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Early Cretaceous foraminifera from atoll environment (Márévár Valley, Mecsek Mountains, Hungary)

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(with 9 figures and 3 plates)

This paper presents the microfaunal examination of the Márévár (Eastern Mecsek) occurrence of the Hidasivölgy Marl Formation. The foraminifera-dominated microfauna clearly indicates the type of palaeoenvironment. The foraminiferal assemblage is composed of 35 taxa (frequent genera: *Trocholina, Neotrocholina, Lenticulina, Dentalina, Nodosaria, Spirillina*). The benthic foraminifera fauna is divided into four (A, B, C, D) morphogroups in relation to microhabitat depth in the sediments. Morphogroup A: epifaunal foraminifera (*Neotrocholina, Trocholina, Patellina, Spirillina, Ammodiscus*) live in up to 1 cm depth in the sediment. Morphogroup B: shallow infaunal foraminifera (*Dentalina*, *Nodosaria*, *Pseudonodosaria*) live in depth of less than 5 cm. Morphogroup C: shallow to deep infaunal foraminifers (*Dorothia, Tritaxia, Reophax*) live deeper than 5 cm depth in the sediments. Morphogroup D: epifaunal to deep infaunal foraminifers (lenticulinids) distribute within a wide range of depths in the substrate. The foraminifera assemblage of the Márévár occurrence can be characterized with low diversity and abundance but with significant ratio of morphogroup A (dominance of the trocholinids, neotrocholinids).

The results of the microfauna and macrofauna observations indicate normal salinity, warm water, shallow marine environment in lagoon region. In addition, an input of large amount of volcanic material could be reconstructed for the time. Involving these facts into the presently accepted formation model, the Márévár occurrence of the Hidasivölgy Marl represents an outer part of the lagoon in between the basalt volcano and the atoll situated at the rim of the volcanic build-up during the Early Valanginian. Because of repeated volcanic activity, it is most probable that the lagoon filled up and mixture of volcanic material and sediments redeposited into the deeper slope around the volcanic cone.

Introduction and geological settings

The Early Cretaceous volcanism and the related marine sedimentation are peculiar events of the geological evolution of the Mecsek Mountains. Fundamental evidence of this process was preserved in the sedimentary formations of the Márévár Valley located between Magyaregregy and Kisújbánya, Eastern Mecsek (Tisza Unit) (Fig. 1). This paper summarizes the results of the foraminifera investigation of the formation which has not observed yet from micropalaeontological point of view. On the basis of the results it is possible to create a more precise reconstruction of the palaeoenvironment and to enrich the details of the formation model (CSÁSZÁR, 2002).

The investigated section of the Hidasivölgy Marl Formation is situated at the entrance of the Márévár Valley – in the southern cutting of the stream behind the spa. This outcrop of the formation seemed to be the most proper for the micropalaeontological investigations.

The site formerly was mentioned and described as „Krajcár-malom", the first publication was written by HOFMANN and VADÁSZ (1912). Afterwards HORVÁTH (1968) and CZABALAY (1971) provided new data on the macrofauna and the circumstances of the formation. Czabalay described a rich mollusc fauna – mainly rudists, oysters – while later Tursnek (CSÁSZÁR and TURNSEK, 1997) described many corals (Fig. 2 and 3). According to the former interpretations (VADÁSZ, 1935; HORVÁTH, 1968), the Hidasivölgy Marl sedimented as material eroded by transgression-regression processes, repeated several times.

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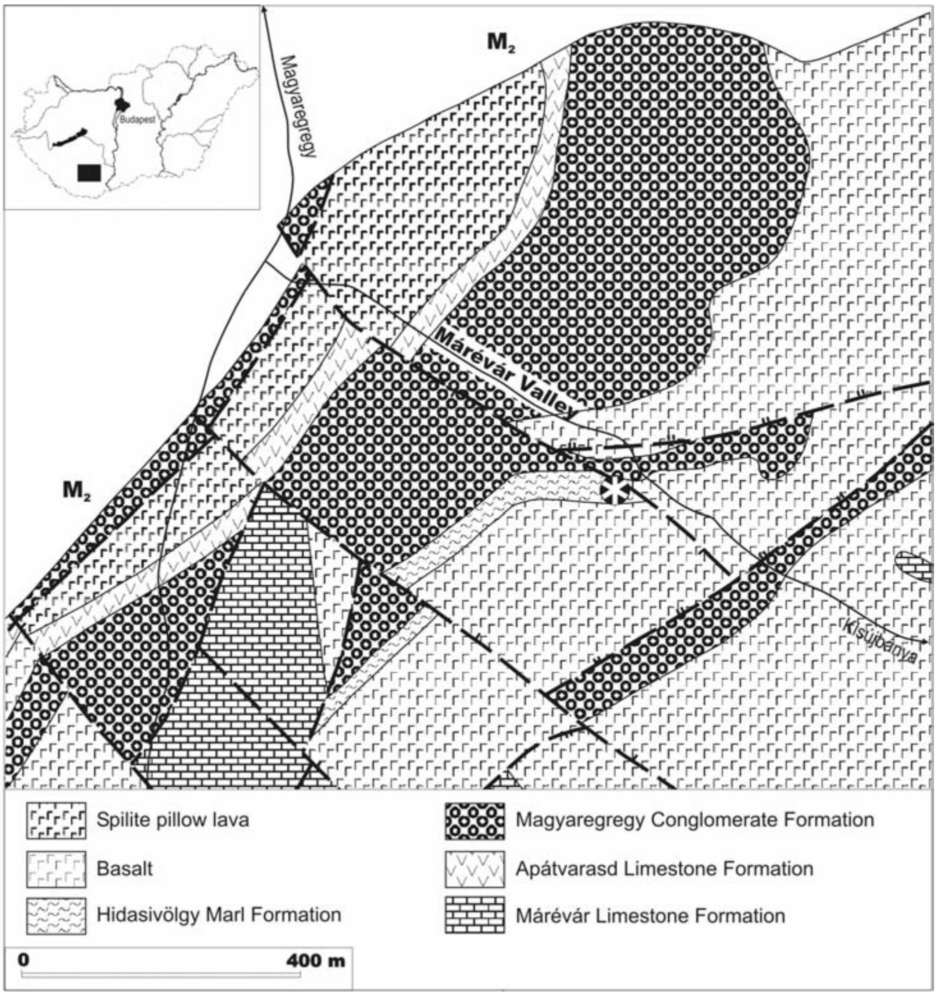

Fig. 1. Geological map of the Márévár Valley (CSÁSZÁR, 2002). Asterisk indicates the investigated section.

