Sidó, pl. 2, fig. 3–5.
1979 *Dorothia oxycona* (REUSS, 1860) – KAPTARENKO-CHERNOUSOVA, PLOTNIKOVA & LIPNIK, p. 24, pl. 5, fig. 5.
1983 *Dorothia oxycona* (REUSS, 1860) – MOULLADE, pl. 1, fig. 17.
1988 *Dorothia oxycona* (REUSS, 1860) – GASINSKI, pl. 11, fig. d.
1988 *Dorothia oxycona* (REUSS, 1860) – KAMINSKI, GRADSTEIN & BERGGREN, p. 195, pl. 9, fig. 9.

Description: conical, dumpy test, poorly oval in cross section, early stage: trochospiral, with four or more chambers by whorl, then reduced to biserial; aperture is at the inner side in the biserial stage; agglutinated wall.
Distribution: Late Albian (Hungary), Late Cretaceous to Paleocene (Trinidad), Late Albian (Atlantic Ocean, DSDP), Albian to Cenomanian (Poland).

Genus *Marssonella* CUSHMAN, 1933
Marssonella sp.

Description: conical test, circular in section, with thiny early trochospire five chambers per whorl followed by a biserial stage of rapidly increasing in diameter; a low basal arched aperture with a narrow bordering flap; agglutinated wall.
Distribution: Albian (Hungary)

Subordo Spirillinina HOHENEGGER & PILLER, 1975
Familia Spirillinidae REUSS & FRITSCH, 1861
Genus *Spirillina* EHRENBERG, 1843
Spirillina sp.
(Plate 1, Figure 13)

Description: discoidal, planispiral,test with five closely appressed whorls, tubular chamber; aperture is at the end of the tubular chamber; calcareous wall.
Distribution: Albian (Hungary)

Familia Patellinidae RHUMBLER, 1906
Subfamilia Hergottellinae LOEBLICH & TAPPAN, 1984
Genus *Paleopatellina* Agalarova, POROSCHINA & GAODAKTCHAN, 1973

Paleopatellina aptica (AGALAROVA, 1951)
(Plate 1, Figure 14)

1980 *Paleopatellina aptica* (AGALAROVA, 1951) – KASSIMOVA, POROSHINA & GAODAKCTHAN, p. 122, pl. 12, fig. 5.

Description: low conical test, all chambers visible from the convex side, only the final pair of the last whorl is visible on the flattened umbilical side, nicked edge in the umbilical side; arched aperture in the umbilical side; calcareous wall.
Distribution: Aptian (Azerbaijan)

Genus *Turrispirillina* CUSHMAN, 1927

Turrispirillina sp.
(Plate 1, Figure 15)

Description: conical test, low cone, aperture is at the end of the tube on the flattened concave side; finely perforate, calcareous wall.
Distribution: Albian (Hungary)

Subordo Miliolina DELAGE & HÉROUARD, 1896
Superfamilia Miliolacea EHRENBERG, 1839
Familia Hauerinidae SCHWAGER, 1876
Subfamilia Haueribinae SCHWAGER, 1876
Genus *Cycloforina* LUCZKOWSKA, 1972

Cycloforina sp.

Description: quinqueloculine test, five chambers are visible from the exterior side, half coil in length; circular aperture at the produced end of the final chamber; calcareous, imperforate wall.
Distribution: Albian (Hungary)

Subordo Lagenina DELAGE & HÉROUARD, 1896
Superfamilia Nodosariacea EHRENBERG, 1838
Familia Nodosariidae EHRENBERG, 1838
Subfamilia Nodosariinae EHRENBERG, 1838
Genus *Dentalina* RISSO, 1826

Dentalina sp.

Description: uniserial, arched, elongated test; oblong prolonged chambers, rounded in cross section; radiate aperture in the end of the final chamber; calcareous wall.
Distribution: Albian (Hungary)

Genus *Nodosaria* LAMARCK, 1812

Nodosaria obscura REUSS, 1846
(Plate 1, Figure 16)

1863 *Nodosaria obscura* m. - REUSS, p. 40, pl. 2, fig. 13.
1951 *Nodosaria obscura* Reuss, 1845 – BARTENSTEIN & BRAND, p. 312, pl. 10, fig. 247–248.
1971 *Nodosaria obscura* Reuss, 1846 – FUCHS, p. 16, pl. 3, fig. 20.
1979 *Nodosaria obscura* Reuss, 1846 – KAPTARENKO-CHERNOUSOVA, PLOTNIKOVA & LIPNIK, p. 27, pl. 5, fig. 10.

