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Biostratigraphy of the Cenomanian-Turonian boundary in the Eastern Carpathians (Dâmboviţa Valley): preliminary observations

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ABSTRACT. Planktonic and benthic foraminiferal assemblages from an Upper Albian to Lower Turonian interval in the East Carpathians were investigated in a well and in an outcrop from the Stoeneşti – Cetăţeni area (Dâmboviţa Valley), Romania. The benthic foraminiferal extinction that occurred at the Cenomanian/Turonian boundary and the first stage of the faunal recovery are documented here for the first time in the Romanian Carpathians. Bioevents and changes in the foraminiferal record from this area show that low oxygen conditions occured already in the Late Cenomanian, as suggested by the presence of radiolarian-rich shales. Impoverished assemblages of small, thin walled agglutinated foraminifera are present in the lowermost Turonian after the benthic-free interval corresponding to the "Bonarelli Level". Calcareous nannofossils are also documented from this level in the well from the Stoeneşti locality.

Key words: Eastern Carpathians, foraminifera, calcareous nannofossils, biostratigraphy, Cenomanian/Turonian boundary, low oxygen.

1. INTRODUCTION

One of the Cretaceous intervals of widespread anoxia resulting in the global deposition of carbon-rich sediments is Oceanic Anoxic Event 2 (OAE2), which occurred close to the Cenomanian/Turonian boundary (Schlanger and Jenkins, 1976). Carbon-rich sediments and associated microfaunal changes have now been documented from numerous DSDP and ODP sites (*e.g.*, Kuhnt, 1992) and onshore sections worldwide (*e.g.*, Kaiho, 1994), and reflect a major perturbation of the global carbon cycle.

The Cenomanian/Turonian Boundary Event is well documented in southern Europe where it is referred to as the "Bonarelli Level" (Arthur and Premoli-Silva, 1982; Luciani and Cobianchi, 1999; Scopelliti et al., 2004; Gräfe, 2005) and in northern and western Europe (Ernst et al., 1984; Hilbrecht et al., 1996; Svobodá et al., 2004; Bąk, 2006). However, relatively few studies deal with the benthic foraminiferal turnover over this interval (Leckie, 1985; Leary and Peryt, 1991; Kuhnt, 1992; Coccioni et al., 1995; Paul et al., 1999; Peryt, 2004). Many of these studies only provide information on bathymetrically shallow (Leckie, 1985; Hilbrecht et al., 1996; Čhech et al., 2005; Gräfe, 2005) or deep sites below the CCD (Kuhnt, 1992; Švábenická et al., 1997; Bąk, 2006).

In Romania, the Cenomanian/Turonian Boundary Event has never been documented in any detail, but some mention of the associated radiolarian-rich levels had been made by Neagu (1970) in the Upper Cenomanian of the Teleajen Nappe in the Eastern Carpathians. This paper presents preliminary biostratigraphical results from an Upper Albian to Lower Turonian succession in the Stoeneşti - Cetăţeni area (Dâmboviţa Valley), which was deposited in a lower bathyal depositional setting.

The main purpose of this paper is to document the near extinction of benthic foraminiferal across the Cenomanian/Turonian boundary interval, and the initial stage of faunal recovery in the lowermost Turonian. In addition, this study brings new information about the stratigraphic range of some agglutinated species.

2. GEOLOGICAL SETTING

The present study concentrates on the lower part of the Upper Cretaceous succession that can be followed along the Dâmboviţa Valley between Stoeneşti and Cetăţeni. The Upper Cretaceous deposits developed in the southern part of the East Carpathians in Dâmboviţa Valley represent a part of the sedimentary cover of the Ceahlău Nappe, Outer Dacides (Săndulescu et al., 1981). The lower part of this stratigraphic succession in the Stoeneşti – Coteneşti area is represented by massive sandstones followed by finer deposits spanning from the Late Albian ("Vraconian") to Turonian with a short Middle – Late Cenomanian interval of flysch-type sedimentation (Murgeanu and Patrulius 1957; Murgeanu et al., 1963).

Above them, a sequence of Turonian – Santonian red marls and marly limestones with *Inoceramus* are present, followed by Campanian – Maastrichtian red marls with *Belemnitella*. The age of these sediments was confirmed based on ammonites and planktonic foraminifera by Murgeanu et al. (1963), Tocorjescu (1963), and Avram (1967).

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3. MATERIAL AND METHODS

Thirty-three samples from an outcrop in Coteneşti and 12 samples from a well drilled in Stoeneşti (given to the BBU Geology Department by Holcim S.A.) were investigated for their micropaleontological content (Fig. 1).

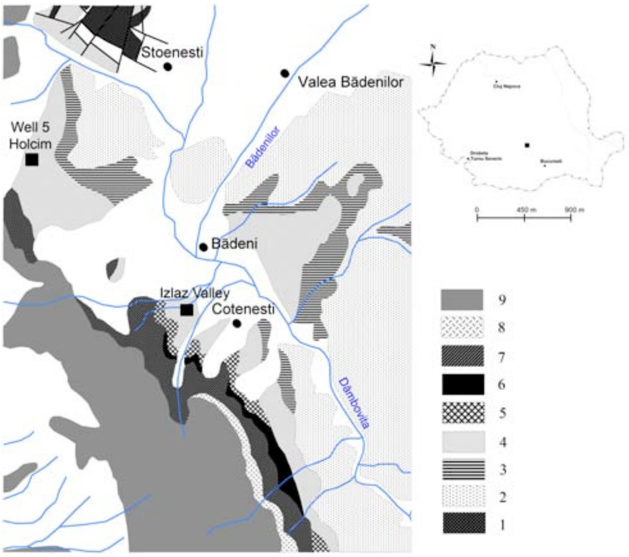

Fig. 1. *Geological map of the Stoeneşti - Coteneşti area showing the position of the Well-5 Holcim, Stoeneşti and the Izlaz Valley outcrop, Coteneşti. 1: Jurassic limestones; 2: Albian sandstones; 3: Upper Albian sandy marls; 4: Cenomanian - Turonian green and grey marls; 5: Santonian - Lower Campanian red marls and glauconitic sands/sandstones; 6: Upper Campanian- Lower Maastricthian red marls; 7- Maastrichtian red marls; 8: Upper Maastricthian – Ypresian red marls; 9: Eocene limestones and flysch deposits; 10: Pleistocene alluvial deposits; 11: Recent landslides (Modified after Geological Map of Romania, 1: 50.000, Sheet 128a, Câmpulung Muscel).*

The outcrop from the Izlaz Valley consists of Upper Cenomanian green–grey marls and sandy marls with very thin interbedded sandstones in the lower part of the 15 m thick deposits. Thin laminated dark marls are also present (Fig. 2).

