ACTA PALAEONTOLOGICA ROMANIAE V. 5 (2005), P. 451-461

LATE BADENIAN FORAMINIFERA, CALCAREOUS NANNOFOSSILS AND PTEROPOD ASSEMBLAGES IDENTIFIED IN BOREHOLES FROM CLUJ-NAPOCA

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Abstract: Several boreholes drilled on the right side of Someşul Mic Valley, in Piața Abator – Piața Mihai Viteazu, in order to extend the sewerage network of Cluj-Napoca municipality, evidenced for the first time the presence of the Upper Badenian deposits in Cluj-Napoca. These deposits have been analyzed for their foraminifera, calcareous nannofossils and pteropods content.
The marly-clayey deposits of the Upper Badenian (Kossovian), respectively the "*Spirialis* Marls" (which belong to the upper part of the Mireş Subgroup, or to the Pietroasa Formation), have been intercepted at a depth of about 5 m, and they are about 3 m thick.
The foraminiferal assemblages belong to *Velapertina* Biozone and the calcareous nannofossils' assemblages belong to *Discoaster exilis* Biozone (NN6). Pteropods belonging to *Limacina* genera are also present.

Key words: Late Badenian (Kossovian), foraminifera, calcareous nannofossils, pteropods, biostratigraphy, paleoecology, Transylvania.

INTRODUCTION

The present study completes the data concerning the Upper Badenian of Cluj-Napoca, with new arguments based on foraminifera, calcareous nannofossils and pteropods.

In order to extend the sewerage network of Cluj-Napoca city, in the Piața Abator – Piața Mihai Viteazu sector, several boreholes were drilled on the right side of Someşul Mic Valley.

GEOLOGICAL SETTING AND THE STUDIED AREA

In Cluj-Napoca city area, the most extended deposits are the Lower Badenian (the Dej Formation) and the Sarmatian (the Iris and Feleac Formations) ones (Fig. 1).

The Upper Badenian deposits ("*Spirialis* Marls") do not crop out in the studied area, so that their direct study is hindered.

Mészáros and Clichici (1988) have mentioned the presence of the Upper Badenian deposits in the basement of the central part of Cluj-Napoca

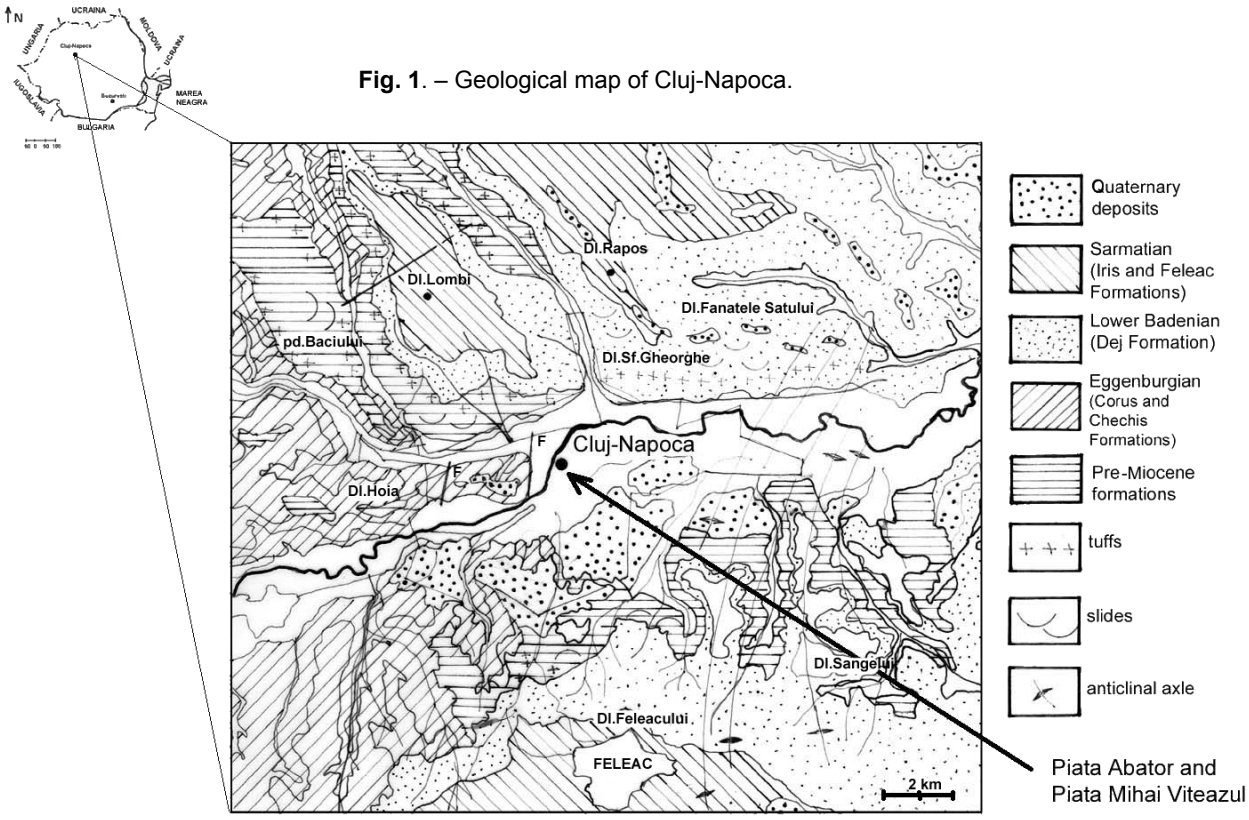

Fig. 1. – Geological map of Cluj-Napoca.

