

Proceedings of the Eighth International Workshop on Agglutinated Foraminifera



IWAF-8

Cluj-Napoca 2008

Edited by:
M.A. Kaminski
& **S. Filipescu**

**Proceedings of the Eighth International
Workshop
On Agglutinated Foraminifera
(Cluj-Napoca, Romania, September 7-13, 2008)**

Edited by

Michael A. Kaminski
Earth Sciences Department,
King Fahd University of Petroleum & Minerals,
Dhahran, 31261, Saudi Arabia

and

Sorin Filipescu
Department of Geology,
Babeş–Bolyai University,
Str. Kogălniceanu 1, Cluj-Napoca, 400084, Romania

Published by

The Grzybowski Foundation

Grzybowski Foundation Special Publication No. 16

Upper Cretaceous Deep-Water Agglutinated Foraminifera from the Contessa Highway Section, Umbria-Marche Basin, Italy: Taxonomy and Biostratigraphy

MICHAEL A. KAMINSKI¹, CLAUDIA G. CETEAN², RAMONA BĂLC³, and RODOLFO COCCIONI⁴

1. Department of Earth Sciences, University College London, Gower Street, London WC1E 6BT, U.K.; *Current address*: Earth Sciences Department, King Fahd University of Petroleum & Minerals, Dhahran, 31261, Saudi Arabia; e-mail: kaminski@kfupm.edu.sa

2. Department of Geology, Babeş-Bolyai University, M. Kogălniceanu 1, 400084, Cluj Napoca, Romania; current address: Institute of Geological Sciences, Polish Academy of Sciences, ul. Senacka 1, 31-002 Kraków, Poland; e-mail: ndcetean@cyf-kr.edu.pl

3. Faculty of Environmental Science, Babeş-Bolyai University, str. Fântânele 30, 400294, Cluj Napoca, Romania

4. Dipartimento della Terra, della Vita e dell'Ambiente, Università degli Studi di Urbino "Carlo Bo", Campus Scientifico, Località Crocicchia, 61029, Urbino, Italy; email: cron@info-net.it

ABSTRACT

The taxonomy and biostratigraphy of deep-water agglutinated foraminifera (DWAF) are documented in a 299 m thick section collected from the Upper Cretaceous (Turonian to Maastrichtian) of the Scaglia Bianca and Scaglia Rossa Formations in the Contessa Highway section of Italy. A total of 94 species belonging to 48 genera are documented from the section, including two new species: *Subreophax longicameratus* n.sp., and *Hormosinella fusiformis* n.sp.. The DWAF assemblages display a general trend of increasing abundance and diversity from the Cenomanian/Turonian boundary to the Cretaceous/Paleogene boundary.

The biostratigraphy of DWAF in the Upper Cretaceous part of the Contessa Highway section is calibrated to the 2008 ICS timescale by means of the calcareous nannofossil biostratigraphy. Nine calcareous nannofossil biozones are determined in the interval CC10 to CC26, but some of the Upper Cretaceous nannofossil biozones could not be determined owing to poor preservation or the absence of index taxa.

The first occurrences of biostratigraphically important DWAF species are compared with the first occurrences in the Upper Cretaceous of the Carpathians and the North Atlantic. The agglutinated foraminiferal biozones of the Carpathian schemes of Geroch & Nowak (1984) and Neagu *et al.* (1992) and the North Atlantic zonation of Kuhnt *et al.* (1992) cannot be applied in their entirety to the Contessa Highway section owing to the scarcity of some index taxa. Four Upper Cretaceous DWAF biozones described from the Atlantic and Western Tethys are recognised in the Scaglia formations at Contessa: the lower Turonian *Bulbobaculites problematicus* Zone, the upper Turonian to Coniacian *Uvigerinamina jankoi* Zone, the Santonian to Campanian *Caudamina gigantea* Zone, and the Maastrichtian *Remesella varians* Zone. However, some of the cosmopolitan index taxa, such as *Bulbobaculites problematicus* and *Uvigerinamina jankoi* have truncated stratigraphic ranges. The oligotrophic palaeoenvironmental conditions represented by the red deep-water Scaglia Rossa limestones cause flysch-type species such as *Uvigerinamina jankoi* and *Caudamina gigantea* to be rare, and in the case of *Recto-protomarssonella rugosa*, an index species for the Lower Campanian, to be absent. Nevertheless, the *Uvigerinamina jankoi* Zone in Contessa can be correlated with the Carpathian Basins and the North Atlantic.

Agglutinated foraminiferal assemblages are similar in taxonomic composition to those of the Carpathian Basins but in addition, a series of small abyssal-type *Haplophragmoides* species known from the North Atlantic DSDP/ODP sites are present in the Contessa Highway section, probably as a result of oligotrophic conditions in the central Tethys. The abundance of agglutinated foraminifera at Contessa displays minima during sea level high stands in the late Turonian, late Coniacian, late Santonian, early Campanian. These low abundance assemblages likely indicate enhanced oligotrophy as result of sediment starvation. The foraminiferal abundance and diversity values generally increase upsection, and typical "flysch-type" species appear in the record, indicating more detrital influx and a change to more mesotrophic conditions in the Campanian.

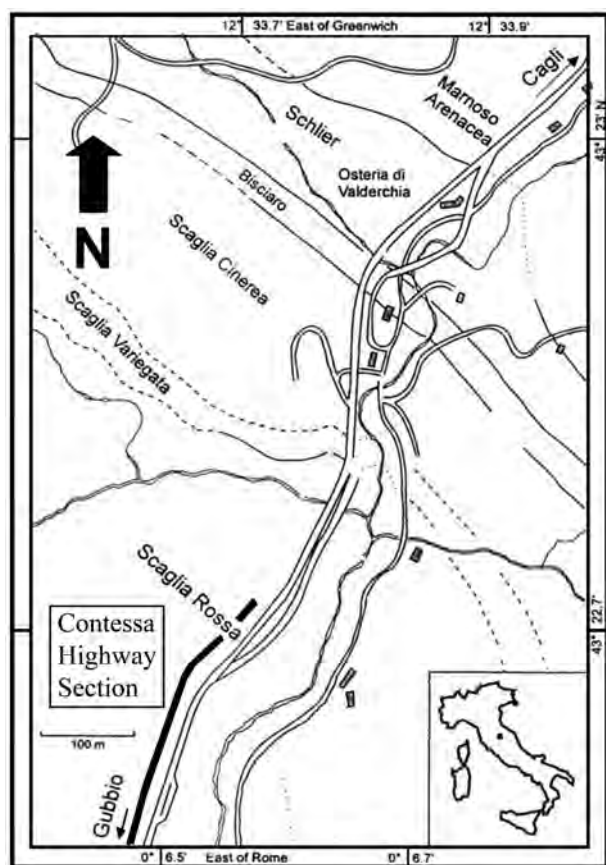


Figure 1. Location of the Contessa Highway section (modified after Giusberti *et al.*, 2009).

INTRODUCTION

The Upper Cretaceous to Lower Eocene limestones of the Scaglia Bianca and Scaglia Rossa Formations from the Gubbio area have been investigated in a multitude of isotopic, paleomagnetic, and micropaleontological studies, making this section one of the standard reference sections for the Tethys area. The Upper Cretaceous in the area of Gubbio consists of two formations, the Cenomanian to lower Turonian Scaglia Bianca Formation, and the overlying Scaglia Rossa Formation. Both formations consist of hard, thin- to medium-bedded deep-water pelagic limestones that were deposited in a bathyal setting at an interpreted paleodepth of 1500 to 2500m (Premoli-Silva & Sliter, 1994). A low-resolution study of agglutinated foraminifera in acid residues from the Upper Cretaceous of the Contessa and Bottaccione sections was carried out by Kuhnt (1990), revealing a diverse assemblage of mostly small size, finely agglutinated foraminifera. Although agglutinated foraminifera have been studied in acid residues from upper Paleozoic and Jurassic limestones since the late 19th century (e.g., Haeusler, 1883), the study of Kuhnt (1990) demonstrated that the Scaglia limestone facies harbours a rich assemblage of predominantly small-size, delicate, finely

agglutinated species. Such assemblages from pelagic deep-water limestones that include delicate tubular forms not normally preserved in washed residues were termed the “Scaglia-type” foraminiferal assemblage by Kuhnt & Kaminski (1989).

The purpose of the current study is to document the biostratigraphy of DWAF at a medium level of resolution over the whole Upper Cretaceous interval from the Cenomanian/Turonian boundary to the Cretaceous/Paleogene boundary, in order to better understand the stratigraphic history of the cosmopolitan Late Cretaceous to Paleogene taxa, and to establish a continuous record that we can use to better understand the depositional setting and environmental conditions represented by the deep-water limestone formations in the Umbria-Marche Basin. Because the limestone exposures near Gubbio serve as reference sections for Cretaceous–Paleogene stratigraphy, another purpose of our study was to improve the global biostratigraphy of the Late Cretaceous DWAF species described mainly from the Carpathian region. This study represents the first attempt at achieving a complete documentation of the taxonomic composition of Upper Cretaceous benthic foraminifera from the Contessa Highway section.

Previous studies of DWAF at Gubbio

The original study of the DWAF in the Contessa section was carried out by Kuhnt (1990), who studied 17 acid residue samples of Turonian to Paleocene age collected from the Contessa Highway section. This original study was expanded by Kuhnt & Kaminski (1996), who described the faunal turnover across the Cretaceous/Paleogene boundary interval in Contessa, and by Coccioni *et al.* (1995), who documented the turnover across the Bonarelli interval. The Paleogene DWAF were studied by Galeotti *et al.* (2004) and Giusberti *et al.* (2009), who documented the faunal change across the Paleocene/Eocene boundary interval; and the biostratigraphic ranges of DWAF over the whole Paleogene interval (155 m thick at Contessa) were documented by Kaminski & Gradstein (2005) based on a medium-level of sampling resolution (one sample every 2.5 m). This study represents the link between the Paleogene study of Kaminski & Gradstein (2005) and the Cenomanian–Turonian study of Coccioni *et al.* (1995).

METHODS

We collected a set of evenly-spaced samples from the Turonian to Maastrichtian of the Contessa Highway section, near Gubbio Italy (lat. 43°22'47"N; long. 13°33'49"E). The sample spacing is one sample every five metres, but additional samples were studied from the top of the Maastrichtian. All samples consist of indurated limestones belonging to the Scaglia Bianca



Figure 2. The Upper Cretaceous Scaglia Rossa deposits exposed in the Contessa Highway section.

and Scaglia Rossa Formations, and are numbered according to their stratigraphic height in metres above the Bonarelli Level. The limestone samples (100 g) were slowly dissolved in dilute HCl to release the agglutinated foraminifera, and washed over a 63 μm sieve. Foraminifera were picked from the acid residues and mounted onto cardboard reference slides. Specimens were photographed on a JEOL JSM-6480LY SEM at University College London.

The foraminiferal abundance data were analysed statistically using Q-mode cluster analysis using the application Statistica 6.0 to delineate stratigraphically important assemblages. The abundance data were first edited to eliminate species that comprise <1% of the total assemblage. The remaining species counts were then converted to percentage and log-transformed to reduce the influence of dominant species. The resulting dendrogram is based on Euclidian distance using Ward's linkage method.

Sixty-two samples were analysed for the calcareous nannofossil content. Smear slides were initially prepared following the method described by Monechi & Thierstein (1985). Calcareous nannofossil slides were processed using the standard smear slide technique. Samples were first crushed using a mortar &

pestle, and the fine fraction obtained by repeated decantation. Samples from the intervals: CHW B+5 – B+75 and CHW B+150 to B+205 were repeated using a different method. A small amount of fresh limestone was abraded on a glass slide, distilled water was added and the composition was homogenised with a toothpick; after drying the cover glass was applied and fixed with Norland optical adhesive. This was done to verify the results obtained from the first set of smear slides. The smear slides were examined in light microscopy at 100x magnification, at least 1000 field of views were investigated in order to find species of biostratigraphical importance.

Some taxa could not be identified precisely due to several reasons, including the presence of broken, incomplete, or overgrown specimens, or ones covered with sedimentary particles, but mostly due to dissolution and recrystallization processes. Poor preservation and the occurrence of a small number of specimens made impossible any quantitative analysis.

Nannofossil zones were recognised using the Tethyan Late Cretaceous zonal schemes of Sissingh (1977) and Perch-Nielsen (1985). In this study, stages names are used according to their definitions and age

calibrations in the “ICS Geological Time Scale, 2008” (Ogg *et al.*, 2008).

RESULTS

Calcareous nannofossil biostratigraphy

Calcareous nannofossils document the early Turonian to Maastrichtian age of the Contessa Highway succession investigated in this study. Several biozones are distinguished based on the encountered bioevents, but the assignment of biozones is very difficult at certain levels due to the absence of marker species. The main bioevents in stratigraphic order are: the first occurrence (FO) of *Quadrum gartneri* (5m above the Bonarelli level), the FOs of *Eiffelithus eximius* and *Lucianorhabdus maleformis* (sample B+55m), FO of *Micula staurophora* (B+90m), FO of *Reinhardtites antophorus* (B+105m), FO of *Broinsonia parca parca* (B+150m), FO of *Cribracorona gallica* (B+160m), FOs of *Reinhardtites levis* and *Prediscosphaera stoveri* (B+165m), FO of *Broinsonia parca constricta* (B+170m), last occurrences (LOs) of *Eiffelithus eximius* and *Reinhardtites antophorus* (B+205m), LO of *Tranolithus orionatus* (B+210m), LO of *Reinhardtites levis* (B+270m), FO of *Micula murus* (B+280m), FO of *Nephrolithus frequens* (B+295m). The full inventory of calcareous nannofossil species found at Contessa is given in Appendix 1.

Some notable absences of stratigraphic important species include: *Marthasterites furcatus* in the upper Turonian, although this species is considered to be resistant to dissolution (Thierstein, 1976; Perch-Nielsen, 1985; Roth & Krumbach, 1986); *Lucianorhabdus cayeuxii* in the upper Coniacian; *Ceratolithoides aculeus*, *Uniplanarius sissinghii* and *Uniplanarius trifidus* in the mid-upper Campanian. The following biozones were encountered:

The upper part of CC10 (*Microrhabdulus decoratus* Zone). The characteristic assemblage comprises species of the genera *Rhagodiscus* spp., *Eprolithus* spp., *Watznaueria* spp., *Retecapsa* spp., together with *Eiffelithus turriseiffelii* and *Prediscosphaera cretacea*. The LO of *Rhagodiscus asper* was observed in this biozone, at the same level as in the limestone exposures from the southern Norwegian Sea shores (Bergen & Sikora, 1999), Europe and even the Austral realm (Burnett, 1998). Based on the followed biozonation schemes and other studies concerning the Cenomanian/Turonian boundary (Ghisletti & Erba in Premoli Silva & Sliter, 1994 in the nearby Bottacione section; Nederbragt & Fiorentino, 1999; Tsikos *et al.*, 2004; Kolonic *et al.*, 2005; Tantawy, 2008) we place this boundary at the FO of *Quadrum gartneri*, 5m above the Bonarelli level.

CC11 (*Quadrum gartneri* Zone). This biozone is characterised by very poor abundance. Thirty-five species were identified, mostly species usually resistant to dissolution and recrystallisation such as *Watznaueria barnesae* (Thierstein, 1980; Roth & Krumbach, 1986). The LO of *Helenea chiastia* was observed in this biozone (at B+12.5m) although several studies recorded the LO of this species before the FO of *Quadrum gartneri* (Burnett, 1998; Catanzariti *et al.*, 2007).

CC12 – CC13 (*Lucianorhabdus maleformis* – *Marthasterites furcatus* Zones). The abundance increases in this biozone but a drop in diversity was also observed with only 21 species present in the interval. Due to the absence of the marker taxon the limit between the two biozones cannot be precisely established, the same for the Turonian/Coniacian boundary, which is usually placed within biozone CC13. The absence of *Marthasterites furcatus* was also noted by Monechi & Thierstein (1985) in the nearby Bottacione section.

CC14 (*Micula staurophora* biozone). The diversity of the assemblage remains the same and there is an increase in abundance. The dominant species include *Watznaueria barnesae*, *Retecapsa crenulata* and *Micula staurophora*. The FO of *Micula staurophora* is usually used to mark the base of the middle Coniacian (Rawson *et al.*, 1996, Bergen & Sikora, 1999).

CC15 – CC17 (*Reinhardtites antophorus* – *Lucianorhabdus cayeuxii* – *Calculites obscurus* Zones). The absence of *Lucianorhabdus cayeuxii* in the Contessa Highway section also mentioned above made it impossible to differentiate between biozones CC15 and CC16. The FO of *Calculites obscurus* could not be used in this study because it was observed stratigraphically higher than usual in the Contessa Highway section (probably also due to dissolution and recrystallisation). Therefore, the boundary between biozones CC16 and CC17 could not be established.

CC18 – CC22 (*Broinsonia parca* – *Calculites ovalis* – *Ceratolithoides aculeus* – *Uniplanarius sissinghii* – *Uniplanarius trifidus* Zones). Abundance and diversity are higher in this part of the limestone succession than below with over 40 species identified in the assemblage. The lack of the key Tethyan marker species in this interval remains unexplained, because these species were recorded from the nearby Bottacione section (Gardin *et al.*, 2001). Also a series of FOs was observed in this interval, the FOs are stratigraphically younger than

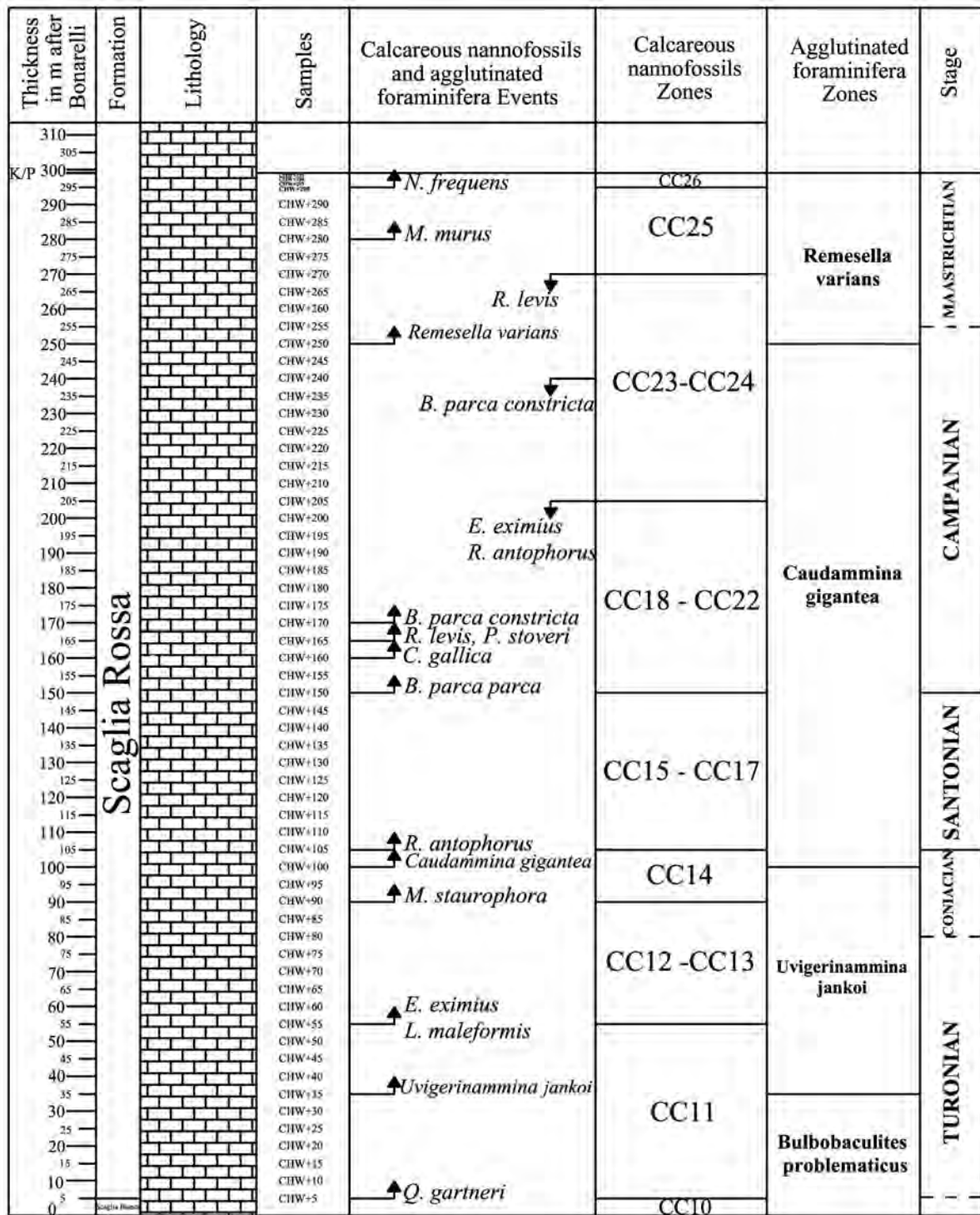


Figure 3. Lithology and biostratigraphy of the Contessa Highway section, with calcareous nannofossil and DWAF biozonations.

usually recorded in Europe. The FO of *Predisco-sphaera stoveri* was recorded in the lower Maastrichtian by Catanzariti *et al.* (2007) in the Helminthoid Flysch of northern Italy, while other studies record it in the upper Campanian – defining the base of biozone UC15dBP (Burnett, 1998). The FO of *Reinhardtites levis* was observed in the upper Campanian (Sissingh, 1977; Perch-Nielsen, 1985; Campbell *et al.*, 2004) indicating the base of the

biozone CC22. The FO of *Cribracorona gallica* is usually recorded within biozone UC20 (Lees & Bown, 2005) or in CC25 in the Bottacione section (Gardin *et al.*, 2001).

CC23–CC24 (*Tranolithus orionatus* – *Reinhardtites levis*). The diversity of the assemblage remains constant in this interval but the abundance declines. The LO of *Tranolithus orionatus* which is used to

separate these two biozones could not be determined because this species is very rare in the Contessa Highway section.

CC25 (*Arkhangelskiella cymbiformis*). In this biozone an abundance of *Micula murus* (with dimensions between 3 and 8 μ) was noticed within the assemblage. Other frequent species include *Micula staurophora*, *Arkhangelskiella cymbiformis*, and *Placozygus fibuliformis*. Species such as *Arkhangelskiella maastrichtiana*, *Cribrocorona gallica*, *Zeughrabdotos* spp. and *Retecapsa* spp. are rare in the assemblage. Both abundance and diversity have lower values, with 20 species identified in this interval.

CC26 (*Nephrolithus frequens*). The base of this biozone is defined by the FO of *Nephrolithus frequens* with both abundance and diversity dropping rapidly. The assemblage contains only 14 species.