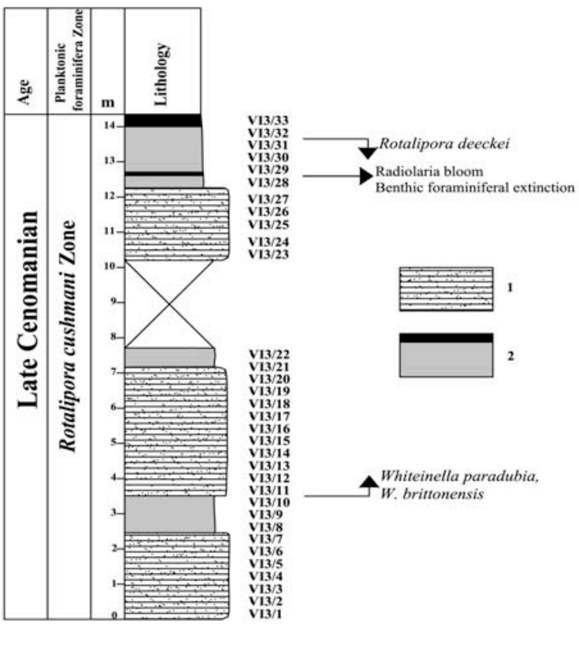

Fig. 2. *Biostratigraphy of the Izlaz Valley section showing the position of the samples and main bioevents. Lithology: 1 - green sandy marls, 2 - grey to dark marls.*

The well from Stoeneşti represents a complete succession of Late Albian to Early Turonian age starting with sandstones in the lower part, followed by a succession of grey marls and sandy marls characteristic of the Cenomanian. The Cenomanian/Turonian transition consists of black shales, while the lowermost Turonian is represented by alternating red and grey marls (Fig. 3). Based on the sedimentological features and the type of fauna we estimate for this Cenomanian - Turonian succession a lower slope paleodepth.

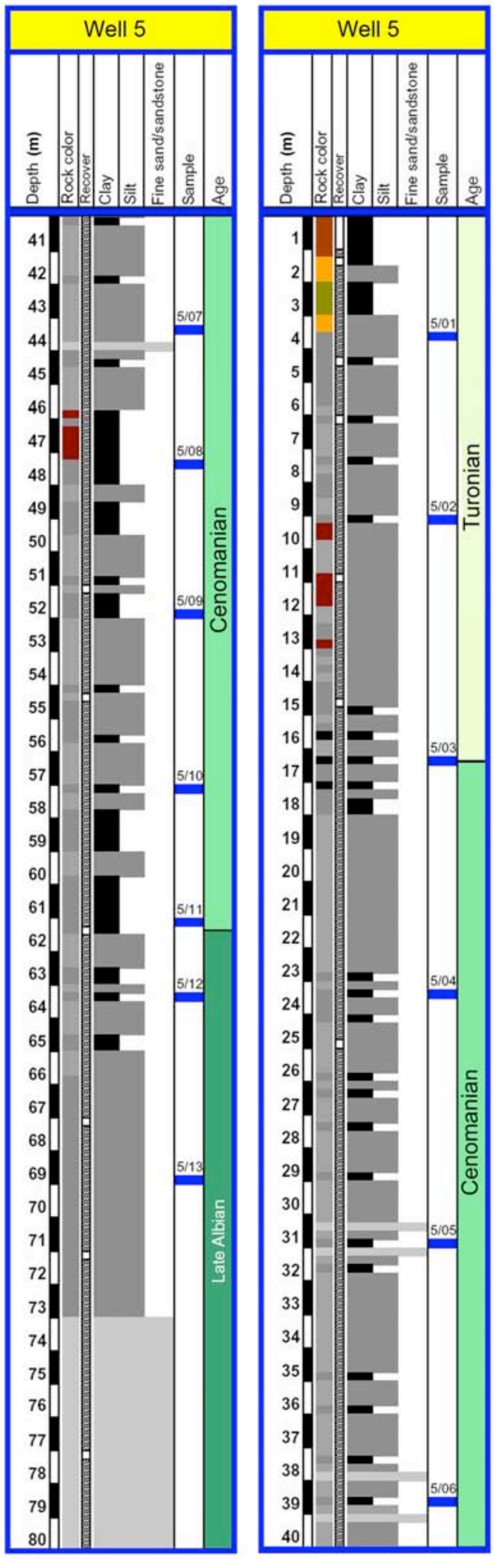

Fig. 3. *Lithological column of Well-5 Holcim, showing the position of the samples and ages of the deposits based on planktonic foraminifera.*

For foraminifera, samples were boiled in water with sodium carbonate and washed over a 63 µm sieve. Whenever possible, more than 300 individuals were picked. Preservation of foraminifera is good in the outcrop, but varies from very good to poor in the well. Planktonic foraminifera biostratigraphy is based on the Late Cretaceous scheme of Robaszynski and Caron (1995).

Individual specimens were photographed by using the scanning electron microscope in the Department of Biology of the Babeş-Bolyai University (BBU). Photographs of specimens in immersion oil were taken using a Olympus SZ61 microscope in the Geology Department of BBU.

Samples investigated for calcareous nannofossils (samples 5/1-5/3, Well-5, Holcim, Fig. 3) were prepared using the standard smear slide technique for light microscope (LM) observation.

