ACTA PALEONTOLOGICA ROMANIAE V. 3 (2001), P. 53-65

MIOCENE CALCAREOUS NANNOFOSSILS FROM DEJ – RETEAG – CICEU AREA (TRANSYLVANIAN BASIN, ROMANIA): BIOSTRATIGRAPHICAL IMPORTANCE AND PALAEOECOLOGICAL DATA

Carmen CHIRA[1] & Ramona BALC[2]

Abstract. Two nannoplankton biozones are present in the areas from the northern part of the Transylvania, between Dej – Ciceuri – Reteag – Negrileşti: NN4 - *Helicosphaera ampliaperta* Zone (Ottnangian) and NN5 - *Sphenolithus heteromorphus* Zone (Early Badenian = Moravian), which prove the presence of the Miocene deposits, and especially from the boundary Early Miocene/ Middle Miocene. Concerning the boundary NN4/ NN5, there are different opinions for the Central Paratethys, and especially for the start of the Early Badenian (in the upper part of the NN4 zone or the lower part of the NN5 zone). For the Transylvanian Basin, in conformity with the recent opinions, the Early Badenian is indicate by the beginning of the NN5 zone. In the investigated area from the northern Transylvania, was more precisely remarked the presence of the boundary NN4/ NN5 zone and the nannofossil assemblages corresponding to NN5a subzone, with *Umbilicosphaera rotula* (= *Calcidiscus annula*).

Key words: Calcareous Nannnofossils, Early/ Middle Miocene: Ottnangian, Badenian; Biostratigraphy, Palaeoecology, Northern Transylvania.

INTRODUCTION

The investigated area is located in the north – western Transylvanian Basin (Cluj and Bistriţa – Năsăud counties) (Figure 1).

The occurences from Râpa Dracului - Dej, Negrileşti Valley, Ciceu-Giurgeşti, Ciceu-Poieni, Reteag, Ciceu Mihăieşti - Mihăieşti Valley have been in detail analysed (Figure 1).

The calcareous nannofossils have been studied both by light and electronic microscopes. Generally, calcareous nannofossils have a high value for biostratigraphy and also paleoecological significance. The most frequently used zonations of the Cenozoic are those of Martini (1971) and Okada & Bukry (1980).

The deposits outcropping in this part of Transylvania are of Ottnangian – Badenian age and belong to Hida and Dej Formations.

Hida Formation (Hofmann, 1879, Koch 1900) is bounded by two levels of conglomerates and preserves in its lower part the character of the Eggenburgian microfauna, while in the upper part the microfauna disappears because of the gradual decrease of salinity (as also recently was mentioned by Filipescu, 2001). After Mészáros (1991), the nannoplankton assemblages, belonging to NN4 zone, prove the Ottnangian age.

Dej Formation (Popescu, 1970), is assimilated to the entire "Dej Tuff Complex" (Moisescu & Popescu, 1967) represented by tuffs, tuffites, clays and silts. The age of this formation is Early Badenian (Moravian or Langhian partim).

The lower part of the Dej Formation was separated as Ciceu – Giurgeşti Member (Popescu, 1970), and is represented by conglomerates, siltic clays and tuffs. The nannoplankton assemblages have been considered as belonging to NN4 – NN5 zones, from the standard zonation of Martini (1971).

REMARKS ON OTTNANGIAN – BADENIAN CALCAREOUS NANNOFOSSILS FROM THE CENTRAL PARATETHYS AND TRANSYLVANIA

Some remarks concerning the Early Miocene (Ottnangian, Karpatian) and Middle Miocene (Badenian) from the Central Paratethys and also from the Transylvanian Depression are given.

[1, 2] *Babeş-Bolyai University, Department of Geology-Paleontology, Str. M. Kogălniceanu nr. 1, 3400 Cluj-Napoca, Romania.*