Description: elongate test with lengthwise continuous 8 strong ribs in all chambers, circular chambers in cross section; terminal aperture in the short neck of the final chamber, calcareous, perforate wall.
Distribution: Late Albian (Ukraine), Cretaceous (Germany), Middle Barremian (Austria).

Genus *Pseudonodosaria* BOOMGAART, 1949

Pseudonodosaria humilis (ROEMER, 1841)
(Plate 2, Figure 1)

1971 *Nodosaria humilis* ROEMER, 1841 – FUCHS, p. 15, pl. 3, fig. 12–14, 17.
1979 *Pseudonodosaria humilis* (ROEMER, 1841) – KAPTARENKO-CHERNOUSOVA, PLOTNIKOVA & Lipnik, p. 31, pl. 6, fig. 8.
1994 *Pseudonodosaria humilis* (ROEMER, 1841) – MEYN & VESPERMANN p. 97, pl. 11, fig. 1–15.

Description: elongate, cylindrical test; early chamber strongly overlapping and increasing gradually in diameter, reduced final chamber, distant straight horizontal suture, smooth surface; terminal aperture; calcareous wall.
Distribution: Middle Barremian (Austria), Berriasian to Albian (Crimea), Valanginian to Albian (Germany).

Genus *Tristix* MACFADYEN, 1941

Tristix excavata (REUSS, 1863)
(Plate 2, Figure 2)

1863 *Rhabdogonium excavatum* m.; – REUSS, p. 91, pl. 12, fig. 8.
1965 *Tristix excavata* (REUSS, 1863) – NEAGU, p. 24, pl. 5, fig. 14–15.
1979 *Tristix excavatus* (REUSS, 1863) – KAPTARENKO-CHERNOUSOVA, PLOTNIKOVA & LIPNIK, p. 29, pl. 6, fig. 3.

Description: elongated test with sharp edges, uniserial, triangular in cross-section; strongly concave sides; oval chambers with strongly depressed suture; terminal aperture; calcareous, hyaline wall.
Distribution: Barremian to Albian (Crimea), Albian (Romania).

Familia Vaginulinidae REUSS, 1860
Subfamila Lenticulininae CHAPMAN, PARR, & COLLINS, 1978
Genus *Lenticulina* LAMARCK, 1804

Lenticulina muensteri (ROEMER, 1839)
(Plate 2, Figure 3)

1951 *Lenticulina (Lenticulina) muensteri* (ROEMER, 1839) – BARTENSTEIN & BRAND, p. 283, pl. 5, fig. 109, pl. 14A, fig. 13–14, pl. 14B, fig. 3–6, pl. 16, fig. 16–18.
1975 *Lenticulina muensteri* (ROEMER, 1839) – JENDRYKA -FUGLEWICZ, p. 149, pl. 8, 9, 10, 11, fig. 1–6, pl. 19, 20, fig. 1–2.
1981 *Lenticulina muensteri* (ROEMER, 1839) – JENKINS & MURRAY, pl. 7.18, fig. 2.
1988 *Lenticulina muensteri* (ROEMER, 1839) – SZTEJN, pl. 2, fig. 4.
1994 *Lenticulina muensteri* (ROEMER, 1839) – MEYN & VESPERMANN, p. 130, pl. 23, fig. 12–17, pl. 24, fig. 1–17, pl. 25, fig. 1–3.
2003 *Lenticulina muensteri* (ROEMER, 1839) – SZŰCS, p. 22, pl. 3, fig. 6.

Description: planispiral involute test, lot of chambers by whorl, chambers increase slowly, sharp smooth edge, slight dipping suture, smooth surface; radiate terminal aperture in the peripheral angle; calcareous, hyaline wall.
Distribution: Jurassic to Cretaceous (cosmopolitan)

Lenticulina pulchhella (REUSS, 1863)
(Plate 2, Figure 4)

1863 *Cristellaria pulchhella* m.; – REUSS, p. 71, pl. 8, fig. 1.
1965 *Lenticulina (Robulus) pulchhella* (REUSS, 1863) – NEAGU, p. 12, pl. 4, fig. 3–6.
1994 *Lenticulina pulchhella* (REUSS, 1863) – MEYN & VESPERMANN, p. 136, pl. 25, fig. 4–10.
2002 *Lenticulina pulchhella* (REUSS, 1863) – KELE, p. 36, pl. 2, fig. 28–29.