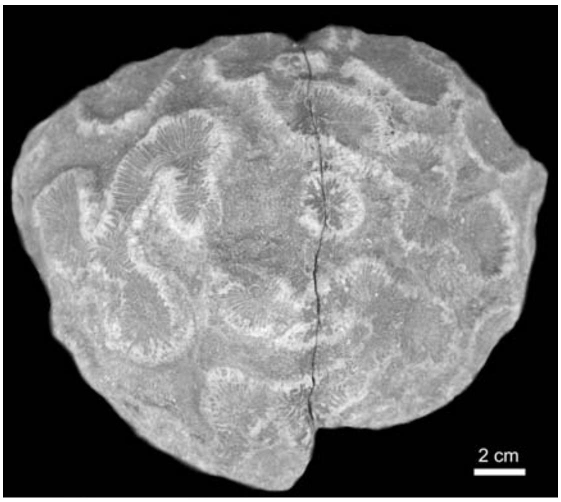

Fig. 2. Colonial coral, a typical macrofauna element in the Hidasivölgy Marl Formation

As a result of the re-investigation of the outcrops CSÁSZÁR (2002) set up another model of the formation of the Lower Cretaceous rocks (Magyaregregy Conglomerate, Hidasivölgy Marl): they are eroded products of the reef sedimentation taken place on the edge of atoll structures surrounding the emerging volcano. The volcanoclastics and skeletal fragments deposited in the basin and on the volcanic slope. The Hidasivölgy Marl Formation in the Márévár Valley is grey or greyish brown in weathered state and consists of calcareous silt-sand with rich fossil content of well-preserved rudists, brachiopods and colony-forming corals. This feature suggests a sedimentation in a relatively shallow region in the vicinity of the reef. Based on the nannoplankton investigations of KOLLÁNYI (in CSÁSZÁR et al., 2000) the age of the formation is Early Valanginian.

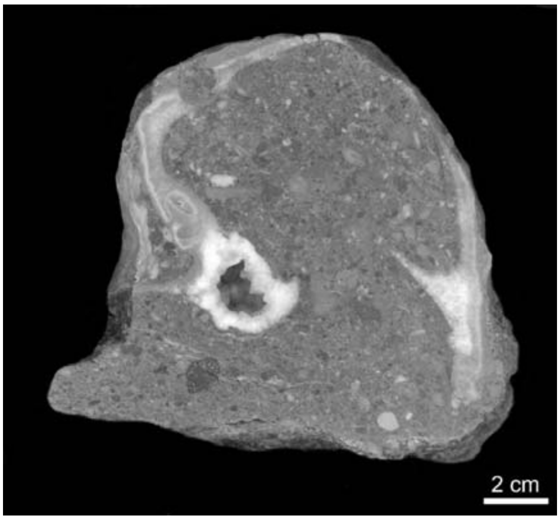

Fig. 3. Polished shell of a rudist filled with marl which contains light bioclasts and dark basalt clasts

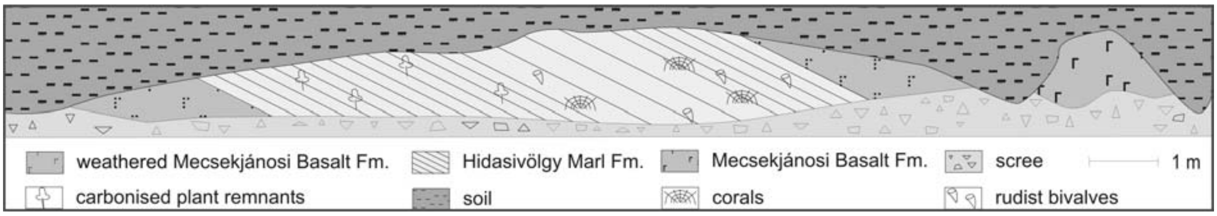

Fig. 4. Section of the Hidasivölgy Marl Formation in Márévár Valley.

Material and methods

Due to the cleaning of the outcrop during the field work the formerly known section could be completed up to 10 metres and the contact of the marl with the Mecsekjános Basalt Formation came to light too. The investigated macrofauna containing greyish-brown calcareous siltstone and silty sandstone interbedded between two basalt bodies (Fig. 4). In order to obtain the microfauna content in good quality, a treatment with hidrogene peroxide was applied on the samples. As a result of the resedimentation of the formation (mixed fauna) the classical investigation (bed by bed sampling) and interpretation along the section could not provide a proper result. For this reason sampling by metres was preferred and the parts with the most representative microfauna could be identified. The microfauna determination was supported with normal thin-section investigation and polarizing microscopic observations of the isolated specimens in transmitted light.

Microfauna studies and palaeoenvironmental interpretation

There are no significant differences in the microfauna content of the samples. The diversity of the fauna is higher in the lower part (0–6 m) than in the higher part (6–10 m) of the section. The microfauna contain predominantly foraminifera. Other microfossils (ostracods, siliceous sponge spicules) are rare. The foraminifera fauna exclusively consists of benthic forms, planktic forms do not appear.

Agglutinated forms – disregarding some samples – are enriched in the lower part of the section.

The foraminifers are dominantly (90%) calcareous, only hyaline forms, agglutinated forms are subordinate (10%). The ratio of the agglutinated/calcareous forms and the abundances of the characteristic taxa are shown in Fig. 5/A, B. The foraminiferal assemblage is composed of 35 taxa. The frequent genera are *Trocholina, Neotrocholina, Lenticulina, Dentalina, Nodosaria, Spirillina*. Trocholinids and neotrocholinids represent 50% of the total foraminifera assemblage (Fig. 5/B).