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city, in boreholes.

Suciu (2002, 2005) provided the first evidences for the presence of the Upper Badenian (Kossovian) in the Cluj-Napoca area, based on micropaleontological (foraminifera) data.

The mentioned new drills (from Piața Abator - Piața Mihai Viteazu area) pierced the terrace deposits (Quaternary in age) and intercepted the gray marly-clayey deposits (respectively the "*Spirialis* Marls") of the Upper Badenian.

The latter ones show an irregular spatial distribution (Fig. 2). They have been intercepted at a depth of about 5.0 m and they are about 3.0 m thick.

The core samples were investigated for their microfaunal, calcareous nannofossil and pteropods content.

MATERIAL AND METHODS

The fossil material was collected from several boreholes executed by S.C. I.C.P.M. S. A. Cluj-Napoca in the year 1996. The well sites are located in the central part of Cluj-Napoca city: boreholes 3369, 3370, 3372, 3373, 3375, and 3376.

The core samples were processed by standard methods, mainly by immersion in water and sieving the disaggregated sediment on a 63-μm mesh. The fossil fauna (foraminifera and pteropods) was handpicked from the entire > 63 μm residue. The foraminifera and pteropods were photographed using a digital camera mounted on a binocular microscope.

The calcareous nannoplankton/nannofossils, prepared by standard methods were studied under the cross-polarized light microscope, with x 1000 magnification, and photographed with x 2000 magnification.

FORAMINIFERA

The foraminiferal assemblages (Tab. 1) are poor in the upper part of the marly deposits.

In the lower part, the calcareous benthic forms dominate, which represent about 60 % of the assemblage.

The agglutinated species are rare and slightly diversified: *Bogdanowiczia pocutica* Pishvanova, *Reticulophragmium crassum* (Reuss) and *Martinotiella communis* (d'Orbigny) (Pl. I).

The species *Bogdanowiczia pocutica* Pishvanova was described from the Kossovian deposits from the Ukrainian Subcarpathians by Pishvanova (1957) (fide Pishvanova, 1978).

Marinescu *et al.* (1980) and Papaianopol *et al.* (1984) considered the same species to indicate the Upper Badenian age, in the Borod Basin.

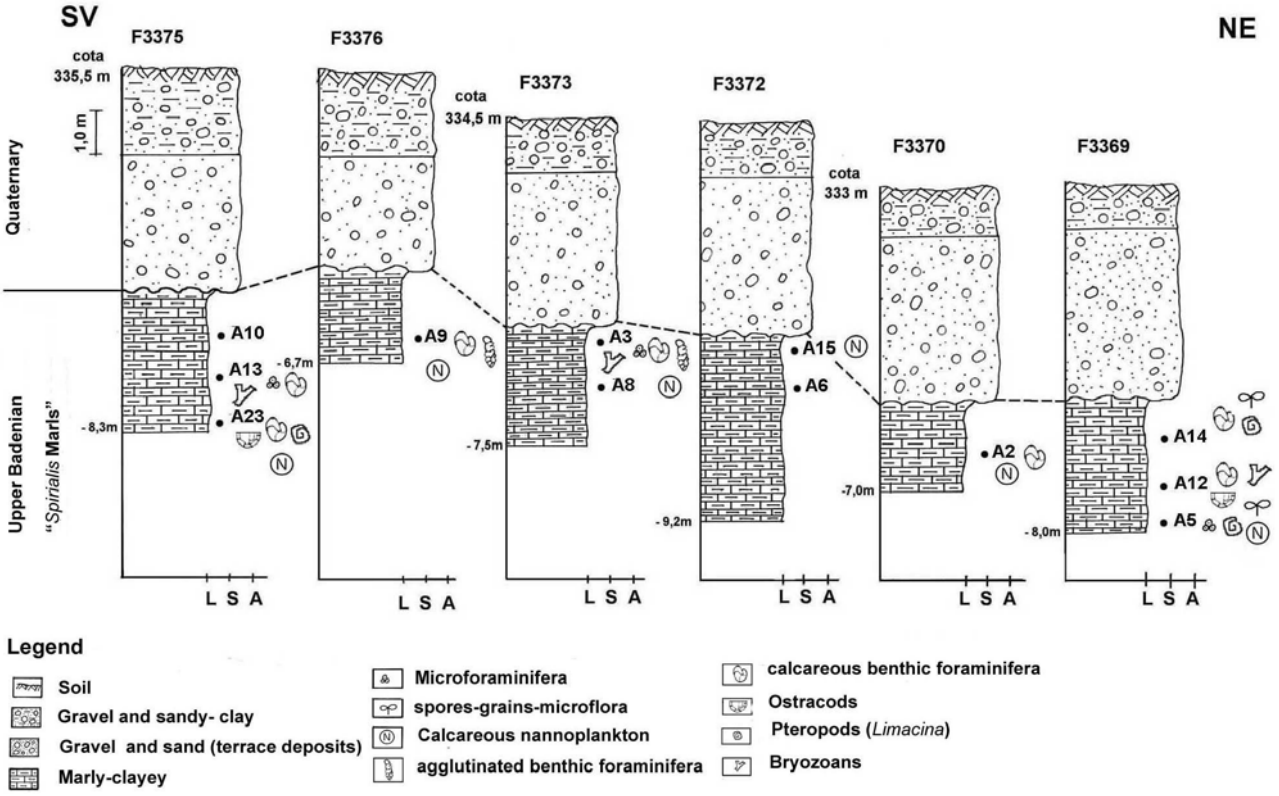
The presence of this species in our samples can justify the Upper Badenian age of these deposits.