Description: planispiral involute test, lot of chambers by whorl, chambers increase slowly in size, inflated chambers, uncoiled last chambers, dipping suture, semi rought surface; radiate aperture in the peripheral angle; calcareous, hyaline wall.
Distribution: Albian (Romania), Late Hauterivian to Late Albian (Germany).

Lenticulina dunkeri (REUSS, 1863)
(Plate 2, Figure 5)

1863 *Cristellaria dunkeri* m.; – REUSS, p. 73, pl. 8, fig. 6.
1994 *Lenticulina dunkeri* (REUSS, 1863) – MEYN & VESPERMANN, p. 137, pl. 25, fig. 11–12, pl. 26, fig. 1–6.

Description: planispiral involute test, lots of chambers increasing slowly, sharp smooth edge, rought surface, slightly uncoiled last chambers, straight terminal chambers; radiate aperture in the peripheral angle; calcareous, hyaline wall.
Distribution: Valanginian to Albian (Germany)

Genus *Marginulinopsis* A. SILVESTRI, 1904

Marginulinopsis jonesi (REUSS, 1863)
(Plate 2, Figure 6)

1863 *Marginulina jonesi* m. – REUSS, p. 61, pl. 5, fig. 19.
1965 *Marginulina jonesi* REUSS, 1863 – Neagu, p. 17, pl. 5, fig. 11–12.
1971 *Lenticulina (Marginulinopsis) jonesi* (REUSS, 1863) – FUCHS, p. 23, pl. 5, fig. 12.
1979 *Marginulinopsis jonesi* (REUSS, 1863) – KAPTARENKO-CHERNOUSOVA, PLOTNIKOVA & LIPNIK, p. 109, pl. 40, fig. 2.
1988 *Marginulina* sp. aff. *M. jonesi* (REUSS) – SZTEJN, pl. 2, fig. 5.
1994 *Marginulinopsis jonesi* (REUSS, 1863) – MEYN & VESPERMANN, p. 153, pl. 31, fig. 5–8, pl. 32, fig. 1–14, pl. 33, fig. 1–14.

Description: elongated test with lengthwise hard 8 ribs, early portion close coiled, later uncoiled chambers, circular in cross section, dipping suture; terminal aperture with long neck; calcareous, hyaline wall.
Distribution: Middle Barremian (Austria), Albian to Cenomanian (Ukraine), Albian (Romania), Valanginian to Albian (Germany).

Subfamila Marginulininae WEDEKIND, 1937
Genus *Astacolus* DE MONTFORT, 1808

Astacolus linearis (Reuss, 1863)
(Plate 2, Figure 7)

1863 *Cristellaria linearis* m. – REUSS, p. 66, pl. 12, fig. 1.
1994 *Astacolus linearis* (REUSS, 1863) – MEYN & VESPERMANN, p. 180, pl. 40, fig. 3–12, 14.

Description: elongated test, early portion coiled, later uncoiled chambers, ovate chambers in cross section, deep straight sutures, sharp edge in the firs coiled chambers; rough surface; radiate aperture in the dorsal angle; calcareous wall.
Distribution: Valanginian to Middle Albian (Germany)

Subfamila Vaginulininae REUSS, 1860
Genus *Citharina* D'ORBIGNY, 1839
Citharina sp.

Description: quadrangle test in outline, flattened and with truncate margin, acute proloculus, numerous later chambers; rounded aperture, produced on the short neck at the dorsal angle; calcareous wall.

Distribution: Albian (Hungary)

Genus *Planularia* (DEFRANCE, 1826)

Planularia tricarinella (REUSS, 1863)
(Plate 2, Figure 8)

1963 *Cristellaria tricarinella* m. – Reuss, p. 68, pl. 7, fig. 9.
1994 *Planularia tricarinella* (Reuss, 1863) – Meyn & Vespermann, p. 226, pl. 55, fig. 1–5, 7–11.