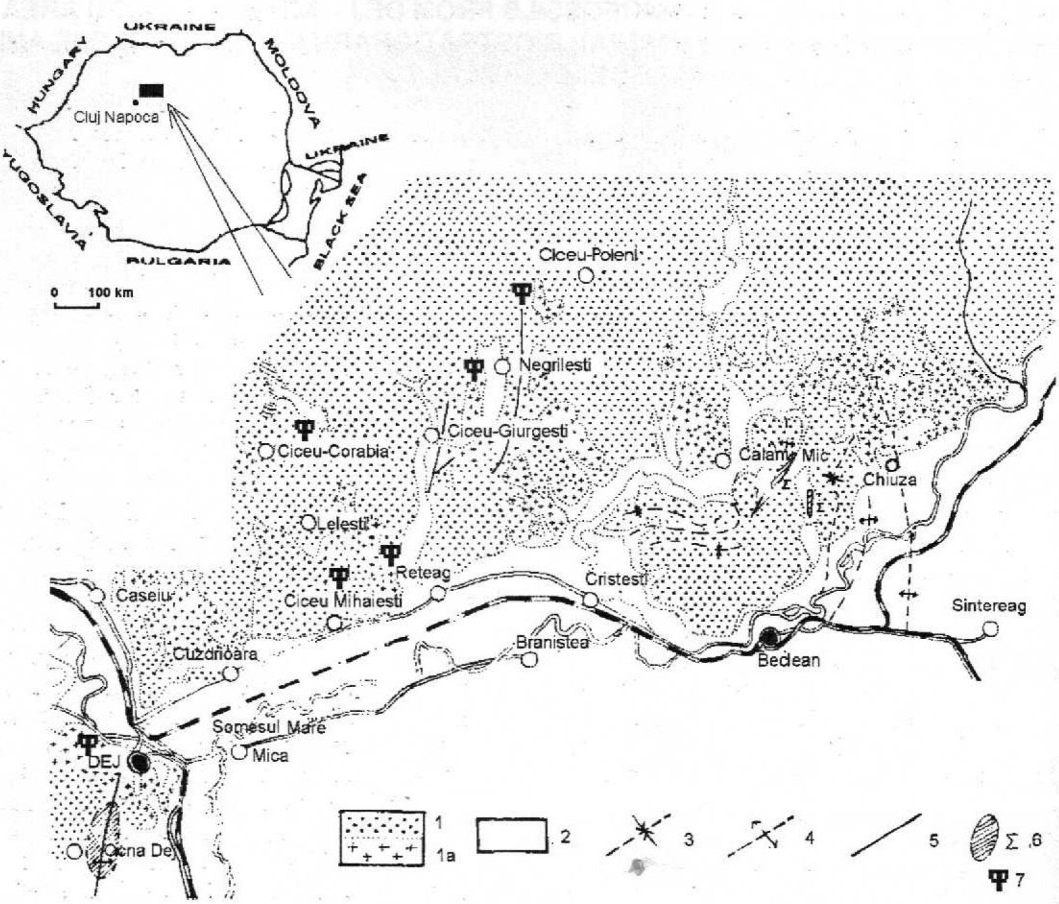


Figure 1. Location map of the studied area. Legend: 1, 1a. Badenian; 1 – Clays; 1a – Dej Tuff; 2. Holocene; 3 – Sincline axe; 4 – Anticline axe; 5 – Fault; 6 – Salt dyapir; 7 – Investigated sections - Fossiliferous sites).

Calcareous nannoplankton from the type Ottnangian in the Central Paratethys indicate, after Martini & Müller (1975a) a correlation with the upper part of the zone NN3 (*Sphenolithus belemnos* zone) and / or part of NN4 zone (*Helicosphaera ampliaperta* zone) of the standard nannoplankton zonation (Martini, 1971). It was remarked, that the calcareous nannoplankton is not very common in the type Ottnangian as well as in other localities from Austria. The most common species is *Coccolithus pelagicus*, then *Helicosphaera carteri*, *Cyclicargolithus floridanus* (= *Cyclococcolithus floridanus*), small *Reticulofenestra* sp. and *Helicosphaera ampliaperta* (Martini & Müller, 1975a).

The Karpatian in the Central Paratethys was studied from type Karpatian equivalents in Austria (Martini & Müller, 1975b). Considering the nannoplankton assemblage of the Ottnangian, in which *Helicosphaera ampliaperta* is present, the lower part of the Karpatian was correlated with the upper part of the zone NN4. In the opinion of Martini & Müller (1975b), *Sphenolithus heteromorphus* seems to invade the Paratethys during Late Karpatian, despite the fact that in the open oceans it has a concurrent range with *Helicosphaera ampliaperta* in the whole zone NN4. Rare specimens similar to *Sphenolithus heteromorphus* were noted sometimes, but these are not associated with *Helicosphaera ampliaperta*, indicating that they belong to the NN5 zone (*Sphenolithus heteromorphus* zone).

From two wells in Moravia, Cicha *et al.* (1971) reported the presence of *Helicosphaera ampliaperta* zone. The index fossil for NN4 zone appear togheter with: *Braarudosphaera bigelowii*, *Coccolithus pelagicus*, *Pontosphaera multipora* (= *Discolithina multipora*), *Helicosphaera carteri*, *H. intermedia*, *Reticulofenestra pseudoumbilicus*, *Reticulofenestra* sp., *Sphenolithus* sp. The whole assemblage is considered identical with the nannoplankton assemblages from the Karpatian of Laa and Retznei, in Austria, which have been placed in zone NN4 (*Helicosphaera ampliaperta* zone) (Martini & Müller, 1975b).

As it has been already shown, in the whole of the Central Paratethys, the Badenian starts with the NN5 zone, whereas the Langhian starts with the upper part of the NN4 Zone – with *Helicosphaera ampliaperta* (Martini, 1968). Moreover, the deposits belonging to Karpatian, the stage previous to Badenian, consist of nannofossil assemblages belonging to the NN4 and even to the NN5 Zone (Martini & Müller, 1975b). Consequently, the Langhian can be correlated with the Karpatian (partially or totally ?), and with the Early Badenian as also previously was mentioned by Mărunţeanu & Chira (1998).

The Miocene deposits from the investigated area belong to Hida Formation and Dej Formation, corresponding to NN4 – NN5 nannoplancton zones from the standard zonation of Martini (1971).

The stratigraphic distribution of the calcareous nannofossils in the Transylvanian Basin demonstrate that the lower boundary of the Badenian correspond to the base of the NN5 Zone, which can be correlate with the Moravian, and cannot be correlate with the beginning of the Langhian, characterized by the upper part of the NN4 Zone (Mărunţeanu & Chira, 1998).

The Moravian is characterized by the NN5 Zone assemblage, its lower boundary corresponding to the extinction of *Helicosphaera ampliaperta* and/ or the first occurences of *Discoaster exilis*.

CALCAREOUS NANNOFOSSILS ASSEMBLAGES FROM DEJ – CICEURI – NEGRILEŞTI AREA – BIOSTRATIGRAPHICAL IMPORTANCE

The nannoplankton assemblages from the studied area belong to NN4 and NN5 zones.

Helicosphaera ampliaperta Biozone (NN4) is present in the lower part of the occurrence from Râpa Dracului – Dej and Negrileşti Valley, which could prove the Ottnangian age.