Among the calcareous benthic foraminifera, the miliolids genera and species are rare, but the smooth and oval-elongate specimens are abundant.

Spiroloculina canaliculata d'Orbigny and *Quinqueloculina ackneriana* d'Orbigny indicate muddy sediments.

Among the planktonic foraminifera we identified the following species:

Fig. 2. - Lithological profile of boreholes from Piața Abator - Cluj-Napoca.



Globigerina bulloides d'Orbigny, *Globigerina bollii* Cita & Premoli-Silva, *Globigerina tarchanensis* (Subotina & Chutzieva), *Globigerinoides quadrilobatus* (d'Orbigny), *Globigerinoides trilobus* (Reuss), and the endemic species *Velapertina indigena* (Luczkowska), an index species for the *Velapertina* Biozone.

Ionesi and Enache-Bouan (1987) showed that the taxa: *Sphaeroidina bulloides* d'Orbigny, *Heterolepa dutemplei* (d'Orbigny), *Riminopsis boueanus* (d'Orbigny), *Gyroidinoides soldanii* (d'Orbigny), *Asterigerinata planorbis* (d'Orbigny), are frequently mentioned in the Upper Badenian from the Central Paratethys.

The same taxa were identified in the samples from the Piața Abator – Piața Mihai Viteazu area.

The foraminiferal assemblages that we determined are very similar with the Kossovian ones identified by Filipescu (1992) at Podeni and which he assigned to the *Velapertina* Biozone (M7 Biozone).

Based on the index species, the studied foraminiferal assemblages can be assigned to the *Velapertina* Biozone, Upper Badenian in age.

Besides the foraminifers, rarely also fragments of ostracods, bryozoans and echinid spicules were present.

Table 1. Microfaunal assemblages from Upper Badenian (Piața Abator and Piața Mihai Viteazu).

Species/ Sample nr.	A23	A13	A9	A3	A2	A5	A12	A14	A11
Bogdanowiczia pocutica Pishvanova		+			+	+		+	
Reticulophragmium crassum (Reuss)					+	+		+	
Cyclammina sp.			+			+		+	
Martinotiella communis (d'Orbigny)	+				+	+		+	
Spiroloculina canaliculata d'Orbigny	+				+	+	+	+	
Quinqueloculina akneriana d'Orbigny		+			+		+	+	
Triloculina sp.					+	+		+	
Lenticulina cultrata (de Montfort)				+					
Lagena sp.					+		+	+	
Globulina gibba d'Orbigny					+				
Hoeglundina elegans (d'Orbigny)	+	+	+		+			+	
Velapertina indigena (Luczkowska)		+		+		+			
Globigerina bollii Cita & Premoli-Silva						+			+
Globigerina bulloides d'Orbigny	+	+				+			+
Globigerina tarchanensis (Subbotina & Chutzieva)		+				+			
Globigerinella obesa (Bolli)								+	
Globigerinoides quadrilobatus (d'Orbigny)		+							+
Globigerinoides trilobus (Reuss)		+		+			+		+
Orbulina suturalis Bronnimann		+		+					
Orthomorphina catesbyi (d'Orbigny)								+	
Cancris auriculus (Fichtel & Moll)		+				+			
Valvulineria complanata (d'Orbigny)					+	+		+	
Eponides repandus (Fichtel & Moll)			+						
Sphaeroidina bulloides (d'Orbigny)	+				+	+		+	
Cibicidoides pseudoungerianus (Cushman)					+			+	
Asterigerinata planorbis (d'Orbigny)				+			+	+	
Amphistegina mamilla Fichtel & Moll	+	+					+		
Amphistegina bohdanowiczi Bieda		+							
Melonis pompilioides (Fichtel & Moll)	+				+	+	+	+	
Pullenia bulloides (d'Orbigny)	+				+		+	+	
Chilostomella ovoidea Reuss					+		+	+	
Riminopsis boueanus (d'Orbigny)					+	+		+	
Heterolepa dutemplei (d'Orbigny)								+	

Gyroidinoides soldanii (d'Orbigny)						+			
fragments of moluscs		+				+			
Limacina (Spirialis; Spiratella)	+					+		+	+
fragments of ostracods	+						+		
Bryozoans		+		+			+		
echinid spicules		+							
Charophytae (Quaternary)				+			+		

NANNOPLANKTON

The calcareous nannofossil assemblages from Piața Abator are well preserved and consist of a great number of taxa, especially in the boreholes F3369 (5,7 – 6 m) and F 3370 (6,2 – 7 m).