Description: large test, triangular outline, coiled early portion, chambers increase rapidly in size, strong depressed periphery tricarinate, strongly curved and elevated sutures; radiate aperture in the dorsal angle; calcareous, hyaline wall.
Distribution: Late Bajocian to Late Barremian (Germany)

Genus *Psiloctharella* (LOEBLICH & TAPPAN, 1986)

Psiloctharella striolata (REUSS, 1863)
(Plate 2, Figure 9)

1963 *Vaginulina striolata* m. – REUSS, p. 46, pl. 3, fig. 7.
1994 *Psiloctharella striolata* (REUSS, 1863) – MEYN & VESPERMANN, p. 235, pl. 57, fig. 10–15.

Description: elongated test, triangular in outline, strongly compressed, sharp carinate, coiled rounded early portion, chambers increase rapidly in size, lengthwise distant rib; aperture is at the dorsal angle; calcareous, hyaline wall.
Distribution: Middle to Late Albian (Germany)

Genus *Vaginulina* D'ORBIGNY, 1826

Vaginulina orthonata REUSS, 1863
(Plate 2, Figure 10)

1963 *Vaginulina orthonata* m. – REUSS, p. 49, pl. 4, fig. 3.

Description: narrow elongated test, triangular in outline, strongly compressed, coiled early portion, finely vertical striated; broad surface; aperture is at the dorsal angle; calcareous, hyaline wall.
Distribution: Late Hauterivian (Germany)

Familia Polymorphinidae D'ORBIGNY, 1839
Subfamila Polymorphininae D'ORBIGNY, 1839
Genus *Eoguttulina* CUSHMAN & OZAWA, 1930

Eoguttulina anglica CUSHMAN & OZAWA, 1930
(Plate 2, Figure 11)

1965 *Eoguttulina anglica* CUSHMAN & OZAWA, 1930 – NEAGU, p. 28, pl. 7, fig. 1–2.

Description: ovate test, rounded in cross section, quickly increasing in size, elongated inflated chambers, deeply depressed suture; smooth surface; terminal radial aperture; calcareous wall.
Distribution: Albian (Romania)

Subfamila Polymorphininae D'ORBIGNY, 1839
Genus *Ramulina* T.R. JONES, 1875

Ramulina sp.
(Plate 2, Figure 12)

Description: elongated test, rounded in cross section, elongated chambers, dipping suture, terminal radial aperture, smooth surface; calcareous wall.
Distribution: Albian (Hungary)

Subordo Robertinina LOEBLICH & TAPPAN, 1984
Superfamilia Duostominacea BROTZEN, 1963
Familia Epistominidae WEDEKIND, 1937
Subfamilia Epistomininae WEDEKIND, 1937
Genus *Epistomina* TERQUEM, 1883

Epistomina cretosa TEN DAM, 1947
(Plate 2, Figure 13–14)

1954 *Hiltermannia cretosa* (TEN DAM, 1947) – HOFKER, p. 190, fig. 25–26.
1967 *Epistomina cretosa cretosa* TEN DAM, 1947 – OHM, p. 148, pl. 20, fig. 2.
1979 *Epistomina cretosa* TEN DAM, 1947 – KAPTARENKO-CHERNOUSOVA, PLOTNIKOVA & LIPNIK, p. 64, pl. 17, fig. 2.
1987 *Epistomina cretosa* TEN DAM, 1947 – WILLIAMSON, p. 53, pl. 3, fig. 5–7.
1988 *Epistomina cretosa* TEN DAM, 1947 – WILLIAMSON & STAM, p. 140, pl. 2, fig. 1–4.

Description: lens shaped test, trochospirally coiled, gradually increasing chambers, broad surface, sharp carinate, radial curved strongly ribbed sutures; calcareous, aragonitic wall.
Distribution: Middle to Late Albian (Newfoundland)

Subordo Globigerinina DELAGE & HÉROUARD, 1896
Superfamilia Favusellacea LONGORIA, 1974
Familia Favusellidae LONGORIA, 1974
Genus *Favusella* MICHAEL, 1973

Favusella washitensis (CARSEY, 1926)
(Plate 2, Figure 15–16, Plate 3, Figure 1)

1954 *Hiltermannia cretosa* (TEN DAM, 1947) – HOFKER, p. 190, fig. 25–26.
1989 *Favusella washitensis* (CARSEY, 1926) – Bodrogi, p. 27, pl. 4, pl. 6, fig. 38.
1989 *Favusella washitensis* (CARSEY, 1926) – WEIDICH, pl. 1, fig. 7.
1990 *Favusella washitensis* (CARSEY, 1926) – WEIDICH, p. 158, pl. 51 fig. 6–10.