Sphenolithus heteromorphus Biozone (NN5) was remarked in the most part of the investigated area. The assemblages of this biozone belong certainly to the Lower Badenian (Moravian age).

At Râpa Dracului – Dej and Negrileşti was remarked the NN4/ NN5 boundary and of the NN5a Subzone, with *Umbilicosphaera rotula* (= *Calcidiscus annula* = *Geminilithella rotula*).

In the samples from Râpa Dracului – Dej (Table 1), was remarked the presence of the species *Helicosphaera ampliaperta*, in the base of the occurrence, which is the marker species for the NN4 zone, and sometimes also *Sphenolithus heteromorphus*, the marker species for the NN5 zone. But, *Sphenolithus heteromorphus*, is mentioned to appear from the upper part of the NN4 zone.

The assemblages which are typical for the NN5 zone are present in the upper part of the section from Râpa Dracului, beginning with the samples below the "Dej Tuff". So, it is possible, that the base of the section belong to Ottnangian, represented by Hida Formation, and the upper part of the section is certainly of Eary Badenian age, respectivelly the lower part of Dej Formation (NN5a Subzone).

In the Ciceuri and Reteag area was remarked the presence of the NN5 Zone.

So, the presence of both nannoplankton zones: NN4 and NN5, could have the significance of the existing of the boundary between the Ottnangian and Early Badenian deposits, while the base of the Early Badenian is documented for Transylvanian Basin, only with the beginning of the NN5 Zone.

From the section of the Râpa Dracului – Dej, 29 samples have been analysed, of which the samples from the upper part of the section, below the "Dej Tuff", contains a large number of diversified specimens, and especially the last one.

In the first samples (2, 3, 7, 9 , 11, 13) (Table 1) from the base of the section appear *Sphenolithus heteromorphus*, species which was mentioned by some researchers also from the upper part of the NN4 zone. In the samples from the base of the section (1, 3) appear sporadically *Helicosphaera ampliaperta*, the marker species for NN4. So, that it is possible that the base of the section belong to the Hida Formation (Ottnangian).

The nannofossils assemblages contain about 30 species (Table 1). The most frequent are: *Reticulofenestra pseudoumbilicus, Syracosphaera histrica, Cyclicargolithus floridanus, Calcidiscus leptoporus, Thoracosphaera* cf. *heimii*. There are also relatively frequent *Sphenolithus heteromorphus, Coccolithus pelagicus, Coccolithus miopelagicus, Sphenolithus moriformis*. Rarely appear *Sphenolithus abies, Holodiscolithus macroporus, Reticulofenestra minuta, R. gelida, Triquetrorhabdulus rugosus, Umbilicosphaera rotula, U. jafari, Calcidiscus macintyrei, Pontosphaera multipora, Helicosphaera ampliaperta, H. walbersdorfensis, H. carteri, Discoaster variabilis, D. exilis, D.* cf. *musicus, D. brouweri*.

In the Reteag – Ciceuri area, in the first two analysed samples the marker species are absent, and the nannofossils assemblages are scarce, containing about 8 species. From the samples 13, appear rarely *Sphenolithu*

Table 1. Calcareous nannofossils from Râpa Dracului – Dej.

Nannofossils / nr. sample	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Sphenolithus heteromorphus		x	x				x		x		x		x															x	x
Sphenolithus neoabies	x					x	x						x																x
Sphenolithus abies		x	x																										x
Sphenolithus moriformis	x		x	x			x				x					x	x											x	x
Coccolithus miopelagicus	x	x	x	x	x			x					x	x											x	x		x	x
Coccolithus pelagicus	x	x			x	x	x	x	x		x								x		x							x	x
Cyclicargolithus floridanus	x	x	x	x	x	x	x	x			x	x	x	x			x	x	x			x						x	
Holodiscolithus macroporus		x	x	x																									
Reticulofenestra gelida	x	x																											
Reticulofenestra minuta	x										x	x																	x
Reticulofenestra pseudoumbilicus	x	x	x	x	x	x	x	x	x		x			x	x	x	x	x	x		x	x	x	x	x	x		x	x
Triquetrorhabdulus farnsworthii													x										x						
Triquetrorhabdulus rugosus	x	x	x										x													x			x
Syracosphaera histrica	x	x	x	x	x	x		x	x		x	x	x	x	x	x	x	x	x			x	x	x					
Calcidiscus leptoporus	x	x	x				x	x	x		x	x	x	x							x						x	x	x
Calcidiscus annula		x	x																									x	x
Calcidiscus macintyrei					x	x								x															x
Pontosphaera multipora	x	x					x																						x
Pontosphaera discopora							x																						
Helicosphaera ampliaperta	x		x																										
Helicosphaera walbersdorfensis																							x						x
Helicosphaera carteri		x																										x	x
Discoaster cf. musicus																								x					x
Discoaster variabilis																													x
Discoaster exilis																													x
Discoaster brouweri																													x
Scapholithus fossilis		x																										x	
Umbilicosphaera jafari																													x
Thoracosphaera cf. heimii		x		x		x	x	x			x				x	x		x	x	x	x				x	x	x	x	x

heteromorphus and *Helicosphaera ampliaperta* and the nannofossils assemblages contains more species. At the level of the 13 sample could be the boundary between NN4 and NN5 zones.

Only the NN5 zone is present in the area Ciceu Mihăieşti, Reteag and Mihăieşti Valley.