Very abundant are *Calciosolenia murray* Gran, *Syracosphaera histrica* Kamptner, *Triquetrorhabdulus rugosus* Bramlette & Wilcoxon, *Rhabdosphaera pannonica* Baldi-Beke, species of *Helicosphaera*: *Helicosphaera carteri* (Wallich), *Helicosphaera wallichii (Lohmann)*, *H. walbersdorfensis* Mueller, *H. mediterranea* Mueller, *H. waltrans* Theodoridis; *Sphenolithus*: *Sphenolithus moriformis* (Broennimann & Stradner), *S. abies* Deflandre, which indicate a Kossovian age, besides the absence of *Discoaster exilis*, the marker species for NN6 zone, after Martini (1971). Rarely *Sphenolithus heteromorphus* Deflandre is also present.

It was remarked that *Discoaster exilis* have its FO in the terminal part of the Lower Miocene and its LO in the Pliocene, characterizing the Moravian deposits in the entire Paratethys (Mărunțeanu, 1992, a.o.)

Other forms identified were: *Reticulofenestra pseudoumbilicus* (Gartner), *R*. cf. *minuta* Roth, *Holodiscolithus macroporus* Deflandre, *Coccolithus miopelagicus* Bukry, *Coccolithus pelagicus* (Wallich), *Calcidiscus macintyrei* (Bukry & Bramlette), *Calciosolenia murray* Gran, *Pontosphaera multipora* (Kamptner), *Thoracosphaera heimii* (Lohmann) (Pl. II, III).

The nannoplankton assemblages contain frequent species of *Rhabdosphaera, Helicosphaera,* and *Syracosphaera histrica* Kamptner, *Calciosolenia murray* Gran, which certainly indicate the Kossovian age (Mărunțeanu *et al.*, 2000).

The samples from the borehole in Piața Mihai Viteazu contain very rich assemblages dominated by discoasters: *Discoaster exilis* Martini & Bramlette, *D. brouweri* Tan, *D. musicus* Stradner; umbilicospheres: *Umbilicosphaera jafari* Mueller, *U. rotula* Kamptner and sphenoliths: *Sphenolithus moriformis* (Broennimann & Stradner), *S. abies* Deflandre, which prove the presence of the Kossovian deposits, too. Rarely also *Sphenolithus heteromorphus* Deflandre is present.

It must be precised that *Helicosphaera mediterranea* Mueller disapear in Lower Moravian (Lower Badenian) and *Discoaster musicus* Stradner in the base of the Kossovian, the last occurrences being very rare, in the "Radiolarian Shales".

Additionally, the following species were also identified: *Calcidiscus macintyrei* (Bukry & Bramlette), *Rhabdosphaera pannonica* Baldi-Beke, *Helicosphaera carteri* (Wallich), *H. walbersdorfensis* Mueller, and *Pontosphaera multipora* (Kamptner).

All these species are presented in Tab. 2, in a systematic order after Young & Bown (1997).

Table 2. Calcareous nannofossils identified in the borehole samples from the Abator and Mihai Viteazu area (according to the classification of Young & Bown, 1997).

NANNOFOSSIL SPECIES	Piața Abator	Piața Mihai Viteazu
CALCAREOUS NANNOPLANKTON: HETEROCOCCOLITS **Family Helicosphaeraceae**		
Helicosphaera carteri (WALLICH, 1877) KAMPTNER (1954)	X	X
Helicosphaera wallichii (LOHMAN, 1902) OKADA & MCINTYRE (1997)	X	
Helicosphaera mediteranea (MUELLER, 1974)	X	
Helicosphaera waltrans THEODORIDIS	X	
Helicosphaera walbersdorfensis (MUELLER, 1974)	X	X
Family Pontosphaeraceae		
Pontosphaera multipora (KAMPTNER, 1948) ROTH (1970)	X	X