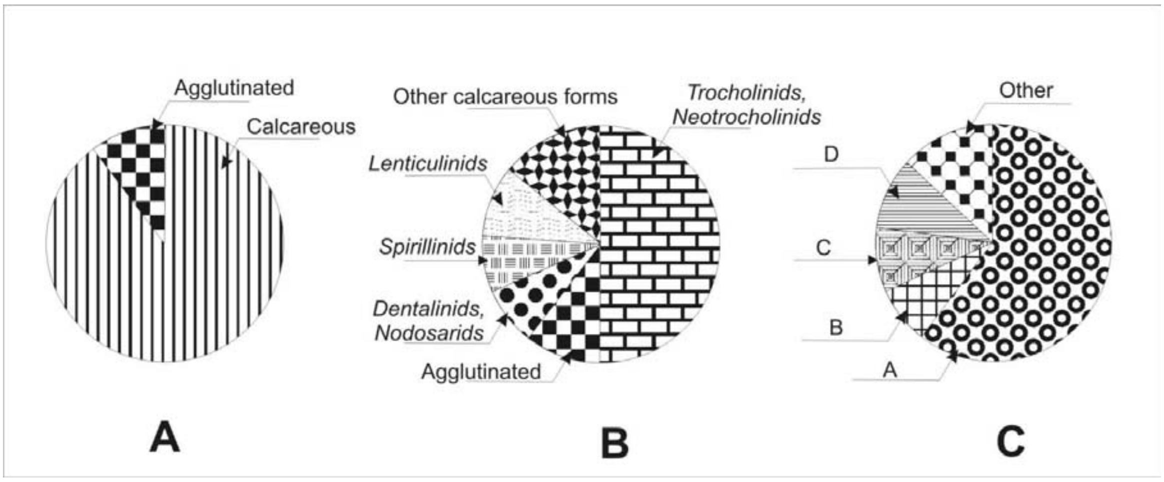

Fig. 5. The ratio of the agglutinated/calcareous forms (A), abundances of the characteristic taxa (B) and the quantitative distribution of the morphogroups (C)

The dominant species show similarities to *Trocholina* cf. *involuta* MANTSUROVA, 1982 and *Neotrocholina* cf. *valdensis* REICHER, 1955 which indicate – in agreement with the former nannoplankton investigations – Valanginian age. Detailed description and determination of trocholinids, neotrocholinids exceed the limits of this publication due to the complexity of the determination and disagreement of the different authors. This topic will be expounded in an other paper under preparation.

According to JONES & CHARNOCK (1985), CORLISS (1991), CORLISS & CHEN (1988), TYSZKA (1994), KOUTSOUKOS et al. (1990), OLÓRIZ et al. (2006) and SZYDLO (2005) the foraminifera assemblage is classified into morphogroups (A, B, C, D)(Fig. 5/C). Fig. 6 summarizes the different morphogroups with their life position and feeding habits.

The four morphogroups of the benthic foraminiferal assemblages can be characterized with the following typical morphological features and microhabitat depth in the sediments:

Epifaunal foraminifera (*Neotrocholina, Trocholina, Patellina, Spirillina, Ammodiscus*) live in less than 1 cm depth in the sediment (CORLISS, 1991). The test form is generally coiled, planispiral to trochospiral (morphogroup A). Except *Ammodiscus*, this group contains calcareous forms. Morphogroup A is dominated by specimens of the family Involutiniidae.

Shallow infaunal foraminifera (*Dentalina*, *Nodosaria*, *Pseudonodosaria*) live in depth of less than 5 cm (OLÓRIZ et al., 2006). The test form is generally elongated, uniserial and the wall is calcareous (morphogroup B).

Shallow to deep infaunal foraminifers (*Dorothia, Tritaxia, Reophax*) live deeper than 5 cm in the sediments. The test form is generally elongated, bi-triserial and the wall is agglutinated (morphogroup C).

Lenticulina lives within a wide range of depths in the substrate because the genus tolerates a wide range of microhabitats from epifaunal to deep infaunal (TYSZKA, 1994; MURRAY, 1991), so this taxon can be classified into a separated morphogroup D.

In general the foraminifera assemblage can be characterized with low diversity and abundance but with significant ratio of morphogroup A (dominance of the trocholinids and neotrocholinids) which determines the palaeoenvironment. According to other researches, the trocholinid group prefers the peri-reef environments (ARNAUD-VANNEAU et al., 1988) and carbonatic platform areas (NEAGU, 1995). NEAGU (1995) studied Berriasian-Valanginian sedimentary rocks from Persani Mountains (Romania) which were formed in litoral peri-reef facies with normal salinity and shallow waters of an inner platform. As a conclusion of STAM (1986), *Spirillina* and *Paalzowella* preferred relatively shallow depth, not more than 50 metres. Predominance and higher diversity of calcareous forms, the lack of the planktonic organisms support the idea of the shallow water palaeoenvironment (DODD & STANTON, 1990). In spite of the shallow marine environment, larger foraminifers and miliolinids are entirely absent from the series, though larger forams are basically very rare in the Valanginian.

In the thin sections the presence of large amount of (mainly volcanic) clasts and the bad preservation of the fragmented faunal elements can be observed (Fig. 7 and 8). Circumstances indicate outline life conditions which are not really apropriate for the microfauna, which may cause the low diversity and small quantity of the foraminifera. This statement and the bad preservation (taphonomy) of the fauna suggest a resedimentation process on the slope of the volcano.

Based on my results and the publications cited above, the microfauna investigations of the formation suggest shallow marine, warm water with normal salinity, inner platform palaeoenvironment in the Early Valanginian. This interpretation can be integrated into the presently accepted formation model (CSÁSZÁR, 2002) about basaltic volcanoes with surrounding atoll structures. In this model, the investigated samples represent the outer part of the lagoon (Fig. 9). It is very probable that this lagoonal region became gradually filled up by continuous volcanic activity and its material – mixing with the basic volcanite – was resedimented on the deeper part of the volcanic slope.

Taxa	Test form	Life position	Feeding strategy	Morphogroup
Neotrocholina	planispiral to trochospiral, coiled	Epifaunal	primary weed fauna, grazing herbivores/ detritivores	A
Trocholina				
Patellina				
Spirillina				
Ammodiscus			active deposit feeder	
Dentalina	elongated, uniserial (calcareous)	Shallow infaunal	deposit feeder/grazing omnivores	B
Nodosaria				
Pseudonodosaria				
Dorothia	elongated, biserial, triserial (agglutinated)	Shallow to deep infaunal	deposit feeder	C
Tritaxia				
Reophax				
Lenticulina	Lenticular	Epifaunal to deep infaunal	active deposit feeder/grazing omnivores	D

Fig. 6. The classification of the studied foraminifera, morphogroups, life position and feeding strategy