The nannofossils assemblages in the Reteag – Ciceuri area contain 27 species (Table 2), more frequent being: *Sphenolithus heteromorphus, Coccolithus pelagicus, Coccolithus miopelagicus, Cyclicargolithus floridanus, Triquetrorhabdulus rugosus, Calcidiscus leptoporus, Umbilicosphaera rotula.* Rarely appear the species of the genera: *Braarudosphaera, Helicosphaera, Discoaster* and *Calciosolenia*.

Table 2. Calcareous nannofossils from Reteag – Ciceuri area.

Species	Negrileşti Valley	Reteag - Ciceu	Mihăieşti Valley
Sphenolithus heteromorphus	X	X	X
Sphenolithus moriformis	X		X
Sphenolithus abies	X		X
Sphenolithus neoabies	X		
Coccolithus miopelagicus	X	X	X
Coccolithus pelagicus	X	X	X
Cyclicargolithus floridanus	X	X	X
Reticulofenestra pseudoumbilicus	X	X	
Reticulofenestra gelida		X	
Triquetrorhabdulus rugosus	X	X	X
Rhabdosphaera poculi		X	
Syracosphaera histrica	X	X	
Calcidiscus leptoporus	X	X	X
Umbilicosphaera rotula (=Calcidiscus annula)	X	X	X
Umbilicosphaera jafari	X		
Pontosphaera multipora	X		
Discoaster exilis			X
Discoaster brouweri			X
Discoaster variabilis			X
Discoaster musicus			X
Helicosphaera ampliaperta	X		
Helicosphaera scissura	X		
Helicosphaera carteri		X	X
Helicosphaera walbersdorfensis			X
Braarudosphaera bigelowii		X	
Calciosolenia murrayi (= Scapholithus fossilis)	X		
Thoracosphaera cf. *heimii*	X	X	

PALAEOECOLOGICAL DATA

Calcareous nannoplankton/ nannofossils use the energy of sunlight for photosynthesis and therefore it seems probable that such factors as salinity and the temperature of the surface waters are more significant in the control of their distribution, than the depth of water. Their distribution patterns are considered to be closely related to the present current systems.

Concerning the Hida Formation, the NN4 zone was recorded by Mészáros *et al.* (1977).

As a consequence of the break of the connections between the Central Paratehys and the Mediaterranean, the marine faunas are replaced by brackish or fresh-water faunas at the level of the Hida Formation.

Helicosphaera ampliaperta is the index species for NN4. By definition, its last occurrence marks the top of Zone NN4 (Martini, 1971). It seems to prefer cooler water temperatures (Müller, 1977).

The marine floras (and also faunas) reached their maximum proliferation in the late early Badenian after establishing the connection with the Tethys at the beginning of Badenian. The cause of this proliferation was a global warming episode – the most important of the Miocene – which occurred at this level (Dej Formation). The subtropical marine assemblages have been attached to NN5 Zone, with *Sphenolithus heteromorphus, Discoaster exilis* and *Discoaster variabilis* as dominat species (Mărunţeanu, 1991). Dumitrică *et al.* (1975) assumed the presence of NN4 Zone at the base of the "Ciceu – Giurgeşti Beds", despite the absence of *Helicosphaera ampliaperta.* The absence of this species in the upper NN4 may be explained by Indo-Pacific influences (Mărunţeanu, 1991).

The warming episode at the beginning of the Middle Miocene coincides with the beginning of the Indo-Mediterranean faunal invasion characterized by the exuberant development of the plankton.

One of the methods to determine relative paleotemperatures is the investigation of the relative abundances of certain species of coccolithophores, useful by themselves as paleoclimatic indicators, and the entire nannofossil assemblage, rather a single species.

As precised (Chira in Chira *et al.*, 2000), the warm nannoplankton taxa, *Sphenolithus heteromorphus* – the index species for the NN5 Zone, *Helicosphaera carteri, Umbilicosphaera rotula* (=*Calcidiscus annula*), which prefers warm, tropical waters, and the most species of *Discoaster*, like *Discoaster variabilis, Discoaster exilis, Discoaster musicus*, prevail in the assemblages. They had an ecological preference for tropical and subtropical oceans, and therefore for warm watermasses throghout Cenozoic.

As also Aubry (1984) mentioned, there are considerable evidence that *Discoaster* – producing organisms were essentially restricted to warm water masses and one of their higher diversification (early Miocene) seem also to correspond to warmer climatic conditions, although *Discoaster variabilis* is considered a temperate form and *Discoaster exilis* is either tolerant of or exhibit preference for colder water.

Coccolithus pelagicus, which is a subpolar species today, is very abundant in Lower Badenian deposits. It evolved in the tropical area during the Early Cenozoic and migrated towards the poles during the Mid – Cenozoic. It seems to be extremely rare or absent in tropical waters today, e. g. *Coccolithus pelagicus* a. o. Other species, like the most *Sphenolithus* and some *Helicosphaera* seem to avoid boreal waters (Martini, 1971).

For the Badenian in the Vienna Basin, Fuchs & Stradner (1977) showed that *Coccolithus pelagicus* characterize subpolar watermasses. *C. pelagicus* was considered as a long – ranging species which provides paleoclimatic information for latest middle Miocene to Pleistocene. *C. pelagicus* prefers cold nutrient – rich surface waters, with a temperature between 7 and 14 degrees C and therefore is a good paleoclimatic indicator. 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 water even in the late Miocene. Because it is a resistant species, the carbonate dissolution would improve the frequence of *C. pelagicus* in sediment, giving a cold aspect to the assemblages.

The index species for NN6 – *Discoaster exilis*, which occur from the upper part of NN5, prefers cooler water.