Upper Cretaceous Biozonation of the Contessa Section based on DWAF

The utility of biozonation schemes based on agglutinated foraminifera is often limited to the basins from which they are described. For example, owing to the unique geological setting with restricted connections to the Atlantic, the North Sea biozonation (e.g., Kaminski & Gradstein, 2005) is not useful outside the basin. In the case of the Umbria-Marche basin, the Apulian plate occupied a geographic position in the middle of the western Tethys seaway during the Late Cretaceous, so we expect to find a cosmopolitan Tethyan DWAF assemblage here. In fact, several of the published biostratigraphical schemes are relevant to this study, including the studies of Geroch & Nowak (1984) for the Polish Carpathians, Neagu *et al.* (1992), for the Romanian Eastern Carpathians, Kuhnt *et al.* (1992) for the Eastern North Atlantic, and Kuhnt & Kaminski (1997) for Zumaya, Spain. The first occurrences of the biostratigraphically important agglutinated genera are shown in Figure 3, and a summary of the stratigraphic ranges is given in Figure 5. The DWAF biozones in the Upper Cretaceous Formations examined in this study are as follows:

Bulbobaculites problematicus Zone (upper part) (from the Bonarelli Level to the FO of *Uvigerinammina jankoi*). This biozone is used here *sensu* Geroch & Nowak (1984, Polish Carpathians), Neagu *et al.* (1992, Romanian Eastern Carpathians), but its use is not consistent across the Carpathian and Tethyan basins. Only the upper part of this biozone is present in the Contessa Highway section, where the nominate taxon makes its appearance at B+25m. In other areas, the FO of *Uvigerinammina jankoi* is

observed above the Cenomanian/Turonian boundary as recorded by Kuhnt & Kaminski (1997, Zumaya, Spain) or a *Uvigerinammina* ex gr. *jankoi* biozone is delineated beginning either from the Cenomanian/Turonian boundary (Bał, 2000, in the Pieniny Klippen Belt in Poland) or lower Turonian (Bubík, 1995 in the Bílé Karpaty Unit in the Western Carpathians, Czech Republic). An acme zone with *Uvigerinammina jankoi* was used by Olszewska (1997) to cover the whole Turonian interval in the Polish Outer Carpathians.

In the Contessa Highway section, the Bonarelli Level (Cenomanian/Turonian boundary) is barren of foraminifera (Coccioni *et al.*, 1995). Above the Bonarelli level, a number of agglutinated foraminiferal species return as “Lazarus taxa” (Cenomanian agglutinated foraminiferal occurrences were reported by Coccioni *et al.*, 1995). The ammodiscids, including *Ammodiscus cretaceus*, *A. peruvianus*, *A. tenuissimus* and several species of *Glomospira*, *G. gordialis*, *G. glomerata*, and *Repmanina charoides* were the first taxa to reappear above OAE 2 in the lower Turonian, as they are opportunistic taxa able to take advantage of empty ecological niches (Kuhnt & Kaminski, 1989). These species are accompanied by *Lituotuba lituiformis*, *Hippocrepina depressa* and *Haplophragmoides* cf. *concaus*. Later recolonisers at Contessa are represented by *Saccamina grzybowskii* and *Haplophragmoides* cf. *walteri*. Among the last to return after the anoxic event were *Subreophax scalaris*, *Rashnovammina munda* and *Bicazammina lagenaria* at B+20m.

Important FOs of agglutinated foraminifera observed in the uppermost part of this zone include *Paratrochamminoides olszewskii*, *P. acervulatus* and *Hormosinelloides guttifer* at B+25m. While *P. olszewskii* is known from the Cenomanian of Moravia (Bubík, 1995), the FO of *P. acervulatus* was considered to be Campanian by Kuhnt (1990) in the Bottacione section. However, *P. acervulatus* is rare until the Campanian and the low sampling resolution of the Kuhnt (1990) study may account for this apparent gap at Contessa. *Hormosinelloides guttifer* is also another species whose FO was considered to be Campanian (Kaminski & Gradstein, 2005) but one study recorded it from the Albian to Cenomanian in Bavaria (Weidich, 1990). The FO of *Praecystammina globigerinaeformis* in the uppermost part of this biozone at B+30m is consistent with its FO observed by Moullade *et al.* (1988) in the North Atlantic (DSDP Legs 93 and ODP Leg 103).

Uvigerinammina jankoi Zone (from the FO of the nominate taxon to the FO of *Caudammina gigantea*): The FO of *U. jankoi* is recorded immediately above the Cenomanian/Turonian boundary in the Atlantic,

and the acme of this species is known from the middle/upper Campanian (Kuhnt *et al.*, 1992). In the Contessa Highway section, *Uvigerinammina* is present only as single specimens, and its FO was found at B+35m in the middle part of calcareous nannofossil Zone CC11.

The FO of *Praesphaerammina gerochi* is observed at the base of Zone CC14 (Coniacian) at Contessa. This is the earliest recorded FO of this species, which was previously reported as Paleocene by Olszewska (1997) and Kaminski *et al.* (1988). Its Late Cretaceous origin is confirmed by its finding in the Maastrichtian in the Mitoi Valley, Eastern Carpathians (Cetean, 2009).

In this biozone the FOs of *Verneulinoides polystrophus* (in the lower part of Zone CC11-12, upper Turonian), *Paratrochamminoides gorayskii*, *P. heteromorphus*, *P. draco* (lower Santonian) and *Paratrochamminoides deflexiformis* (upper Turonian) were observed. Also some other biostratigraphically important agglutinated foraminifera have their FOs in the Santonian: *Gerochammina obesa* (lower Santonian), *G. lenis* (upper Santonian), *Ammosphaeroidina pseudopauciloculata* and *Hyperammina dilatata* (lower Santonian). Neagu *et al.* (1992) reported the FO of *Gerochammina obesa* in the uppermost Turonian, and the FO of *G. lenis* in the lower Campanian. In the Contessa Highway section, these taxa appear higher (*G. obesa*) or lower (*G. lenis*) but following the same order as in the Romanian Eastern Carpathians (Cetean, 2009).

Caudammina gigantea Zone (from the FO of the nominal taxon to the FO of *Remesella varians*)

This biozone widely used in all the biostratigraphic schemes based on agglutinated foraminifera (Geroch & Nowak 1984; Neagu *et al.*, 1992; Olszewska, 1997; Kuhnt & Kaminski, 1997; Kuhnt *et al.*, 1992; Setoyama *et al.*, this volume). The FO of *Caudammina gigantea* is observed at different stratigraphic levels in the Carpathians, Tethys and North Atlantic basins. The occurrence of the bathyal – abyssal species *C. gigantea* is likely to be depth-related, and its FO is recorded as high as the upper Maastrichtian in ODP Hole 959D on the Côte d’Ivoire-Ghana Transform Margin (Kuhnt *et al.*, 1998). The most common occurrence is however, in the lower and middle Campanian. This is observed in the North Atlantic (Moullade *et al.*, 1988; Kuhnt *et al.*, 1992) where the overlap between *Uvigerinammina jankoi* and *Caudammina gigantea* is used as an indicator for the middle Campanian, and in the Bílé Karpaty Unit in the Czech Republic (Bubík, 1995). In the Carpathians, Geroch & Nowak (1984) and Neagu *et al.* (1992) defined a “*Goesella rugosa*” biozone for the lower Campanian to cover this interval until the

FO of *C. gigantea*. However, *Rectoprotomarssonella rugosa* is a large, coarsely agglutinated species that is not present in the pelagic limestones at Contessa (see Kaminski *et al.*, 2008).

The FO of *Caudammina gigantea* in the lower Campanian *Globotruncanita elevata* Zone is documented by Bąk (2000) in the Pieniny Klippen Belt in Poland, while Neagu *et al.* (1992) placed it at the boundary between the *Globotruncanita elevata* and *Globotruncana ventricosa* Zones. Olszewska (1997) used the *Caudammina gigantea* acme for uppermost Santonian to lower Campanian. The upper boundary of the *Caudammina gigantea* Zone also differs from one basin to another in the Tethys (including the Carpathian basins) and North Atlantic, and is defined differently by various authors. Geroch & Nowak (1987) placed this boundary at the FO of *Rzehakina fissistomata*, which occurs near the Cretaceous/Paleogene boundary, and Bubík (1995) followed the same scheme for the Bílé Karpaty Unit in the Czech Republic.

In the Contessa Highway section, the FO of *Caudammina gigantea* is observed in sample B+100m, in the upper part of calcareous nannofossil Zone CC14, which correlates to the uppermost part of the Coniacian according to Ogg *et al.* (2008). The FOs of DWAF in the *Caudammina gigantea* Zone in the Contessa Highway section include:

- *Caudammina excelsa* at B+110m in the lower part of Zone CC15-17 (lower Santonian);
- *Annectina grzybowskii* at B+130m in the middle part of the Zone CC15-17 interval (mid Santonian);
- *Cribrostomoides trinitatensis* and *Trochamminoides subcoronatus* at B+140-145m in the upper Santonian;
- *Spiroplectinella laevis*, *S. dentata*, *Placentammina placenta*, *Trochamminoides dubius*, *Rzehakina epigona* *R. minima*, and *Glomospira diffundens* at around B+160m in the lower part of Zone CC18-22 (lower Campanian);
- *Spiroplectinella israelkyi*, *Paratrochamminoides uviformis* and *Trochamminoides grzybowskii* at around B+200m near the Zone CC22/CC23 boundary (lower part of the upper Campanian);
- *Arthrodendron* spp. at B+230m in middle part of the Zone CC23-24 interval (upper Campanian).

The LO of *Bulbobaculites problematicus* is recorded at the CC17/CC18 boundary (Santonian/Campanian boundary) at B+150m. This species has its LO in the lower Campanian *Globotruncanita elevata* Zone in the Izlaz Valley section in the Romanian Eastern Carpathians (Cetean, 2009). Bąk (2000) also recorded the LO of *Bulbobaculites problematicus* in the *Globotruncanita elevata* Zone in the Pieniny Klippen Belt in Poland.

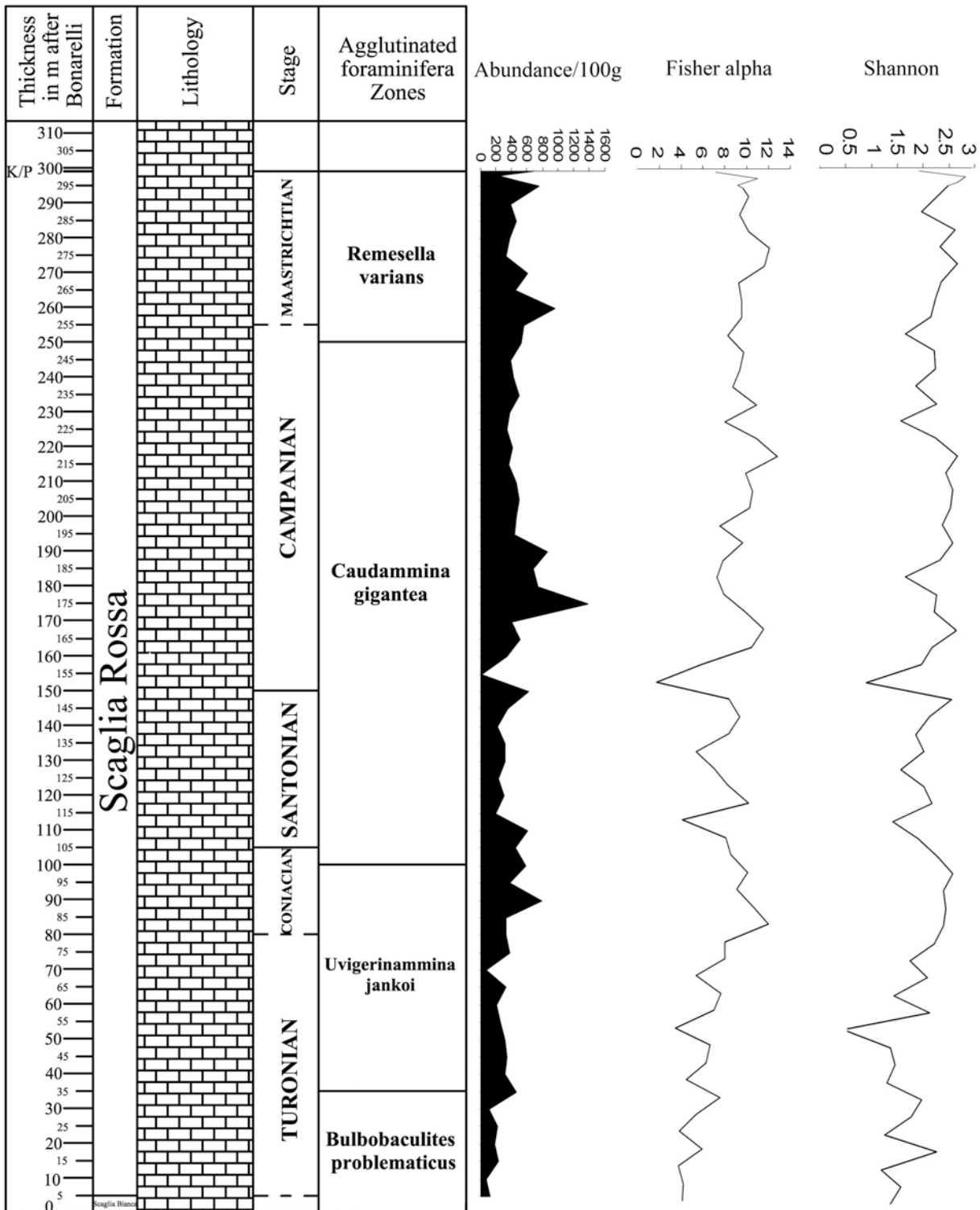


Figure 4. Abundance & Diversity of DWAF in the Upper Cretaceous of the Contessa Highway Section.

Remesella varians Zone (from the FO of the nominal taxon to the Cretaceous/Paleogene boundary).

The FO of *Remesella varians*, which occurs in the upper Maastrichtian was used by Kuhnt & Kaminski (1997) at Zumaya, Spain and by Kuhnt *et al.*, (1992) in the North Atlantic as the lower boundary of this

biozone. Kuhnt *et al.* (1992) mentioned that *Remesella varians* can be used as an indicator for the middle Maastrichtian and younger. This species appears in the Contessa Highway section in sample B+250m in the upper part of calcareous nannofossil Zone CC23-24 (undifferentiated) close to the base of the Maastrichtian. The upper boundary of this

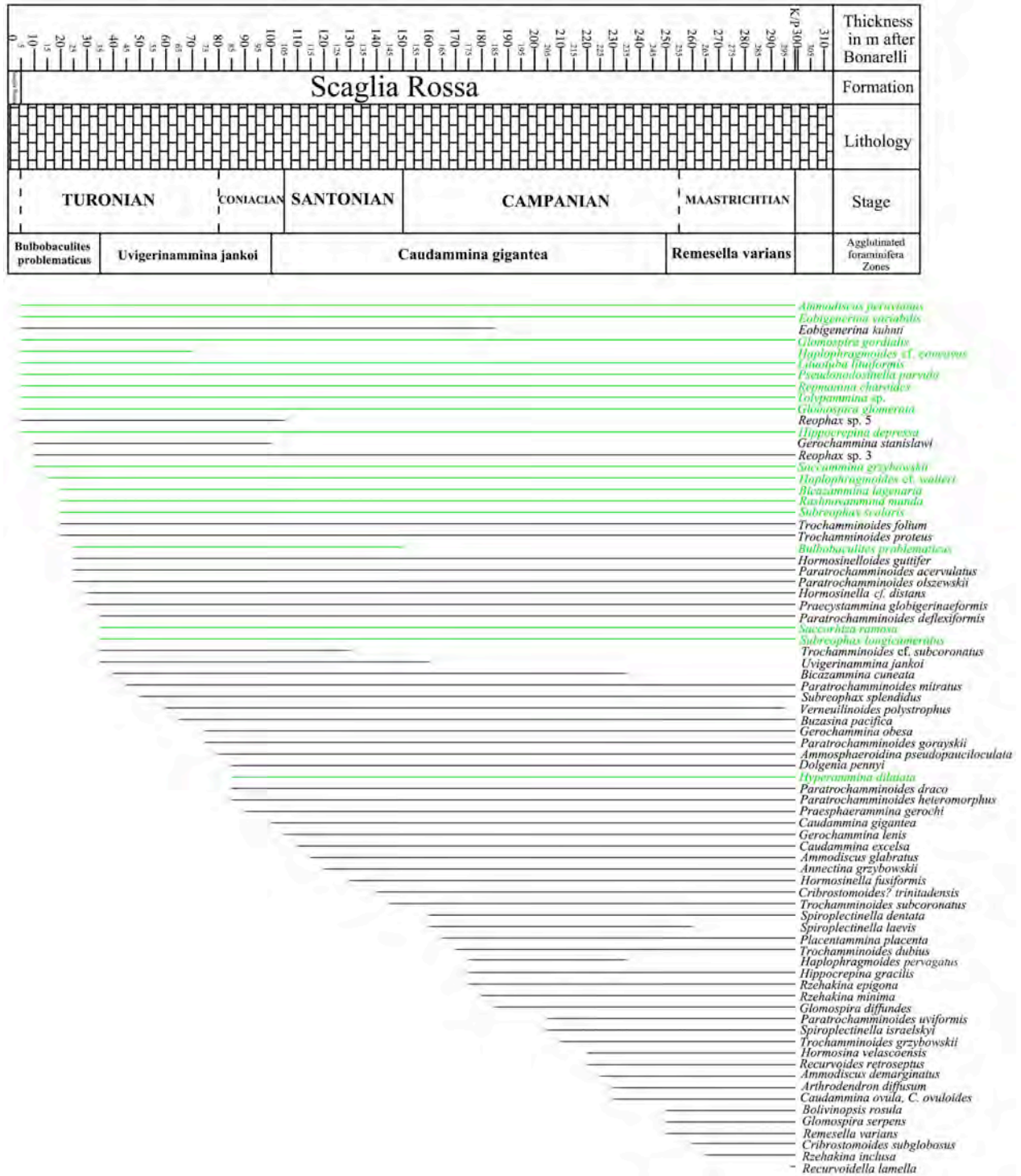


Figure 5. Stratigraphic ranges of DWAF in the Upper Cretaceous of the Contessa Highway Section. Lazarus taxa known from the Cenomanian are shown in green.

biozone is drawn here at the Cretaceous/Paleogene boundary (Kuhnt & Kaminski, 1997; Kuhnt *et al.*, 1992), although the species *Remesella varians* ranges as high as the Paleocene/Eocene boundary in the Contessa Highway section (Galeotti *et al.*, 2004).

Concurrent with the FO of *Remesella varians*, two other cosmopolitan DWAF species appear in the Contessa Highway section: *Glomospira serpens* and *Bolivinospis rosula*. In the mid-Maastrichtian the FO of *Rzehakina inclusa* is observed at B+260m, while

the FO of *Recurvoidella lamella* was observed in the uppermost Maastrichtian, close to the boundary between nannofossil Zones CC25 and CC26.

Agglutinated Foraminiferal Abundance & Diversity

The abundance and diversity of the agglutinated foraminiferal assemblages (Figure 4) show low values during the Turonian and Coniacian. While the low diversity and abundance values in the Lower Turonian can be explained by slow recovery of benthic foraminifera after the the Cenomanian/Turonian boundary anoxic event (OAE 2, e.g., Coccioni *et al.*, 1995) low values in the rest of this interval are due probably to oligotrophic environmental conditions as indicated by the type of agglutinated foraminifera biofacies. Both abundance and diversity increase in the Santonian, but in the lower Campanian show a minimum in values that can be attributed to the early Campanian sea-level maximum when the area likely became more oligotrophic (the deposition of the Scaglia Formations is assumed to have taken place away from any source of clastic sediments, e.g., Kaminski & Gradstein, 2005). A maximum in both abundance and diversity is recorded in the upper Campanian, but while abundance drops again, diversity values remain high in the Maastrichtian. The abundance of agglutinated foraminifera at in the Contessa Highway section decreases in intervals deposited during sea level high stands in the late Turonian, late Coniacian, late Santonian, early Campanian. These low abundance assemblages likely indicate enhanced oligotrophy as result of reduced nutrient flux and sediment starvation during sea-level high stands (e.g., Erbacher *et al.*, 1996).

Agglutinated foraminiferal biofacies.

The term “Scaglia” agglutinated foraminifera biofacies (summarised by Kaminski & Gradstein, 2005) was used to define assemblages that include small and fragile tubular forms such as the modern komokiaceans. Large, coarsely agglutinated species are noticeably absent from the Scaglia-type assemblage. Nevertheless, Scaglia-type assemblages do display a type of substrate dependence. In the acid residues of the Scaglia limestones, we observe a variety of tubular forms that lived attached to empty planktonic foraminiferal tests, and even within these tests. Attachment surfaces are observed on various tolypamminids. In the modern ocean, studies by A. Gooday have reported DWAF that live attached to empty foraminiferal tests or internally, within other foraminiferal tests (Gooday & Haynes, 1983). The presence of suitable pre-existing biogenic substrates is a prerequisite in this case. The Scaglia-type

biofacies also contains calcareous-cemented forms such as *Spiroplectinella*, and *Remesella*. However, if the abundant small tubular forms are disregarded then the agglutinated foraminifera biofacies in the Contessa Highway section can be further subdivided based on the faunal composition. The Q-mode cluster analysis identifies three statistically significant assemblages that accurately reflect the stratigraphical positions of the studied samples (Figure 6):

Cluster 1. Turonian to lower Santonian Abyssal (Scaglia-type) biofacies. This cluster includes the samples from B+5m to B+75m. The agglutinated assemblages are dominated by several species of *Haplophragmoides*, *Paratrochamminoides*, *Rashnovammina* and *Bicazammina*. Other species present include *Bulbobaculites problematicus* and *Praecystammina globigerinaeformis*, but samples generally display low diversity (Figure 4). The assemblage contains some of the abyssal taxa known from the Krashenninikov fauna of the Plantagenet Formation of the abyssal North Atlantic, such as *Haplophragmoides perexplicatus*, *H. pseudokirki*, and small biserial forms.

Cluster 2. This cluster includes the interval from B+80m to B+170m, extending from the Lower Santonian to lower Campanian. This assemblage is transitional between the Abyssal (Scaglia-type) biofacies and the “Flysch-type” facies. Some of the flysch-type foraminifera have their first occurrences in this interval, creating a mixture of biofacies. *Ammosphaeroidina pseudopauciloculata*, *Caudamina excelsa*, *Annectina grzybowskii*, *Hyperammina dilatata*, and the coarsely agglutinated species *Dolgenia pennyi* appear in the assemblages.

Cluster 3. This assemblage extends from sample B+175 to the top of the studied interval, representing Middle Campanian to uppermost Maastrichtian. Agglutinated foraminiferal “Flysch-type” biofacies. Although not coarsely agglutinated (compared for example with the Carpathian flysch) almost all the characteristic agglutinated foraminifera are present in the Scaglia Rossa Formation in this interval, including *Rzehakina epigona*, *R. minima*, *Spiroplectinella dentata*, *Psammosiphonella discreta* and even *Nothia latissima* and *Arthrodendron* spp. in the upper Maastrichtian. The larger agglutinated foraminifera such as *Arthrodendron diffusum* are especially characteristic of the “flysch-type” assemblages from clastic substrates (see Kaminski *et al.*, 2008). Because of the appearance of these coarse-walled species, we postulate that the Umbria–Marche basin received increased amounts of terrigenous sediment (possibly an increased aeolean component, since turbidites are absent) beginning in the early Campanian.