Family Calciosoleniaceae		
Calciosolenia murrayi DEFLANDRE IN DEFLANDRE & FERT (1954)	X	
Family Syracosphaeraceae		
Syracosphaera histrica KAMPTNER (1941)	X	
Family Rhabdosphaeraceae		
Rhabdosphaera pannonica BALDI-BEKE (1960)	X	X
Family Noelaerhabdaceae		
Reticulofenestra pseudoumbilicus (GARTNER, 1967) GARTNER (1969)	X	
Reticulofenestra cf. *minuta* ROTH (1970)	X	
Family Coccolithaceae		
Coccolithus miopelagicus BUKRY (1971)	X	
Coccolithus pelagicus (WALLICH, 1877) SCHILLER (1930)	X	
Family Calcidiscaceae		
Calcidiscus macintyrei BUKRY & BRAMLETTE	X	X
Umbilicosphaera jafari MÜLLER (1974)		X
Umbilicosphaera rotula		X
HOLOCOCCOLITHS **Family Calyptrosphaeraceae**		
Holodiscolithus macroporus (DEFLANDRE *in* DEFLANDRE & FERT, 1954) ROTH (1970)	X	X
NANNOLITHS **Family Braarudosphaeraceae**		
Braarudosphaera bigelowii (GRAN & BRAARUD, 1935) DEFLANDRE (1947)	X	
Family Discoasteraceae		
Discoaster musicus STRADNER (1959)		X
Discoaster exilis MARTINI & BRAMLETTE (1963)		X
Discoaster brouweri TAN (1927) emended BRAMLETTE & RIEDEL (1954)		X
Family Sphenolithaceae		
Sphenolithus heteromorphus DEFLANDRE (1953)	X	X
Sphenolithus moriformis (BRÖNNIMANN & STRADNER, 1960) BRAMLETTE & WILCOXON (1967)	X	X
Sphenolithus abies DEFLANDRE *in* DEFLANDRE & FERT (1954)	X	X
Family Triquetrorhabdulaceae		
Triquetrorhabdulus rugosus BRAMLETTE & WILCOXON (1967)	X	
CALCAREOUS DINOFLAGELLATES		
Thoracosphaera heimii (LOHMANN 1919) Kamptner 1941	X	X

MOLLUSCS

The samples were very scarce in mollusks. They contained pteropods and very juvenile specimens of bivalves and gastropods (prodisoconch and protoconchs). The pteropods belong to *Limacina valvatina* species.

Class Gastropoda CUVIER, 1795
Order Thecosomata BLAINVILLE, 1824
Family Limacinidae GRAY, 1847
Genus *Limacina* BOSC, 1817

***Limacina valvatina* (REUSS, 1867**)
Pl. I, fig. 15, 16, 17

1981 *Spiratella valvatina* (Reuss) – Krach, p. 125, pl. III, fig. 2-4, 7, 8, pl. V, fig. 1, 2, 10-11, pl. VI, fig. 1, 2

1984 *Limacina valvatina* (Reuss) – Janssen, p. 381, pl. 20, fig. 1, 2

1991 *Limacina valvatina* (REUSS) – Zorn, p. 19, pl. 1, fig. 1-3

1993 *Limacina valvatina* (REUSS) – Janssen & Zorn, p. 179, pl. 1, fig. 4-11, pl. 2, fig. 1-11, pl. 3, fig. 1-12

1999 *Limacina valvatina* (REUSS) – Zorn, p. 728, pl. 1, fig. 4, 6-10

2002 *Limacina valvatina* (Reuss) – Bohn-Havas & Zorn, pl. I, fig. 1-4, 5, 6

2003 *Limacina valvatina* (Reuss) - Bohn-Havas & Zorn, pl. 2, fig. 2, 4

Material: sample A23 (borehole 3375 - 8-8.3 m), A5 (3369 - 7.7-8.0 m), A14 (3369 - 5.7 - 6.0 m) and A11 (Piata Mihai Viteazu – below the statue).

Remarks: The specimens are pyritized, and a few are pelomorphozed.

Limacina valvatina was identified in Upper Badenian deposits from Chiuza (north of the Transylvanian Basin) by Silye (2001).

In the Transylvanian Basin, a level with pteropods (*Limacina*) ("Spirialis marls") occurs. Gabos (1974) described from this level 5 species of *Limacina* (*L. andrussowi andrussowi* KITTL, *L. hospes* (ROLLE), *L.* cf. *stenogyra* (PHILIPPI), *L. subtarchanensis* ZHIZCHENKO, and *L. koeneni* KITTL).

"Radiolarian shales" and "Spirialis marls" together belong to the Pietroasa Formation (Filipescu, 1996) (Upper Badenian).

Distribution: *Limacina valvatina* occured in the Late Oligocene to the Badenian interval in the Paratethys (Zorn, 1991, 1999), and in the Karpatian to the Late Badenian interval in the Central Paratethys, where it is very frequent (Zorn, 1999, Bohn-Havas & Zorn, 2002, 2003).

PALEOECOLOGY

Based on foraminifera, the deposits from Piaţa Abator - Piatţa Mihai Viteazu were probably accumulated in marine deep waters, of the inner-shelf or the bathyal facies.

The calcareous nannofossils assemblages indicate cooler waters as compared to the Lower Badenian ones.

The species of *Discoaster*, like *D. exilis* and *D. musicus*, prevail in the assemblages from the samples in the Mihai Viteazu area. They had an ecological preference for tropical and subtropical oceans, and therefore for warm water masses throughout the Cenozoic (Rahman & Roth, 1990). *D. exilis* is either tolerant, or exhibits preference for colder waters.

Helicosphaera carteri is adapted today to the tropical and subtropical waters of the Atlantic - with a range of tolerance between 16 and 26^0C, after McIntyre & Be (1967).

Although *Coccolithus pelagicus* is a subpolar species today, it is also abundant in Badenian deposits. It evolved in the tropical area during the early Cenozoic and migrated towards the poles during the mid - Cenozoic (Haq & Lohmann 1976). Some calcareous nannoplankton seems to be extremely rare or absent in tropical waters today, e.g. *Coccolithus pelagicus* and others. Other species, like most of the *Sphenolithus* and some *Helicosphaera* seem to avoid boreal waters (Martini, 1971).