The living conditions of some species is given by many authors. *Braarudosphaera bigelowii* is assumed as a species that inhabits coastal waters and through its life-history the free-swimming generation appears to alternate with filamentous or other sessile forms that colonize on rocks or other solid foundations. It is generally accepted that modern *Braarudosphaera bigelowii* occurs in abundance only from the near shore water (near shore sediments shallower than 24 m are characterzed by the abundant occurrence of *B. bigelowii*, comprising nearly 50 percent of the assemblage in Senday Bay) and that it is very rare or absent in the typical pelagic sediments despite a few exceptions. The distribution of *Braarudosphaera bigelowii* is apparently controled only by the depth of water.

On the contrary, it was remarked that *Calcidiscus leptoporus* is almost absent in the nearshore sediments.

Usually, high frequency of cribriliths in fossil assemblages is considered indicative of shallower marine environments (Aubry, 1990, a. o.). It was remarked that the genera *Pontosphaera* (*Discolithina*) and *Chiastmolithus*, especially, show more variety in the near shore than in the oceanic samples.

Pontosphaera multipora is considered a nearshore environment species.

The living species *Helicosphaera carteri* from the Atlantic Ocean and from the Pacific Ocean has a geographic distribution which has been interpreted as dependent upon water temperature. *Helicosphaera carteri* is eurythermal. Although more common in tropical and subtropical nannofloral provinces, it is also recorded rarely in transitional, arctic and subarctic assemblages and tolerates water temperatures as low as 5 degrees C and as high as 30 degrees C.

As Aubry (1990) remarked, it is often considered that most fossil helicoliths are indicative of hemipelagic deposition. But, the distribution patterns shown by living and fossil species of *Helicosphaera* are not clearly understood.

CONCLUSIONS

The study of the areas from the northern part of the Transylvania, between Dej – Ciceuri – Reteag – Negrileşti, prove the presence of the Miocene deposits, and especially from the boundary Early Miocene/ Middle Miocene.

Two nannoplankton biozones are present: *Helicosphaera ampliaperta* Zone (NN4) and *Sphenolithus heteromorphus* Zone (NN5). The first one was remarked nearby Dej and Negrileşti, which can indicate the Ottnangian age of these deposits. The second one is mentioned in the Dej and Ciceuri areas, and is specific for the Early Badenian age deposits.

Concerning the boundary NN4/ NN5, there are different opinions for the Central Paratethys, and especially for the start of the Early Badenian (in the upper part of the NN4 zone or the lower part of the NN5 zone). For the Transylvanian Basin, in conformity with the recent opinions, the Early Badenian is indicate by the beginning of the NN5 zone.

In conclusion, in the investigated area from the north – western Transylvania, was more precisely remarked the presence of the boundary NN4/ NN5 zone and the nannofossil assemblages corresponding to NN5a subzone, with *Umbilicosphaera rotula* (= *Calcidiscus annula*).

REFERENCES

Aubry, M - P., 1984, 1988, 1989, 1990, Handbook of Cenozoic Calcareous Nannoplankton. Book 1: Ortholithae (Discoasters). 266 p.; Book 2: Ortholithae (Holococcoliths, Ceratoliths and others), 279 p.; Book 3: Ortholithae (Pentalithe,and others), Heliolithae (Helicoliths, Cribriliths, Lopadoliths and others), 220 p. Heliolithae (Fasciculiths, Sphenoliths and others), 381 p.; Book 4: Heliolithae (Helicoliths, Cribriliths, Lopadoliths and others), 381 p., Micropal. Press: Amer. Mus. Nat. Hist., New York.

Chira, C., Filipescu, S., Codrea, V., 2000, Palaeoclimatic evolution in the Miocene from the Transylvanian Depression reflected in the fossil record. In Hart, M. B. (ed.) *Climates: Past and Present. Geological Society, London, Special Publications*, 181, p. 55 – 64, 3 Figures, London.

Cicha, I., Hagn, H., Martini, E, 1971, Das Oligozän und Miozän der Karpaten. Ein Vergleich mit Hilfe planktonischer Organismen. *Mitt. Bayer. Staatssamml. Paläont. hist. Geol.*, 11, p. 279 – 293, 1 tab ., München.

Dumitrică, P., Gheța, N., Popescu, G., 1975, Date noi cu privire la biostratigrafia şi corelarea Miocenului mediu din aria carpatică. *D.S. Inst.Geol.*, LXI/4, Stratigr., p. 65 - 84, 3 Table ., Bucureşti.

Filipescu, S., 2001, Cenozoic lithostratigraphic units in Transylvania. Algae and Carbonate Platforms in the western part of Romania. In Bucur, I. I., Filipescu, S., Săsăran. E. (Eds.). *Field Trip Guide Book, 4[th] Regional Meeting of IFAA*, p. 75 – 92, Cluj-Napoca.

Fuchs, R., Stradner, H., 1977, Über Nannofossilien im Badenien (Mittelmiozän) der Zentralen Paratethys. *Beitr. Paläont. Österr.*, 2, p. 1 - 58, 4. Abb., 2 tab., 8 Taf, Wien.

Hofmann, K., 1879, Bericht über die im östlichen Theile des Szilagyer Comitates während der Sommercampagne 1878 vollführten geologischen Spezialaufnahmen. *Földt. Közl.*, IX/5 – 6, p. 231 – 283, Budapest.

Koch, A., 1900, Die Tertiärbildungen des Beckens der Siebenbürgischen Landestheile. II Neogene Abtheilung, 370 p., 50 Figure, 3 Plate, Budapest.