Description: trochospirally coiled test, globular chambers rapidly enlarging, radial suture, three whorls, surface distinctly honeycomblike; interomarginal arched aperture; calcareous, aragonitic wall.
Distribution: Albian to Cenomanian (Hungary), Early Albian to Cenomanian (Germany).

Superfamilia Globigerinacea CARPENTER, PARKER & JONES, 1862
Familia Hedbergellidae LOEBLICH & TAPPAN, 1961
Genus *Hedbergella* BRÖNNIMANN & BROWN, 1958

Hedbergella planispira (TAPPAN, 1940)
(Plate 3, Figure 2–3)

1979 *Hedbergella planispira* (TAPPAN, 1940)– ROBASZYNSKI & CARON, p. 139, pl. 27, fig. 1–3, pl. 28, fig. 1–4.
1993 *Hedbergella planispira* (TAPPAN, 1940) – MARTINOTTI, p. 71, pl. 3, fig. 8–11.
1989 *Hedbergella planispira* (TAPPAN, 1940) – BODROGI, pl. 4, p. 25, pl. 5, fig. 29–30.
1990 *Hedbergella planispira* (TAPPAN, 1940) – WEIDICH, p. 167, pl. 58, fig.9–11.
1997 *Hedbergella planispira* (TAPPAN, 1940) – BOUDAGHER-FADEL, BANNER & WHITTAKER, pl. 11.1, p. 1–3.

Description: low trochospirally coiled test, globular and gradually enlarging chambers, the last 4–5 chambers with the same size, deep radial suture, smooth surface; interomarginal, umbilical arched aperture; calcareous wall.
Distribution: Albian to Cenomanian (France), Albian to Cenomanian (Hungary), Albian (Germany).

Hedbergella delrioensis (CARSEY, 1926)
(Plate 3, Figure 4)

1979 *Hedbergella delrioensis* (CARSEY, 1926) – ROBASZYNSKI & CARON, p. 123, pl. 22, fig. 1–2, pl. 23, fig. 1–3.
1989 *Hedbergella delrioensis* (CARSEY, 1926) – BODROGI, pl. 4, p. 24, pl. 5, fig. 32–33.
1998 *Hedbergella delrioensis* (CARSEY, 1926) – BELLIER, p. 338, pl. 1, fig. 1–3.

Description: trochospirally coiled test, gradually enlarging, globular chambers, deep radial suture, smooth surface; interomarginal, umbilical arched aperture; calcareous wall.
Distribution: Early Cretaceous (France), Albian to Cenomanian (Hungary).

Subordo Rotaliina DELAGE & HÉROUARD, 1896
Superfamilia Chilostomellacea BRADY, 1881
Familia Gavelinellidae HOFKER, 1956
Subfamila Gavelinellinae HOFKER, 1956
Genus *Gavelinella* BROTZEN, 1942

Gavelinella intermedia (BERTHELIN, 1880)
(Plate 3, Figure 5–6)

1965 *Gavelinella intermedia* (BERTHELIN, 1880) – NEAGU, p. 32, pl. 8, fig. 1–2.
1966 *Gavelinella intermedia* (BERTHELIN, 1880) – MICHAEL, p. 432, pl. 50, fig. 4–13.
1975 *Gavelinella intermedia* (BERTHELIN, 1880) – SIDÓ, pl. 8, fig. 4–5.
1981 *Gavelinella intermedia* (BERTHELIN, 1880) – JENKINS & MURRAY, p. 194, pl. 7.11, fig. 7–9.
1987 *Gavelinella intermedia* (BERTHELIN, 1880) – WILLIAMSON, p. 56, pl. 2, fig. 9–10.
1988 *Gavelinella intermedia* (BERTHELIN, 1880) – GASINSKI, pl. 15, fig. h.
1990 *Gavelinella intermedia* (BERTHELIN, 1880) – WEIDICH, p. 153, pl. 29, fig. 1–13.