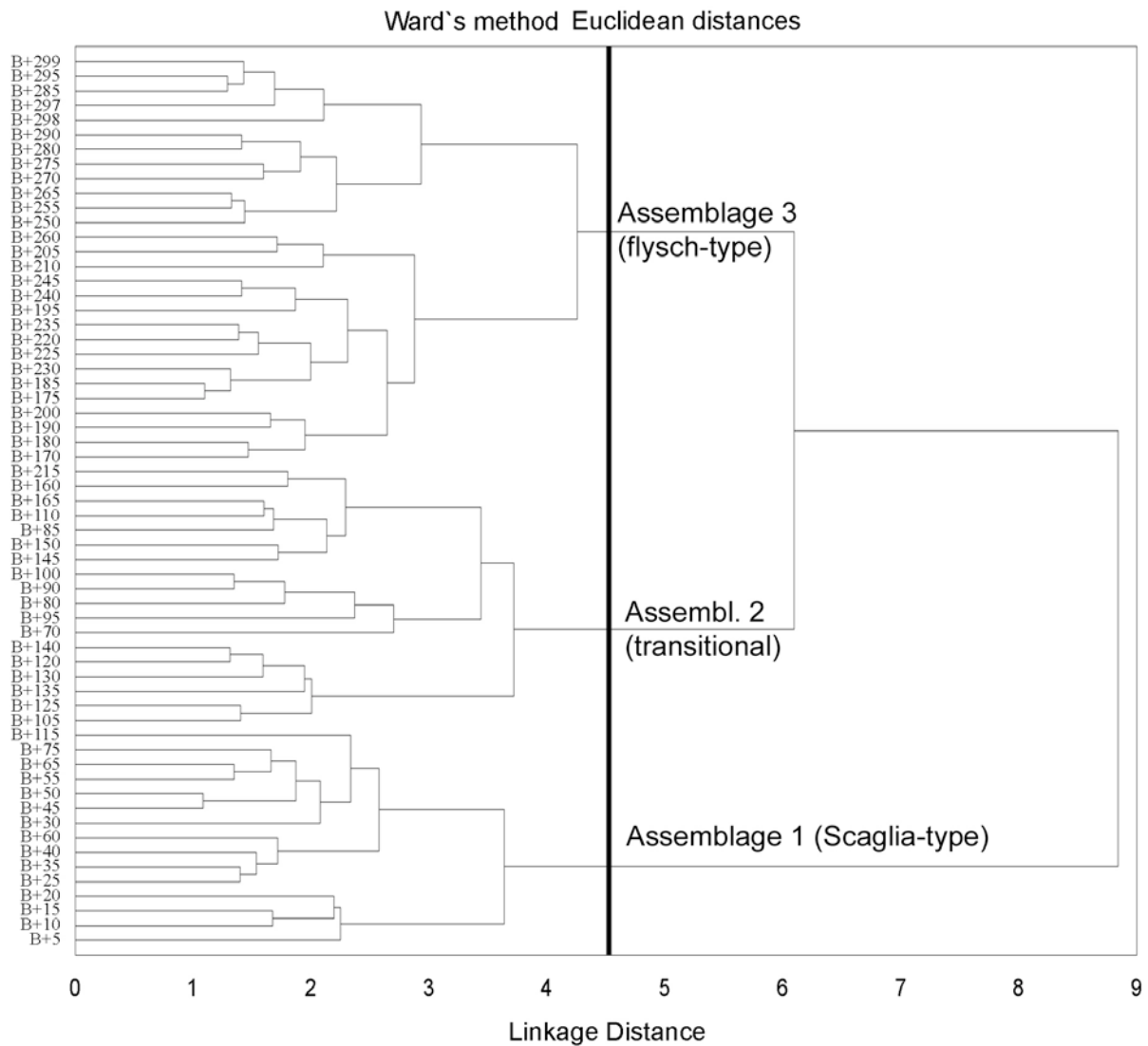


Figure 6. Dendrogram of Q-mode cluster analysis based on log-transformed relative abundance data of species >1% of the assemblage. Vertical line identifies three statically significant sample clusters. Sample B+155 was eliminated from the dendrogram because of low faunal abundance.

DISCUSSION

The stratigraphic utility of DWAF at Contessa

The deep-water foraminifera recovered in the acid residues of the Upper Cretaceous limestones at Contessa are generally well-preserved and abundant in the studied samples, and therefore the potential exists for improving their calibration of their stratigraphic ranges to the standard timescale. In this study, we used the calcareous nannofossil stratigraphy studied from the same samples to achieve age calibrations. One caveat, however, was the fact that calcareous nannofossils proved difficult to analyse owing to the strongly lithified nature of the limestones.

We recognise four Upper Cretaceous zones using the stratigraphic ranges of cosmopolitan agglutinated foraminifera, and these zones can be compared with the Carpathian and North Atlantic zonal schemes (Figure 7). Unfortunately, some of the zonal index

species are rare in the Contessa Highway Section, which adversely affects the robustness of the DWAF zonal scheme. Some of the cosmopolitan index taxa, such as *Bulbobaculites problematicus* and *Uvigerinammina jankoi* have truncated stratigraphic ranges. One of the Carpathian–North Atlantic index taxa (*Rectoprotomarssonella rugosa*) was not present at all in our samples. This robust, coarsely agglutinated species was apparently ecologically excluded from these oligotrophic, deep-water pelagic limestones. As a result, the *Caudammina gigantea* Zone in Contessa corresponds to the whole of the Santonian–Campanian interval. The *Remesella varians* Zone in Contessa is a useful stratigraphic horizon, because the index taxon is well-represented in our samples. The interval represented by the zone at Contessa closely correlates with the whole of the Maastrichtian stage.

EPOCH	STAGE	Contessa Highway Section (this study)	Geroch&Nowak (1984) Polish Outer Carpathians	Olszewska (1997) Polish Outer Carpathians	Neagu et al. (1992) Romanian Eastern Carpathians	Kuhnt & Kaminski (1997) Zumaya, Spain
		LATE CRETACEOUS	Maastrichtian	Remesella varians		
Campanian	Caudamina gigantea		Caudamina gigantea	Rzehakina inclusa	Caudamina gigantea	C. ovula group
			Rectoprotomarsonella rugosa	Caudamina gigantea	Rectoprotomarsonella rugosa	Rectoprotomarsonella rugosa
Santonian						
Coniacian	Uvigerinammina jankoi		Uvigerinammina jankoi	Spiroplectinella costata	Uvigerinammina jankoi	Uvigerinammina jankoi
Turonian	Bulbobaculites problematicus		Bulbobaculites problematicus	Uvigerinammina jankoi		Bulbobaculites problematicus
Cenomanian			Plectorecurvoides alternans	Bulbobaculites problematicus		
					Haplophragmoides falcatosuturalis	

Figure 7. Comparison to published DWAZ zonal schemes (Geroch & Nowak, 1984; Olszewska, 1997; Neagu *et al.*, 1992; Kuhnt & Kaminski, 1997).

Our study of the Contessa Highway section extends the documented stratigraphic ranges of a number of cosmopolitan “fysch-type” species that are known from the Upper Cretaceous and Paleogene. In particular, species such as *Annectina grzybowskii*, *Cribrostomoides? trinitatensis*, and *Trochamminoides subcoronatus* have not been previously reported from the Santonian (see Kaminski & Gradstein, 2005). These forms evidently migrated into the Carpathian fysch basins from the central Tethys.

Paleoecology

Based on the presence of calcareous benthic foraminifera such as: *Gavelinella*, *Gyroidinoides*, *Osangularia*, *Praebulimina*, *Pullenia*, and *Pleurostomella*, Premoli-Silva & Sliter (1994) estimated that the Scaglia Rossa at Gubbio was deposited at paleodepths greater than 1500m but not more than 2500m, owing to the fact that the CCD fluctuated between 2500–3000m in the South Atlantic during this period. With the exception of the time interval

represented by the Bonarelli event, the Scaglia Rossa limestone exposed in the Contessa Highway section was deposited above the CCD for the whole duration of the Late Cretaceous.

Kuhnt (1990) noted the similarity of DWAF assemblages in the Turonian to lower Santonian interval between the Scaglia Rossa Formation and the Plantagenet Formation of the North Atlantic, which was deposited at paleodepths greater than 4000m (Jansa *et al.*, 1979). Kuhnt estimated that the bathymetric setting of Scaglia Rossa must have been deeper than 1500m.

The existence of two types of agglutinated foraminiferal biofacies (already mentioned by Kuhnt, 1990) that coexisted for a period of time can be certainly be confusing regarding the bathymetrical setting of the Scaglia Rossa Formation deposition. The mixture of abyssal biofacies and flysch-type biofacies (Kaminski & Gradstein, 2005) that coexist in the Scaglia Rossa Formation with a significant component of thin and fragile tubular forms was given the name “Scaglia-type” biofacies.

Studies on modern foraminifera (Altenbach, 1999; De Rijk *et al.*, 2000) have shown that the depth distribution of species depends on the trophic continuum and preferred life conditions (oligotrophy in this case). Some agglutinated foraminifera such as *Repmantina charoides* migrate to shallower water depths in the Mediterranean Sea under increasingly oligotrophic conditions. The presence of the abyssal biofacies of agglutinated foraminifera in the Turonian – lower Santonian limestones of the Scaglia Rossa Formation can thus not necessarily be a result of the bathymetric setting (which was not abyssal) but of trophic conditions indicating oligotrophy.

In the Campanian many typical “flysch-type” species appear in the record. The foraminiferal abundance and diversity values generally increase upsection, though fluctuations in abundance are observed that are likely result from fluctuations in sea level. During times of sea-level rise nutrients are leached into the ocean from the coastal zone, while nutrient flux decreases at times of sea-level high stands (Erbacher *et al.*, 1996). The abundance of DWAF per gram sediment in pelagic settings is therefore a reflection of the Late Cretaceous sea-level curve. In the upper Campanian some larger, more coarsely agglutinated forms such as *Arthrodendron* spp. and *Nothia* spp. appear, indicating a change in the trophic structure to a more mesotrophic environment. It is also likely that increasing amounts of clastic input into the basin also played a role in this faunal change, but carbonate contents in the Maastrichtian are still high, around 97-98% in the Contessa Highway section.

As summarised by Kuhnt (1990) and Kaminski & Gradstein (2005), the paleoenvironment of the Upper Cretaceous members of the Scaglia Rossa Formation

was characterised by pelagic sedimentation with very low detritic input (mostly aeolian), deposited above the CCD, and with low organic flux as and well-oxygenated bottom water. The presence of fragile tubular forms that resemble modern komokiaceans fully backs this interpretation.

SYSTEMATICS

The Kaminski (2004) classification of agglutinated foraminifera was used for the taxa listed below.

Order ASTRORHIZIDA Lankester, 1885
 Suborder ASTRORHIZINA Lankester, 1885
 Superfamily ASTRORHIZACEA Brady, 1881
 Family RHABDAMMINIDAE Brady, 1884
 Subfamily BATHYSIPHONINAE Avnimelech, 1952
 Genus *Nothia* Pflauman, 1964

Nothia spp.

Plate 1, fig. 1

Description. Tubular fragments with a thin and flattened wall. Fine to coarsely agglutinated, test medium in size. Very finely agglutinated specimens are present in the Contessa Highway section.

Occurrence. Rare in the uppermost Maastrichtian in the Contessa Highway section.

Genus *Psammosiphonella* Avnimelech, 1952

Psammosiphonella cylindrica (Glaessner, 1937)
Rhabdammina cylindrica Glaessner, 1937, p.354, pl.1, fig.1.
Psammosiphonella cylindrica (Glaessner) –Kaminski & Gradstein, 2005, p. 119, pl. 6, figs 9-13.

Remarks. Specimens have a rather smooth surface.

Occurrence. Lower Campanian to Maastrichtian.

Superfamily KOMOKIACEA Tendal & Hessler, 1977
 Family RHIZAMMINIDAE Brady, 1879
 Genus *Rhizammina* Brady, 1879

Rhizammina algaeformis Brady, 1879

Plate 1, figs 2-3

Rhizammina algaeformis Brady, 1879, p.20, pl.4, figs 16-17.
Rhizammina cf. *algaeformis* (Brady). –Kuhnt, 1990, p. 324, pl. 1, fig. 1.

Remarks. This very finely agglutinated species dominates the agglutinated assemblages. Specimens recovered from Contessa are here attributed to this species based on the thin wall sometimes having small holes probably left by the dissolved small planktonic foraminifera.

Occurrence. Upper Cretaceous.

Rhizammina sp.

Description. Tubular fragments with a thin wall, finely agglutinated. Wall smoothly finished, small in size, sometimes bent or irregularly curved.

Remarks. These specimens recovered resemble *Rhizammina indivisa* (Brady, 1884), but they can also represent broken fragments of *Rhizammina algaeformis* (Brady, 1879).

Occurrence. Upper Cretaceous.

Suborder SACCAMMININA Lankester, 1885
 Superfamily SACCAMMINACEA Brady, 1884
 Family SACCAMMINIDAE Brady, 1884
 Subfamily SACCAMMININAE Brady, 1884
 Genus *Placentamina* Thalmann, 1947

Placentamina placenta (Grzybowski, 1898)

Plate 1, fig. 4

Reophax placenta Grzybowski, 1898, p. 276-277, pl. 10, figs. 9-10.

Saccamina placenta (Grzybowski). –Kuhnt, 1990, p. 325, pl. 2, fig. 1 –Kaminski & Geroch, 1993, p. 249, pl. 2, figs 5-7.

Placentamina placenta (Grzybowski). –Kaminski & Gradstein, 2005, p. 139, pl. 11, figs 1-6.

Remarks. Kuhnt (1990) identified smaller specimens from the Santonian as *S. cf. placenta*. We have not made this distinction.

Occurrence. Rare in the upper Campanian to Maastrichtian.

Genus *Saccamina* Carpenter, 1869

Saccamina grzybowskii (Schubert, 1902)

Plate 1, fig. 5

Reophax grzybowskii Schubert, 1902, p. 20, pl.1, fig. 13a-b

Saccamina grzybowskii (Schubert). –Kuhnt, 1990, p. 325, pl. 2, fig. 3. –Kaminski & Gradstein, 2005, p. 132, pl. 10, figs 1-9.

Remarks. Finely agglutinated specimens were recovered from Contessa Highway section.

Occurrence. Rare in the Upper Cretaceous.

Suborder HIPPOCREPININA Saidova, 1981
 Superfamily HIPPOCREPINACEA Rhumbler, 1895
 Family HIPPOCREPINIDAE Rhumbler, 1895
 Subfamily HIPPOCREPININAE Rhumbler, 1895
 Genus *Hippocrepina* Parker, 1870

Hippocrepina depressa Vašíček, 1947

Plate 1, fig. 7

Hippocrepina depressa Vašíček, 1947, p. 243, pl. 1, figs 1,2. –Bubík, p. 82, pl. 8, fig. 12

Occurrence. Rare in uppermost Maastrichtian.

Hippocrepina gracilis Holbourn & Kaminski, 1997

Plate 1, fig. 6

Hippocrepina gracilis Holbourn & Kaminski, 1997, p. 34, pl. 4, figs. 3-5.

Description. Holbourn & Kaminski (1997) described the species as follows: Test a narrow, elongated, compressed tube, very gently arched, and gently tapered

towards the base. Compressed specimens have a median furrow. Wall finely agglutinated and smoothly finished. Aperture is the open end of the tube.

Remarks. Although this species is recorded as Valanginian to Albian at Site 263, Indian Ocean, the description fits very well with the specimens recovered from the Contessa Highway section.

Occurrence. Campanian to Maastrichtian.

Family HYPERAMMINIDAE Eimer & Fickert, 1899
 Subfamily HYPERAMMININAE Eimer & Fickert, 1899
 Genus *Hyperamina* Brady, 1878

Hyperamina dilatata Grzybowski, 1896

Hyperamina dilatata Grzybowski, 1896, p. 274, pl. 8, fig. 17a-b. –Liszka & Liszkowa, 1981, p. 162, pl. 1, fig. 8.

“*Hyperamina*” *dilatata* Grzybowski. –Kaminski & Gradstein, 2005, p. 140, pl. 12, figs 1-5.

Occurrence. Rare in the uppermost Maastrichtian.

Subfamily SACCORHIZINAE Eimer & Fickert, 1899
 Genus *Saccorhiza* Eimer & Fickert, 1899

Saccorhiza cf. ramosa (Brady, 1878)

Plate 1, fig. 8

Hyperamina ramosa Brady, 1878, p.33, pl. 3, figs 14-15

Saccorhiza ramosa (Brady). –Barker, 1960, pl. 23, figs 15-17

Saccorhiza cf. ramosa (Brady). –Kuhnt, 1990, p. 325, pl. 2, figs 6-7

Remarks. Kuhnt (1990) mentioned that the tube branches in some specimens, however, this was not observed in any specimen recovered from the Turonian to Maastrichtian in the Contessa Highway section. Our specimens differ from the modern species *S. ramosa* in their small dimensions

Occurrence. Common.

Suborder AMMODISCINA Mikhalevich, 1980
 Superfamily AMMODISCACEA Reuss, 1862
 Family AMMODISCIDAE Reuss, 1862
 Subfamily AMMODISCINAE Reuss, 1862
 Genus *Ammodiscus* Reuss, 1862

Ammodiscus cretaceus (Reuss, 1845)

Plate 1, fig. 9

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

Ammodiscus cretacea (Reuss). –Cushman, 1934, p. 45.

Ammodiscus cretaceus (Reuss). –Kuhnt, 1990, p.310, pl.1, figs 2-3. –Kaminski & Gradstein, 2005, p.147, pl.14, figs 1a-10.

Occurrence. Rare.

Ammodiscus demarginatus Grzybowski, 1898

Ammodiscus demarginatus Grzybowski, 1898, p. 284, pl. 10, fig. 34

Ammodiscus demarginatus Grzybowski. –Kaminski *et al.*, 1993, p. 109, pl. 6, fig. 1a-c.

Description. Test finely agglutinated, surface rough. The tube is at first coiled in two to three small whorls, then runs in a direction oblique to the earlier whorls and embraces them, broadening markedly, forming two to two and one-half whorls. The end of the tube then uncoils and projects somewhat.

Occurrence. Very rare in the upper Campanian.

Ammodiscus infimus Franke, 1936

Ammodiscus infimus Franke, 1936, p. 15, pl. 1, fig. 14a-b. –Coccioni *et al.*, 1995, p. 143, pl. 1, figs 15-16.

Occurrence. Rare in the lower Turonian.

Ammodiscus glabratus Cushman & Jarvis, 1928

Plate 1, fig. 10

Ammodiscus glabratus Cushman & Jarvis, 1928, p. 87, pl. 12, fig. 6a,b. –Kaminski & Gradstein, 2005, p.148, pl. 15, figs 1a-6.

Occurrence. Rare to common in Upper Santonian to Maastrichtian.

Ammodiscus peruvianus Berry, 1928

Plate 1, figs 11-12

Ammodiscus peruvianus Berry, 1928, p. 342, pl. 27. –Kaminski & Gradstein, 2005, p. 159, pl. 18, figs 1a-6.

Occurrence. Common.

Ammodiscus tenuissimus Grzybowski, 1898

Ammodiscus tenuissimus Grzybowski, 1898, p. 282, pl. 10, fig. 35. –Kaminski & Geroch, 1993, p. 253, pl. 5, figs 1-3b. –Kaminski & Gradstein, 2005, p. 163, pl. 20, figs 1a-7. *Ammodiscus planus* Loeblich, 1946. –Kuhnt, 1990, p. 311, pl. 1, fig. 5.

Occurrence. Common.

Genus *Dolgenia* Kemper, 1995

Dolgenia pennyi (Cushman & Jarvis, 1928)

Plate 1, fig. 13

Ammodiscus pennyi Cushman & Jarvis, 1928, p.87, pl.12, figs 4-5. –Kaminski & Gradstein, 2005, p.155, pl.17, figs 1-6.

Ammodiscus cf. *pennyi* Cushman & Jarvis, 1928. –Kuhnt, 1990, p. 311, pl. 1, fig. 5.

Remarks. The species is transferred to the genus *Dolgenia* Kemper, 1995 based on its coarsely agglutinated wall and irregular coiling in the last whorls.

Occurrence. Rare.

Subfamily AMMOVERTELLININAE Saidova, 1981

Genus *Annectina* Suleymanov, 1963

Annectina grzybowskii (Jurkiewicz, 1960)

Glomospira grzybowskii Jurkiewicz, 1960, p. 339, pl. 38, figs 7, 10, 11.

Annectina grzybowskii (Jurkiewicz). –Kaminski & Gradstein, 2005, p. 192, pl. 28, figs 1-7.

Occurrence. Very rare in the uppermost Campanian.

Genus *Glomospirella* Plummer, 1945

Glomospirella sp.

Description. Proloculus followed by streptospirally enrolled undivided tubular second chamber, tubular chamber later becomes planispirally coiled. Wall finely agglutinated, smoothly finished; aperture at the open end of the tube.

Occurrence. Rare in lower Turonian.

Subfamily USBEKISTANIINAE Vyalov, 1977

Genus *Glomospira* Rzehak, 1885

Glomospira diffundens Cushman & Renz, 1946

Glomospira gordialis (Jones & Parker) var. *diffundens* Cushman & Renz, 1946, p. 15, pl. 1, fig. 30.

Glomospira gordialis diffundens Cushman & Renz. –Hemleben & Troester, 1984, p. 519, pl. 1, fig. 21.

Glomospira diffundens Cushman & Renz. –Kaminski & Gradstein, 2005, p. 175, pl. 23, figs 1-9.

Occurrence. Rare starting from upper Campanian.

Glomospira glomerata (Grzybowski, 1898)

Ammodiscus glomeratus Grzybowski, 1898, p.285, pl.11, fig. 4.

Glomospira glomerata (Grzybowski). –Kaminski & Geroch, p. 256, pl. 6, figs 9-12.

"*Glomospira*" *glomerata* (Grzybowski). –Kaminski & Gradstein, 2005, p. 178, pl. 24, figs 1-6 (with synonymy).

Occurrence. Common in Turonian to Maastrichtian.

Glomospira gordialis (Jones & Parker, 1860)

Plate 1, fig. 14

Trochammina squamata (Jones & Parker) var. *gordialis* Jones & Parker, 1860, p. 292-307 (no type figure given).

Glomospira gordialis (Jones & Parker). –Berggren & Kaminski, 1990, p. 73, pl. 1, fig. 1. –Kaminski & Gradstein, 2005, p. 181, pl. 25, figs 1-8.

Occurrence. Common in Turonian to Maastrichtian.

"*Glomospira*" *irregularis* (Grzybowski, 1898)

Plate 1, fig. 15

Ammodiscus irregularis Grzybowski, 1898, p. 285, pl. 11, figs 2, 3.

Glomospira? *irregularis* (Grzybowski). –Hemleben & Troester, 1984, p. 519, pl. 1, fig. 22.

Glomospira irregularis (Grzybowski). –Kaminski & Geroch, 1993, p. 256, pl. 6, figs 6-8b.

"*Glomospira*" *irregularis* (Grzybowski). –Kaminski & Gradstein, 2005, p. 185, pl. 26, figs 1a-7 (with synonymy).