The investigations were carried out under a light microscope (Nikon Optiphot 2 - Pol) at a magnification of 1000x using parallel and crossed nicols.

4. RESULTS

4.1. Well-5 Holcim, Stoeneşti

4.1.1. Foraminifera

The studied interval spans the *Rotalipora appenninica* Zone (Late Albian) to the upper part of the *Whiteinella archaeocretacea* Zone (Early Turonian). Probably owing to the poor preservation that occurs at some levels in the well, we were unable to identify the *Rotalipora reicheli* biozone in our samples. Planktonic foraminiferal biozones and the stratigraphic distribution of calcareous and agglutinated benthic foraminifera are shown in Table 1 and Table 2.

Table 1. *Distribution of agglutinated foraminifera in Well-5 Holcim, Stoeneşti.*

Agglutinated Foraminifera	**Late Albian**	**Early Cenomanian**			**Middle - Late Cenomanian**					**Early Turonian**		
	R. apenninica Zone	*R. globotruncanoides* Zone			?*R. reicheli* Zone		*R. cushmani* Zone			*W. archaeocretacea* Zone		
Sample no.	**5/12**	**5/11**	**5/10**	**5/9**	**5/8**	**5/7**	**5/6**	**5/5**	**5/4**	**5/3**	**5/2**	**5/1**
Ammodiscus cretaceus	x	x	x	x					x			
Ammodiscus planus	x	x		x	x				x			
Ammodiscus infimus				x		x	x					
Arenobulimina presli						x			x			
Bathysiphon sp.				x			x		x			
Bulbobaculites problematicus	x	x	x	x	x	x	x	x	x		x	
Bulbobaculites lueckei						x	x					
Dorothia conulus				x			x		x			
Dorothia pupa		x		x			x		x			
Falsogaudrynella moesiana	x		x	x								
Gaudryna carinata	x	x	x				x		x			
Gaudryna sp.	x		x	x			x		x			
Gerochammina stanislawi	x			x			x		x		x	
Glomospira charoides				x		x					x	
Glomospira gordialis			x	x		x	x			**Extinction interval**		
Haplophragmoides sp.											x	
Haplophragmoides falcatosuturalis		x	x	x		x			x			
Haplophragmoides kirki	x	x	x	x		x			x			
Haplophragmoides nonioides	x	x		x		x	x		x			
Haplophragmoides sp.1	x		x	x			x		x			
Hormosina velascoensis				x								
Kalamopsis grzybowskii	x	x	x	x		x	x		x			
Hyperammina gaultina							x					
Nothia sp.	x	x	x	x	x	x	x	x	x			
Plectorecurvoides irregularis	x											
Pokornyammina clara		x	x			x			x			
Praedorothia gradata	x			x		x	x					
Protomarssonella sp.		x	x	x			x		x			
Pseudobolivina sp.2	x	x		x		x	x				x	x
Recurvoides sp.	x	x	x	x			x	x	x			
Reophax parvulus	x	x	x			x	x		x		x	
Rhizammina sp.	x	x	x	x	x		x	x	x		x	
Scherochorella minuta	x	x	x	x		x	x					
Spiroplectammina roemeri							x		x			
Tritaxia gaultina carinata	x	x	x	x	x	x	x		x			

Benthic foraminiferal assemblages are well diversified, and include both calcareous and agglutinated taxa. However, in the whole succession a high number of agglutinated genera were identified and calcareous benthics represent only a minor component (25-10%) of the assemblages for the Cenomanian, and are absent in the lowermost Turonian.

Long-ranging genera of agglutinated foraminifera in the Upper Albian – Lower Turonian succession include deep infaunal forms such as *Bulbobaculites problematicus*, *Gerochammina stanislawi*, *Reophax parvulus* and tubular forms such as *Nothia* sp., *Rhizammina* sp. and *Kalamopsis grzybowskii.* These genera represent the dominant component of the microfauna in Cenomanian, together with other long ranging forms such as *Tritaxia gaultina carinata, Haplophragmoides nonioninoides, H. kirki*, *Dorothia pupa* and *Protomarssonella* sp.

The presence of *Pokornyammina clara* spans the whole Cenomanian in the studied interval. This genus established by Neagu and Platon, 1994 (previously described as *Thalmannammina recurvoidiformis* Neagu and Tocorjescu, 1970), has been reported before in other micro-paleontological studies in different nappes of the Eastern

Carpathians as having its first occurrence (FO) in the Late Albian (Ion, 1975a,b). Its presence in the Early Cenomanian had been mentioned by Neagu et al. (1992).

Table 2. *Distribution of calcareous foraminifera (benthics and planktonics) and calcareous nannofossils in Well-5 Holcim, Stoeneşti.*