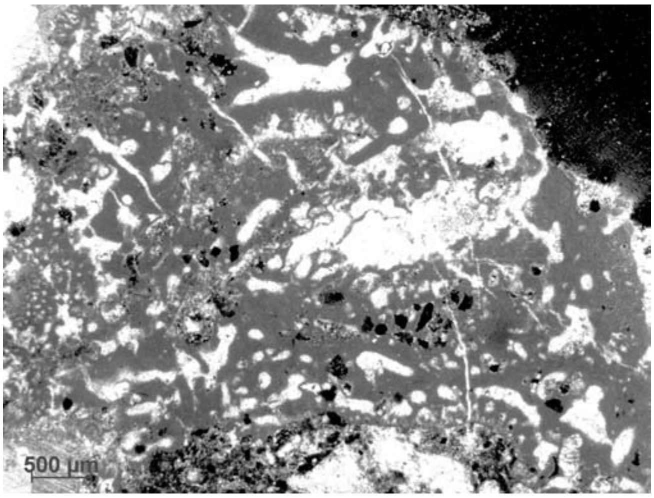

Fig. 7. Coral fragments and basalt clasts in marl

Conclusion

This paper summarizes the results of the microfauna investigations of the Hidasivölgy Marl Formation in the Márévár Valley (Mecsek Mountains, Hungary). The microfauna is dominated by the foraminifera which – in spite of the relatively bad preservation – provide indicative data for palaeoenvironment reconstruction. Based on the interpretation of the microfauna, the morphogroups and their comparison with the references, the macrofauna (rudists and corals) observations and the textural features suggesting the mixing with large amount of volcanic material, the palaeoenvironmental reconstruction could be established. The foraminifera assemblage indicates shallow marine environment with normal salinity, warm water lagoon in the Early Valanginian. This conclusion can be incorporated into the presently accepted formation model (CSÁSZÁR, 2002). It means that the Márévár occurrence of the Hidasivölgy Marl formed at an outer lagoonal region between the basaltic volcano and the atoll structure in the Early Valanginian. As the consequence of repeated volcanic activity, the lagoonal region may have filled up and the volcanic material mixed with the sediments, then resedimented into the deeper part of the slope of the volcanic cone.

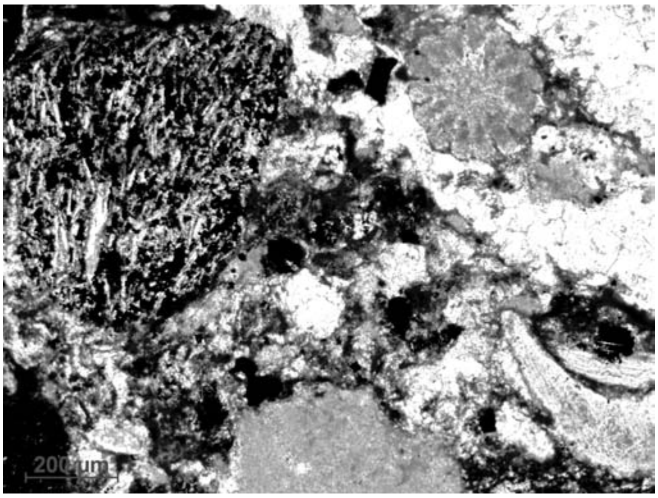

Fig. 8. Rudists, oysters and echinoid spine fragments with basalt clast in Hidasivölgy Marl Formation

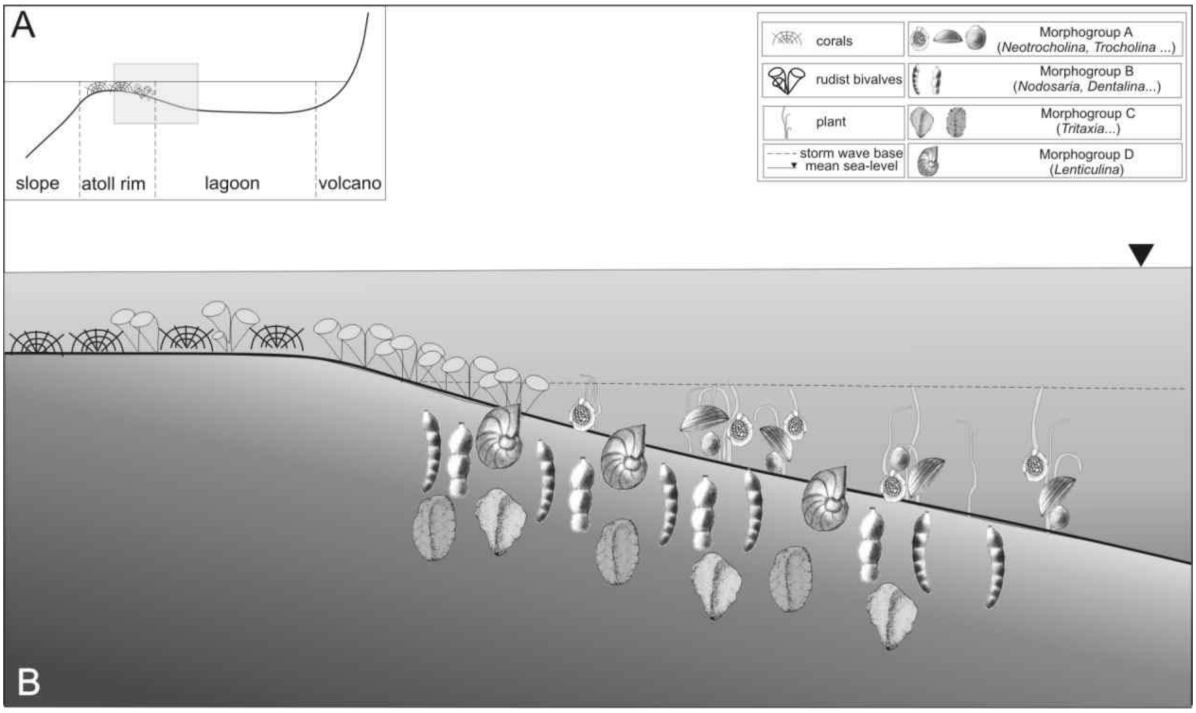

Fig. 9 (A) Palaeoenvironmental reconstruction of the Mecsek-type atoll (based on CSÁSZÁR, 2002). (B) The enlarged section of the schematic model shows the distribution of the foraminifera fauna, the microhabitat depth and life position in the sediment of the atoll structure.