Remarks. We place the genus name in quotation marks, because the type of coiling displayed by this species is streptospiral, whereas the type species is coiled glomospirally.

Occurrence. Common in Turonian to Maastrichtian.

"*Glomospira*" *serpens* (Grzybowski, 1898)

Plate 1, fig. 16

Ammodiscus serpens Grzybowski, 1898, p. 285, pl. 10, figs 31 (not figs 32 & 33).

Glomospira serpens (Grzybowski). –Kaminski & Geroch, 1993, p. 256, pl. 6, figs 2-5.

“*Glomospira*” *serpens* (Grzybowski). –Kaminski & Gradstein, 2005, p. 189, pl. 27, figs 1a-6b (with synonymy).

Remarks. We place the genus name in quotation marks, because the type of coiling displayed by this species is triloculine.

Occurrence. Rare from the lower Maastrichtian.

Genus *Repmanina* Suleymanov, 1966

Repmanina charoides (Jones & Parker, 1860)

Plate 1, figs 17a,b

Trochammina squamata var. *charoides* Jones & Parker, 1860, p. 304 (type figure not given).

Glomospira charoides (Jones and Parker). –Berggen & Kaminski, 1990, p. 60, pl. 1, fig. 2 (lectotype).

Repmanina charoides (Jones & Parker). –Kaminski *et al.*, 2005, p. 390, pl. 2, figs 7-8.

Occurrence. Common.

Order SCHLUMBERGERINIDA Mikhalevich, 1980

Suborder RZEHAKININA Saidova, 1981

Superfamily RZEHAKINACEA Cushman, 1933

Family RZEHAKINIDAE Cushman, 1933

Subfamily RZEHAKININAE Cushman, 1933

Genus *Rzehakina* Cushman, 1927

Rzehakina epigona (Rzehak, 1895)

Plate 1, fig. 18

Silicina epigona Rzehak, 1895, p. 214, pl. 6, fig. 1a-c.

Rzehakina epigona (Rzehak). –Bubík & Kaminski, 2000, p. 75, pl. 1, figs 1a-4b. –Kuhnt, 1990, p. 324, pl. 4, fig. 1.–Kaminski & Gradstein, 2005, p. 205, pl. 31, figs 1a-4b (with synonymy).

Occurrence. Very rare starting from the *Globotruncana ventricosa* Zone.

Rzehakina inclusa (Grzybowski, 1901)

Spiroloculina inclusa Grzybowski 1901, p.260, pl.8, fig.20.

Rzehakina inclusa (Grzybowski). –Kaminski & Geroch, 1993, p. 272, pl. 15, fig. 4a-c. –Kaminski & Gradstein, 2005, p. 209, pl. 33, figs 1-6b.

Occurrence. Very rare in Maastrichtian, Contessa Highway section.

Rzehakina minima Cushman & Renz, 1946

Plate 1, fig. 19

Rzehakina epigona (Rzehak) var. *minima* Cushman & Renz, 1946, p. 24, pl. 3, fig. 5.

Rzehakina minima Cushman & Renz. –Kaminski & Gradstein, 2005, p. 215, pl. 35, figs 1a-10 (with synonymy).

Occurrence. Very rare beginning from the *Globotruncana ventricosa* Zone.

Suborder HORMOSININA Mikhalevich, 1980

Superfamily HORMOSINELLACEA Rauser &

Reitlinger, 1986

Family HORMOSINELLIDAE Rauser & Reitlinger, 1986

Genus *Caudammia* Montanaro-Gallitelli, 1955

Caudammia excelsa (Dylązanka, 1923)

Plate 2, fig. 1

Hyperammia excelsa Dylązanka, 1923, p. 66, pl. 1, fig. 3.

Hormosina excelsa (Dylązanka) –Kaminski & Geroch, 1993, p. 281, pl. 17, figs 1-4b.

Caudammia excelsa (Dylązanka). –Kaminski & Gradstein, 2005, p. 230, pl. 40, figs 1a-8.

Occurrence. Very rare in the upper Maastrichtian.

Caudammia gigantea (Geroch, 1960)

Plate 2, fig. 2

Hormosina ovulum (Grzybowski) var. *gigantea* Geroch, 1960, p. 43, pl. 2, figs 18-19.

Hormosina gigantea Geroch. –Bubík, 1995, p.82, pl.9, fig.2.

Caudammia gigantea (Geroch). –Bał, 2004, p. 27, pl. 4, figs 1-3. –Kaminski & Gradstein, 2005, p. 235, pl. 41, figs 6-8.

Occurrence. Rare.

Caudammia ovula (Grzybowski, 1896) emend.

Geroch, 1960

Plate 2, fig. 3

Reophax ovulum Grzybowski, 1896, p. 276, pl. 8, figs 19-21.

Hormosina ovulum ovulum (Grzybowski). –Kaminski *et al.*, 1988, p. 186, pl. 2, fig. 10 (with synonymy).

Caudammia ovula (Grzybowski). –Kaminski & Gradstein, 2005, p. 233, pl. 41, figs 1a-8 (with synonymy).

Occurrence. Very rare.

Caudammia ovuloides (Grzybowski, 1901)

Reophax ovuloides Grzybowski, 1901, p. 233, pl. 8, fig. 3.

Hormosina ovuloides (Grzybowski). –Kaminski *et al.*, 1988, p. 186, pl. 2, figs 3-4.

Caudammia ovuloides (Grzybowski). –Kaminski & Gradstein, 2005, p. 238, pl. 42, figs 1a-7 (with synonymy).

Occurrence. Very rare.

Genus *Hormosinella* Shchedrina, 1969

Hormosinella cf. distans (Brady 1881)

Plate 2, figs 4-5

Reophax distans, Brady, 1881, p. 50, no figure given.

Hormosinella cf. distans (Brady). –Kuhnt, 1990, p. 316, pl. 3, fig.1

Hormosinella distans (Brady). –Kaminski & Gradstein, 2005, p. 246, pl. 45, figs 1-11.

Remarks. Kuhnt (1990) distinguished specimens from the Contessa Highway section from Recent ones based on the smaller test, finer agglutination and variable chamber shape. We note that the chamber shape of our specimens is more spherical than the

types of *H. distans* in the Brady Collection. However, the variable chamber shape can be a result of compression. Kaminski & Gradstein (2005) illustrated a specimen from the upper Campanian of Bottaccione as *Hormosinella distans* (Brady, 1881).

Occurrence. Rare beginning in the upper Campanian.

***Hormosinella fusiformis* n.sp.**

Plate 2, figs 6-12

Description. Test straight or bent slightly, comprising a series of elongated, fusiform shaped chambers connected by long, narrow stolons. Test very small and delicate. Wall thin, very finely agglutinated almost glassy in appearance comprising of a single layer of quartz granules.

Type Level. Upper Campanian, Sample B+245.

Type specimens. The holotype (plate 5, fig. 6, PF68309) and one paratype (PF68310) have been deposited in the collections of the Department of Paleontology, Natural History Museum, London.

Remarks. Due to the very delicate nature of the test only individual chambers are preserved. It differs from *Hormosinella distans* (Brady) by having more elongated chambers, delicate stolons and by having an even more fragile test.

Occurrence. Rare from the late Santonian to the Cretaceous/Paleogene boundary.

Genus *Hormosinelloides* Zheng, 2001

***Hormosinelloides guttifer* (Brady, 1884)**

Plate 2, fig. 13

Reophax guttifer Brady, 1884, p. 278.

Hormosinelloides guttifer (Brady). –Zheng & Fu, 2001, p. 278.

Remarks. Zheng & Fu (2001) established the genus *Hormosinelloides* with *Reophax guttifer* Brady as the type species. In *H. guttifer* the chambers embrace, (i.e., they are attached near the base of the apertural neck of the preceding one). In dissected specimens the end of the apertural neck of the older chamber can be seen to protrude into the chamber lumina of the following chamber. By contrast, in both *Subreophax* and *Hormosinella*, chambers are separated solely by stolons formed by constrictions of the wall (chambers do not overlap). Kaminski & Gradstein (2005) designated a lectotype for the species, which is preserved in the Brady Collection at the Natural History Museum, London, in Slide BMNH ZF 2276.

Genus *Subreophax* Saidova, 1975

***Subreophax aduncus* (Brady, 1882)**

Plate 2, figs 14-16

Reophax adunca Brady, in Tizard & Murray, 1882, p. 715

Subreophax aduncus (Brady). –Saidova, 1975, p. 57.

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

Remarks. Characterised by its meandering test and small, beadlike pseudochambers that do not increase in size as added.

Occurrence. Common throughout the section.

***Subreophax pseudoscalaris* (Samuel, 1977)**

Plate 3, fig. 6

Reophax pseudoscalaria Samuel, 1977, p. 36, pl. 3, figs 14a,b.

Subreophax pseudoscalaris (Samuel). –Kaminski & Gradstein, 2005, p. 282, pl. 56, figs 1-6.

Remarks. This species has large, somewhat irregular pseudochambers that have a thick wall.

Occurrence. Rare in the Maastrichtian.

***Subreophax scalaris* (Grzybowski, 1896)**

Plate 3, fig. 7

Reophax guttifer Brady var. *scalaria* Grzybowski, 1896, p. 277, pl. 8, fig. 26.

Subreophax scalaris (Grzybowski). –Kaminski *et al.* 1988, p. 187, pl. 2, figs 16-17. –Kaminski & Gradstein, 2005, p. 279, pl. 55, figs 1-7.

Remarks. Characterised by its straight to meandering test and rounded, flattened pseudochambers that increase in size as added.

Occurrence. Abundant.

***Subreophax splendidus* (Grzybowski, 1898)**

Plate 3, fig. 8

Reophax splendida Grzybowski, 1898, p.278, pl.10, fig.16

Reophax splendidus Grzybowski. –Neagu, 1970, p. 36, pl. 2, fig. 5

Subreophax aff. *splendidus* (Grzybowski). –Kuhnt, 1990, p. 326, pl. 3, figs 15-16.

Description. Kuhnt (1990) described the species as follows: Test large, bent or curved, wall coarsely agglutinated, chambers irregularly ovoid, flattened. Aperture small, terminal, with a very short protruding neck. Outline often irregular due to strong compression.

Remarks. Differs from *S. scalaris* in having fewer and larger chambers, separated by distinctly depressed suture and a more coarsely agglutinated wall.

Occurrence. Rare in the Coniacian to upper Maastrichtian.

***Subreophax longicameratus* n.sp.**

Plate 2, figs. 17-21; Plate 3, figs. 1-5

Subreophax sp. 1 Kuhnt, 1990, p.326, pl. 3, fig. 14

Subreophax sp. 1 Kuhnt. –Coccioni *et al.*, 1995, p. 150, pl. 2, fig. 11

Description. Test comprising a series of elongated pseudochambers, oval to almost rectangular in shape arranged in a rectilinear to sinuous pattern as in

Subreophax scalaris. Wall finely agglutinated, chamber wall collapsed in some of the specimens.

Type Level. Lowermost Maastrichtian, Sample B+260.

Remarks. It differs from other species of *Subreophax* (*S. scalaris*, *S. splendidus*) by the elongate shape of the pseudochambers and by the larger size of the test. Kuhnt (1990) did not provide a description of this species noting just that it resembles *Subreophax scalaris* but differs in having more elongated chambers.

Type specimens. The holotype (plate 2, fig. 17, PF68311) and three paratypes (PF68312 - PF68314) have been deposited in the collections of the Department of Paleontology, Natural History Museum, London.

Occurrence. Rare from late Albian to lower Turonian Scaglia Bianca Formation (Coccioni *et al.*, 1995), frequent from the Lower Turonian to the Cretaceous/Paleogene boundary in the Scaglia Rossa Formation. It also occurs in the Paleocene member of the Scaglia Rossa Formation.

Superfamily HORMOSINACEA Haeckel, 1894

Family ASCHEMOCELLIDAE, Vyalov, 1966

Genus *Arthrodendron* Ulrich, 1904

Arthrodendron diffusum Ulrich, 1904

Plate 3, fig. 9

Arthrodendron diffusum Ulrich, 1904, p.138, pl.14, figs 1–3

Arthrodendron diffusum Ulrich, 1904. –Kaminski *et al.*, 2008, p. 108, pl. 1, figs 1–4 (with synonyms).

Aschemonella carpathica Neagu, 1964, p. 582, text-fig. 4, figs 1–6.

Aschemocella carpathica (Neagu). –Kuhnt, 1990, p. 311, pl. 3, fig. 13.

Description. Large compressed fragments of probably initially ovoid shaped chambers. Wall thick, coarsely agglutinated, usually with a rough finish.

Remarks. Fragments probably belong to *Arthrodendron diffusum* because of the initially irregularly ovoidal shape that can be deduced in some larger fragments. Fragments recovered from the Contessa Highway section are finely agglutinated.

Occurrence. Rare from the uppermost Campanian to Maastrichtian.

Subfamily REOPHACIDAE Cushman, 1927

Reophax sp. 3 Kuhnt, 1990

Plate 3, fig. 10

Reophax sp. 3 Kuhnt, 1990, p. 324, pl. 3, fig. 10

Occurrence. Rare in the Turonian to Maastrichtian.

Reophax sp. 5 Kuhnt, 1990

Reophax sp. 5 Kuhnt, 1990, p. 324, pl. 3, fig. 11.

Occurrence. Rare in the Contessa Highway Section, Turonian to middle Santonian.

Family HORMOSINIDAE Haeckel, 1894

Subfamily HORMOSININAE Haeckel, 1894

Genus *Hormosina* Brady, 1879

Hormosina velascoensis (Cushman, 1926)

Nodosinella velascoensis Cushman, 1926, p. 583, pl. 20, fig. 9.

Hormosina velascoensis (Cushman). –Kaminski & Gradstein, 2005, p. 243, pl. 44, figs 1–8.

Occurrence. Rare.

Genus *Pseudonodosinella* Saidova, 1970

Pseudonodosinella parvula (Huss, 1966)

Plate 3, fig. 11

Reophax parvulus Huss, 1966, p. 21, pl. 1, figs 26–30.

Pseudonodosinella parvula (Huss). –Geröch & Kaminski, 1995, p. 118, pl. 2, figs 1–19 (with synonymy).

Occurrence. Common.

Suborder LITUOLINA Lankester, 1885

Superfamily LITUOTUBACEA Loeblich & Tappan, 1984

Family LITUOTUBIDAE Loeblich & Tappan, 1984

Genus *Lituotuba* Rhumbler, 1895

Lituotuba lituiformis (Brady, 1879)

Plate 3, fig. 12

Trochammina lituiformis Brady, 1879, p. 59, pl. 5, fig. 16.

Lituotuba lituiformis (Brady). –Kaminski & Gradstein, 2005, p. 287, pl. 58, figs 1–8.

Occurrence. Common.

Genus *Paratrochamminoides* Soliman, 1972

Paratrochamminoides acervulatus (Grzybowski, 1896)

Plate 3, fig. 16

Trochammina acervulatus Grzybowski, 1896, p.274, pl.9, fig.4.

Paratrochamminoides acervulatus (Grzybowski). –Kaminski & Kuhnt, 2004, p. 280 (no figure given). –Kaminski & Gradstein, 2005, p. 291, pl. 59, figs 1a–7b.

Occurrence. Rare to common in the middle Turonian to Maastrichtian.

Paratrochamminoides deflexiformis (Noth, 1912)

emend. Kaminski & Gradstein, 2005

Plate 3, fig. 17

Trochammina deflexiformis Noth, 1912, p.14, pl.1, fig.10.

Paratrochamminoides deflexiformis (Noth). –Kaminski & Gradstein, 2005, p. 293, pl. 60, figs 1a–4b.

Occurrence. Rare in the upper Turonian to Maastrichtian.

Paratrochamminoides draco (Grzybowski, 1901)

Plate 3, fig. 18

Trochammina draco Grzybowski, 1901, p.280, pl.8, fig.10
Paratrochamminoides draco (Grzybowski). –Kaminski & Geroch, 1993, p. 277, pl. 16, figs 5a-c. –Bubík, 1995, p. 84, pl. 3, fig. 2a, b.

Description. Test large, oval in outline. Coiling initially glomospiral, consisting of 2-3 whorls, with the axis of coiling reversing 180°, doubling back, and finally uncoiling. Chambers are well-separated, elongate, with 4-5 in the last whorl. Sutures depressed. Aperture at the open end of the tube. Wall thick, finely agglutinated.

Occurrence. Rare from the lower Santonian to Maastrichtian.

Paratrochamminoides gorayskii (Grzybowski, 1898), emend. Kaminski & Geroch, 1993
 Plate 4, figs. 1-2

Ammodiscus gorayskii Grzybowski, 1898, p. 283, pl. 11, fig. 5.

Paratrochamminoides gorayskii (Grzybowski). –Kaminski & Geroch, 1993, 255, pl. 5, fig. 8a-d. –Kaminski & Kuhnt, 2004, p. 281 (no figure given). –Kaminski & Gradstein, 2005, p. 297, pl. 61, figs 1a-5.

Occurrence. Rare in the lower Santonian to Maastrichtian.

Paratrochamminoides heteromorphus (Grzybowski, 1898)

Trochammina heteromorpha Grzybowski, 1898, p. 286, pl. 11, fig. 16.

Paratrochamminoides heteromorphus (Grzybowski). –Kuhnt, 1990, p. 320, pl. 5, fig. 18. –Kaminski & Geroch, 1993, p. 258, pl. 7, fig. 3a,b. –Kaminski & Kuhnt, 2004, p. 281 (no figure given). –Kaminski & Gradstein, 2005, p. 298, pl. 62, figs 1-10 (with synonyms).

Occurrence. Rare in the lower Santonian to Maastrichtian.

Paratrochamminoides mitratus (Grzybowski, 1901)
 Plate 4, fig. 3

Trochammina mitrata Grzybowski, 1901, p.280, pl.8, fig.3.

Paratrochamminoides sp. 2. –Kuhnt, 1990, p. 320, pl. 5, figs 14-16.

Paratrochamminoides mitratus (Grzybowski). –Kaminski & Geroch, 1993, p. 278, pl. 16, fig. 4a,b. –Kaminski & Kuhnt, 2004, p. 282 (no figure given). –Kaminski & Gradstein, 2005, p. 302, pl. 63, figs 1a-7.

Occurrence. Rare to common in the upper Turonian to Maastrichtian.

Paratrochamminoides olszewskii (Grzybowski, 1898)
 Plate 4, fig. 4

Trochammina olszewskii Grzybowski, 1898, p. 298, pl. 11, fig. 6.

Paratrochamminoides olszewskii (Grzybowski). –Kaminski & Geroch, 1993, p. 257, pl. 7, figs 1a-2b. –Kaminski & Kuhnt, 2004, p. 282 (no figure given). –Kaminski & Gradstein, 2005, p. 305, pl. 64, figs 1a-7.

Occurrence. Common in the Lower Turonian to Maastrichtian.

Paratrochamminoides uviformis (Grzybowski, 1901)
 Plate 4, figs. 5a,b

Trochamminoides uviformis Grzybowski, 1901, p. 281, pl. 8, figs 1-2.

Paratrochamminoides uviformis (Grzybowski). –Kaminski & Geroch, 1993, p. 278, pl. 16, fig. 7a,b. –Kaminski & Kuhnt, 2004, p. 283 (no figure given).

Description. Test comprising of numerous chambers coiled in a high trochospire consisting about three whorls. Chambers rounded, aperture interiomarginal.

Occurrence. Rare in the upper Campanian to Maastrichtian.

Genus *Conglophragmium* Bermúdez & Rivero, 1963

Conglophragmium irregularis (White, 1928)
 Plate 4, fig. 6

Trochamminoides irregularis White, 1928, p. 307, pl. 42, fig. 1.

Paratrochamminoides irregularis (White). –Kuhnt, 1990, p. 320, pl. 5, fig. 10.

Conglophragmium irregularis (White). –Kaminski & Gradstein, 2005, p. 286, pl. 57, figs 1-6.

Occurrence. Rare.

Family TROCHAMMINOIDEAE Haynes & Nwabufone, 1998

Genus *Trochamminoides* Cushman, 1910

Trochamminoides dubius (Grzybowski, 1901)
 Plate 3, figs. 13-14

Ammodiscus dubius Grzybowski, 1901, p. 274, pl. 8, figs 12, 14.

Trochamminoides dubius (Grzybowski). –Kuhnt, 1990, p. 326, pl. 5, fig. 11. –Kaminski & Geroch, 1993, p. 275, pl. 15, fig. 9a, b. –Kuhnt, 1990, pl. 5, fig. 11. –Kaminski & Gradstein, 2005, p. 309, pl. 65, figs 1a-8.

Occurrence. Very rare from upper Campanian to Maastrichtian.

Trochamminoides folius (Grzybowski, 1898)
 Plate 4, fig. 8-9

Trochammina folium Grzybowski, 1898, p. 288, pl. 11, figs 7- 9.

Trochamminoides folius (Grzybowski). –Kaminski & Geroch, 1993, p. 306, pl. 9, figs 1a-4b.

Description. Test oval in outline, flattened, with elongate, broad chambers. Two to three whorls visible, three to four chambers in the last whorl.

Occurrence. Rare from lower Turonian to Maastrichtian.

Trochamminoides grzybowskii Kaminski & Geroch, 1992
 Plate 3, fig. 15 ; Plate 4, fig. 7

Trochammina elegans Grzybowski, 1898, p. 287, pl. 11, fig. 10.

Trochamminoides grzybowskii Kaminski & Geroch, 1992, p. 64, fig. 1a,b. –Kaminski & Gradstein, 2005, p. 311, pl. 66, figs 1a-4.

Occurrence. Very rare from upper Campanian to lower Maastrichtian.

Trochamminoides proteus (Karrer, 1866)

Tochammina proteus Karrer, 1866, pl. 1, fig. 8.

Trochamminoides proteus (Karrer). –White, 1928, p. 308, pl. 42, fig. 2. –Kaminski & Gradstein, 2005, p. 317, pl. 67, figs 1a-5b.

Occurrence. Very rare from the lower Turonian to Maastrichtian.

Trochamminoides subcoronatus (Grzybowski, 1896)

Trochammina subcoronata Grzybowski, 1896, p. 283-284, pl. 9, fig. 3a-c.

Trochamminoides subcoronatus (Grzybowski). –Kaminski, *et al.*, 1988, p. 192, pl. 4, fig. 19. –Kaminski & Gradstein, 2005, p. 319, pl. 67, figs 1a-6.

Occurrence. Rare.

Superfamily LITUOLACEA de Blainville, 1827

Family HAPLOPHRAGMOIDIDAE Maync, 1952

Genus *Buzasina* Loeblich & Tappan, 1985

Buzasina pacifica (Krasheninnikov, 1973)

Plate 4, fig. 10

Labrospira pacifica Krasheninnikov, 1973, p. 209, pl. 2, figs 4-5.

Buzasina pacifica (Krasheninnikov). –Kaminski & Gradstein, 2005, p. 337, pl. 73, figs 1-5.

Occurrence. Rare to common from the Coniacian.

Genus *Haplophragmoides* Cushman, 1910

Haplophragmoides concavus (Chapman, 1892)

Trochammina concava Chapman, 1892, p. 327, pl. 6, fig. 14a-b.