For the Badenian deposits from the Vienna Basin, Fuchs & Stradner (1977) showed that *Coccolithus pelagicus* characterizes subpolar water masses. Rahman & Roth (1990) considered *C. pelagicus* as a long - ranging species that provides paleoclimatic information for latest Middle Miocene to Pleistocene. *C. pelagicus* prefers cold nutrient-rich surface waters, with a temperature between 7 and 14^0 C (McIntyre & Be, 1967), and therefore it is a good paleoclimatic indicator (Haq *et al.* 1977). It seems that the species might have changed its ecological preference and was not a cold - water indicator during late Miocene. Subsequent studies confirmed the earlier observations that *C. pelagicus* is indeed indicative of cold waters even in the late Miocene (Haq *et al.* 1977; Rahman & Roth 1990). Because it is a resistant species, the carbonate dissolution would improve the frequency of *C. pelagicus* in the sediment, imprinting a cold aspect to the assemblages (Rahman & Roth 1990).

Other considerations have been also made by Mészaros (1991), Chira (1999, 2000) a.o.

CONCLUSIONS

Based on foraminifera, calcareous nannofossils and pteropods, the presence of the Upper Badenian (Kossovian) was demonstrated in the Piata Abator - Piata Mihai Viteazu sector of Cluj-Napoca.

These deposits correspond to the "*Spirialis* Marls" which, according to the most recent interpretations belong to the upper part of the Mireş Subgroup (Popescu, 1972) or to the Pietroasa Formation (Filipescu, 1996).

The foraminiferal assemblages belong to *Velapertina* Biozone, and the calcareous nannofossils assemblages belong to *Discoaster exilis* Biozone (NN6). Pteropods belonging to *Limacina valvatina* (Reuss) are also present.

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PLATE CAPIONS

PLATE I

Fig. 1. *Bogdanowiczia pocutica* Pishvanova (sample A13- Borehole F3375- 7-7,3 m)
Fig. 2. *Reticulophragmium crassum* (Reuss) (sample A2- Borehole F3370- 6,2-7 m)
Fig. 3. *Spiroloculina canaliculata* d'Orbigny (sample A23- Borehole F3375- 8-8,3 m)
Fig. 4. *Quinqueloculina akneriana* d'Orbigny (sample A12- Borehole F3369- 6,7-7 m)
Fig. 5. *Hoeglundina elegans* (d'Orbigny) (sample A9- Borehole F3376- 6-6,3 m)
Fig. 6. *Velapertina indigena* (Luczkowska) (sample A13- Borehole F3375- 7-7,3 m)
Fig. 7. *Globigerina bollii* Cita & Premoli-Silva (sample A11- Piata Mihai Viteazu)
Fig. 8. *Globigerina bulloides* d'Orbigny (sample A11- Piata Mihai Viteazu)
Fig. 9. *Globigerina tarchanensis* (Subbotina & Chutzieva) (sample A5- Borehole F3369- 7,7-8 m)
Fig. 10. *Sphaeroidina bulloides* (d'Orbigny) (sample A14- Borehole F3369- 5,7-6 m)
Fig. 11. *Heterolepa dutemplei* (d'Orbigny) (sample A14- Borehole F3369- 5,7-6 m)
Fig. 12a,b. *Riminopsis boueanus* (d'Orbigny) (sample A2- Borehole F3370- 6,2-7 m)
Fig. 13a,b. *Gyroidinoides soldanii* (d'Orbigny) (sample A5- Borehole F3369- 7,7-8 m)
Fig. 14a,b. *Asterigerinata planorbis* (d'orbigny) (sample A3- Borehole F3373- 5-5,3 m)
Obs. The scale bare is 0,5 mm
Fig. 15-16. *Limacina valvatina* (Reuss) (sample A14- Borehole F3369- 5,7-6 m); x 80
Fig.17. *Limacina valvatina* (Reuss) species (sample A23- Borehole F3375- 8-8,3 m)
Fig.18. Juvenils forms of gastropods and bivalves.

PLATE II

Calcareous nannoplankton assemblage from Piața Abator (Cluj-Napoca) - Lower Badenian (x 2000)

Fig.1a, 1b (1). *Sphenolithus heteromorphus* Deflandre (1953).
Fig. 1a, 1b (2); 3a, 3b. *Sphenolithus moriformis* (Brönnimann & Stradner, 1960) Bramlette & Wilcoxon (1967); 1a, 3a – N II; 1b, 3b – N + .
Fig. 2a, 2b, *Sphenolithus abies* Deflandre în Deflandre & Fert (1954). 2a – N II; 2b – N + .
Fig. 4a, 4b, 5a, 5b. *Reticulofenestra pseudoumbilicus* (Gartner, 1967) Gartner, 1969; 4a, 5a – N II; 4b, 5b – N +.
Fig. 6, 7. *Holodiscolithus macroporus* Deflandre în Deflandre & Fert (1954) Roth (1970). N II.
Fig. 8. *Helicosphaera walbersdorfensis* Müller (1974). N + .
Fig. 9a, 9b. *Coccolithus miopelagicus* Bukry (1971); 9a – N II; 9b – N + .
Fig. 10a, 10b. *Pontosphaera multipora* (Kamptner, 1948) Roth (1970) and *Coccolithus pelagicus* (Wallich, 1877) Schiller (1930); 10a – N II; 10b – N + .
Fig. 11a, 11b. *Calcidiscus macintyrei* (Bukry & Bramlette, 1969) Loeblich & Tappan (1978); 11a – N II; 11b – N + .
Fig. 12a, 12b, 13a, 13b. Coccospheres of *Reticulofenestra pseudoumbilicus* (Gartner, 1967) Gartner (1969); 12a, 13 a – N II; 12b, 13 b – N + .