Calcareous Foraminifera & Calcareous nannofossils		**Late Albian**	**Early Cenomanian**			**Middle - Late Cenomanian**					**Early Turonian**		
		R. apenninica Zone	*R. brotzeni* Zone			?*R. reicheli* Zone		*R. cushmani* Zone			*W. archaeocretacea* Zone		
	Sample no.	**5/12**	**5/11**	**5/10**	**5/9**	**5/8**	**5/7**	**5/6**	**5/5**	**5/4**	**5/3**	**5/2**	**5/1**
Calcareous benthics	*Astacolus crepidulus*			x	x								
	Berthelina cenomana				x			x		x			
	Dentalina legumen			x	x			x		x			
	Dentalina sp.	x		x	x	x	x	x	x	x			
	Frondicularia sp.			x									
	Gavelinella schloenbachii				x		x	x		x			
	Globorotalites brotzeni		x	x	x			x					
	Gyroidinoides nitidus			x	x			x		x			
	Laevidentalina sp.			x	x	x			x	x			
	Lagena apiculata	x	x	x						x			
	Lenticulina sp.	x	x		x			x		x			
	Nodosaria lepida	x	x	x	x			x		x			
	Nodosaria sp.	x	x	x	x			x		x			
	Pleurostomella reussi				x			x					
	Ramulina novaculeata	x		x			x	x					
Calcareous plantoniks	*Dicarinella cf. algeriana*										**Extinction interval**	x	
	Hedbergella delrioensis	x	x	x	x			x		x			
	Hedbergella planispira	x	x	x	x			x		x			
	Praeglobotruncana gibba									x			
	Rotalipora appenninica	x	x	x	x		x						
	Rotalipora brotzeni		x	x	x			x					
	Rotalipora cushmani							x		x			
	Rotalipora deeckei									x			
	Rotalipora gandolfii	x	x	x	x								
	Rotalipora micheli			x	x			x					
	Rotalipora montsalvensis							x		x			
	Whiteinella brittonensis									x			
	Whiteinella sp.											x	
Calcareous nannofossils	*Axopodorhabdus albianus*											x	x
	Biscutum constans											x	x
	Cylindralithus biarcus											x	x
	Eiffelithus turriseiffelii											x	x
	Eprolithus floralis											x	x
	Eprolithus octopetalus											x	x
	Gartnerago segmentatum											x	x
	Manivitella pemmatoidea											x	x
	Microrhabdulus decoratus												x
	Prediscosphaera columnata											x	x
	Quadrum gartneri												x
	Quadrum intermedium											x	x
	Rhagodiscus achlyostaurion											x	x
	Watznaueria barnesiae											x	x

The two biozones established by Neagu et al. (1992) for the Eastern Carpathians based on agglutinated foraminifera are: the *Haplophragmoides falcatosuturalis* Zone for the Late Albian (Vraconian) - Early Cenomanian interval and the *Bulbobaculites problematicus* Zone for the Middle Cenomanian to Late Turonian interval. In our samples, *Haplophragmoides falcatosuturalis* has a larger stratigraphical range, extending to the end-Cenomanian anoxic event. Therefore, the two biozones as documented by Neagu et al. (1992), could not be separated in the studied deposits.

Three last occurrences LO's of agglutinated species were observed in the investigated stratigraphic interval. *Plectorecurvoides irregularis* has its LO in the upper part of the *Rotalipora appenninica* Zone (Late Albian), *Falsogaudrynella moesiana* disappears in the upper part of the *R. globotruncanoides* Zone, *Scherochorella minuta* has its LO in the lower part of the *R. cushmani* Zone (upper part of the Middle Cenomanian). The stratigraphic range of *Falsogaudrynella moesiana* documented by Kaminski et al. (1995) is Albian; in our succession this species extends to the top of the Lower Cenomanian.

The Cenomanian/Turonian boundary (corresponding to sample 5/3 in Fig. 3) is is placed within black shales that are barren of foraminifera.

The first Early Turonian foraminiferal assemblage consists entirely of agglutinated taxa: *Haplophragmoides* sp., *Glomospira charoides*, *Bulbobaculites problematicus*, *Gerochammina stanislawi, Rhizammina* sp., *Reophax parvulus* and *Pseudobolivina* sp. 2 (*sensu* Kuhnt, 1992).

The low diversity of agglutinated foraminifera (Fig. 4), having small dimensions and thin walls, are similar to the reported recolonization faunas after the Cenomanian/ Turonian boundary anoxic level from different land sections and ODP sites (Kuhnt, 1992; Coccioni et al., 1995 among others).

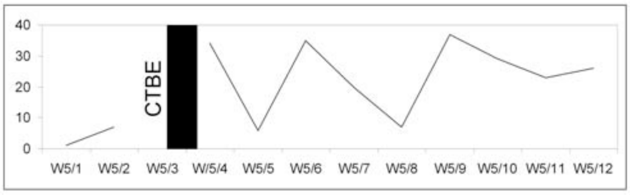

Fig. 4. *Number of species per sample in Well-5 Holcim, Stoeneşti.*

Early Turonian planktonic foraminifera in Well-5 Holcim, Stoeneşti are very rare, only two specimens of *Whiteinella* sp. were found in the first investigated sample after the boundary. Grey to dark marls at the top of the deposits in the well suggest that low oxygen conditions may had occured again in the Early Turonian, as only one agglutinated species *Pseudobolivina* sp. 2 (*sensu* Kuhnt, 1992) can be found together with the planktonic foraminifera *Dicarinella* cf. *algeriana* in the studied interval.

4.1.2. Calcareous nannofossils

In order to confirm the Early Turonian age of the upper part of the well succesion, three samples were investigated for calcareous nannofossils. The black clay level (corresponding to sample 5/3 in Fig. 3) which was found to be barren of foraminifera, is also lacking calcareous nannofossils.

Above this level, calcareous nannofossils assemblage consists of new species: *Quadrum intermedium*, *Eprolithus octopetalus*, *Quadrum gartneri* and *Microrhabdulus decoratus*, together with long-ranging taxa as: *Eiffelithus turriseiffellii*, *Eprolithus floralis*, *Cretarhabdus conicus*, *Watznaueria barnesiae*. The presence of these new species confirms an Early Turonian age.

4.2. Izlaz Valley, Coteneşti

Rotalipora cushmani is present in the whole studied succession from the Izlaz Valley outcrop. Two main bioevents were identified: the FOs of *Whiteinella paradubia* and *W. brittonensis* at 3.5 m from the base of the outcrop and the LO of *R. deeckei* at 13.7 from the base of the outcrop.

These changes in the composition of planktonic foraminiferal assemblages allowed us to determine the investigated interval as representing the middle to upper part of the *Rotalipora cushmani* Zone.

Benthic foraminifera from the Izlaz Valley are very similar to the Late Cenomanian fauna recorded in Well-5, Stoeneşti. However, *Scherochorella minuta* is missing in the outcrop samples. This might confirm a late Cenomanian age, as this agglutinated species disappears in the lower part of the *R. cushmani* Zone (late Middle Cenomanian) in the Well-5 Holcim.