Haplophragmoides concavus (Chapman). –Reicherter *et al.*, 1994, fig. 7A-C. –Coccioni *et al.*, 1995, p. 144, pl. 2, fig. 17.

Occurrence. Rare in the lower Turonian to lower Coniacian.

Haplophragmoides decussatus Krasheninnikov,

1973

Haplophragmoides decussatus Krasheninnikov, 1973, p. 208, pl. 2, fig. 3a, b. –Krasheninnikov, 1974, p. 635, pl. 1, fig. 6a-b. –Bubík, 1995, pl. 3, fig. 9a-b.

Haplophragmoides cf. concavus (Chapman). –Coccioni *et al.*, 1995, p. 144, pl. 2, fig. 15.

Remarks. Specimens from the Bottaccione section, Italy described and figured by Coccioni *et al.* (1995) are very similar with the species *H. decussatus* from the Upper Cretaceous from Indian Ocean.

Occurrence. Rare to common from the lower Turonian to middle Maastrichtian.

Haplophragmoides kirki Wickenden, 1932

Haplophragmoides kirki Wickenden, 1932, p. 85, pl. 1, fig. 1. –Kaminski & Gradstein, 2005, p. 351, pl. 78, figs 1a-6b.

Occurrences. Rare.

Haplophragmoides pervagatus Krasheninnikov, 1973

Plate 4, fig. 11

Haplophragmoides pervagatus Krasheninnikov, 1973, p. 215, pl. 1, fig. 7.

Occurrence. Rare in the upper Campanian.

Haplophragmoides perexplicatus Krasheninnikov, 1973

Plate 4, fig. 12

Haplophragmoides perexplicatus Krasheninnikov, 1973, p. 208, pl. 1, fig. 6a, b. –Krasheninnikov, 1974, p. 635, pl. 1, fig. 5a-b. –Bubík, 1995, pl. 12, fig. 4b.

Occurrence. Rare to common in the lower Santonian to middle Maastrichtian.

Haplophragmoides pseudokirki Krasheninnikov, 1974

Haplophragmoides pseudokirki Krasheninnikov, 1974, p. 635, pl. 1, fig. 8a,b. –Bubík, 1995, pl. 3, fig. 16a-b.

Occurrence. Rare to common in the Contessa Highway section.

Haplophragmoides cf. walteri (Grzybowski, 1989)

Plate 4, figs 13-14

Trochammina walteri Grzybowski, 1898, p. 290, pl. 11, fig. 31.

Haplophragmoides walteri (Grzybowski). –Kaminski & Geroch, 1993, p. 263, pl. 10, figs 3a-7c, p. 309, pl. 10, figs 3a, b, c.

Haplophragmoides cf. walteri (Grzybowski). –Moullade *et al.* 1988, p. 364, pl. 8, fig. 7. –Kuhnt, 1990, p. 314, pl. 4, figs 10-12. –Coccioni *et al.*, 1995, p. 144, pl. 2, fig. 16.

Remarks. Differs from the typical *H. walteri* by its smaller size, by having fewer chambers in the final whorl and by always having straight sutures (never sigmoidal).

Occurrence. Rare to common in the Contessa Highway Section.

Haplophragmoides suborbicularis (Grzybowski, 1896) emend. Kaminski & Gradstein, 2005

Cyclammina suborbicularis Grzybowski, 1896, p. 284, pl. 9, figs 5, 6.

Haplophragmoides suborbicularis (Grzybowski). –Bubík, 1995, pl. 3, fig. 13a-b. –Kaminski & Gradstein, 2005, p. 358, pl. 81, figs 1-4.

Occurrence. Very rare in the lower Maastrichtian in the Contessa Highway Section.

***Haplophragmoides* sp. 1** Kuhnt, 1990*Haplophragmoides* sp. 1 Kuhnt, 1990, p. 314, pl. 4, fig. 15.**Description.** Test small, wall finely agglutinated, smooth. Four to five chambers in the last whorl, depressed umbilicus. Often distorted by compression.**Occurrence.** Rare to common in the lower Turonian to upper Santonian.

Family SPHAERAMMINIDAE Cushman, 1933

Subfamily PRAESPHAERAMMININAE Kaminski & Mikhalevich, 2004

Genus *Praesphaerammina* Kaminski & Filipescu, 2000***Praesphaerammina gerochi*** (Hanzlíková, 1972)

Plate 4, fig. 15

Sphaerammina gerochi Hanzlíková, 1972, p.45, pl.8, figs 4-7.*Praesphaerammina gerochi* (Hanzlíková). –Kaminski & Gradstein, 2005, p. 367, pl. 84, figs 1-4.**Occurrence.** Rare from upper Campanian to Maastrichtian.

Superfamily RECURVOIDACEA Alekseychik-Mitskevich, 1973

Family AMMOSPHAEROIDINIDAE Cushman, 1927

Subfamily AMMOSPHAEROIDININAE Cushman, 1927

Genus *Ammosphaeroidina* Cushman, 1910***Ammosphaeroidina pseudopauciloculata*** (Mjatliuk, 1966)

Plate 4, fig. 16

Cystamminella pseudopauciloculata Mjatliuk, 1966, p. 246, pl. 1, figs 5-7, pl. 2, fig. 6, pl. 3, fig. 3.*Ammosphaeroidina pseudopauciloculata* (Mjatliuk). –Kaminski *et al.* 1988, p. 193, pl. 8, figs 3-5. –Kaminski & Gradstein, 2005, p. 376, pl. 87a, figs 1a-5; pl. 87b, figs 1a-10 (with synonymy).**Occurrence.** Rare in the lower Santonian to Maastrichtian.***Praecystammina globigerinaeformis***

Krasheninnikov, 1973

Praecystammina globigerinaeformis Krasheninnikov, 1973, p. 211, pl. 3, figs 1a-c, 2. –Kuhnt, 1990, p. 322, pl. 5, figs 4-6.**Occurrence.** Common to abundant in the upper Turonian to Maastrichtian.***Praecystammina* sp. 1**

Plate 5, fig. 1

Description. Test minute, with three chambers visible in umbilical view, four in spiral view. Outline lobate. Aperture a small round areal opening surrounded by a protruding lip.**Remarks.** Differs from *P. globigerinaeformis* in possessing a small round aperture rather than an oval one. This may be an early form of *P.**globigerinaeformis*, as these are the oldest forms of the genus in Contessa, found in sample B+80m (upper Turonian–lower Coniacian).

Subfamily RECURVOIDINAE Alekseychik-Mitskevich, 1973

Genus *Cribrostomoides* Cushman, 1910, emend. Jones *et al.*, 1993***Cribrostomoides subglobosus*** (Cushman, 1910)

Plate 5, fig. 3

Lituola subglobosa M. Sars, 1869 (nomen nudum).*Haplophragmoides subglobosum* (Sars). –Cushman, 1910, p. 105, figs 162-164.*Cribrostomoides subglobosus* (Cushman) forma *subglobosus*. –Jones *et al.* 1993, pl. 1, figs. 1-5; pl. 2, figs 6-8; pl. 3, figs 1-7. –Kaminski & Gradstein, 2005, p. 391, pl. 92, figs 1-3.**Occurrence.** Very rare in the upper Maastrichtian.**?*Cribrostomoides trinitatis*** Cushman & Jarvis, 1928

Plate 5, fig. 2

Cribrostomoides trinitatis Cushman & Jarvis, 1928, p. 91, pl. 12, fig. 12a-b. –Kaminski *et al.*, 1988, p. 188, pl. 6, figs 1a-2b (with synonymy).“*Cribrostomoides*” *trinitatis* Cushman & Jarvis. –Kaminski & Gradstein, 2005, p. 396, pl. 93, figs 1a-7.*Cribrostomoides* sp. 1 Kuhnt, 1990, p.311, pl.4, figs 19-20.**Remarks.** Kaminski & Gradstein (2005) tentatively placed this species in the genus *Cribrostomoides* because specimens display multiple interiomarginal openings and lacks any lips, whereas the type species of the genus has a surrounding lip.**Occurrence.** Rare in the lower Campanian to Maastrichtian.Genus *Recurvoidella* Uchio, 1960***Recurvoidella lamella*** (Grzybowski, 1898) emend.

Charnock & Jones, 1990

Plate 5, fig. 4

Trochammina lamella Grzybowski, 1898, p. 290, pl. 11, fig. 25.*Recurvoidella lamella* (Grzybowski). –Charnock & Jones, 1990, p. 173, pl. 6, figs 11-12; pl. 17, fig. 7**Occurrence.** Very rare in the uppermost Maastrichtian.Genus *Recurvoides* Earland, 1934***Recurvoides retroseptus*** (Grzybowski, 1896) emend.

Kaminski & Gradstein, 2005

Cyclammina retrosepta Grzybowski, 1896, p. 284, pl. 9, figs 7-8.*Recurvoides retroseptus* (Grzybowski). –Kaminski & Gradstein, 2005, p. 410, figs 1a-2b (with synonymy).**Occurrence.** Rare in the upper Campanian to Maastrichtian.

Family AMMOBACULINIDAE Saidova, 1981
 Subfamily AMMOBACULININAE Saidova, 1981
 Genus *Bulbobaculites* Maync, 1952

Bulbobaculites problematicus (Neagu, 1962)

Plate 5, figs 5-7

Ammobaculites agglutinans problematicus Neagu, 1962, p. 61, pl. 2, figs 22-24.
Ammobaculites problematicus (Neagu). –Neagu, 1970, p. 39, pl. 6, figs 1-5.

Haplophragmium problematicum (Neagu). –Kuhnt, 1990, p. 312, pl. 4, figs 3-9.

Bulbobaculites problematicus (Neagu). –Kuhnt & Kaminski, 1990, p. 465, text fig. 5, 5A.

Occurrence. Rare to common in the Turonian to lower Campanian.

Suborder SPIROLECTAMMININA Mikhalevich, 1992
 Superfamily SPIROLECTAMMINACEA Cushman, 1927
 Family SPIROLECTAMMINIDAE Cushman, 1927
 Subfamily SPIROLECTAMMININAE Cushman, 1927
 Genus *Bolivinopsis* Yakovlev, 1891

Bolivinopsis rosula (Ehrenberg, 1854)

Plate 5, fig. 8

Spirolecta rosula Ehrenberg, 1854, pl. 32, fig. 26.

Spirolectamina rosula (Ehrenberg). –Bubík, 1995, p. 87, pl. 14, fig. 11

Bolivinopsis rosula (Ehrenberg). –Cushman, 1946, p. 101, pl. 44, figs 4-8.

Description. Test elongate, narrow, early stage with large planispiral coil of a diameter greater than the early part of the following long biserial stage, which is of nearly constant width throughout, sutures commonly oblique in the later stage. Wall finely agglutinated, imperforate, with calcareous cement. Aperture an interiomarginal arch.

Remarks. This species was designated by Kiselman (1964) as the senior synonym of *Bolivinopsis capitata* Yakovlev, 1891, making it the type species of *Bolivinopsis* by virtue of synonymy.

Occurrence. Rare to common in the lower Maastrichtian.

Genus *Spiroplectinella* Kiselman, 1972

Spiroplectinella dentata (Alth, 1850)

Textularia dentata Alth, 1850, p. 262, pl. 13, fig. 13.

Spirolectamina dentata (Alth). –Kuhnt, 1990, p. 325, pl. 6, fig. 14.

Spiroplectinella dentata (Alth). –Kaminski & Gradstein, 2005, p. 439, pl. 106, figs 1a-8.

Occurrence. Rare in upper Campanian.

Spiroplectinella israelskyi (Hillebrandt, 1962)

Plate 5, fig. 9

Spirolectamina israelskyi Hillebrandt, 1962, p. 30, pl. 1, figs 5a-7b. –Kuhnt, 1990, p. 325, pl. 6, figs 16-17.

Spiroplectinella israelskyi (Hillebrandt). –Kaminski & Gradstein, 2005, p. 442, pl. 107, figs 1-11.

Occurrence. Rare to common in the upper Campanian to Maastrichtian.

Spiroplectinella laevis (Roemer, 1842)

Textularia laevis Roemer, 1842, p. 97, pl. 15, fig. 17.

Spirolectamina laevis (Roemer). –Cushman, 1932, p. 87, pl. 11, figs 2a-b.

Spirolectamina cf. *laevis* (Roemer). –Kuhnt, 1990, p. 325, pl. 6, fig. 15.

Remarks. This species is here transferred to the genus *Spiroplectinella* because the biserial adult stage increases rapidly in breadth.

Occurrence. Rare to common in the lower Campanian to lower Maastrichtian.

Family TEXTULARIOPSIDAE Loeblich & Tappan, 1982

Genus *Bicazamma* Neagu & Neagu, 1995

Bicazamma lagenaria (Krasheninnikov, 1974)

Plate 5, figs 10-11

Pseudobolivina lagenaria Krasheninnikov, 1974, pp. 639-640, pl.5, figs 1a-b, 2c – Moullade *et al.*, 1988, p. 366, pl. 9, figs 7-8. –Kuhnt, 1990, p. 322, pl. 6, figs 3-6

Remarks. The aperture of this species is rounded to oval and situated on a short neck and differs from the one of the genus *Pseudobolivina* (a high interiomarginal arch). The genus *Bicazamma* Neagu & Neagu (1995) appears to be more appropriate to include these forms, as they become lax uniserial in the terminal portion of the test. The generic affiliation of this species is discussed in further detail by Cetean *et al.*, this volume.

Occurrence. Rare to common in the Turonian to Maastrichtian.

Bicazamma cuneata (Krasheninnikov, 1974)

Pseudobolivina cuneata Krasheninnikov, 1974, p. 639, pl. 4, figs 8a-b, 9a.

Remarks. Differs from *B. lagenaria* by having chambers that increase rapidly in size, the last three to four chambers are large, inflated, and spherical. The generic affiliation of this species is discussed in further detail by Cetean *et al.*, this volume.

Occurrence. Rare in the middle Turonian to upper Campanian.

Genus *Eobigenerina* Cetean, Setoyama, Kaminski, Neagu, Bubík, Filipescu & Tyszka, 2008

Eobigenerina variabilis (Vašiček, 1947)

Plate 5, figs 12a-b

Bigenerina variabilis Vašiček, 1947, p.246, pl.1, figs 10-12.

Pseudobolivina variabilis (Vašiček). –Neagu, 1970, p. 41, pl. 5, figs 13-16.

Eobigenerina variabilis (Vašiček). –Cetean *et al.*, 2008, p. 6-7.

Description. Test initially biserial, then lax uniserial, and finally uniserial, with few uniserial chambers. The biserial – lax uniserial portion comprises the greater part of the test. Wall noncalcareous, solid, finely agglutinated, silicified. Aperture terminal, round, on a shoulder or short neck.

Remarks. Differs from *Rashnovammia* and *Hagimashella* in the addition of a truly uniserial terminal part. Differs from *Aptotoichus* in having a much reduced biserial part, in lacking a lax uniserial stage, and in its finely agglutinated wall. Type species of the genus *Eobigenerina* Cetean, Setoyama, Kaminski, Neagu, Bubík, Filipescu & Tyszka, 2008.

Occurrence. Rare to common in the middle Turonian to Maastrichtian.

Eobigenerina kuhnti Cetean, Setoyama, Kaminski,

Neagu, Bubík, Filipescu & Tyszka, this volume

Pseudobolivina sp. 4 Kuhnt, 1990, p. 324, pl. 6, figs. 6-7.

Remarks. Kuhnt (1990) described this species as having up to four chambers in a uniserial terminal part and therefore it is included in the genus *Eobigenerina*. The generic affiliation of this species is discussed in further detail by Cetean *et al.*, this volume.

Occurrence. Rare in the lower Turonian to lowermost Maastrichtian.

Genus *Rashnovammia* Neagu & Neagu, 1995

Rashnovammia munda (Krasheninnikov, 1974)

Plate 5, fig. 16

Pseudobolivina munda Krasheninnikov, 1973, p. 210, pl. 2, figs 10-11.

Pseudobolivina cf. *munda* Krasheninnikov. –Kuhnt, 1990, p. 324, pl. 6, figs 1-2.

Remarks. The aperture of this species is rounded to oval and situated on a short neck and differs from the one of the genus *Pseudobolivina* (a high interiomarginal arch). The genus *Rashnovammia* Neagu & Neagu (1995) appears to be a more appropriate genus for these forms. The generic affiliation of this species is discussed in further detail by Cetean *et al.*, this volume.

Occurrence. Common to abundant middle Turonian to Maastrichtian.

Family PSEUDOBOLOVINIDAE Wiesner, 1931

Genus *Parvigenerina* Vella, 1957

Parvigenerina sp. 3 (Kuhnt, 1990)

Plate 5, figs 13-14

Pseudobolivina sp. 3 Kuhnt, 1990, p. 324, pl. 6, fig. 5.

Description. Elongated, narrow, edge-shaped test. Chambers are oval, elongated in the direction of growth, slowly increasing in size as added. Biserial

chamber arrangement is biserial to loosely biserial and twisted in the direction of growth at about 90°.

Remarks. *Parvigenerina* is characterised by its loosely biserial adult chambers and its terminal aperture. The generic affiliation of this species is discussed in further detail by Cetean *et al.*, this volume.

Occurrence. Rare in the lower to upper Campanian.

Suborder TROCHAMMININA Saidova, 1981

Superfamily TROCHAMMINACEA Schwager, 1877

Family TROCHAMMINIDAE Schwager, 1877

Subfamily TROCHAMMININAE Schwager, 1877

Genus *Trochammia* Parker & Jones, 1859

Trochammia sp. 2 Bąk, 2004

Trochammia sp. 2 Bąk, 2004, p. 32, pl. 10, figs 12-15.

Trochammia sp. 7 Bubík, 1995, pl. 7, fig. 15a-c.

Description. Large specimens with a rounded equatorial outline, 4 chambers in the last whorl. Wall coarsely grained; umbilical and spiral sides are flat or slightly convex due post-burial chambers collapse.

Remarks. Specimens recovered are always flattened and have a fine agglutinated wall.

Occurrence. Rare.

Suborder VERNEULININA Mikhalevich & Kaminski, 2004

Superfamily VERNEULINACEA Cushman, 1911

Family PROLIXOPLECTIDAE Loeblich & Tappan, 1985

Genus *Gerochammia* Neagu, 1990

Gerochammia lenis (Grzybowski, 1896)

Spiroplecta lenis Grzybowski, 1896, p. 288, pl. 9, figs 24-25.

Spiroplecta deflexa Grzybowski, 1896, p. 288, pl. 9, figs 26-27.

Gerochammia lenis (Grzybowski, 1896). –Neagu, 1990, p. 260, pl. 2, figs 22-32, p. 254, pl. 4, figs 28-31.

Occurrence. Rare to common in the upper Santonian to Maastrichtian.

Gerochammia obesa Neagu, 1990

Plectina grzybowskii Neagu, 1962, p. 64, pl. 2, figs 30-33.

Gerochammia obesa Neagu, 1990, p. 260, pl. 2, figs 1-21. –Bubík, 1995, p. 80, pl. 7, fig. 3.

Remarks. Differs from *Gerochammia lenis* in its short biserial stage and well-developed low trochospiral stage.

Occurrence. Rare to common in the uppermost Coniacian/lowermost Santonian to Maastrichtian.

Gerochammia stanislawi Neagu, 1990

Gerochammia stanislawi Neagu, 1990, p. 253, pl. 1, fig. 1-26. –Bubík, 1995, p. 80, pl. 7, fig. 2; pl. 13, fig. 8.

Occurrence. Rare from Turonian to middle Santonian.

Genus *Rectogerochammina* Kaminski, Cetean & Neagu, 2010

Rectogerochammina eugubina Kaminski, Cetean & Neagu, 2010

Plate 5, figs 17a-b

Rectogerochammina eugubina Kaminski, Cetean & Neagu, 2010, p. 122, textfigs 1–2.

Description. Test free, elongated, tapered at both ends, with parallel sides. Coiling initially high trochospiral, reducing to biserial, and finally uniserial. Wall agglutinated, noncalcareous and imperforate, silicified. Aperture terminal, a round opening at the end of a short neck.

Remarks. Differs from *Gerochammina* in the presence of a terminal uniserial part.

Occurrence. Rare in the Contessa Highway section, mid to upper Campanian.

Family VERNEUILINIDAE Cushman, 1911

Subfamily VERNEUILINOIDINAE Suleymanov, 1973

Genus *Verneulinoides* Loeblich & Tappan, 1949

Verneulinoides polystrophus (Reuss, 1846)

Plate 5, fig. 18

Bulimina polystropha Reuss, 1846, p. 109, pl. 24, fig. 53.

Verneulinoides polystropha (Reuss). –Cushman, 1937, p. 11, pl. 1, figs 14–15.

Verneulinoides polystrophus (Reuss). –Kuhnt, 1990, p. 327, pl. 6, fig. 11. –Bubík, 1995, pl. 13, figs 10.

Occurrence. Common to abundant from the Coniacian to upper Maastrichtian.

Suborder ATAXOPHRAGMIINA Fursenko, 1958

Superfamily ATAXOPHRAGMIACEA Schwager, 1877

Family GLOBOTEXTULARIIDAE Cushman, 1927

Subfamily LIEBUSELLINAE Saidova, 1981

Genus *Remesella* Vašíček, 1947

Remesella varians (Glaessner, 1937)

Plate 5, fig. 20

Textulariella? varians Glaessner, 1937, p. 366, pl. 2, fig. 15.

Remesella mariae Vašíček, 1947, p. 246, pl. 2, fig. 14a, b, text fig. 2.

Remesella varians (Glaessner). –Kuhnt, 1990, pl. 6, figs 19–21. –Bubík, 1995, p. 86, pl. 15, fig. 11. –Kaminski & Gradstein, 2005, p. 511, pl. 129, figs 1–7 (with synonymy).

Occurrence. Rare beginning in the lower Maastrichtian.

Family REOPHACELLIDAE Mikhalevich & Kaminski, 2004

Subfamily REOPHACELLIDAE Mikhalevich & Kaminski, 2004

Genus *Uvigerinammina* Majzon, 1943

Uvigerinammina jankoi Majzon, 1943

Plate 5, fig. 19

Uvigerinammina jankoi Majzon, 1943, p. 158, pl. 2, fig. 15a, b. –Geroch, 1957, p. 240, pl. 14, figs. 1–10, pl. 15, figs. 1–16. –Bubík, 1995, p. 89, pl. 13, fig. 13.

Occurrence. Unusually rare our samples. This species is known to form acmes in the North Atlantic Upper Cretaceous sections, such as at ODP Site 641 and in the Indian Harbour well in the Labrador Sea.

CONCLUSIONS

We document the taxonomy and biostratigraphy of agglutinated foraminifera in acid residues from the Scaglia Bianca and Scaglia Rossa Formations in the Contessa Highway section of Italy. A total of 94 species belonging to 48 genera are documented from the section, including two new species. The stratigraphic ranges of DWAF are calibrated to the 2008 ICS timescale by means of the calcareous nannofossil biostratigraphy. Nine calcareous nannofossil zones were recognised in the section, but some zones were not distinguished owing to poor preservation.