Acknowledgements

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Systematic description

After LOEBLICH & TAPPAN (1988, 1992)

CLASS FORAMINIFEREA J.J. LEE, 1990

Order Lituolida LANKESTER, 1885
Superfamily Ammodiscacea REUSS, 1862
Family Ammodiscidae REUSS, 1862
Genus *Ammodiscus* REUSS,1862

Ammodiscus cretaceus (REUSS, 1862)
(Plate 1, Figure 1)

1989 *Ammodiscus cretaceus* (REUSS, 1862) - RIEGRAF & LUTERBACHER p. 1087, pl. 1, fig. 7.
2008 *Ammodiscus cretaceus* (REUSS, 1862) – MOULLADE et al. pl. 1, fig. 1–2.

Description: Test discoidal (compressed), planispirally enrolled, evolute; undivided tubular chambers with numerous closely pressed whorls, evenly increasing chambers; aperture at the end of the tubular chamber; agglutinated wall.

Superfamily Hormosinacea HAECKEL, 1894
Family Hormosinidae HAECKEL, 1894
Genus *Reophax* de MONFORT, 1808

Reophax sp.
(Plate 1, Figure 2)

Description: Test elongated; few rounded chambers, rapidly increasing; coarsely agglutinated wall.

Superfamily Verneuilinacea CUSHMAN, 1911
Familiy Tritaxiidae PLOTNIKOVA, 1979
Genus *Tritaxia* REUSS, 1860

Tritaxia pyramidata REUSS, 1863
(Plate 1, Figure 3)

1863 *Tritaxia pyramidata* REUSS, p. 32, pl. 1, fig. 9.
1994 *Tritaxia pyramidata* REUSS, 1863 - MEYN & VESPERMANN, p. 76, pl. 4, fig. 3–8.

Description: Test triserial, triangular in cross-section; generally concave sides but may be straight; inflated chambers with depressed suture, rounded last chamber; rounded and terminal aperture at the inner margin in the triserial stage; agglutinated wall.

Tritaxia tricarinata (REUSS, 1845)
(Plate 1, Figure 4)

1965 *Tritaxia tricarinata* (REUSS, 1845) - NEAGU, p. 6, pl. 1, fig. 17–18.
1990 *Tritaxia tricarinata* (REUSS, 1845) - WEIDICH, p. 106, pl. 12, fig. 24.

Description: Test triserial with sharp edges, triangular in cross-section; strongly concave sides; slightly inflated chambers with strongly depressed suture; rounded and terminal aperture at the inner margin in the triserial stage; agglutinated wall.

Order Textulariida LANKESTER, 1885
Superfamily Textulariacea EHRENBERG, 1838
Family Eggerellidae CUSHMAN, 1937
Genus *Marssonella* CUSHMAN, 1933

Marssonella cf. *kummi* (ZEDLER, 1961)
(Plate 1, Figure 5)

1989 *Protomarssonella kummi* (ZEDLER, 1961) - RIEGRAF & LUTERBACHER p. 1096, pl. 3, figs. 6–7.
2007 *Marssonella kummi* (ZEDLER, 1961) - ABU-ZIED pl. 8, fig. U-V.

Description: Test conical, circular in section, with thiny early trochospire; several chambers per whorl followed by a biserial stage of chambers rapidly increasing in diameter; a low basal arched aperture with a narrow bordering flap; agglutinated wall.

Remark: Determination as cf. is because of the poor preservation and the limited references.

Marssonella sp.
(Plate 1, Figure 6)

Description: Test conical, circular in section, with thiny early trochospire; several chambers per whorl followed by a biserial stage of evenly increasing in diameter; a low basal aperture; agglutinated wall.

Order Spirillinida GORBACHIK & MANTSUROVA, 1980

Suborder Involutinina HOHENEGGER & PILLER, 1975
Family Involutinidae BÜTSCHLI, 1880
Genus *Trocholina* PAALZOW, 1922

Trocholina conica (SCHLUMBERGER, 1898)
(Plate 1, Figure 7–8)

1947 *Trocholina conica* (SCHLUMBERGER, 1898) - HENSON pl. 12, Fig. 9.
1988 *Trocholina conica* (SCHLUMBERGER, 1898) - OLSZEWSKA & WIECZOREK pl. 2, fig. 27.

Description: Test flat conical; globular proloculus followed by trochospirally enrolled tubular second chamber, all whorls visible on the convex spiral side, only the final whorl visible on the umbilical side; nodes and pillars of lamellar structure around the wide umbilicus; deep periumbilical ditch; regular, circularly ordered nodes; radial striae; aperture at the end of the tubular chamber; coarsely perforated wall.

Trocholina campanella ARNAUD-VANNEAU, 1988
(Plate 1, Figure 9)

1988 *Trocholina campanella* - ARNAUD-VANNEAU p. 359, pl. 1, figs. 2-3

Description: Test steep conical; globular proloculus followed by trochospirally enrolled tubular second chamber, all whorls visible on the convex spiral side, only the final whorl visible on the umbilical side; less visible nodes; aperture at the end of the tubular chamber; coarsely perforated wall.

Trocholina cf. *involuta* MANTSUROVA, 1982
(Plate 1, Figure 10)

1995 *Trocholina involuta* MANTSUROVA, 1982 - NEAGU p.6 , pl. 7, fig. 60-73, pl. 9, fig. 16-19.

Description: Test steep conical; globular proloculus followed by trochospirally enrolled tubular second chamber, all whorls visible on the convex spiral side, only the final whorl visible on the umbilical side; very bulging, large, irregular nodes; light, radial striae; aperture at the end of the tubular chamber; coarsely perforated wall.
Remark: Determination as cf. is because of the poor preservation and the limited references.

Genus *Neotrocholina* REICHEL, 1956

Neotrocholina cf. *burgeri* (EMBERGER, 1955)
(Plate 2, Figure 11)

1995 *Neotrocholina burgeri burgeri* (EMBERGER, 1955) - Neagu p.16 , pl. 1, fig. 1-12, 17-20, 2-24, 27-28.

Description: Test flat conical; globular proloculus followed by trochospirally enrolled tubular second chamber, all whorls visible on the convex spiral side, only the final whorl visible on the umbilical side; well-developed periumbilical ditch; thick, radial striae; irregular nodes; aperture at the end of the tubular chamber; coarsely perforated wall.

Remark: Determination as cf. is because of the poor preservation conditions and the limited references.

Neotrocholina cf. *valdensis* REICHER, 1955
(Plate 2, Figure 12)

1955 *Neotrocholina valdensis* - REICHER p. 404, p. 16 figs. 5a-b.
1995 *Neotrocholina valdensis valdensis* REICHER, 1955 - Neagu p.10 , pl. 2, fig. 13-21, 28-44, 49-51.