At 12.6 m from the base on the outcrop, a thin dark shales interval is observed. Benthic foraminifera are absent in this interval, instead a high number of spherical recrystalized and pyritized radiolarians are present. Also, high numbers of radiolarians are observed at others levels in the outcrop (between 7 - 8 m from the base of the outcrop) together with impoverished benthic foraminiferal assemblages.

5. DISCUSSION

Radiolarian-rich black shales are recorded in the Carpathian basin and in other Tethyan areas around the Cenomanian/Turonian boundary (Luciani and Cobianchi, 1999; Scopelliti et al., 2004; Bąk, 2006 among others). These short-lived radiolarian-rich levels are thought to represent episodes of coastal upwelling in the Subsilesian–Silesian basin in Poland (Bąk, 2006). High numbers of radiolarians in the Gubbio “Bonarelli Level” are considered to be indicators of highly eutrophic conditions that resulted in the expansion of the oxygen minimum zone (Coccioni and Luciani, 2004).

We encountered a level of radiolarian-rich dark shales within the upper part of *Rotalipora cushmani* Zone in the Izlaz Valley, Coteneşti. In this level benthic foraminifera are absent, planktonic foraminifera are scarce and represented by large forms of *Rotalipora* sp. and few specimens of *Whiteinella* sp. This may indicate that low oxygen conditions occured since Late Cenomanian in this part of the Carpathian basin as recorded by high-resolution sampling of this interval.

Changes in the foraminiferal assemblages during the Late Cenomanian as indicators of temporary low oxygen levels were observed in several land sections in Europe and Japan. Low diversity foraminiferal assemblages suggesting an interval with dysoxic conditions at the sea floor were reported in the Gubbio section of Umbria-Marche, Italy in the middle of the *Rotalipora cushmani* Zone (Coccioni and Luciani, 2004). A benthic foraminiferal extinction was also found in the Upper Cenomanian of the Hokkaido area, Japan, preceding the black shale interval corresponding to the “Bonarelli Level” where a second benthic-free level was recorded (Kaiho, 1994). In the Menoyo section, Spain, a major faunal turnover was observed in the upper Cenomanian at the top of the *Rotalipora cushmani* Zone, consisting of a stepwise disappearance of 33 species of benthic foraminifera, some of which return when the oxygenation levels are restored (Peryt, 2004).

The Cenomanian/Turonian boundary interval is barren of foraminifera in most of the studied sites from the North Atlantic and Europe (Kuhnt, 1992; Coccioni and Luciani, 2004; Scopelliti et al., 2004; Bak, 2006 among others), but in the Ganuza section, Spain and the deepest sites of Demerara Rise, ODP Leg 207, a benthic extinction is not evident, only low diversity and poor assemblages occur as result of low oxygen levels represented by this interval (Peryt, 2004; Friedrich et al., 2006).

The Cenomanian/Turonian boundary interval from Well-5, Holcim is represented by a level of black shales barren of foraminifera and calcareous nannofossils.

FO of *Quadrum intermedium* can be observed in Well-5, Holcim, sample 5/2, below the FO of *Quadrum gartneri*. Burnett (1998) and Čech et al. (2005) reported this event in Late Cenomanian, using this species to define UC5c subzone. Paul et al. (1999) reported the FO of *Quadrum* *intermedium* above the FO of *Quadrum gartneri* in the Early Turonian. Varol (1992) mentioned the presence of this species in a short interval between Early and Middle Turonian.

This bioevent (FO of *Quadrum intermedium*) in the Well-5 Holcim succession is synchronous with the FO of *Eprolithus octopetalus*. This species has a short range in the Late Cenomanian-Early Turonian (Varol, 1992). Gorostidi and Lamolda (1993) had reported it only in the upper part of Late Cenomanian. Burnett (1998) identified it only in Early Turonian below the FO of *Quadrum gartneri*, at the base of UC6b subzone. Luciani and Cobianchi (1999) reports the FO of *Eprolithus octopetalus* in CC11 Zone, in the lower part of *Helvetoglobotruncana helvetica* Zone.

The FO of *Quadrum gartneri* is used as an indicator for the Cenomanian/Turonian boundary. Burnett (1998) placed this event in the upper part of the Early Turonian (UC7 Zone). Kennedy *et al.* (2000) and Tsikos et al. (2004) used this event to establish both the Cenomanian/Turonian boundary and the end of the anoxic event (OAE2). In the investigated samples from Well-5 Holcim, this species is present together with *Axopodorhabdus albianus*, as it was reported by Hardas and Mutterlose (2006) at Demerara Rise (ODP Leg 207). Bralower (1988) described the FO of *Quadrum gartneri* below the LO of *Axopodorhabdus albianus*. Most studies report the FO of *Quadrum gartneri* above LO of *Axopodorhabdus albianus* (Lamolda et al., 1997; Burnett, 1998; Nederbragt and Fiorentino, 1999; Luciani and Cobianchi, 1999; Paul et al., 1999; Tsikos et al., 2004).

The first step of faunal recolonization in our samples above the benthic-free interval corresponding to the boundary event is represented by small, thin-walled agglutinated foraminifera. In the lowermost Turonian, six species return as "Lazarus taxa": *Glomospira charoides*, *Bulbobaculites problematicus*, *Gerochammina stanislawi*, *Rhizammina* sp., *Reophax parvulus* and *Pseudobolivina* sp. 2 (*sensu* Kuhnt, 1992). However, *Glomospira charoides* and a species of *Haplophragmoides* constitute 70% of the agglutinated foraminiferal assemblage; a characteristic of stressed environments that have low diversity and a high dominance of few taxa (Jorissen et al., 1995). This type of agglutinated assemblage, described as "Biofacies B" by Kuhnt and Kaminski (1989) are known from oxygen-depleted Cretaceous to Paleogene environments and consist mostly of opportunistic taxa such as *Glomospira* sp., *Ammodiscus* and thin tubular form *Rhizammina* sp. Additional species may be present in the Lower Turonian recovery interval, such as *Pseudobolivina* sp. 2 and diverse species of *Haplophragmoides*: *H. concavus*, *H.* cf. *pseudokirki* from the deep-water limestone Scaglia succession at Gubbio, and North Atlantic ODP Site 641A (Kuhnt 1990, 1992; Coccioni et al. 1995). The recovery fauna from the lowermost Turonian of Well-5 Holcim is very similar to the correlative fauna from North Atlantic ODP Site 641A documented by Kuhnt (1992).