Agglutinated foraminiferal assemblages are similar in taxonomic composition to those of the Carpathian Basins but in addition, a series of small abyssal-type *Haplophragmoides* species are common in the Contessa Highway section, probably as a result of oligotrophic conditions in the central Tethys. Four Upper Cretaceous DWAF biozones described from the Atlantic and Western Tethys are recognised in the Scaglia formations at Contessa: the lower Turonian *Bulbobaculites problematicus* Zone, the upper Turonian to Coniacian *Uvigerinammina jankoi* Zone, the Santonian to Campanian *Caudammina gigantea* Zone, and the Maastrichtian *Remesella varians* Zone. However, some stratigraphically important flysch-type species such as *Uvigerinammina jankoi* and *Caudammina gigantea* are very rare in the studied samples, and the index species for the Lower Campanian, *Rectoprotomarssonella rugosa*, is altogether absent. Consequently, the agglutinated foraminiferal biozones of the Carpathian zonation of Geroch & Nowak (1984) and Neagu *et al.* (1992) and the North Atlantic zonation of Kuhnt *et al.* (1992) cannot be applied in their entirety to the Contessa Highway section owing to the scarcity of some index taxa. This may be attributed to the oligotrophic palaeoenvironmental conditions represented by the deep-water Scaglia Rossa limestones, compared with the Carpathian flysch deposits.

The paleoenvironment of the Upper Cretaceous members of the Scaglia Rossa Formation was characterised by pelagic sedimentation with very low detritic input (mostly aeolian), deposited above the CCD, and with low organic flux as and well-oxygenated bottom water. The foraminiferal abundance and diversity values generally increase

upsection, though fluctuations in abundance are observed that are likely result from fluctuations in sea level. The abundance of agglutinated foraminifera at Contessa displays minima in the upper Turonian, upper Coniacian, upper Santonian, and lower Campanian. These low abundance assemblages likely indicate enhanced oligotrophy during sea level high stands, in agreement with the Erbacher *et al.* (1996) model that relates oceanic productivity to sea-level fluctuations. In the Campanian many typical "flysch-type" species appear in our faunal record, indicating a change in the trophic structure to a more mesotrophic environment. It is also likely that an increasing input of clastic sediments into the Umbria-Marche basin also played a role in this faunal change.

ACKNOWLEDGEMENTS

The revision of agglutinated foraminiferal genera is supported by a consortium of petroleum companies and micropalaeontological consultancies (BP, Chevron, Saudi Aramco, Shell, Total, PDVSA, RPS Energy, Fugro Robertson Ltd., Petronas, Petrobras). CGC thanks the Cushman Foundation for kindly supporting this project through the W.V. Sliter studentship award. We thank Fabrizio Frontalini (Urbino) for help with the statistical analysis, Clive Jones (NHM) for curating the new species, and Miroslav Bubík and Eiichi Setoyama (Kraków) for reading a draft of the paper. This is contribution nr. 90 of the Deep-Water Agglutinated Foraminiferal Project, and nr. 36 of the Sezione di Geobiologia, Patrimonio Culturale e Analisi del Paesaggio of the DiSUAN of the Urbino University.

REFERENCES

- Altenbach, A., Pflaumann, U., Schiebel, R., Thies, A., Timm, S. & Trauth, M. 1999. Scaling percentages and distributional patterns of benthic foraminifera with flux rates of organic carbon. *Journal of Foraminiferal Research*, **29** (3), 173-185.
- Alth, A. 1850. Geognostische - paläontologische Beschreibung der nächsten Umgebung von Lemberg. *Abhandlungen Naturwissenschaften Wien*, **3**, 171-284.
- Barker, R.W. 1960. Taxonomic notes on the species figured by H.R. Brady in his report on the foraminifera dredged by H.M.S. Challenger during the years 1873-1876. *Society of Economic Paleontologists and Mineralogists Special Publication*, **9**, 238 pp.
- Bąk, K. 2000. Biostratigraphy of deep-water agglutinated Foraminifera in Scaglia Rossa-type deposits of the Pieniny Klippen Belt, Carpathians, Poland. In: Hart, M.B., Kaminski, M.A. & Smart, C.W. (eds), *Proceedings of the Fifth International Workshop on Agglutinated Foraminifera*. Grzybowski Foundation Special Publication, **7**, 15-40.
- Bąk, K. 2004. Deep-water agglutinated foraminiferal changes across the Cretaceous/Tertiary and Paleocene/Eocene transitions in the deep flysch environment; eastern Outer Carpathians, (Bieszczady Mts., Poland). In: Bubík, M. & Kaminski, M.A., (eds), *Proceedings of the Sixth International Workshop on Agglutinated Foraminifera*. Grzybowski Foundation Special Publication, **8**, 1-56.
- Bergén, J.A. & Sikora, P.J. 1999. Microfossil diachronism in southern Norwegian North Sea chalks: Valhall and Hod fields. In: Jones, R.W., Simmons, M.D. (eds), *Biostratigraphy in Production and Development*. Geological Society, London, Special Publication, **152**, 85-111.
- Berggren, W.A. & Kaminski, M.A. 1990. Abyssal Agglutinates: Back to Basics. In: Hemleben, C., Kaminski, M.A., Kuhnt, W. & Scott, D.B. (eds), *Paleoecology, Biostratigraphy, Paleooceanography and Taxonomy of Agglutinated Foraminifera*, NATO ASI Series C, **327**, Kluwer Academic Press. 53-76.
- Berry, E.W. 1928. The smaller foraminifera of the middle Lobitos shales of northwestern Peru. *Eclogae Geologicae Helvetiae*, **21**, 390-405.
- Brady, H.B. 1878. On the reticularian and radiolarian rhizopoda (Foraminifera and Polycystina) of the North-Polar Expedition of 1875, 1876. *Annals and Magazine of Natural History*, series 5, **1**, 425.
- Brady, H.B. 1879. Notes on some of the reticularian Rhizopoda of the "CHALLENGER" Expedition; Part I. On new or little known Arenaceous types. *Quarterly Journal of Microscopical Sciences*, **19**, 20-67 + 3 pl.
- Brady H.B. 1881. Notes on some of the reticularian Rhizopoda of the Challenger Expedition. Part III. 1. Classification. 2. Further notes on new species. 3. Note on *Biloculina* mud. *Quarterly Journal of Microscopical Science*, new ser. **21**, 31-71.
- Brady, H.B. 1882. Report on Foraminifera. In: Tizard & Murray J., Exploration of the Farøe Channel during the summer of 1880, in Her Majesty's hired ship "Knight-Errant". *Proceedings of the Royal Society of Edinburgh*, **11**, 638-720.
- Bubík, M. 1995. Cretaceous to Paleogene agglutinated foraminifera of the Bile Karpaty unit (West Carpathians, Czech Republic). In: Kaminski, M.A., Geroch, S. & Gasinski, M.A. (eds), *Proceedings of the Fourth International Workshop on Agglutinated Foraminifera*. Grzybowski Foundation Special Publication, **3**, 71-116.
- Bubik, M. & Kaminski, M.A. 2000. Remarks on the type locality and current status of the foraminiferal species *Rzehakina epigona* (Rzehak, 1895). In: Hart, M.B., Kaminski, M.A. & Smart, C.W. (eds), *Proceedings of the Fifth International Workshop on Agglutinated Foraminifera*. Grzybowski Foundation Special Publication, **7**, 71-80.
- Burnett, J.A. 1998. Upper Cretaceous. In: Bown, P.R. (Ed.), *Calcareous Nannofossil Biostratigraphy*. British Micropalaeontological Society Publications Series. Chapman & Hall, London, 132-199.
- Campbell, R.J., Howe, R.W. & Rexilius, J.P. 2004. Middle Campanian-lowermost Maastrichtian nannofossil and foraminiferal biostratigraphy of the northwestern Australian margin. *Cretaceous Research*, **25**, 827-864.
- Catanzariti, R., Ellero, A., Levi, N., Otría, G. & Pandolfi, L. 2007. Calcareous nannofossil biostratigraphy of the

- Antola Unit succession (Northern Apennines, Italy): new age constraints for the Late Cretaceous Helminthoid Flysch. *Cretaceous Research*, **28**, 841-860.
- Cetean, C. 2009. *Cretaceous Foraminifera from the southern part of the Eastern Carpathians, between Stoenești and Cetățeni, Paleocology and Biostratigraphy*. Unpublished Ph.D. thesis, Babeș-Bolyai University, 214 pp.
- Cetean, C.G., Setoyama, E., Kaminski, M.A., Neagu, T., Bubík, M., Filipescu, S. & Tyszka, J. (this volume). *Eobigenerina*, a cosmopolitan deep-water agglutinated foraminifer, and remarks on late Paleozoic to Mesozoic species formerly assigned to *Pseudobolivina* and *Bigenerina*.
- Chapman, F. 1892. The Foraminifera of the Gault of Folkestone – II. *Journal of the Royal Microscopical Society*, **1892**, 319-330.
- Coccioni, R., Galeotti, S. & Gravili, M. 1995. Latest Albian–earliest Turonian deep-water agglutinated foraminifera in the Bottaccione section (Gubbio, Italy). Biostratigraphic and palaeoecologic implications. *Revista Española de Paleontología, No. Homenaje al Dr. Guillermo Colom*, 135-152.
- Cushman, J.A. 1910. A monograph on the foraminifera of the North Pacific Ocean; Part I – Astrorhizidae and Lituolidae. *United States National Museum Bulletin*, **71**, 134 pp.
- Cushman, J.A. 1926. The foraminifera of the Velasco Shale of the Tampico Embayment. *American Association of Petroleum Geologists Bulletin*, **10** (6), 581- 612.
- Cushman, J.A. 1932. *Textularia* and related forms from the Cretaceous. *Contributions from the Cushman Laboratory for Foraminiferal Research*, **8**, 86-96.
- Cushman, J.A. 1934. The generic position of "*Cornuspira cretacea* Reuss". *Contributions from the Cushman Laboratory for Foraminiferal Research*, **10**, 44-47.
- Cushman, J.A. 1937. A monograph of the foraminiferal family Verneuilinidae. *Cushman Laboratory for Foraminiferal Research Special Publication*, **7**, 1-157.
- Cushman, J.A. 1946. Upper Cretaceous Foraminifera of the Gulf Coastal Region of the United States and adjacent areas. *U.S. Geological Survey Professional Paper*, **206**, 241 pp.
- Cushman, J.A. & Jarvis, P.W. 1928. Cretaceous foraminifera from Trinidad. *Contributions from the Cushman Laboratory for Foraminiferal Research*, **4**, 85-103.
- Cushman, J.A. & Renz, H.H. 1946. The foraminiferal fauna of the Lizard Springs Formation of Trinidad, British West Indies. *Cushman Laboratory for Foraminiferal Research Special Publication*, **18**, 1-48.
- De Rijk, S., Jorisson, F.J., Rohling, E.J. & Troelstra, S.R. 2000. Organic flux control on bathymetric zonation of Mediterranean benthic foraminifera. *Marine Micropaleontology*, **40**, 151-166
- Dyląganka, M. 1923. Warstwy inoceramowe z łomu w Szymbarku koło Gorlic [The Inoceramus beds from a quarry in Szymbark near Gorlice]. *Rocznik Polskiego Towarzystwa Geologicznego*, **1**, 36-80.
- Erbacher, J., Thurow, J. & Littke, R. 1996. Evolution patterns of radiolaria and organic matter variations: A new approach to identify sea-level changes in mid-Cretaceous pelagic environments. *Geology*, **24** (6), 499-502.
- Ehrenberg, C.G. 1854. *Microgeologie*. Leopold Voss Verlag, Leipzig, 374 pp + 41 pls.
- Franke, A. 1936. Die Foraminiferen des deutschen Lias. *Abhandlungen der Preussischen geologischen Landesanstalt, neue Folge*, **169**, 1-138.
- Galeotti, S., Kaminski, M.A., Coccioni, R. & Speijer, R.P. 2004. High-resolution Deep-water agglutinated foraminiferal record across the Paleocene/Eocene transition in the Contessa Road Section (Central Italy). In: Bubík, M. & Kaminski, M.A. (eds), *Proceedings of the Sixth International Workshop on Agglutinated Foraminifera*. Grzybowski Foundation Special Publication, **8**, 83-103.
- Gardin, S., Del Panta, F., Monechi, S. & Pozzi, M. 2001. A Tethyan reference record for the Campanian and Maastrichtian stages: the Bottaccione section (Central Italy); review of data and new calcareous nannofossil results. In: Odin, G.S. (Ed.), *Characterisation at Tercis les Basins (France) and correlation with Europe and other continents. The Campanian-Maastrichtian Boundary*, Elsevier, 746-782.
- Glaessner, M.F. 1937. Studien über Foraminiferen aus der Kreide und dem Tertiär des Kaukasus; 1. Die Foraminiferen der ältesten Tertiärschichten des Nordwest-Kaukas. *Problems of Paleontology*, **2-3**, 349-408. Moscow.
- Geroch, S. 1957. *Uvigerinamina jankoi* Majzon (Foraminifera) in the Carpathian flysch. *Rocznik Polskiego Towarzystwa Geologicznego*, **25**, 231-244.
- Geroch, S. 1960. Microfaunal assemblages from the Cretaceous and Paleogene Silesian Unit in the Beskid Śląski Mts. (western Carpathians). *Biuletyn Instytutu Geologicznego*, **153**, 7-138.
- Geroch, S. & Nowak, W. 1984. Proposal of Zonation for the late Tithonian - late Eocene, based upon arenaceous foraminifera from the outer Carpathians, Poland. In: Oertli, H. (Ed.) *Benthos '83; 2nd International Symposium on Benthic Foraminifera Pau (France), April 11-15, 1983*. Elf Aquitaine, Esso Rep and Total cfp, Pau & Bourdeaux, pp. 225-239.
- Giusberti, L., Coccioni, R., Sprovieri, M. & Tateo, F. 2009. Perturbation at the sea floor during the Paleocene–Eocene thermal maximum: Evidence from benthic foraminifera at Contessa Road, Italy. *Marine Micropaleontology*, **70**, 102-119.
- Grzybowski, J. 1896. Otwornice czerwonych iłów z Wadowic. *Rozprawy Wydziału Matematyczno-Przyrodniczego, Akademia Umiejętności w Krakowie, serya 2*, **30**, 261-308.
- Grzybowski, J. 1898. Otwornice pokładów naftonosnych okolicy Krosna. *Rozprawy Wydziału Matematyczno-Przyrodniczego, Akademia Umiejętności w Krakowie, serya 2*, **33**, 257-305.
- Grzybowski, J. 1901. Otwornice warstw inoceramowych okolicy Gorlic. *Rozprawy Wydziału Matematyczno-Przyrodniczego, Akademia Umiejętności w Krakowie, serya 2*, **41**, 219-286.
- Gooday, A.J. & Haynes, J.R. 1883. Abyssal foraminifera, including two new genera, endrusting the interior of Bathysiphon rusticus tubes. *Deep-Sea Research*, **30** (6A), 591-614.
- Haeusler, R. 1883. Über die neue Foraminiferengattung *Thuraminopsis*. *Neues Jahrbuch für Mineralogie*, **2**, 68-72.

- Hanzlíková, E. 1972. Carpathian Upper Cretaceous foraminifera of Moravia (Turonian – Maastrichtian). *Rozprawy Ustredniho Ustavu Geologickeho*, **39**, 1-160.
- Hemleben, C. & Troester, J. 1984. Campanian-Maastrichtian deep-water foraminifers from Hole 543A, Deep Sea Drilling Project. *Initial Reports of the Deep Sea Drilling Project*, **78A**, 509-532.
- Hillebrandt, A. von, 1962. Das Paleozän und seine Foraminiferen-fauna im Becken von Reichenhall und Salzburg. *Abhandlungen, Bayerische Akademie der Wissenschaften, Mathematisch- Naturwissenschaftliche Klasse*, **108**, 9-180. München.
- Holbourn, A.E.L. & Kaminski, M.A. 1997. *Lower Cretaceous benthic foraminifera of the Indian Ocean*. Grzybowski Foundation Special Publication, **4**, 172 pp.
- Huss, F. 1966. Otwornice aglutynujące serii podśląskiej jednostki roponośnej Węglówki. *Prace Geologiczne. Komisja Nauk Geologicznych. Polska Akademia Nauk. Oddział w Krakowie*, **34**, 7-71.
- Jansa, L.F., Enos, P., Tucholke, B.E., Gradstein, F.M. & Sheridan, R.E. 1979. Mesozoic-Cenozoic sedimentary formations of the North Atlantic basin; western North Atlantic. In: Talwani, M., Hay, W. & Ryan, W.B.F., (eds), *Deep Drilling results in the Atlantic Ocean: Continental margins and paleoenvironment*. American Geophysical Union, Maurice Ewing Series, **3**, 1-57
- Jones, T.R. & Parker, W.K. 1860. On the Rhizopodal fauna of the Mediterranean compared with that of the Italian and some other Tertiary deposits. *Quarterly Journal of the Geological Society of London*, **16**, 292-307.
- Jurkiewicz, H. 1960. Otwornice z łupków czarnorzeczki wschodniej części jednostki śląskiej [Foraminifera from the Czarnorzeczka shales of the eastern part of the Silesian Unit]. *Rocznik Polskiego Towarzystwa Geologicznego*, **30**, 333-344.
- Kaminski, M.A. 2004. The Year 2000 Classification of the Agglutinated Foraminifera. In: Bubík, M. & Kaminski, M.A., (eds), *Proceedings of the Sixth International Workshop on Agglutinated Foraminifera*. Grzybowski Foundation Special Publication, **8**, 237-255.
- Kaminski, M.A. & Geroch, S. 1992. *Trochamminoides grzybowskii*, nom. nov., a new name for *Trochammina elegans* Grzybowski, 1898 (Foraminifera). *Journal of Micropalaeontology*, **11**, 137.
- Kaminski, M.A. & Geroch, S. 1993. A revision of foraminiferal species in the Grzybowski Collection. In: Kaminski, M.A., Geroch, S. & Kaminski, D. (eds), *The Origins of Applied Micropaleontology: The School of Józef Grzybowski*. Grzybowski Foundation Special Publication, **1**, Alden Press, Oxford, 239-323.
- Kaminski, M.A. & Gradstein, F.M. 2005. *Atlas of Paleogene cosmopolitan deep-water agglutinated foraminifera*. Grzybowski Foundation Special Publication, **10**, 574+vii pp.
- Kaminski, M.A. & Kuhnt, W. 2004. What, if anything, is a *Paratrochamminoides*? a key to the morphology of the Cretaceous to Cenozoic species of *Conglophragmium* and *Paratrochamminoides* (Foraminifera). In: Bubík M. & Kaminski M.A. (eds), 2004. *Proceedings of the Sixth International Workshop on Agglutinated Foraminifera*. Grzybowski Foundation Special Publication, **8**, 273-285.
- Kaminski, M.A., Bubík, M. & Ceteau, C.G. 2008. *Rectoprotomarssonella* n.gen., a new agglutinated foraminiferal genus from the Upper Cretaceous of the Carpathian flysch. *Micropaleontology*, **53** (6) 517-521 [for 2007].
- Kaminski, M.A., Ceteau, C.G. & Neagu, T. 2010. *Rectogerochammina eugubina*, n.gen., n.sp. a new agglutinated foraminifer from the Upper Cretaceous of Gubbio, Italy. *Revue de Micropaléontologie*, **53**, 121-124.
- Kaminski, M.A., Gradstein, F.M., Berggren, W.A., Geroch, S. & Beckmann, J.P. 1988. Flysch-type agglutinated foraminiferal assemblages from Trinidad: Taxonomy, Stratigraphy and Paleobathymetry. *Abhandlungen der Geologischen Bundesanstalt*, **41**, 155-228.
- Kaminski, M.A., Uchman, A., Neagu, T. & Ceteau, C.G. 2008. A larger agglutinated foraminifer originally described as a marine plant: The case of *Arthrodendron* Ulrich, 1904 (Foraminifera), its synonyms and homonyms. *Journal of Micropalaeontology*, **27** (2), 103-110.
- Karrer, F. 1866. Über das auftreten von Foraminiferen in den älteren Schichten des Wiener Sandsteins. *Sitzungsberichte K. Akad. der Wissenschaften. Math.-Naturw. Classe Wien*, Bd. **52**, (Jahrg. 1865), Abt. 1, Heft 9, pp.
- Kisselman, E.N. 1964. Otryad Textulariida. In: Subbotina, N.N. (Ed.), *Foraminifery Melovykh i Paleogenovykh otlozhenii Zapadno-Sibirskoi Nizmennosti*. Trudy VNIGRI, **234**, 153-192.
- Kolonic, S., Wagner, T., Forster, A., Sinnige Damsté, J.A., Wadsworth-Bell, B., Erba, E., Turgeon, S., Brumsack, H.-J., Chellai, El H., Tsikos, H., Kuhnt, W., Kuypers, M.M.M., 2005. Black shale deposition on the northwest African Shelf during the Cenomanian/Turonian oceanic anoxic event: Climate coupling and global organic carbon burial. *Paleoceanography*, **20**, 1-18.
- Krashenninikov, V.A. 1973. Cretaceous benthonic foraminifera, Leg 20, Deep Sea Drilling Project. *Initial Reports of the Deep Sea Drilling Project*, **20**, 205-221.
- Krashenninikov, V.A. 1974. Upper Cretaceous benthonic agglutinated foraminifera, Leg 27, Deep Sea Drilling Project. *Initial Reports of the Deep Sea Drilling Project*, **27**, 631-661.
- Kuhnt, W. 1990. Agglutinated foraminifera of western Mediterranean Upper Cretaceous pelagic limestones (Umbrian Apennines, Italy, and Betic Cordillera, Southern Spain). *Micropaleontology*, **36**, 297-330.
- Kuhnt, W. & Kaminski, M.A. 1989. Upper Cretaceous deep-water agglutinated benthic foraminiferal assemblages from the western Mediterranean and adjacent areas. In: Wiedmann, J. (Ed.), *Cretaceous of the Western Tethys. Proceedings of the 3rd International Cretaceous Symposium, Tubingen, 1987*. Sweitzerbart'sche Verlagsbuchhandlung, Stuttgart, 91-120.
- Kuhnt, W. & Kaminski, M.A. 1996. The response of benthic foraminifera to the K/T boundary event - a review. *Bull. Centres Rech. Explor.-Production Elf Aquitaine Memoire*, **16**, 433-442.