Description: Test flat conical; globular proloculus followed by trochospirally enrolled tubular second chamber, all whorls visible on the convex spiral side, only the final whorl visible on the umbilical side; light, periumbilical ditch; radial striae; irregular nodes; aperture at the end of the tubular chamber; coarsely perforated wall.

Remark: Determination as cf. is because of the poor preservation conditions and the limited references.

Suborder Spirillinina HOHENEGGER & PILLER, 1975
Family Spirillinidae REUSS & FRITSCH, 1861
Genus *Spirillina* EHRENBERG, 1843

Spirillina elongata (BIELECKA and POZARYSKI, 1954)
(Plate 1, Figure 13)

1970 *Spirillina elongata* (BIELECKA & POZARYSKI, 1954) – Winter, p. 41, pl. 4, fig. 141.

Description: Test discoidal (compressed), planispiral, evolute; tubular chambers with 5–6 closely apressed whorls; aperture at the end of the tubular chamber; hyaline calcareous wall.

Spirillina infima (STRICKLAND, 1846)
(Plate 1, Figure 14)

1988 *Spirillina infima* (STRICKLAND, 1846) – OLSZEWSKA & WIECZOREK pl. 2, fig. 16.
1989 *Spirillina infima* (STRICKLAND, 1846) – GREGORY p. 187, pl.1, fig. 22.

Description: Test discoidal (circular), planispiral, evolute; tubular chamber with 5–6 closely apressed whorls, rapidly increasing last chambers; aperture at the end of the tubular chamber; hyaline calcareous wall.

Family Patellinidae RHUMBLER, 1906
Genus *Patellina* WILLIAMSON, 1858

Patellina feifeli (PAALZOW, 1932)
(Plate 1, Figure 15)

1970 *Patellina feifeli feifeli* (PAALZOW, 1932) – WINTER, p. 42, pl. 4, fig. 146.
2007 *Patellina feifeli* (PAALZOW, 1932) – ABU-ZIED pl. 8, fig. G'-H'.

Description: Test low conical, 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.

Patellina sp.
(Plate 1, Figure 16)

Description: Test flat conical, all chambers visible on the convex side, only the final pair of the last whorl is visible on the flattened umbilical side; arched aperture on the umbilical side; calcareous wall.

Order Lagenida LANKESTER, 1885
Superfamily Nodosariacea EHRENBERG, 1838
Family Nodosariidae EHRENBERG, 1838
Genus *Dentalina* Risso, 1826

Dentalina communis (D'ORBIGNY, 1826)
(Plate 2, Figure 1)

1951 *Dentalina communis* (D'ORBIGNY, 1826) - BARTENSTEIN & BRAND, p. 485, pl. 9, figs. 228–231.
1970 *Dentalina communis* (D'ORBIGNY, 1826) - WINTER, p. 19, pl. 3, fig. 70.

Description: Test uniserial, elongated, slightly arched; oval 5–6 chambers, circular in cross section, gradually enlarging chambers; slightly depressed, curved sutures, radiate aperture on the end of the final chamber; calcareous, hyaline wall.

Genus *Laevidentalina* LOEBLICH & TAPPAN, 1986

Laevidentalina nana (REUSS, 1863)
(Plate 2, Figure 2)

1863 *Dentalina nana* m. - Reuss, p. 39, pl. 2, fig. 10, 18.
1994 *Laevidentalina nana* (REUSS, 1863) - MEyn & VESPERMANN, p. 85, pl. 7, fig. 8–16, pl. 8, fig. 1–3.

Description: Test uniserial, elongated, slightly arched; oval 5–6 chambers, circular in cross section, gradually enlarging chambers; slightly depressed, curved sutures; smooth surface; rounded aperture in the end of the final chamber; calcareous, hyaline wall.

Genus *Nodosaria* LAMARCK, 1812

Nodosaria cf. *lirulata* LOEBLICH & TAPPAN, 1950
(Plate 2, Figure 3)

1991 *Nodosaria lirulata* LOEBLICH & TAPPAN, 1950 - BHALLA & TALIB, p. 96, pl. 1, fig. 7

Description: Test uniserial, elongated, somewhat arched; oval chambers, rounded in cross section; deeply depressed sutures; numerous lenghtwise ribs; terminal aperture on the end of the final chamber; calcareous, hyaline wall.

Remark: Determination as cf. is because of the poor preservation and the limited references.

Nodosaria sp.1.
(Plate 2, Figure 4)

Description: Test uniserial, elongated; ~4 rounded chambers, circular in cross section; gradually enlarging chambers; deeply depressed sutures; smooth surface; calcareous, hyaline wall.

Nodosaria sp.2.
(Plate 2, Figure 5)

Description: Test uniserial, elongated; rounded chambers, circular in cross section; deeply depressed sutures; smooth surface; terminal rounded aperture in the end of the final chamber; calcareous, hyaline wall.

Genus *Lingulina* D'ORBIGNY, 1826

Lingulina loryi (BERTHELIN, 1880)
(Plate 2, Figure 6)

1989 *Lingulina loryi* (BERTHELIN, 1880) - RIEGRAF & LUTERBACHER p. 1101, pl. 4, figs. 1–10.
2007 *Lingulina loryi* (BERTHELIN, 1880) - ABU-ZIED pl. 8, fig. J.

Genus *Frondicularia* DEFRANCE, 1826

Frondicularia lamellata TAPPAN, 1940
(Plate 2, Figure 7)

1982 *Frondicularia lamellata* TAPPAN, 1940 - HAIG pl. 3, figs. 25–29.
1998 *Frondicularia lamellata* Tappan, 1940 - HOLBURN & MOULLADE p. 355, pl. 2, fig. 5.

Description: Test compressed palmate, lanceolate; irregularly increasing flat chambers with depressed highly arched suture; terminal aperture in the end of the final chamber; calcareous wall.

Genus Tristrix MACFADYEN, 1941

Tristix cf. *excavata* (REUSS, 1863)
(Plate 2, Figure 8)

2007 *Tristix excavata* (REUSS, 1863) - GRADSTEIN pl. 3, fig. 10
2007 *Tristix excavata* (REUSS, 1863) - ABU-ZIED pl. 9, fig. N.

Description: Test elongated with sharp edges, uniserial, triangular in cross-section; strongly concave sides; oval chambers with strongly depressed suture; terminal depressed aperture; calcareous, hyaline wall.
Remark: Determination as cf. is because of the poor preservation and the limited references.