Description: trochospiral and flattened test, involute umbilical and evolute spiral side, curved depressed chambers in the spiral side; rought surface; low interomarginal aperture; calcareous wall.
Distribution: Late Aptian to Late Albian (Newfoundland), Albian (Romania), Aptian to Lover Cenomanian (Germany), Albian to Cenomanian (England).

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Plate 1

(scale: 100µm)
(scanning electron micrographs with the exception of Figs. 4, 5 and 8 which are polarized microscopic photos of the isolated foraminifera)

Figs. 1–2. *Lagenammina grzybowskii* (SCHUBERT, 1901) (sample: 119 m)
Fig. 3. *Glomospira* sp. (sample: 119 m)
Fig. 4. *Spiroplectammina* sp. 1 (sample: 102 m)
Fig. 5. *Spiroplectammina* sp. 2 (sample: 102 m)
Figs. 6–8. *Spiroplectinata complanata* (REUSS, 1860) (sample: 102 m)
Figs. 9–10. *Tritaxia pyramidata* REUSS, 1863 (sample: 104 m)
Fig. 11. *Tritaxia tricarinata* (REUSS, 1845) (sample: 104 m)
Fig. 12. *Dorothia oxycona* (REUSS, 1860) (sample: 106 m)
Fig. 13. *Spirillina* sp. (sample: 119 m)
Fig. 14. *Paleopatellina aptica* (AGALAROVA, 1951) (sample: 108 m)
Fig. 15. *Turrispirillina* sp. (sample: 119 m)
Fig. 16. *Nodosaria obscura* REUSS, 1845 (sample: 119 m)