6. CONCLUSIONS

The upper Albian to Lower Turonian succession from Well-5, Stoeneşti and the Izlaz Valley outcrop at Coteneşti prove that this area of the Eastern Carpathians represents an excellent lower bathyal setting for studying the Cenomanian/Turonian boundary event as foraminifera can be correlated with other groups of microfossils (calcareous nannofossils, radiolaria). We document for the first time the benthic-free interval corresponding to the "Bonarelli Level" in the Romanian Carpathians and the faunal changes associated with it. A radiolarian-rich level devoid of benthic foraminifera, is encountered in the studied sections from the upper Cenomanian *Rotalipora cushmani* Zone, showing that the deterioration of paleoenvironmental conditions began earlier in this part of the Carpathian basin. After the Cenomanian/Turonian boundary event, in the Lower Turonian, the first stage of the recolonization after the anoxic interval consists of small, thin walled agglutinated genera similar to those reported from other deep-water settings.

Further studies in this area will bring new information about the detailed response of the benthic foraminifera to CTBE in the Romanian Carpathians, in order to develop a more generalized model of foraminiferal extinction, recovery, and faunal succession that accompanied this event.

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PLATE I: Figs. 1-11: SEM, Figs. 12-27: Immersion oil photographs.

Fig. 1. Nothia sp*., Well-5 Holcim, 5/7*
Fig. 2. Kalamopsis grzbowskii *(Dylążanka), Izlaz Valley, 3/3*
Fig. 3. Reophax parvulus *Huss, Well-5 Holcim, 5/7*
Fig. 4. Haplophragmoides falcatosuturalis *Neagu, Izlaz Valley, 3/3*
Fig. 5. Bulbobaculites problematicus *Neagu, Izlaz Valley, 3/27*
Fig. 6. Pokornyammina clara *Neagu & Platon, Well-5 Holcim, 5/4*
Fig. 7. Gerochammina stanislawi *Neagu, Izlaz Valley, 3/13*
Fig. 8. Protomarssonella sp*., Izlaz Valley, 3/27*
Fig. 9. Tritaxia gaultina carinata *Neagu, Izlaz Valley, 3/13*
Fig. 10. Dorothia pupa *Reuss, Well-5 Holcim, 5/4*
Fig. 11. Ramulina novaculeata *Bullard, Izlaz Valley, 3/3*
Figs. 12, 14. Glomospira charoides *Jones&Parker, Well-5 Holcim, 5/2*
Figs. 13, 15. Glomospira charoides *Jones & Parker, Well-5 Holcim, 5/2*
Fig. 16. Haplophragmoides falcatosuturalis *Neagu, Well-5 Holcim, 5/4*
Fig. 17. Haplophragmoides falcatosuturalis *Neagu, Izlaz Valley, 3/26*
Fig. 18. Haplophragmoides falcatosuturalis *Neagu, Izlaz Valley, 3/2*
Figs. 19-21. Pokornyammina clara *Neagu & Platon, Izlaz Valley, 3/4*
Fig. 22. Pokornyammina clara *Neagu & Platon, Well-5 Holcim, 5/4*
Fig. 23. Gerochammina stanislawi *Neagu, Izlaz Valley, 3/3*
Fig. 24. Gerochammina stanislawi *Neagu, Izlaz Valley, 3/4*
Figs. 25-27. *Different specimens of* Pseudobolivina sp.2*, sensu Kuhnt (1992), Well-5 Holcim, 5/2*

PLATE I

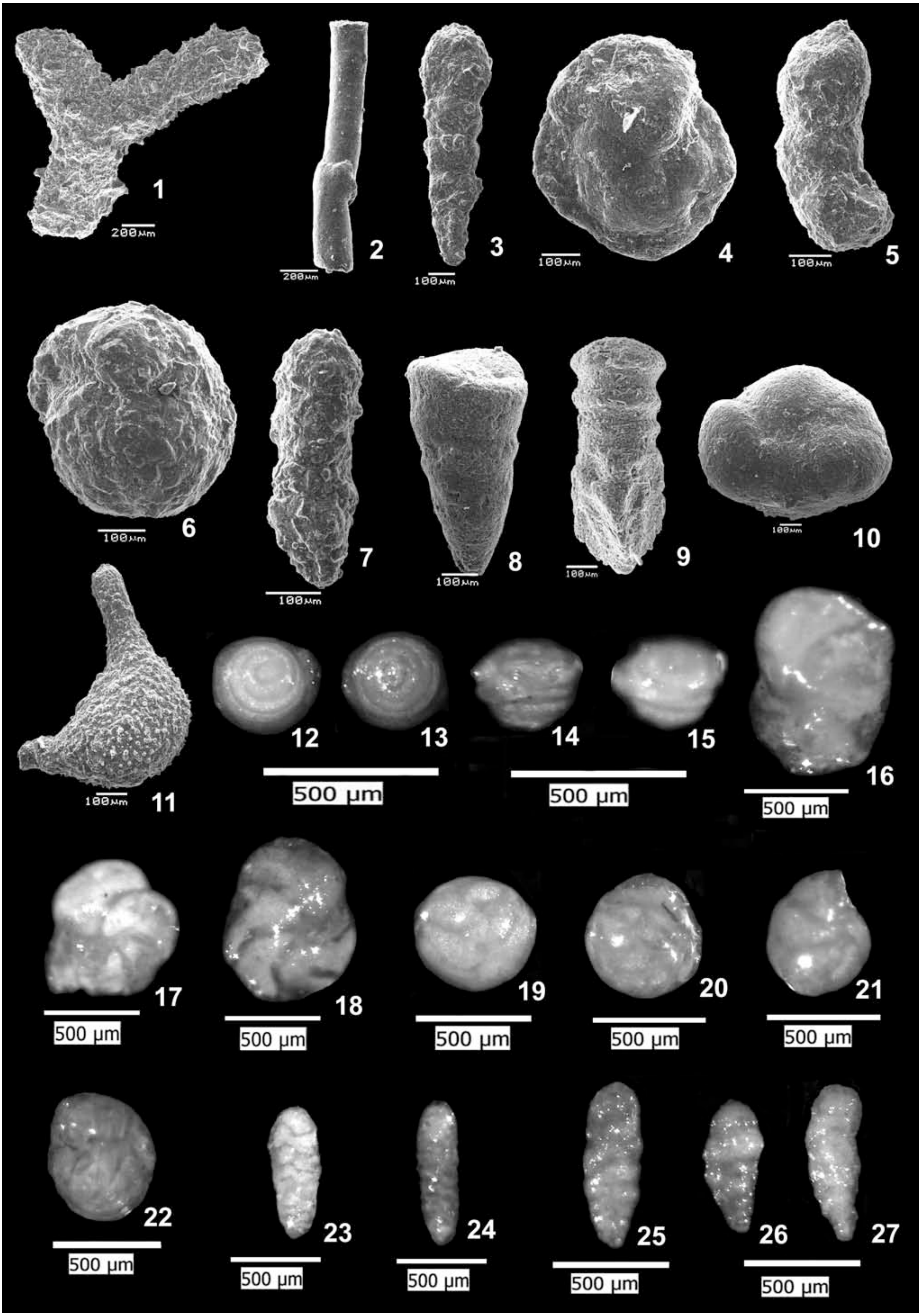
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PLATE II