Family Vaginulinidae REUSS, 1860
Genus *Lenticulina* LAMARCK, 1804

Lenticulina muensteri (ROEMER, 1839)
(Plate 2, Figure 9)

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.
1994 *Lenticulina muensteri* (ROEMER, 1839) - MEYN & VESPERMANN, p. 130, pl. 23, fig. 12–17, pl. 24, fig. 1–17, pl. 25, fig. 1–3.

Description: Test planispiral; several chambers by whorl, slowly increasind chambers, sharp smooth edge; slightly dipping suture (rib); broad sutural nodes in the central region; smooth surface; radiate terminal aperture in the peripheral angle; calcareous, hyaline wall.

Lenticulina roemeri (REUSS, 1863)
(Plate 2, Figure 10)

1863 *Cristellaria roemeri* m. - REUSS, p. 75, pl. 8, fig. 9.
1994 *Lenticulina roemeri* (REUSS, 1863) - MEYN & VESPERMANN, p. 145, pl. 28, fig. 1–9.

Description: Test planispiral; lots of slowly increasing chambers, slightly uncoiled last chambers, straight terminal chambers; sharp wide smooth edge; radial curved sutures (rib); broad sutural nudes in the central region, rought surface; radiate aperture in the peripheral angle; calcareous, hyaline wall.

Lenticulina macrodisca (REUSS, 1863)
(Plate 2, Figure 11)

1863 *Cristellaria macrodisca* m. - REUSS, p. 78, pl. 9, fig. 5a, b.
1990 *Lenticulina macrodisca* (REUSS, 1863) - WEIDICH, p. 124, pl. 21, fig. 1-2.

Description: Test planispiral; numerous slowly increasing chambers, straight terminal chambers; sharp narrow smooth edge, broad sutural nudes in the central region, smooth surface, circular outline; radiate aperture in the peripheral angle; calcareous, hyaline wall.

Lenticulina nodosa (REUSS, 1863)
(Plate 2, Figure 12)

1963 *Robulina nodosa* m. - REUSS, p.78, pl. 9, fig. 6.
1994 *Lenticulina nodosa* (REUSS, 1863) - MEYN & VESPERMANN, p. 146, pl. 29, fig. 9–14, pl. 30, fig. 1–6.

Description: Test planispiral; lots of slowly increasing chambers, uncoiled last chambers; sharp narrow smooth edge, sharp radial slightly curved sutures (rib); rought surface, straight terminal chambers; radiate aperture in the peripheral angle; calcareous, hyaline wall.

Lenticulina sp.
(Plate 2, Figure 13)

Description: Test planispiral, lots of chambers, uncoiled last chambers, straight terminal chambers; sharp crisscross edge; sharp radial curved sutures (rib); rough surface; radiate aperture in the peripheral angle; calcareous, hyaline wall.

Lenticulina dunkeri (Reuss, 1863)
(Plate 2, Figure 14)

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: Test planispiral; numerous of chambers, uncoiled last chambers, terminal chambers; sharp narrow edge; lightly curved sutures (rib); smooth surface, radiate aperture in the peripheral angle; calcareous, hyaline wall.

Genus *Astacolus* DE MONTFORT, 1808
Astacolus schloenbachi (REUSS, 1863)
(Plate 2, Figure 15)

1863 *Cristellaria Schlönbachi* m. - REUSS, p. 65, pl. 6, fig. 14–15.
1994 *Astacolus schloenbachi* (REUSS, 1863) - MEYN & VESPERMANN, p. 186, pl. 41, fig. 16–17, pl. 42, fig. 1–6.

Description: Test elongated; first coiled, later uncoiled chambers, oval chambers in cross section; deep straight sutures; rough surface; radiate aperture in the dorsal angle; calcareous wall.

Genus *Psilocitharella* LOEBLICH and TAPPAN, 1986

Psilocitharella kochi (ROEMER, 1841)
(Plate 2, Figure 16)

1951 *Vaginulina kochi* ROEMER, 1841 - BARTENSTEIN & BRAND, p. 293, pl. 6, figs. 158–159.
1994 *Psilocitharella kochi kochi* (ROEMER, 1841) - MEYN & VESPERMANN, p. 230, pl. 47, fig. 11–18.

Description: Test compressed, triangular in outline, strongly compressed, sharp carinate, early portion rounded, coiled; chambers increase rapidly in size; cross rib; aperture in the dorsal angle; calcareous, hyaline wall.

Psilocitharella striolata (REUSS, 1863)
(Plate 2, Figure 17)

1863 *Vaginulina striolata* m. - REUSS, p. 46 , pl. 3, fig. 6.
1994 *Psilocitharella striolata* (REUSS, 1863) - MEYN & VESPERMANN, p. 235, pl. 57, fig. 10–15.

Description: Test strongly compressed, triangular in outline; early portion of chambers rounded, coiled, chambers increase rapidly in size; radiate aperture in the dorsal angle; calcareous, hyaline wall.

Psilocitharella cf. *arguta* (REUSS, 1863)
(Plate 2, Figure 18)

1863 *Vaginulina arguta* m. - REUSS, p. 47 , pl. 8, fig. 4.
2007 *Psilocitharella arguta* (REUSS, 1863) - ABU-ZIED pl. 9, fig. L'-M'.

Description: Test compressed, triangular in outline, strongly compressed, sharp carinate, early portion rounded, coiled and bulged; chambers increase rapidly in size; oval aperture in the dorsal angle; calcareous, hyaline wall.
Remark: Determination as cf. is because of the poor preservation conditions and the limited references.

Superfamily Polymorphinacea D'ORBIGNY, 1839
Family Polymorophinidae D'ORBIGNY, 1839
Genus *Eoguttulina* Cushman & OZAWA, 1930

Eoguttulina sp.
(Plate 2, Figure 19)

Description: Test oval, rounded in cross section; elongated inflated chambers, quickly increasing in size; slightly depressed suture; smooth surface; terminal depressed aperture; calcareous wall.

Genus *Ramulina* T. R. JONES, 1875
Ramulina sp.
(Plate 2, Figure 20)

Description: Test globular, elongated; chambers loosely connected by stolon like necks; rough surface; calcareous wall.

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Plate 1

Fig. 1 *Ammodiscus cretaceus* (REUSS, 1862)

Fig. 2 *Reophax* sp.