Martini, E., 1968, Calcareous nannoplankton from the type Langhian. *Proc. IV Sess. RCMNS, Bologna 1967, Giorn. Geol.*, 2, XXXV/II, p. 163 – 172, Bologna.

Martini, E., 1971, Standard Tertiary and Quaternary Calcareous Nannoplankton Zonation. In Farinacci, A. (Ed.), *Proc. II Planktonic Conf., Roma, 1970*, Tecnoscienza, p. 739 – 785, Rome.

Martini, E., Müller, C., 1975a, Calcareous nannoplankton and silicoflagellates from the type Ottnangian. *Proc. VIth Congr. RCMNS Bratislava 1975*, p. 121 – 124, 1 tab., Bratislava.

Martini, E., Müller, C., 1975b, Calcareous nannoplankton from the Karpatian in Austria (Middle Miocene). *Proc. VIth Congr. RCMNS Bratislava 1975*, p. 125 – 128, 1 Table ., Bratislava.

Mărunțeanu, M., 1991, Distribution of the Miocene Calcareous Nannofossils in the Intra- and Extra-Carpathian Areas of Romania. *Proced. IV. INA Conf.*, Knihovnicka ZPN, 14b, 2, p. 247 – 261, 1 Figure, 4 tabs., Prague.

Mărunțeanu, M., Chira, C., 1998, Marine middle Miocene calcareous nannoplankton: a comparative study of the Subcarpathians and Transylvanian Basin. Abstract. *XVI. Carpatho – Balkan Congress, Vienna, 1998.*

Mészáros, N., Ianoliu, C., Pion, N., 1977, Nannoplanctonul din stratele de Hida şi semnificația lui stratigrafică. *D. S. Inst. Geol.*, 63/4, p. 155 – 161, Bucureşti.

Mészáros, N., 1991, Nannofossil Zones in the Paleogene and Miocene Deposits of the Transylvanian Basin. *Proc. IV. INA Conf.*, Knihovnicka ZPN, 14 b, 2, p. 87 - 92, 3 Figure, Prague.

Moisescu, V., Popescu, G., 1967, Studiul stratigrafic al formațiunilor paleogene şi miocene din regiunea Chinteni – Baciu – Sînpaul (nord – vestul Transilvaniei). *St. cerc. geol., geof., geogr., (Geol.)*, 12/1, p. 211 – 224, 4 Figure, Bucureşti.

Müller, C., 1977, Distribution of calcareous nannoplankton in Oligocene to Holocene sediments of the Red Sea and the Indian Ocean reflecting paleoenvironment. In Heirtzler, J. R., *et al.* (Eds.), *Indian Ocean Geology and Biostratigraphy. American Geophysical Union*, p. 371 – 379, Washington.

Okada, H., Bukry, D., 1980, Supplementary modification and introduction of code numbers to the low-latitude coccolith biostratigraphic zonation (Bukry, 1973, 1975). *Marine Micropal.*, 4, p. 321-325.

Popescu, G., 1970, Planktonic Foraminiferal Zonation in the Dej Tuff Complex. *Rev. Roum. Géol., Géoph., Géogr., ser. Géol.*, 14/2, p. 189 - 203, Bucureşti.

PLATES

Plate I

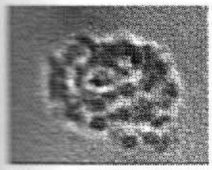
Figures 1 a,b *Helicosphaera* cf. *ampliaperta* Bramlette & Wilcoxon, 1a – NII; 1b – N+: x 2.000; Râpa Dracului – Dej.
Figures 2 a,b *Sphenolithus heteromorphus* Deflandre, 2a – NII; 2b – N+; x 2.000; Râpa Dracului – Dej.
Figures 3 a,b *Helicosphaera walbersdorfensis* Müller, 3a – NII; 3b – N+; x 2.000, Râpa Dracului – Dej.
Figures 4 a,b *Sphenolithus abies* Deflandre, 4a – NII; 4b – N+; x 2.000, Râpa Dracului – Dej.
Figures 5 a,b *Coccolithus pelagicus* (Wallich) Schiller, 5a – NII; 5b – N+; x 2.000, Râpa Dracului – Dej.
Figures 6 a,b *Coccolithus miopelagicus* Bukry, 6a – NII; 6b – N+; x 2.000, Râpa Dracului – Dej.
Figures 7 a,b *Umbilicosphaera rotula* Kampner (=*Calcidiscus annula*) (Cohen)). 7a – NII; 7b – N+; x 2.000, Râpa Dracului – Dej.
Figures 8 a,b *Cyclicargolithus floridanus* (Roth & Hay) Bukry. 8a – NII; 8b – N+; x 2.000, Râpa Dracului – Dej.
Figures 9 a,b *Calciosolenia murrayi* Gran (=*Scapholithus fossilis* Deflandre), 9a - NII; 9b – N+; x 2.000, Râpa Dracului – Dej.
Figures 10 a,b *Pontosphaera discopora* Schiller, 10a – NII; 10b – N+; x 2.000, Râpa Dracului – Dej.
Figure 11 *Reticulofenestra pseudoumbilicus* (Gartner) Gartner, N+; x 2.000, Râpa Dracului – Dej.
Figure 12 *Calcidiscus* cf. *macintyrei* (Bukry & Bramlette) Loeblich & Tappan. S.E.M.,x 14.000, Râpa Dracului – Dej.
Figure 13 *Calcidiscus macintyrei* (Bukry & Bramlette) Loeblich & Tappan. S.E.M.,x 14.000, Râpa Dracului – Dej.