Figs. 1-4. *Different specimens of* Dicarinella cf. algeriana *Caron, Well-5 Holcim, 5/1 (1 -spiral view, 2 -umbilical view, 3 –oblique lateral view, 4 -lateral view)*
Figs. 5-7. Rotalipora deeckei *Franke, different specimens in spiral view -5, umbilical view -6, lateral view -7, Izlaz Valley, 3/1*
Figs. 8-9. *Different specimens* of Rotalipora cushmani *Morrow, 8 – spiral view, 9 –umbilical view, Izlaz Valley, 3/1*
Figs. 10-12. *Different specimens of* Rotalipora cushmani *Morrow, 10 – spiral view, 11 –umbilical view, 12 – lateral view, Well-5 Holcim, 5/4*
Figs. 13-15. *Different specimens of* Rotalipora gandolfii *Luterbacher & Premoli Silva, 13 – spiral view, 14 –umbilical view, 15 – lateral view, Well-5 Holcim, 5/9*
Figs. 16-18. Rotalipora brotzeni *Sigal; 16 – spiral view, 17 –umbilical view, 18 – lateral view, Well-5 Holcim, 5/9*

PLATE II

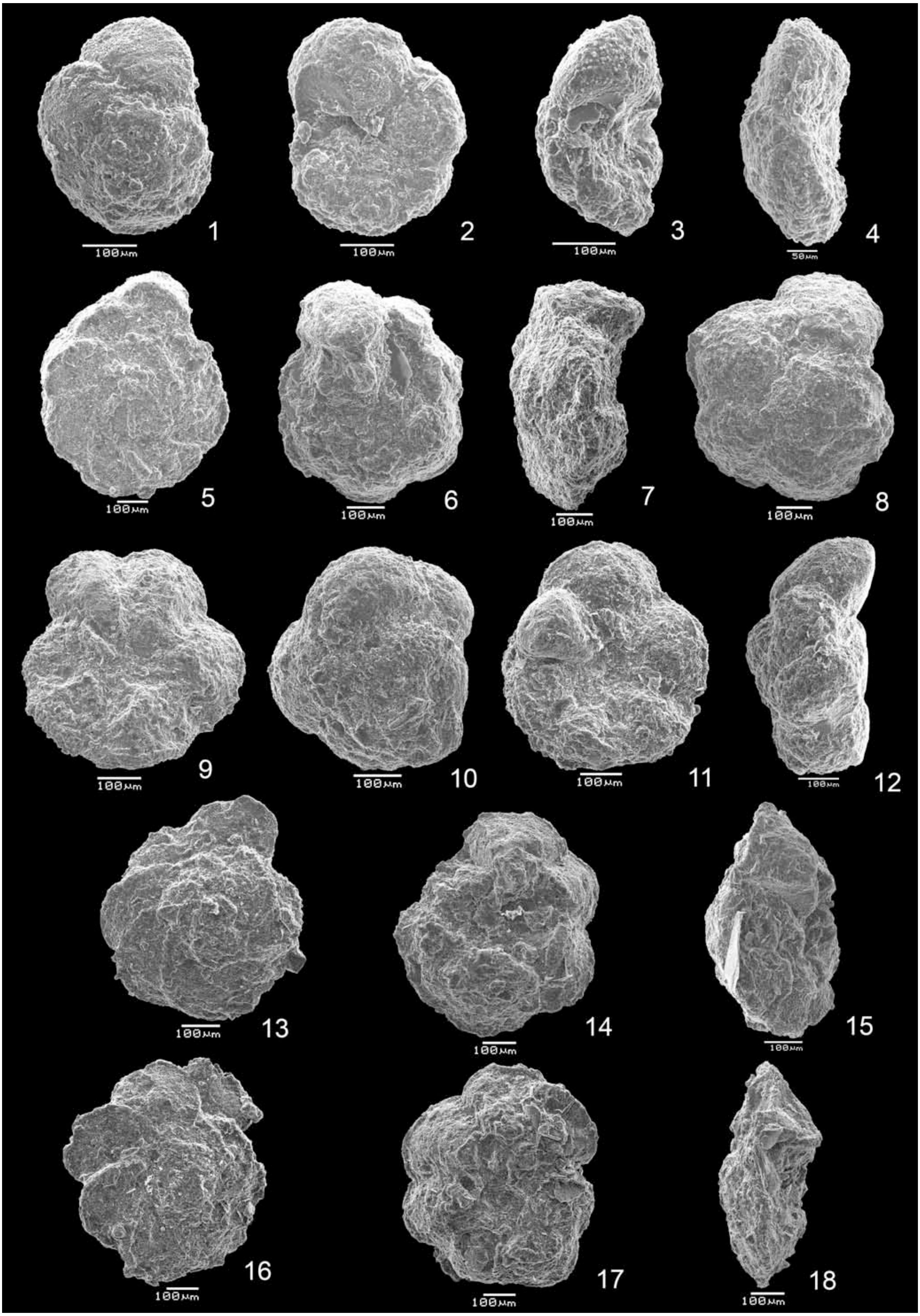
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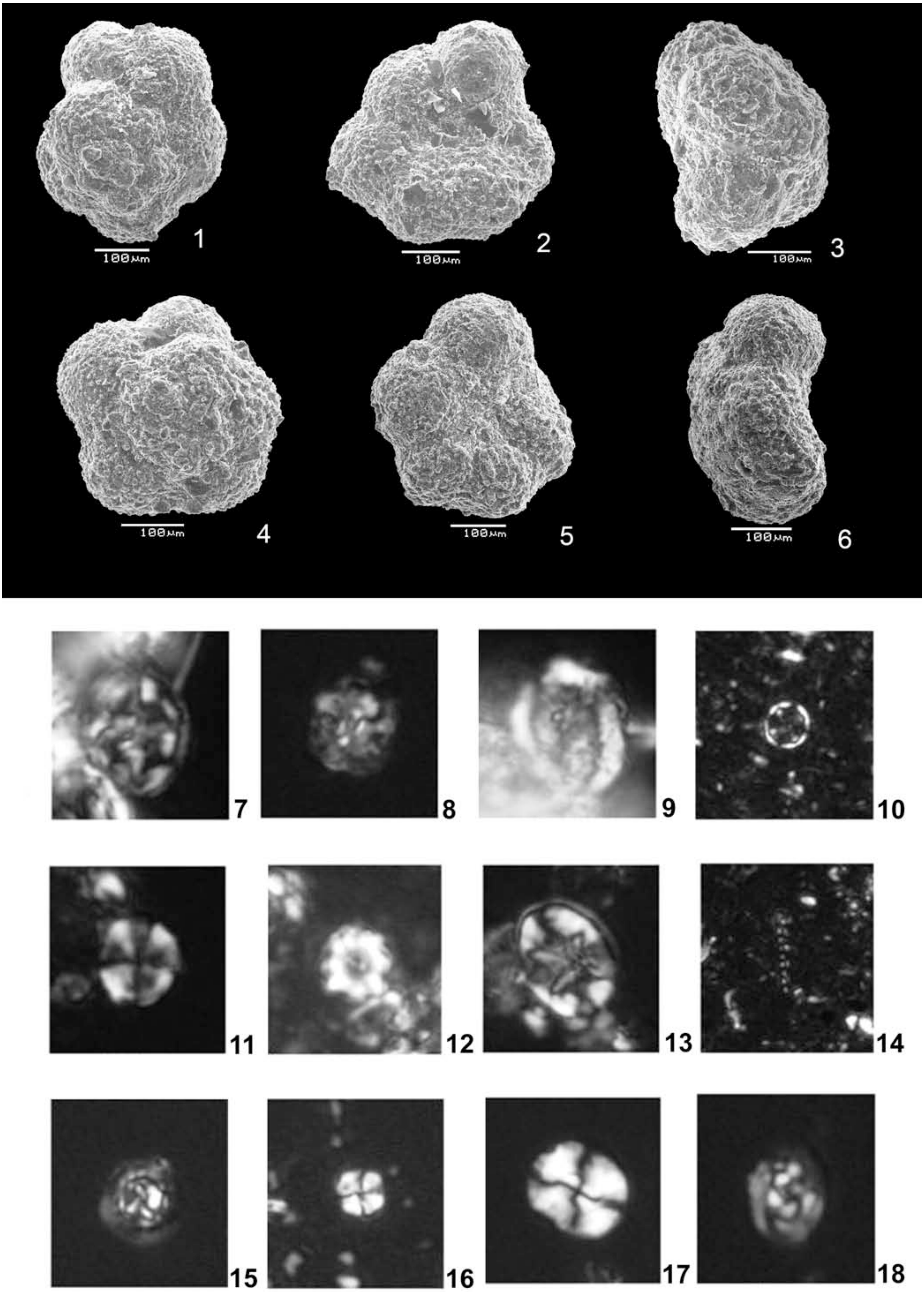