Fig. 3 *Tritaxia pyramidata* REUSS, 1863

Fig. 4 *Tritaxia tricarinata* (REUSS, 1845)

Fig. 5 *Marssonella* cf. *kummi* (ZEDLER, 1961)

Fig. 6 *Marssonella* sp.

Figs. 7–8 *Trocholina conica* (SCHLUMBERGER, 1898)

Fig. 9 *Trocholina campanella* ARNAUD-VANNEAU, 1988

Fig. 10 *Trocholina* cf. *involuta* MANTSUROVA, 1982

Fig. 11 *Neotrocholina* cf. *burgeri* (EMBERGER, 1955)

Fig. 12 *Neotrocholina* cf. *valdensis* REICHER, 1955

Fig. 13 *Spirillina elongata* (BIELECKA and POZARYSKI, 1954)

Fig. 14 *Spirillina infima* (STRICKLAND, 1846)

Fig. 15 *Patellina feifeli* (PAALZOW, 1932)

Fig. 16 *Patellina* sp.

(scale: 100μm)
(scanning electron micrographs with the exception of Figs 7, 10, 11 and 12 which are polarized microscopic photos of the isolated foraminifera)

Plate 1

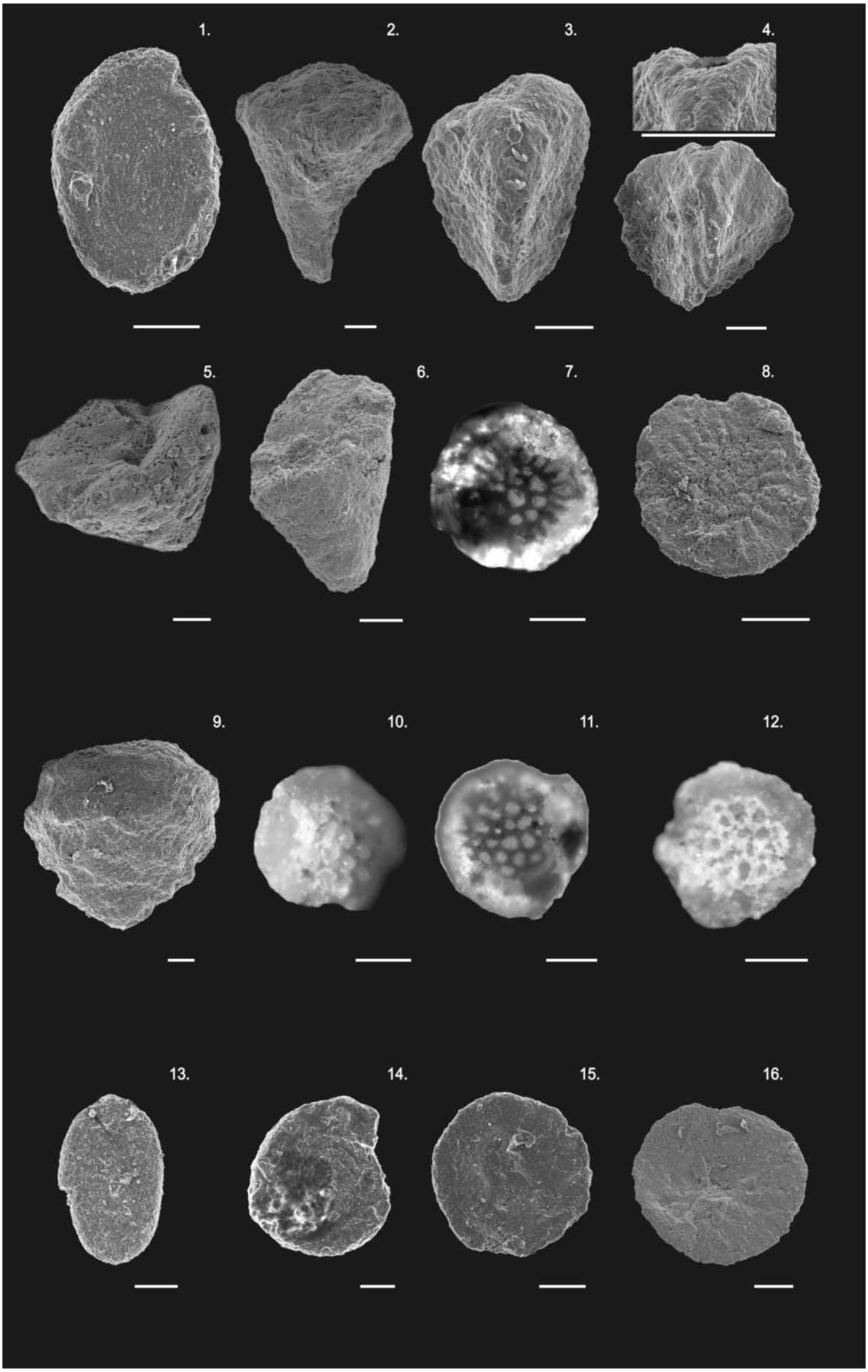

Plate 2

Fig. 1 *Dentalina communis* (D'ORBIGNY, 1826)

Fig. 2 *Laevidentalina nana* (REUSS, 1863)

Fig. 3 *Nodosaria* cf. *lirulata* LOEBLICH and TAPPAN, 1950

Fig. 4 *Nodosaria* sp.1.

Fig. 5 *Nodosaria* sp.2.

Fig. 6 *Lingulina loryi* (BERTHELIN, 1880)

Fig. 7 *Frondicularia lamellata* TAPPAN, 1940

Fig. 8 *Tristix* cf. *excavata* (REUSS, 1863)

Fig. 9 *Lenticulina muensteri* (ROEMER, 1839)

Fig. 10 *Lenticulina roemeri* (REUSS, 1863)

Fig. 11 *Lenticulina macrodisca* (REUSS, 1863)

Fig. 12 *Lenticulina nodosa* (REUSS, 1863)

Fig. 13 *Lenticulina* sp.

Fig. 14 *Lenticulina dunkeri* (REUSS, 1863)

Fig. 15 *Astacolus schloenbachi* (REUSS, 1863)

Fig. 16 *Psilocitharella kochi* (ROEMER, 1841)

Fig. 17 *Psilocitharella striolata* (REUSS, 1863)

Fig. 18 *Psilocitharella* cf. *arguta* (REUSS, 1863)

Fig. 19 *Eoguttulina* sp.

Fig. 20 *Ramulina* sp.

scale: 100µm)
(scanning electron micrographs of the isolated foraminifera)

Plate 1