- Kuhnt, W. & Kaminski, M.A. 1997. Cenomanian to lower Eocene deep-water agglutinated foraminifera from the Zumaya section, northern Spain. *Annales Societatis Geologorum Poloniae*, **67**, 257-270.
- Kuhnt, W., Geroch, S., Kaminski, M.A., Moullade, M. & Neagu, T. 1992. Upper Cretaceous Abyssal Claystones in the North Atlantic and the Western Tethys - Current Status of Biostratigraphical Correlation using Agglutinated Foraminifers. *Cretaceous Research*, **13**, 467-478.
- Kuhnt, W., Moullade, M. & Kaminski, M.A. 1998. Upper Cretaceous, K/T boundary, and Paleocene agglutinated foraminifers from Hole 959D (Côte d'Ivoire – Ghana transform Margin). *Proceedings of the Ocean Drilling Program, Scientific Results*, **159**, 389-411.
- Lees, J.A. & Bown, P.R. 2005. Upper Cretaceous calcareous nannofossil biostratigraphy, ODP Leg 198 (Shatsky Rise, Northwest Pacific Ocean). *Proceedings of the Ocean Drilling Program, Scientific Results*, **198**, 1-60.
- Majzon, L. 1943. Adatok egyes Kárpátaljai Flisrétegekhez, tekintettel a Globotruncanákra [Beiträge zur Kenntniss einiger Flysch-Schichten des Karpaten-Vorlandes mit Rücksicht auf die Globotruncanen]. *A magyar Királyi Földtani Intézet, Évkönyve*, **37**, 1-170.
- Mjatliuk, E.V. 1966. K voprosu o foraminiferakh c kremnevnyim skeletom [On the question of foraminifera with a siliceous skeleton]. *Voprosy Mikropaleontologii*, **10**, 255-269.
- Monechi, S. & Thierstein, H.R. 1985. Late Cretaceous–Eocene nannofossil and magnetostratigraphic correlations near Gubbio, Italy. *Marine Micropaleontology*, **9**, 419-440.
- Moullade, M., Kuhnt, W. & Thurow, J. 1988. Agglutinated benthic foraminifers from Upper Cretaceous variegated clays of the North Atlantic Ocean. *Proceedings of the Ocean Drilling Program, Scientific Results*, **103**, 349-377.
- Neagu, T. 1962. Studiul foraminiferelor aglutinante din argilele Cretacic superioare de pe Valea Sadovei (Câmpulung-Moldovenesc) și bazinul superior al văii Buzăului. *Studii și Cercetări de Geologie, Academia R.P.R., Secția de Geologie și Geografie și Institutul de Geologie și Geografie*, **7**, 45-81.
- Neagu, T. 1964. Large size agglutinated foraminifera from the Carpathian of Rumania. *Rocznik Polskiego Towarzystwa Geologicznego*, **34**, 579-588.
- Neagu, T. 1970. Micropaleontological and stratigraphical study of the upper Cretaceous deposits between the upper valleys of the Buzău and Rîul Negru Rivers (Eastern Carpathians). *Memorii, Institutul Geologic*, **12**, 7-109.
- Neagu, T. 1990. *Gerochammina* n.gen. and related genera from the Upper Cretaceous flysch-type benthic foraminiferal fauna, Eastern Carpathians – Romania. In: Hemleben, C., Kaminski, M.A., Kuhnt, W. & Scott, D.B. (eds), *Paleoecology, Biostratigraphy, Paleoceanography and Taxonomy of agglutinated foraminifera*. NATO ASI series C, **327**, 245-265. Kluwer Academic Press.
- Neagu, T., Platon E., Dumitrescu G. & Selea A. 1992. The biostratigraphical significance of agglutinated foraminifera in the Eastern Carpathians (Upper Cretaceous). *Analele Universității București*, **15-16**, 45-49.
- Nederbragt, A.J. & Fiorentino, A., 1999. Stratigraphy and palaeoceanography of the Cenomanian-Turonian Boundary Event in Oued Mellegue, north-western Tunisia. *Cretaceous Research*, **20**, 47-62.
- Olszewska, B. 1997. Foraminiferal biostratigraphy of the Polish Outer Carpathians: a record of basin geohistory. *Annales Societatis Geologorum Poloniae*, **67**, 325-337.
- Ogg, J., Ogg, G. & Gradstein, F.M. 2008. The Concise Geological Timescale. Cambridge University Press. 177 pp.
- Perch-Nielsen, K. 1985. Mesozoic calcareous nannofossils. In: Bolli, H.M., Saunders, J.B. & Perch-Nielsen, K. (eds), *Plankton Stratigraphy*. Cambridge University Press, Cambridge, 329-426.
- Premoli-Silva, I. & Sliter, W.V. 1994. Cretaceous planktonic foraminiferal biostratigraphy and evolutionary trends from the Bottaccione Section, Gubbio, Italy. *Palaeontographica Italica*, **82**, 1-89.
- Rawson, P.F., Dhondt, A.V., Hancock, J.M. & Kennedy, W.J. (eds), 1996. Proceedings of the Second International Symposium on Cretaceous Stage Boundaries. *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Brussels, Sciences de la Terre Aardwetenschappen*, **66**, 117 pp.
- Reicherter, K., Pletsch, T., Kuhnt, W., Manthey, J., Homeier, G. & Thurow, J. 1994. Mid-Cretaceous paleogeography and paleoceanography of the Betic Seaway (Betic Cordilera, Spain). *Palaeogeography, Palaeoclimatology, Palaeoecology*, **107**, 1-33.
- Reuss, A.E. 1845. *Die Versteinerungen der böhmischen Kreideformation*. Abtheilung 1. E. Schweizerbart'sohne Verlagsbuchhandlung, Stuttgart. 58 pp.
- Reuss, A.E. 1846. *Die Versteinerungen der böhmischen Kreideformation (Nachträge und Ergänzungen zur ersten Abtheilung)*, Abtheilung 2. E. Schweizerbart'sohne Verlagsbuchhandlung, Stuttgart, 148 pp.
- Roemer, F.A. 1841. *Die Versteinerungen des norddeutschen Kreidegebirges*. Hannover, 1-145.
- Roth, P.H. & Krumbach, K.R. 1986. Middle Cretaceous calcareous nannofossil biogeography and preservation in the Atlantic and Indian Oceans: implications for paleoceanography. *Marine Micropaleontology*, **10**, 235-266.
- Rzehak, A., 1895. Über einige merkwürdige Foraminiferen aus österreichischen Tertiär. *Annalen Naturhistorisches Hofmuseum, Wien*, **10**, 213-230.
- Saidova, Kh.M. 1975. Benthosnye Foraminifery Tikhogo Okeana [Benthonic foraminifera of the Pacific Ocean], Institut Okeanologi P.P. Shirshova, Akademiya Nauk SSSR, Moscow, 875 pp.
- Samuel, O. 1977. Agglutinated foraminifers from Paleogene flysch formations in West Carpathians of Slovakia. *Zapadne Karpaty, serie paleontologie*, **2-3**, 7-70.
- Sars, M. 1869. Fortsatte Bemaerkinger over det Dyriske Livs Udbredning i Havets Dybder. *Forhandlinger i Videnskasselskabet i Kristiania*, **1868**, 246-275.
- Setoyama, E., Kaminski, M.A. & Tyszka, J. (this volume). Late Cretaceous Agglutinated Foraminifera and Implications for the Biostratigraphy and Palaeoenvironments of the southwestern Barents Sea.
- Schubert, R.J. 1902. Neue und interessante Foraminiferen aus dem südtiroler Alteriär. *Beiträge zur Paläontologie und Geologie Österreich-Ungarns und des Orients*, **14**, 9-26.
- Singh, W. 1977. Biostratigraphy of Cretaceous calcareous nannoplankton. *Geologie en Mijnbouw*, **56**, 37-65.

- Tantawy, A.A. 2008. Calcareous nannofossil biostratigraphy and paleoecology of the Cenomanian – Turonian transition in the Tarfaya Basin, southern Morocco. *Cretaceous Research*, **29**, 995-1007.
- Thierstein, H.R. 1976. Mesozoic calcareous nannoplankton biostratigraphy of marine sediments. *Marine Micropaleontology*, **1**, 325-362.
- Thierstein, H.R. 1980. Selective dissolution of Late Cretaceous and earliest Tertiary calcareous nannofossils: experimental evidence. *Cretaceous Research*, **2**, 165–176.
- Tsikos, H., Jenkyns, H.C., Wadsworth-Bell, B., Petrizzo, M.R., Forster, A., Kolonic, S., Erba, E., Premoli Silva, I., Baas, M., Wagner, T., & Sinninghe Damsté, J.S. 2004. Carbon-isotope stratigraphy recorded by the Cenomanian–Turonian Oceanic Anoxic Event: correlation and implications based on three key localities. *Journal of the Geological Society, London*, **161**, 711-719.
- Ulrich, E.C. 1904. Fossils and age of the Yakutat Formation. Description of the collections made chiefly near Kadiak, Alaska. In: Emerson, B.K., Palache, C., Dall, W.H., Ulrich, E.O. & Knowlton, F.H. Alaska, vol. 4, Geology and Paleontology. Doubleday, Page & Co. New York, 125-146 [Reprinted in 1910 as the Smithsonian Institution Harriman Alaska Series, vol. 4].
- Vašíček, M. 1947. Poznámky k mikrobiostratigrafii magurského flyše na Moravě. *Věstník Státního Geologického Ústavu Československé Republiky*, **22**, 235-256.
- Weidich, K.F. 1990. Die kalkalpine Unterkreide und ihre Foraminiferen fauna. *Zitteliana*, **17**, 3-312.
- White, M.P. 1928. Some index foraminifera of the Tampico Embayment area of Mexico (Part 2). *Journal of Paleontology*, **2**, 280-317.
- Wickenden, R.T.D. 1932. New species of foraminifera from the Upper Cretaceous of the Prairie Provinces. *Transactions of the Royal Society of Canada ser. 3*, **26**, 85-91.
- Zheng, S. & Fu, Z. 2001. *Fauna Sinica, Phylum Granuloreticulosa, Class Foraminifera, Agglutinated Foraminifera*. Science press, Beijing. 788 pp + 122 pls.



Appendix 1. Nannofossil taxa identified in the Contessa Highway section, listed in alphabetical order of genera

- Ahmuelerella octoradiata* (Górka, 1957) Reinhardt, 1966
Ahmuelerella regularis (Górka, 1957) Reinhardt and Górka, 1967
Arkhangelskiella confusa Burnett, 1997a
Arkhangelskiella cymbiformis Vekshina, 1959
Arkhangelskiella maastrichtiana Burnett, 1997a
Biscutum Black in Black and Barnes, 1959
Biscutum constans (Górka, 1957) Black, 1959
Biscutum ellipticum (Górka, 1957) Grün in Grün and Allemann, 1975
Braarudosphaera bigelowii (Gran and Braarud, 1935) Deflandre, 1947
Broinsonia enormis (Shumenko, 1968) Manivit, 1971
Broinsonia parca (Stradner, 1963) Bukry, 1969, sp. *constricta* Hattner *et al.*, 1980
Broinsonia parca (Stradner, 1963) Bukry, 1969, sp. *expansa* Wise and Watkins in Wise, 1983
Broinsonia parca (Stradner, 1963) Bukry, 1969, sp. *parca*
Calculites ovalis (Stradner, 1963) Prins and Sissingh in Sissingh, 1977
Calculites obscurus (Deflandre, 1959) Prins and Sissingh in Sissingh, 1977
Chiastozygus Gartner, 1968
Chiastozygus amphipons (Bramlette and Martini, 1964) Gartner, 1968
Chiastozygus bifarius Bukry, 1969
Chiastozygus litterarius (Górka, 1957) Manivit, 1971
Cretarhabdus conicus Bramlette and Martini, 1964
Cretarhabdus striatus (Stradner, 1963) Black, 1973
Cribrocorona gallica Bramlette and Martini, 1964
Cribrosphaerella ehrenbergii (Arkhangelsky, 1912) Deflandre in Pivetteau, 1952
Cyclagelosphaera reinhardtii (Perch-Nielsen, 1968) Romein, 1977
Cyclagelosphaera rotaclypeata Bukry 1969
Cylindralithus Bramlette and Martini, 1964
Cylindralithus sculptus Bukry, 1969
Discorhabdus ignotus (Górka, 1957) Perch-Nielsen, 1968
Eiffelithus eximius (Stover, 1966) Perch-Nielsen, 1968
Eiffelithus gorkae Reinhardt, 1965
Eiffelithus turriseiffelii (Deflandre in Deflandre and Fert, 1954) Reinhardt, 1965
Eprolithus Stover, 1966
Eprolithus floralis (Stradner, 1962) Stover, 1966
Eprolithus moratus (Stover, 1966) Burnett, 1998
Gartnerago segmentatum (Stover, 1966) Thierstein, 1974
Helenea chiastia Worsley, 1971
Helicolithus anceps (Górka, 1957) Noël, 1970
Helicolithus trabeculatus (Górka, 1957) Verbeek, 1977
Kamptnerius magnificus Deflandre, 1959
Loxolithus armilla (Black, 1959) Noël, 1965
Lucianorhabdus maleformis Reinhardt, 1966
Manivitella pemmatoidea (Deflandre, 1965) Thierstein, 1971, emend. Black, 1973
Microrhabdulus decoratus Deflandre, 1959
Microrhabdulus undosus Perch-Nielsen, 1973
Micula murus (Martini, 1961) Bukry, 1973
Micula praemurus (Bukry, 1973) Stradner and Steinmetz, 1984
Micula staurophora (Gardet, 1955) Stradner, 1963
Misceomarginatus pleniporus Wind and Wise in Wise and Wind, 1977
Nephrolithus frequens Górka, 1957
Octolithus multiplus (Perch-Nielsen, 1973) Romein, 1979
Placozygus fibuliformis (Reinhardt, 1964) Hoffmann, 1970
Prediscosphaera cretacea (Arkhangelsky, 1912) Gartner, 1968
Quadrum gartneri Prins and Perch-Nielsen in Manivit *et al.*, 1977
Quadrum intermedium Varol, 1992
Radiolithus planus Stover, 1966
Reinhardtites anthophorus (Deflandre, 1959) Perch-Nielsen, 1958
Reinhardtites levis Prins and Sissingh in Sissingh, 1977
Retecapsa angustiforata Black, 1971
Retecapsa crenulata (Bramlette and Martini, 1964) Grün, 1975
Rhagodiscus angustus (Stradner, 1963) Reinhardt, 1971
Rhagodiscus asper (Stradner, 1966) Reinhardt, 1967
Rhagodiscus gallagheri Rutledge and Bown, 1996
Staurolithites Caratini, 1963
Staurolithites flavus Burnett, 1997a
Staurolithites laffitei Caratini, 1963
Tranolithus minimus (Bukry, 1969) Perch-Nielsen, 1984
Tranolithus orionatus (Reinhardt, 1966) Reinhardt, 1966
Uniplanarius gothicus (Deflandre, 1959) Hattner and Wise, 1980
Watznaueria barnesae (Black, 1959) Perch-Nielsen, 1968
Watznaueria ovata Bukry, 1969
Zeugrhabdotus bicrescenticus (Stover, 1966) Burnett in Gale *et al.*, 1996
Zeugrhabdotus diplogrammus (Deflandre in Deflandre and Fert, 1954) Reinhardt, 1965
Zeugrhabdotus embergeri (Noël, 1958) Perch-Nielsen, 1984
Zeugrhabdotus scutula (Bergen, 1994) Rutledge and Bown, 1996

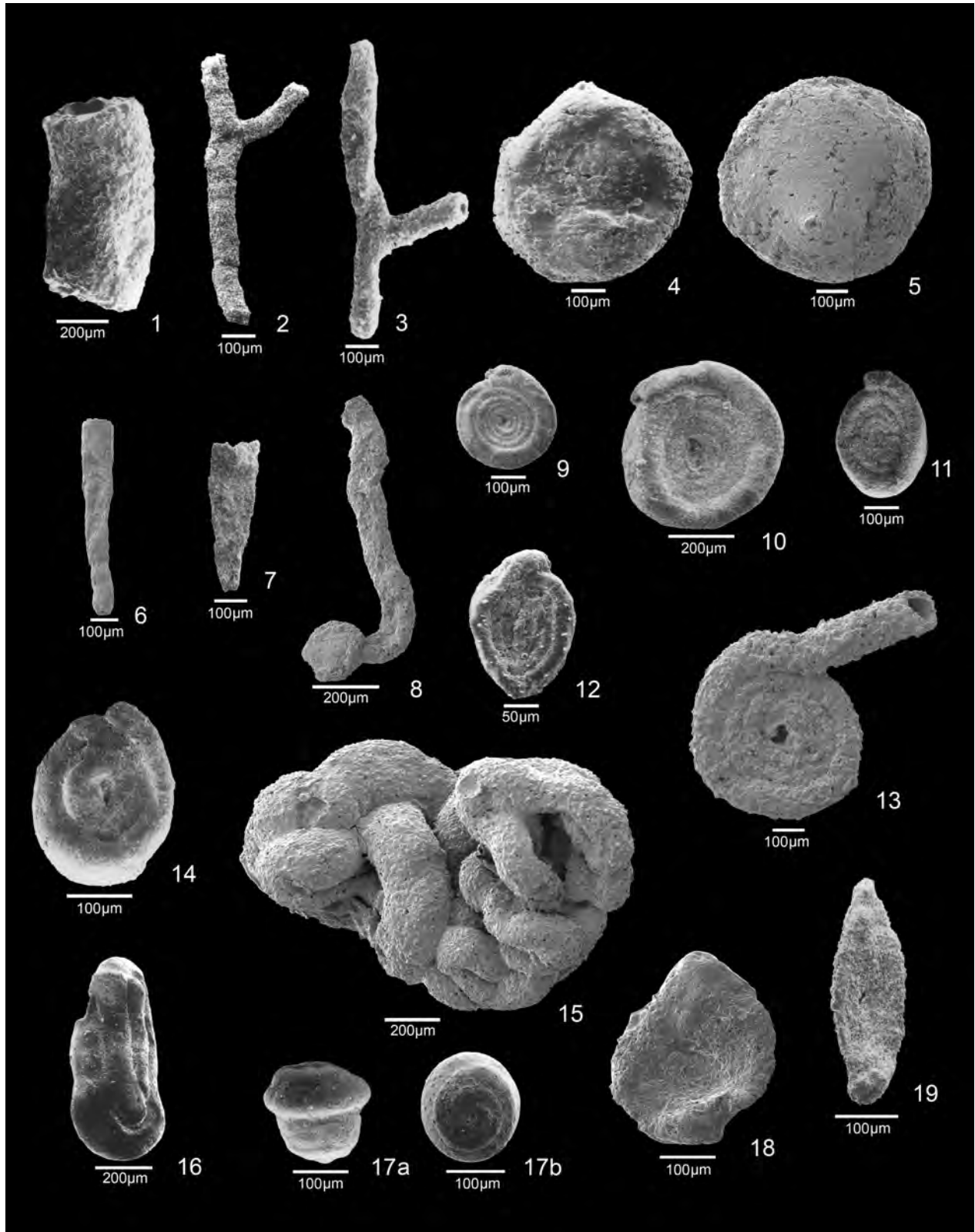


Plate 1. 1. *Nothia* sp., CHW B+299m; 2. *Rhizammina algaeformis* Brady, B+299; 3. *Rhizammina algaeformis* Brady, B+95; 4. *Placentamina placenta* (Grzybowski), B+185; 5. *Saccamina grzybowskii* (Schubert), B+260; 6. *Hippocrepina gracilis* Holbourn & Kaminski, B+180; 7. *Hippocrepina depressa* Vašiček, B+175; 8. *Saccorhiza* cf. *ramosa* (Brady), B+260; 9. *Ammodiscus cretaceus* (Reuss), B+40; 10. *Ammodiscus glabratus* Cushman & Jarvis, B+130; 11-12. *Ammodiscus peruvianus* Berry; 11. B+95; 12. B+185; 13. *Dolgenia pennyi* (Cushman & Jarvis) B+260; 14. *Glomospira gordialis* (Jones & Parker) B+190; 15. “*Glomospira*” *irregularis* (Grzybowski), B+280; 16. “*Glomospira*” *serpens* (Grzybowski), B+299; 17a-b. *Repmanina charoides* (Jones & Parker), B+299; 18. *Rzehakina epigona* (Rzehak), B+275; 19. *Rzehakina minima* Cushman & Renz, B+175.

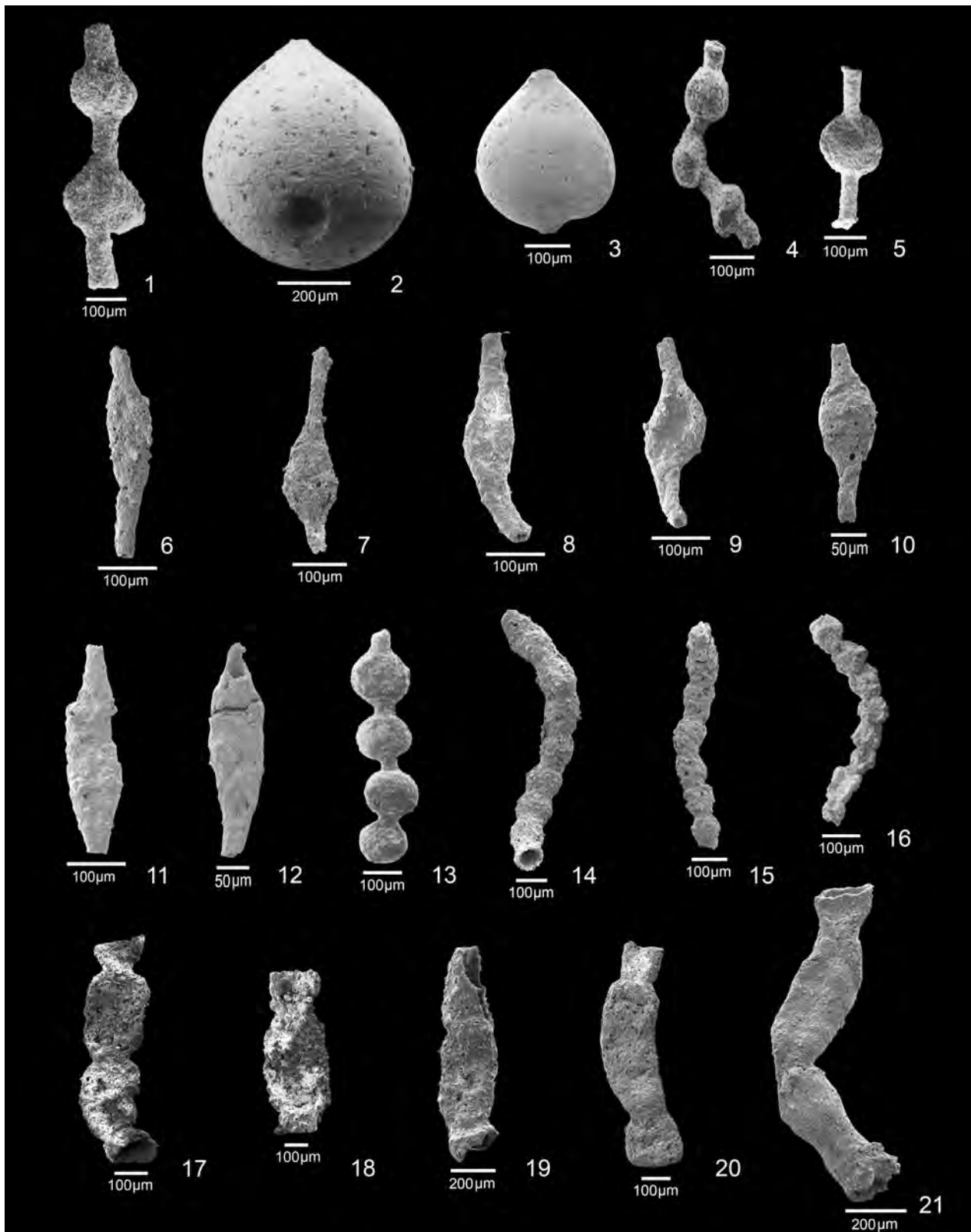


Plate 2. 1. *Caudammina excelsa* (Dylażanka), B+30; 2. *Caudammina gigantea* (Geroch), B+190; 3. *Caudammina ovula* (Grzybowski), B+235; 4-5. *Hormosinella* cf. *distans* (Brady), 4. B+110; 5. B+190; 6-12. *Hormosinella fusiformis* n.sp., 6. holotype, B+245; 7. paratype B+245; 8. B+170; 9. B+250; 10. B+260; 11-12. B+195; 13. *Hormosinelloides guttifer* (Brady), B+150; 14-16. *Subreophax aduncus* (Brady); 14-15. B+255; 16. B+150; 17-21. *Subreophax longicameratus* n.sp., 17. holotype, B+260; 18. paratype, B+260; 19. B+260; 20. B+255; 21. B+370.9 (Paleocene).