Plate II

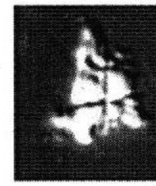
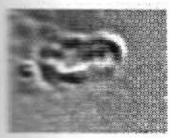
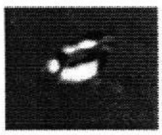
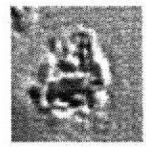
Figures 1, 2, 3 *Discoaster musicus* Stradner, NII; x 2.000, Râpa Dracului – Dej.
Figure 4 *Discoaster brouweri* Tan emend. Bramlette & Riedel, NII; x 2.000, Râpa Dracului – Dej.
Figure 5 *Discoaster* cf. *exilis* Martini & Bramlette, NII; x 2.000, Râpa Dracului – Dej.
Figure 6 *Discoaster* cf. *variabilis* Martini & Bramlette, NII; x 2.000, Râpa Dracului – Dej.
Figures 7 a,b *Thoracosphaera heimii* (Lohmann) Kamptner, 7a – NII; 7b – N+; x 2.000, Râpa Dracului – Dej.
Figures 8 a,b *Helicosphaera carteri* (Wallich) Kamptner; *Cyclicargolithus floridanus* (Roth & Hay) Bukry; *Coccolithus miopelagicus* Bukry; (from left to right); 8a – NII; 8b – N+; x 2.000, Râpa Dracului – Dej.
Figures 9, 10 Râpa Dracului – Dej section.

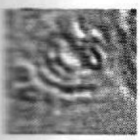
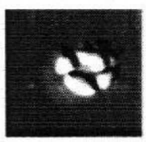
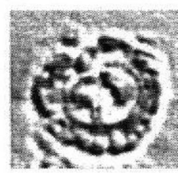
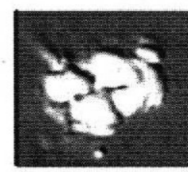
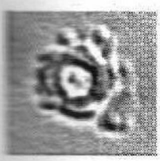
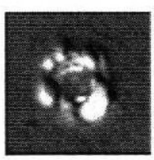
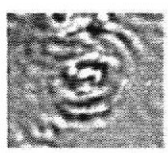
Plate III

Figure 1 *Helicosphaera ampliaperta* Bramlette & Wilcoxon, – N+: x 2.000; Reteag – Ciceuri.
Figures 2 a,b *Helicosphaera carteri* (Wallich) Kamptner, 2a – NII; 2b – N+; x 2.000, Reteag – Ciceuri.
Figure 3 *Braarudosphaera bigelowii* (Gran & Braarud) Deflandre, 3 – NII; x 2.000; Reteag – Ciceuri.
Figures 4 a,b *Sphenolithus heteromorphus* Deflandre. 4a – NII; 4b – N+; x 2.000, Reteag – Ciceuri.
Figures 5 a,b *Sphenolithus moriformis* (Brönnimann & Stradner) Bramlette & Wilcoxon. 5a – NII; 5b – N+; x 2.000, Reteag – Ciceuri.
Figures 6 a,b *Sphenolithus abies* Deflandre. 6a – NII; 6b – N+; x 2.000, Reteag – Ciceuri.
Figures 7 a,b *Coccolithus miopelagicus* Bukry, 7a – NII; 7b – N+; x 2.000, Reteag – Ciceuri.
Figures 8 a,b *Coccolithus pelagicus* (Wallich) Schiller, 8a – NII; 8b – N+; x 2.000, Reteag – Ciceuri.
Figures 9 a,b *Calcidiscus leptoporus* (Murray & Blackman) Loeblich & Tappan. 9a – NII; 9b – N+; x 2.000, Reteag – Ciceuri.
Figure 10 *Discoaster* cf. *exilis* Martini & Bramlette, NII; x 2.000, Reteag – Ciceuri.
Figure 11 *Discoaster brouweri* Tan emend. Bramlette & Riedel, NII; x 2.000, Reteag – Ciceuri.
Figures 12 a,b *Cyclicargolithus floridanus* (Roth & Hay) Bukry. 12a – NII; 12b – N+; x 2.000, Reteag – Ciceuri.
Figures 13 a,b *Umbilicosphaera jafari* Müller, 13a – NII; 13b – N+; x 2.000, Reteag – Ciceuri.
Figures 14 a,b *Triquetrorhabdulus rugosus* Bramlette & Wilcoxon. 14a - NII; 14b – N+; x 2.000, Reteag – Ciceuri.
Figures 15 a,b *Reticulofenestra pseudoumbilicus* (Gartner) Gartner, 15a – NII; 15b - N+; x 2.000, Reteag – Ciceuri.
Figures 16 a,b *Syracosphaera histrica* Kamptner, 16a – NII; 16b - N+; x 2.000, Reteag – Ciceuri.