PLATE III

Calcareous nannoplankton assemblage from Piața Abator (Cluj-Napoca)- Lower Badenian (x 2000)

Fig. 1a, 1b. *Calciosolenia murray* Gran (1912) (= *Scapholithus fossilis* Deflandre în Deflandre & Fert, 1954). 1a – N II; 1b – N +.
Fig. 2a, 2b. *Triquetrorhabdulus rugosus* Bramlette & Wilcoxon (1967). 2a – N II; 2b – N +.
Fig. 3a, 3b. *Coccolithus* cf. *pelagicus* (Wallich, 1877) Schiller (1930). 3a – N II; 3b – N +.
Fig. 4. *Syracosphaera* cf. *histrica* Kamptner (1941). N +.
Fig. 5a, 5b, 6a, 6b. *Helicosphaera carteri* (Wallich, 1877) Kamptner (1954). 5a, 6a – N II; 5b, 6b – N +.
Fig. 7a, 7b, 8a, 8b. *Helicosphaera wallichii* (Lohmann, 1902) Okada & Mcintyre (1977). 7a, 8a – N II; 7b, 8b – N +.
Fig. 9a, 9b, 9c, 10. *Rabdosphaera pannonica* Baldi-Beke (1960). 9a, 9, 10 – N II; 9b – N + .
Fig. 11a, 11b *Braarudosphaera bigelowii* (Gran & Braarud, 1935) Deflandre (1947). 11a – N II; 11b – N +.
Fig. 12a, 12b. *Thoracosphaera heimii* (Lohmann, 1919) Kamptner (1941). 12a – N II; 12b – N +.