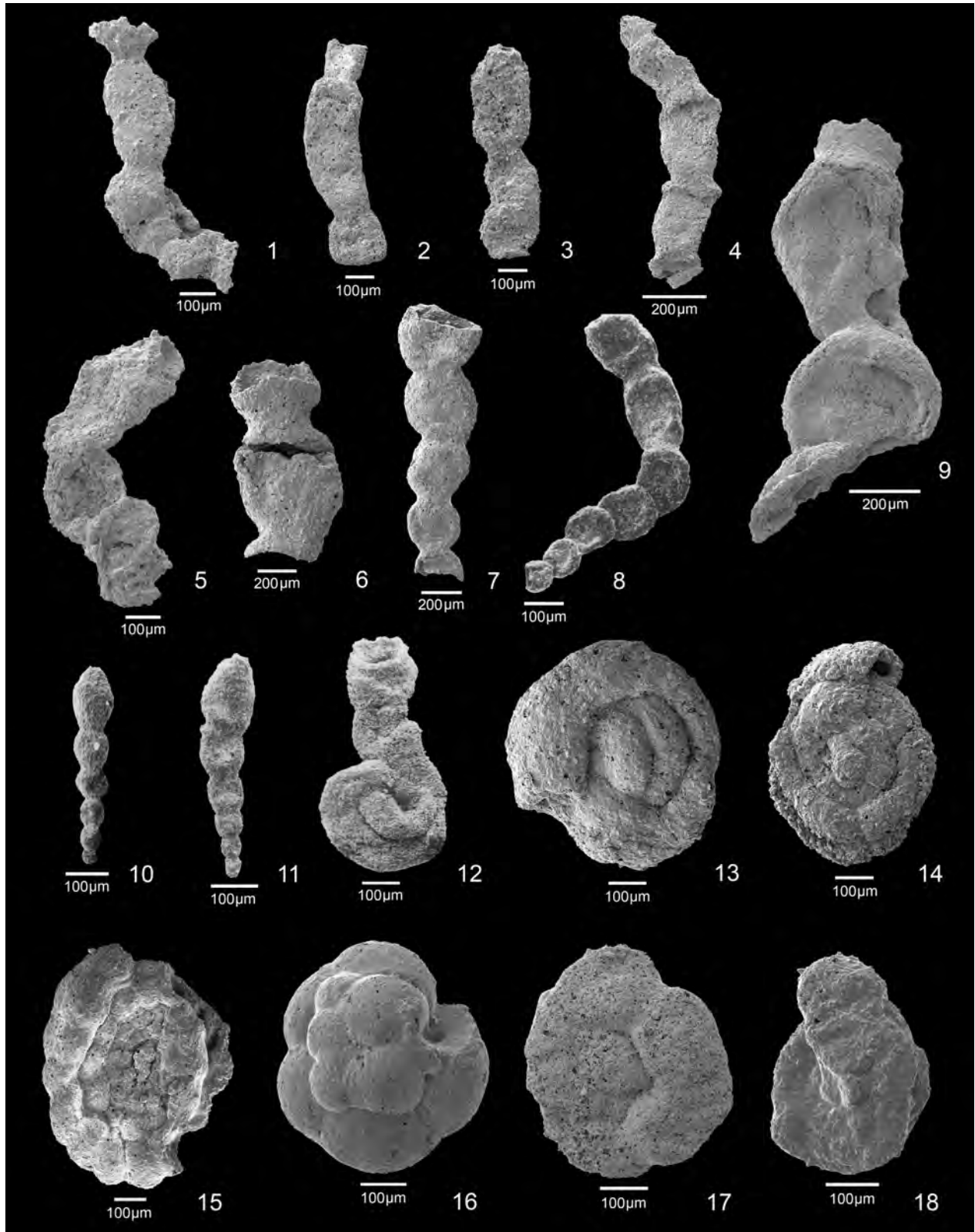


Plate 3. 1-5. *Subreophax longicameratus* n.sp., 1. B+210; 2. B+255; 3. B+250; 4. B+370.9 (Paleocene); 5. B+297; 6. *Subreophax pseudoscalaris* (Samuel), B+255; 7. *Subreophax scalaris* (Grzybowski), B+255; 8. *Subreophax splendidus* (Grzybowski), B+230; 9. *Arthrodendron diffusum* Ulrich, B+225; 10. *Reophax* sp. 3 Kuhnt, B+299; 11. *Pseudonodosinella parvula* (Huss), B+150; 12. *Lituotuba lituiformis* (Brady), B+35; 13-14. *Trochamminoides dubius* (Grzybowski), B+255; 15. *Trochamminoides grzybowskii* Kaminski & Geroch, B+265; 16. *Paratrochamminoides acervulatus* (Grzybowski), B+235; 17. *Paratrochamminoides deflexiformis* (Noth), B+35; 18. *Paratrochamminoides draco* (Grzybowski), B+90.

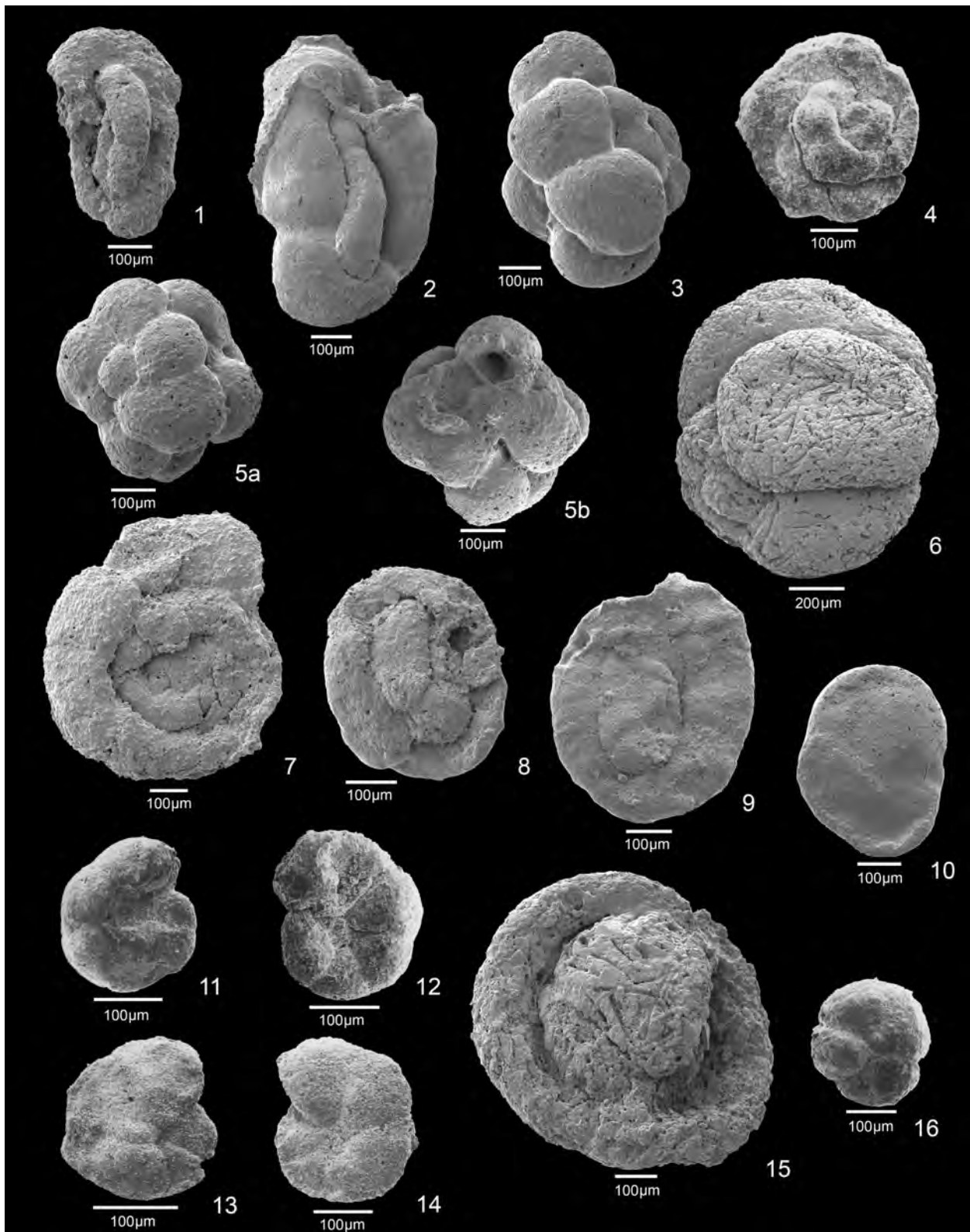


Plate 4. 1. *Paratrochamminoides gorayskii* (Grzybowski), B+260; 2. *Paratrochamminoides gorayskii* (Grzybowski), B+160; 3. *Paratrochamminoides mitratus* (Grzybowski), B+245; 4. *Paratrochamminoides olszewskii* (Grzybowski), B+190; 5a-b. *Paratrochamminoides uviformis* (Grzybowski), B+299; 6. *Conglophragmium irregularis* (White), B+280; 7. *Trochamminoides grzybowskii* Kaminski & Geroch, B+250; 8-9. *Trochamminoides folium* (Grzybowski); 8. B+297; 9. B+45; 10. *Buzasina pacifica* (Krasheninnikov), B+175; 11. *Haplophragmoides pervagatus* Krasheninnikov, B+175; 12. *Haplophragmoides perexplicatus* Krasheninnikov, B+190; 13-14. *Haplophragmoides* cf. *walteri* (Grzybowski), B+35; 15. *Praesphaerammina gerochi* (Hanzlíková), B+245; 16. *Ammosphaeroidina pseudopauciloculata* (Mjatluk), B+175.

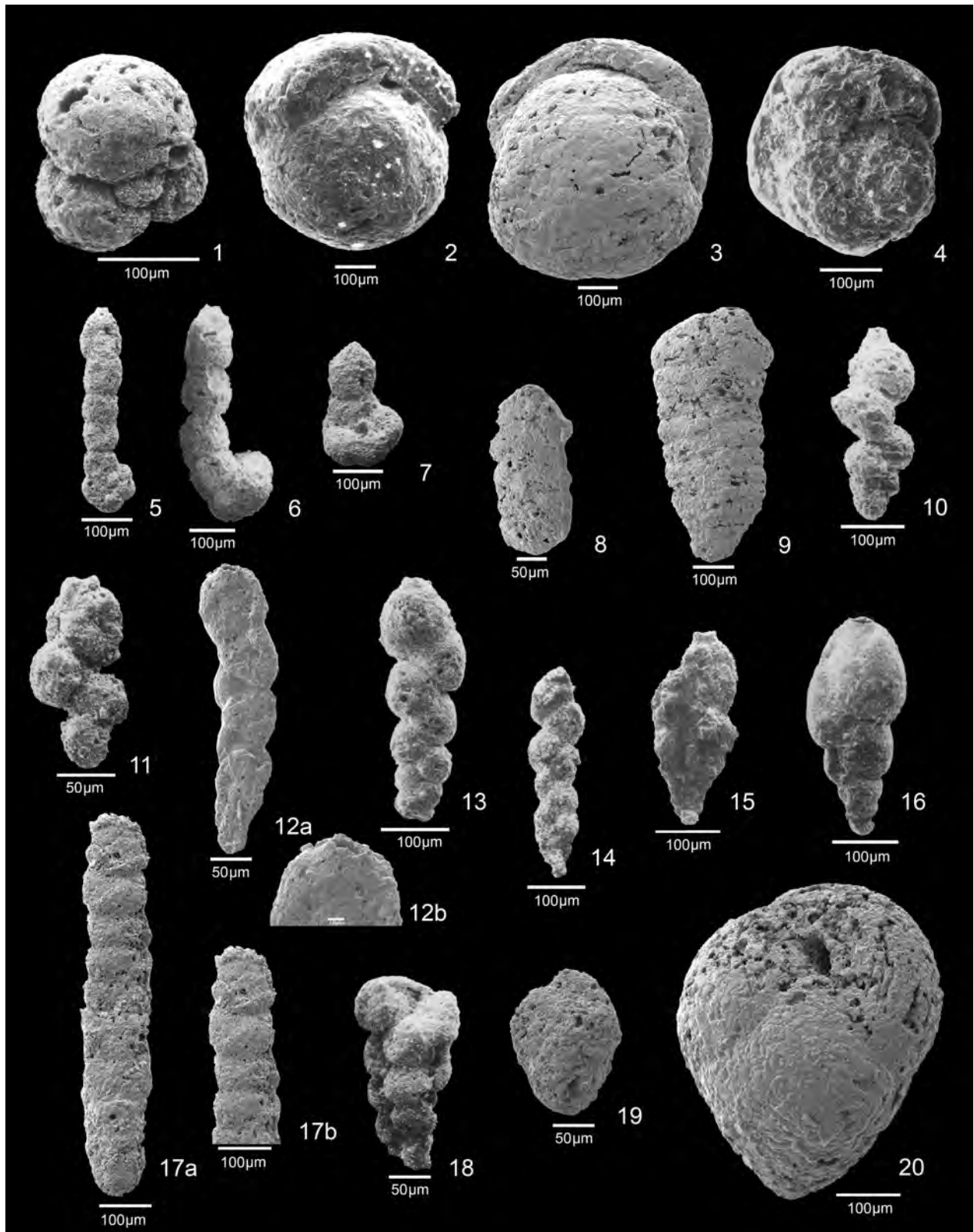


Plate 5. 1. *Praecystamina* sp. 1, B+80; 2. *Cribrostomoides?* *trinitatensis* Cushman & Jarvis, B+299; 3. *Cribrostomoides subglobosus* (Cushman), B+260; 4. *Recurvoidella lamella* (Grzybowski), B+299; 5-7. *Bulbobaculites problematicus* (Neagu); 5. B+35; 6. B+150; 7. B+35; 8. *Bolivinopsis rosula* (Ehrenberg), B+250; 9. *Spiroplectinella israelskyi* (Hillebrandt), B+260; 10. *Bicazammia lagenaria* (Krasheninnikov), B+175; 11. *Bicazammia lagenaria* (Krasheninnikov), B+100; 12a-b. *Eobigenerina variabilis* (Vašiček), B+165; 13. *Parvigenerina* sp. 3 (Kuhnt), B+110; 14. *Parvigenerina* sp. 3 (Kuhnt), B+150; 15. *Rashnovammia munda* (Krasheninnikov), B+100; 16. *Rashnovammia munda* (Krasheninnikov), B+160; 17a-b. *Rectogerochammia eugubina* Kaminski, Cetean & Neagu, B+205; 18. *Verneulinoides polystrophus* (Reuss), B+100, 19. *Uvigerinammia iankoi* Maizon, B+80; 20. *Remesella varians* (Glaessner), B+255.

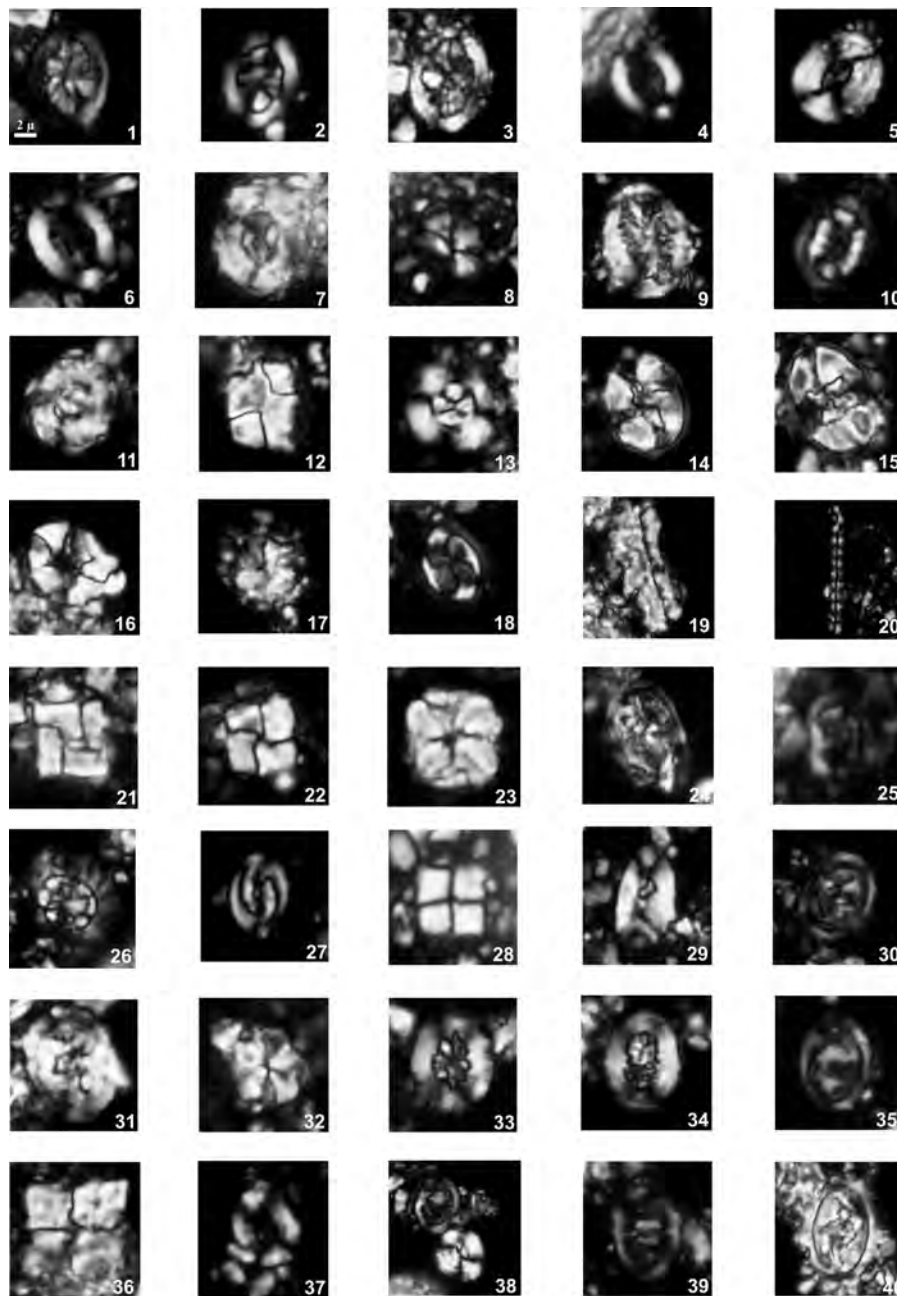


Plate 6. Calcareous nannofossils from Contessa Highway. **1.** *Ahmuelerella regularis* (Górka, 1957) Reinhardt & Górka, 1967 (CHW B+270); **2-3.** *Arkhangelsiella cymbiformis* Vekshina, 1959 (B+155 and B+265); **4.** *Broinsonia enormis* (Shumenko, 1968) Manivit, 1971 (B+10); **5.** *Broinsonia parca* (Stradner, 1963) Bukry, 1969, sp. *constricta* Hattner *et al.*, 1980 (B+170); **6.** *Broinsonia parca* (Stradner, 1963) Bukry, 1969, sp. *expansa* Wise & Watkins in Wise, 1983 (B+165); **7.** *Broinsonia parca* (Stradner, 1963) Bukry, 1969, sp. *parca* (B+150); **8.** *Biscutum constans* (Górka, 1957) Black, 1959 (B+270); **9.** *Cretarhabdus conicus* Bramlette and Martini, 1964 (B+270); **10.** *Cribrosphaerella ehrenbergii* (Arkhangelsky, 1912) Deflandre in Pivetteau, 1952 (B+230); **11.** *Cribracorona gallica* Bramlette & Martini, 1964 (B+165); **12.** *Calculites obscurus* (Deflandre, 1959) Prins & Sissingh in Sissingh, 1977 (B+190); **13.** *Cyclagelosphaera rotaclypeata* Bukry 1969 (B+165); **14.** *Eiffelithus eximius* (Stover, 1966) Perch-Nielsen, 1968 (B+55); **15.** *Eiffelithus gorkae* Reinhardt, 1965 (B+265); **16.** *Eiffelithus turriseiffelii* (Deflandre in Deflandre and Fert, 1954) Reinhardt, 1965 (B+165); **17.** *Eproolithus* sp. Stover, 1966 (B+30cm); **18.** *Helicolithus trabeculatus* (Górka, 1957) Verbeek, 1977 (B+30); **19.** *Lucianorhabdus maleformis* Reinhardt, 1966 (B+55); **20.** *Microrhabdulus decoratus* Deflandre, 1959 (B+45); **21.** *Micula murus* (Martini, 1961) Bukry, 1973 (B+280); **22.** *Micula praemurus* (Bukry, 1973) Stradner & Steinmetz, 1984 (B+280); **23.** *Micula staurophora* (Gardet, 1955) Stradner, 1963 (B+90); **24.** *Misceomarginatus pleniporus* Wind & Wise in Wise & Wind, 1977, (B+190); **25.** *Nephrolithus frequens* Górka, 1957 (B+295); **26.** *Prediscosphaera cretacea* (Arkhangelsky, 1912) Gartner, 1968 (B+270); **27.** *Placozygus fibuliformis* (Reinhardt, 1964) Hoffmann, 1970 (B+25); **28.** *Quadrum gartneri* Prins & Perch-Nielsen in Manivit *et al.*, 1977, (B+5); **29.** *Rhagodiscus angustus* (Stradner, 1963) Reinhardt, 1971 (B+30); **30.** *Reinhardtites anthophorus* (Deflandre, 1959) Perch-Nielsen, 1958 (B+105); **31.** *Reinhardtites levis* Prins & Sissingh in Sissingh, 1977 (B+165); **32.** *Radiolithus planus* Stover, 1966 (B+30); **33.** *Retecapsa angustiforata* Black, 1971 (B+30); **34.** *Retecapsa crenulata* (Bramlette & Martini, 1964) Grün, 1975 (B+160); **35.** *Tranolithus orionatus* (Reinhardt, 1966) Reinhardt, 1966 (B+215); **36.** *Uniplanarius gothicum* (Deflandre, 1959) Hattner & Wise, 1980 (B+170); **37.** *Watznaueria ovata* Bukry, 1969 (B+160); **38.** *Watznaueria barnesae* (Black, 1959) Perch-Nielsen, 1968 (B+165); **39.** *Zeugrhabdotus diplogrammus* (Deflandre in Deflandre & Fert, 1954) Reinhardt, 1965 (B+215); **40.** *Zeugrhabdotus embergeri* (Noël, 1958) Perch-Nielsen, 1984 (B+30)