1a

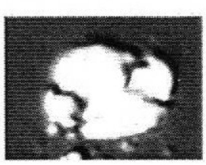
1b

2a

2b

3a

3b

4a

4b

5a

5b

6a

6b

7a

7b

8a

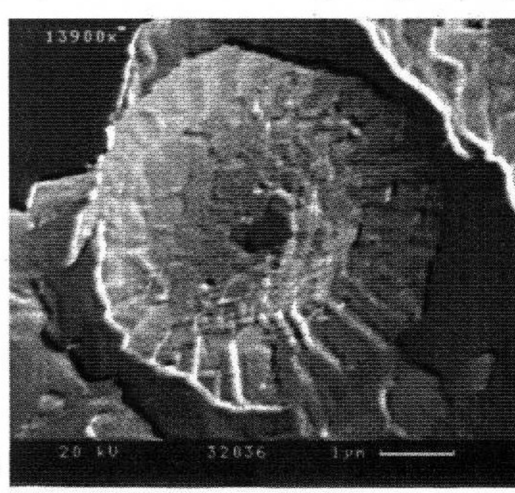
8b

9a

10a

10b

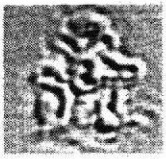
11

9b

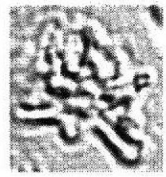

12


13


1

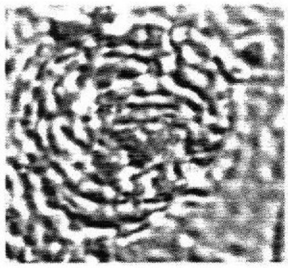

2

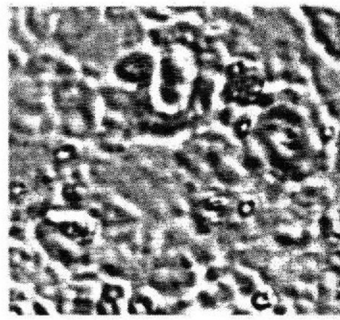

3

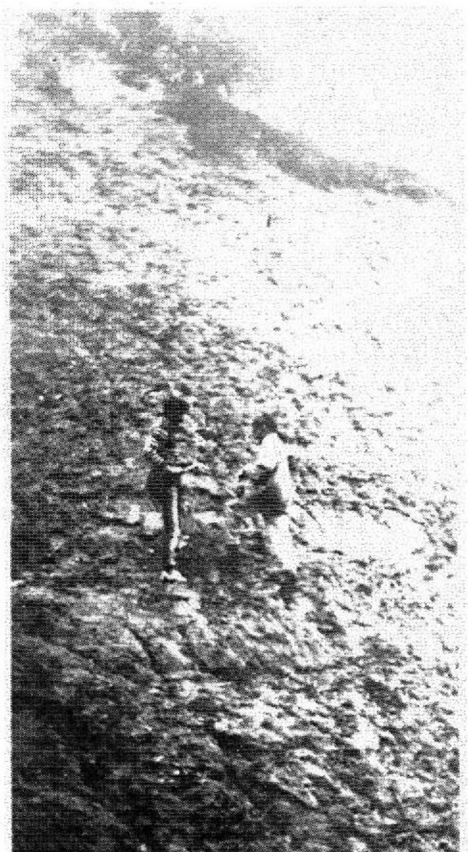

4

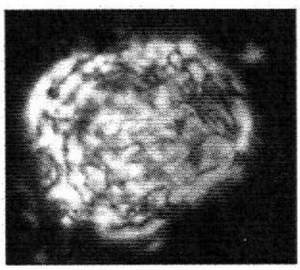

5

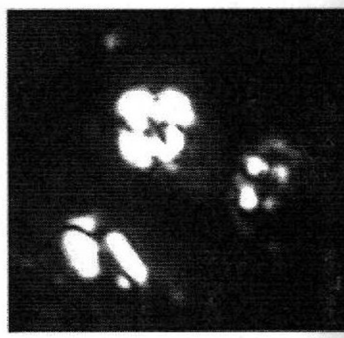

6


7a


8a

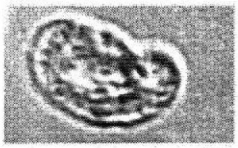


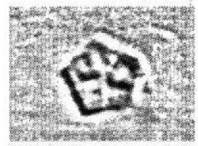

7b


8b

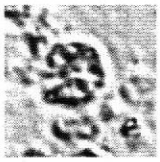
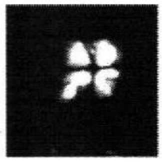
9

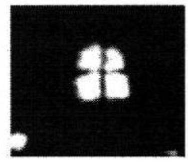

10

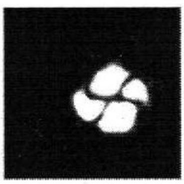
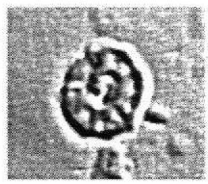

1

2a

2b

3


4a

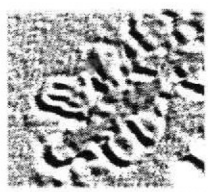
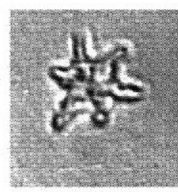
4b

5a

5b

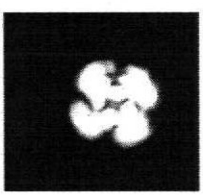
6a

6b

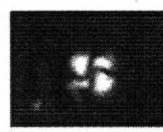

7a

7b

8a

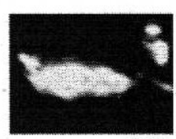
8b

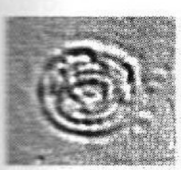
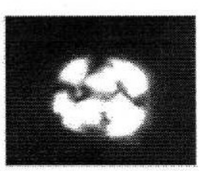
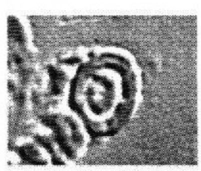
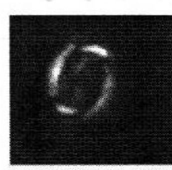

9a

9b

10

11


12a

12b

13a

13b

14a

14b


15a

15b

16a

16b