PLATE I

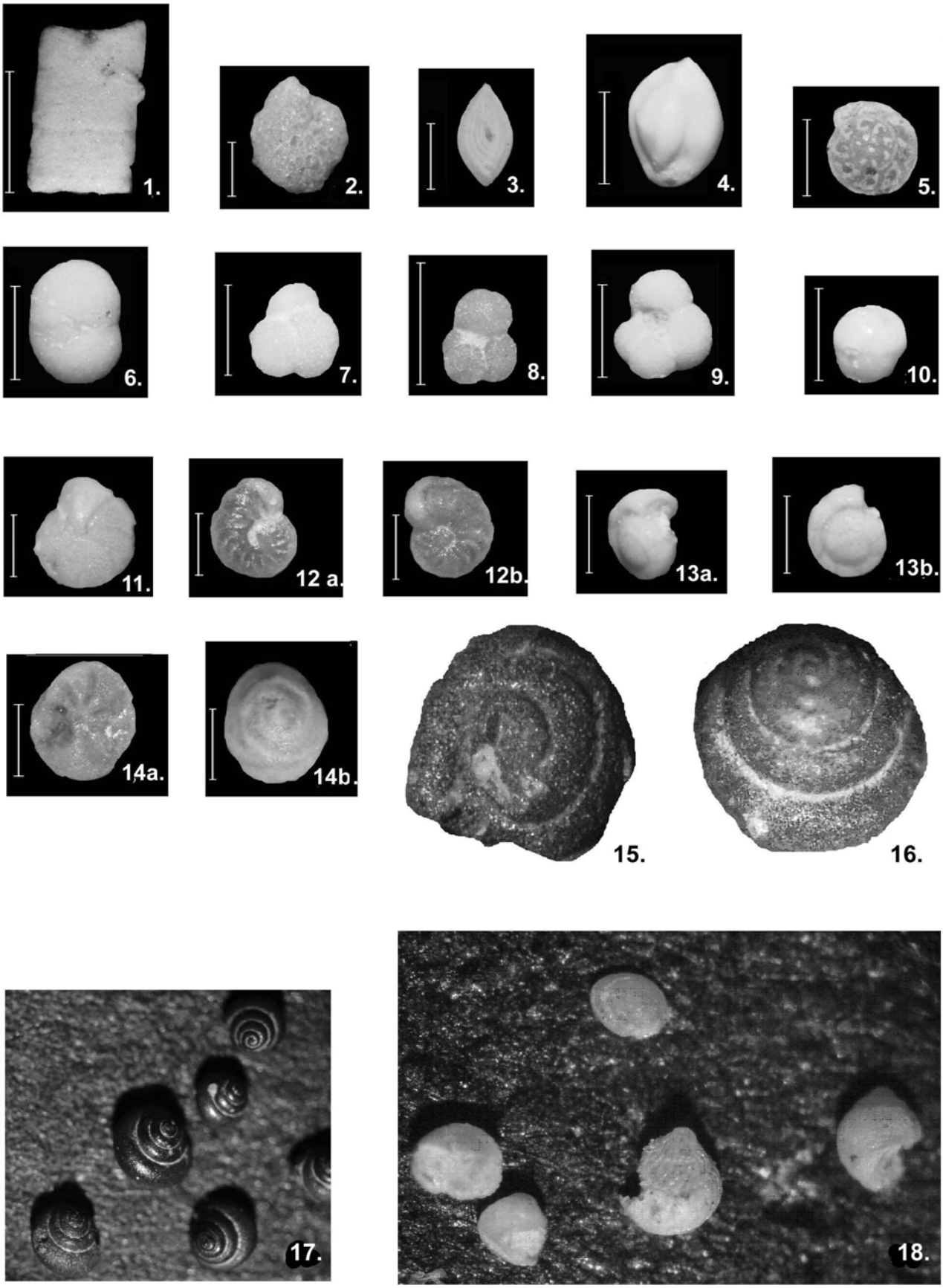
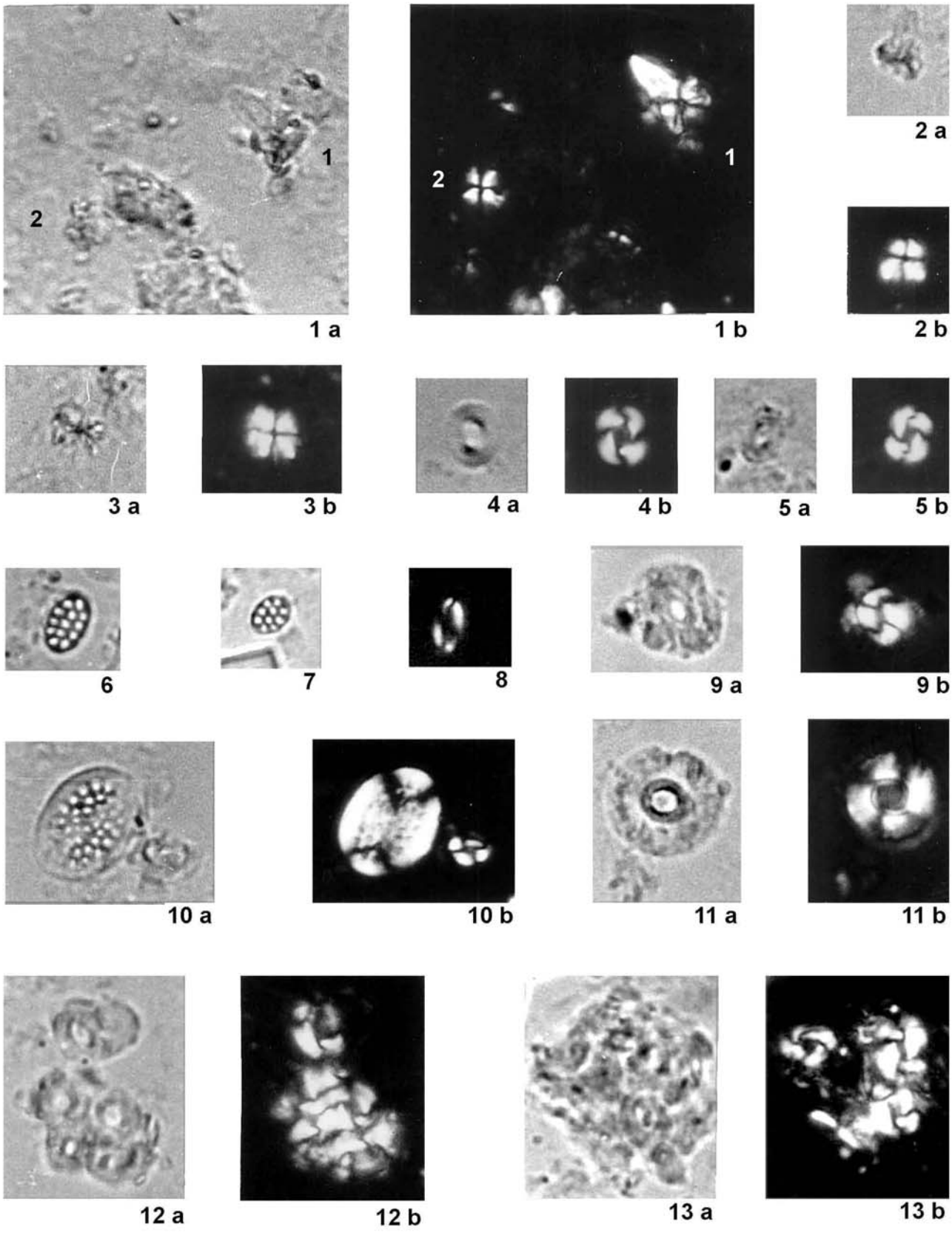


PLATE II


1
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1 a
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PLATE III