PLATE III

Figs. 1-6. *Planktonic foraminifera*
Figs. 1-3. *Different specimens of* Whiteinella paradubia *Sigal, 1 – spiral view, 2 –umbilical view, 3 – lateral view, Izlaz Valley, 3/12*
Figs. 4-6. *Different specimens of* Whiteinella brittonensis *Loeblich & Tappan, 4 – spiral view, 5 –umbilical view, 6 – lateral view, Izlaz Valley, 3/12*
Figs. 7-18. *Calcareous nannofossils*
Fig. 7. Axopodorhabdus albianus *(x 3000)*
Fig. 8. Biscutum constans *(x 3000)*
Fig. 9. Cretarhabdus conicus *(x 3000)*
Fig. 10. Cylindralithus biarcus *(x 2000)*
Fig. 11. Eprolithus floralis *(x 3000)*
Fig. 12. Eprolithus octopetalus *(x 3000)*
Fig. 13. Eiffelithus turriseiffelii *(x 3000)*
Fig. 14. Microrhabdulus decoratus *(x 2000)*
Fig. 15. Prediscosphaera columnata *(x 3000)*
Fig. 16. Quadrum gartneri *(x 2000)*
Fig. 17. Watznaueria barnesiae *(x 3000)*
Fig. 18. Rhagodiscus achlyostaurion *(x 3000)*

PLATE III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