Plate 1

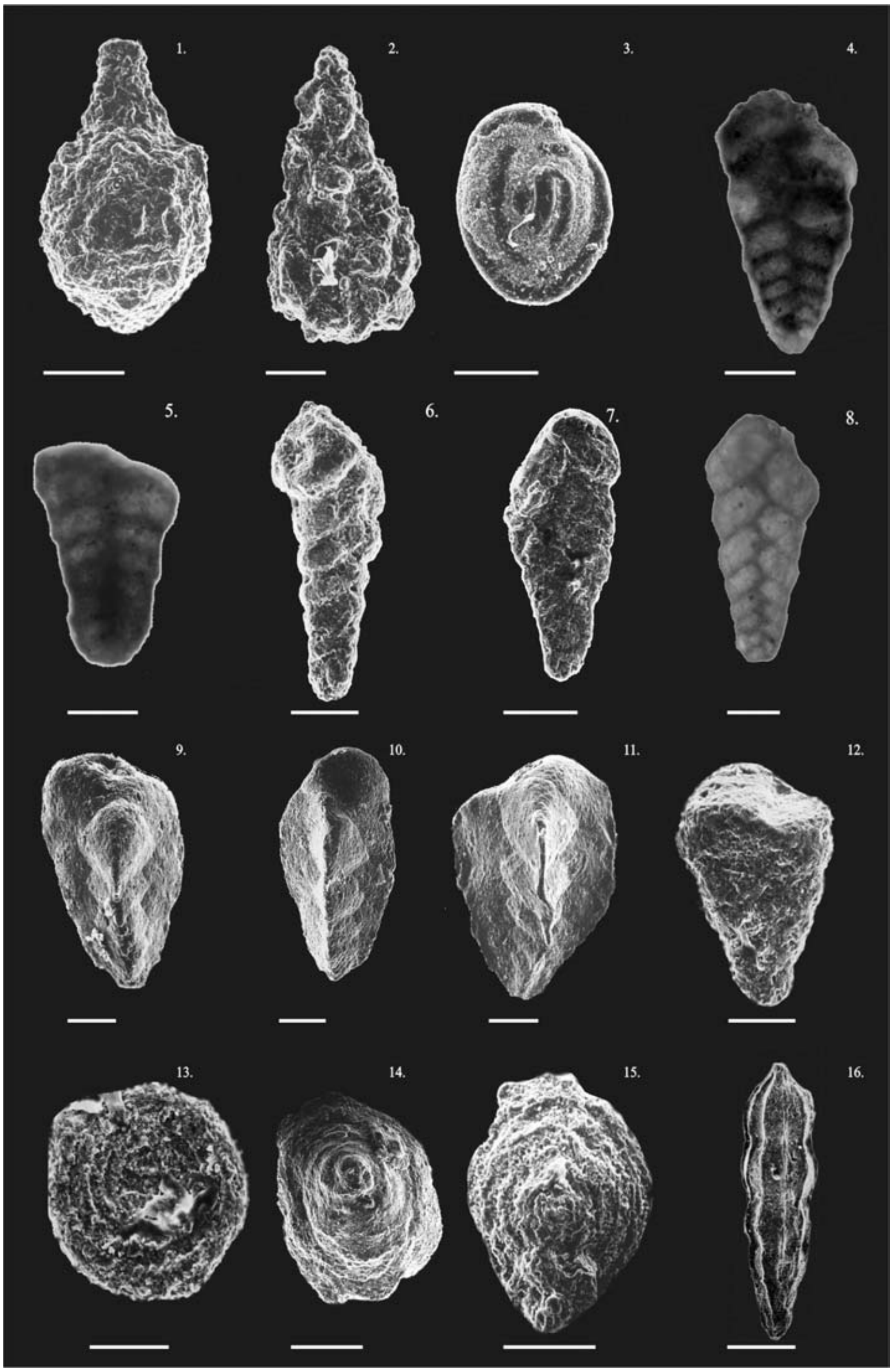

Plate 2

(scale 100µm)
(scanning electron micrographs with the exception of Fig. 12 which is a polarized microscopic photo of the isolated foraminifera)

Fig. 1. *Pseudonodosaria humilis* (ROEMER, 1841) (sample: 119 m)
Fig. 2. *Tristix excavata* (REUSS, 1863) (sample: 140 m)
Fig. 3. *Lenticulina muensteri* (ROEMER, 1839) (sample: 129 m)
Fig. 4. *Lenticulina pulchella* (REUSS, 1863) (sample: 117 m)
Fig. 5. *Lenticulina dunkeri* (REUSS, 1863) (sample: 112 m)
Fig. 6. *Marginulinopsis jonesi* (REUSS, 1863) (sample: 119 m)
Fig. 7. *Astacolus linearis* (REUSS, 1863) (sample: 119 m)
Fig. 8. *Planularia tricarinella* (REUSS, 1863) (sample: 106 m)
Fig. 9. *Psiloctharella striolata* (REUSS, 1863) (sample: 112 m)
Fig. 10. *Vaginulina orthonata* REUSS, 1863 (sample: 106 m)
Fig. 11. *Eoguttulina anglica* CUSHMAN & OZAWA, 1930 (sample: 110 m)
Fig. 12. *Ramulina* sp. (sample: 119 m)
Figs. 13–14. *Epistomina cretosa* TEN DAM, 1947 (sample: 104 m)
Figs. 15–16. *Favusella washitensis* (CARSEY, 1926) (sample: 117 m)

Plate 2

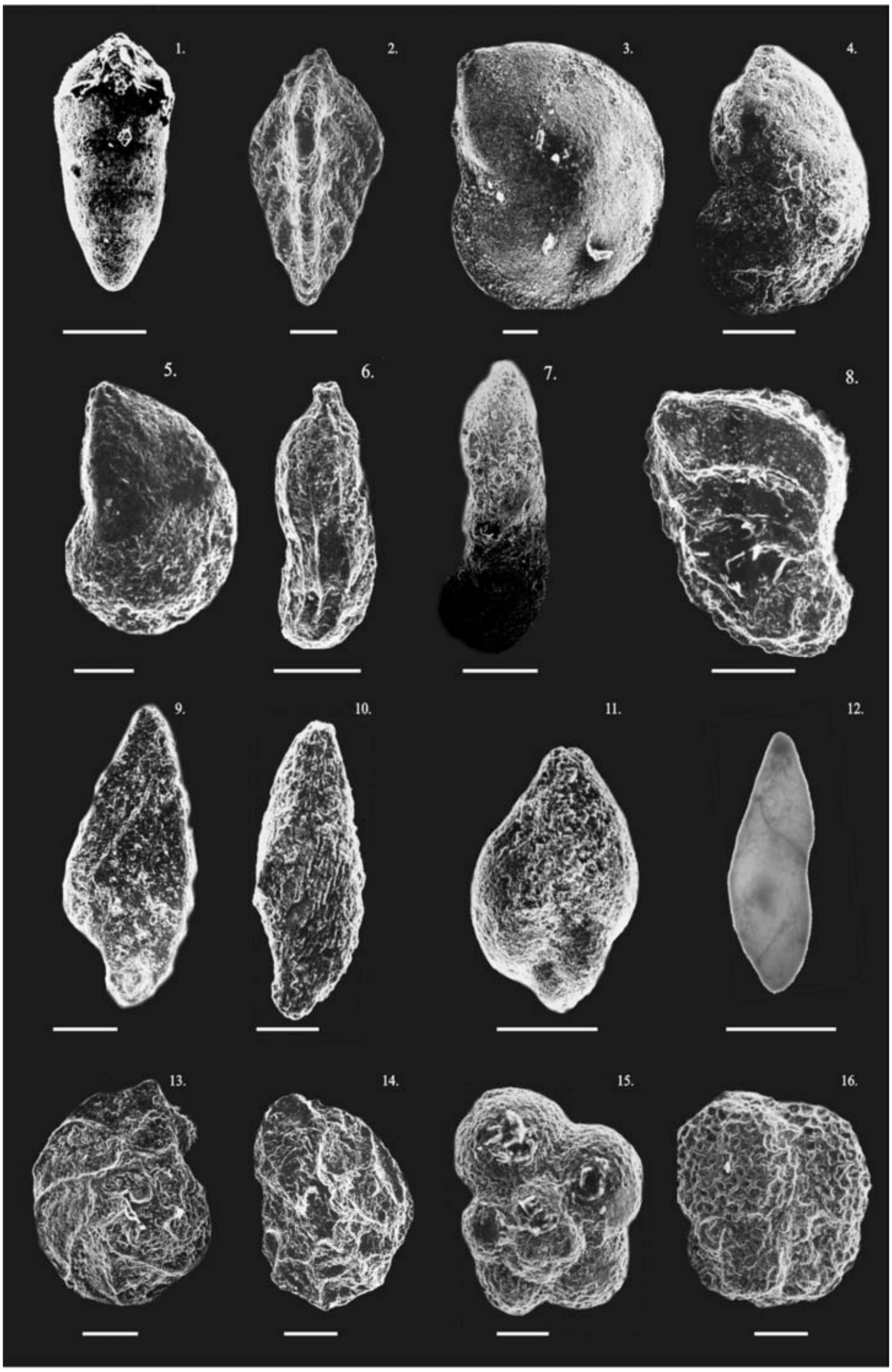

Plate 3

(scale 100μm)

(Figs. 1—8 are scanning electron micrographs, Figs. 9—10 are polarized microscopic photos of isolated teeth, and Figs. 11—19 are polarized microscopic photos of thin sections)

Fig. 1. *Favusella washitensis* (CARSEY, 1926) (sample: 117 m)
Figs. 2–3. *Hedbergella planispira* (TAPPAN, 1940) (sample: 123 m)
Fig. 4. *Hedbergella delrioensis* (CARSEY, 1926) (sample: 117 m)
Figs. 5–6. *Gavelinella intermedia* (BERTHELIN, 1880) (sample: 119 m)
Fig. 7. Sponge spicule, Diactine type - Criccorhabd-shaped (sample: 170 m)
Fig. 8. Sponge spicule, Anactine type - Rhax-shaped (sample: 170 m)
Fig. 9. Shark teeth (sample: 116 m)
Fig. 10. Fish teeth (sample: 132 m)
Fig. 11. *Tritaxia* sp. (sample: 104 m)
Fig. 12. *Orbitolina (Mesorbitolina) texana* (ROEMER, 1849) (sample: 166,4 m)
Fig. 13. *Gavelinella intermedia* (BERTHELIN, 1880) (sample: 112 m)
Figs. 14–15. *Favusella washitensis* (CARSEY, 1926) (sample: 117 m)
Fig. 16. *Spirillina* sp. (sample: 119 m)
Fig. 17. *Cadosina gigantea* BORZA, 1969 (sample: 140 m)
Fig. 18. *Cadosina oraviensis* BORZA, 1969 (sample: 142 m)
Fig. 19. Sponge spicules (sample: 217m)

Plate 3