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

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Abstract. Two nannoplankton biozones are present in the areas from the northern part of the Transylvania, between Dej – Ciceur – Reteag – Negrișeți: 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 Nannofossils, Early/ Middle Miocene: Ottnangian, Badenian; Biostratigraphy, Palaeoecology, Northern Transylvania.

INTRODUCTION

The investigated area is located in the northwestern Transylvanian Basin (Cluj and Bistrița – Năsăud counties) (Figure 1).

The occurrences from Râpa Dracului - Dej, Negrișeți Valley, Ciceu-Giurgești, Ciceu-Poieni, Reteag, Ciceu Mihaiești - Mihaiești 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 part).

The lower part of the Dej Formation was separated as Ciceu – Giurgești Member (Popescu, 1970), and is represented by conglomerates, silicic 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.

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

The Karpatian in the Central Paratethys was studied from type Karpatian equivalents in Austria (Martini & Müller, 1975b). Considering the nanoplankton assemblage of the Ottnangian, in which Heliococeras 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 Heliococeras ampliaperta in the whole zone NN4. Rare specimens similar to Sphenolithus heteromorphus were noted sometimes, but these are not associated with Heliococeras 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 Heliococeras ampliaperta zone. The index fossil for NN4 zone appear together with: Braarudosphaera bigelowii, Coccocithus pelagicus, Pontosphaera multispina (= Discolithina multispina), Heliococeras carteri, H. intermedia, Reticulofenestra pseudoumbilicus, Reticulofenestra sp., and Sphenolithus sp. The whole assemblage is considered identical with the nanoplankton assemblages from the Karpatian of Laa and Retznet, 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 Karpathian, the stage previous to Badenian, consist of nanofossil assemblages belonging to the NN4 and even to the NN5 Zone (Martini & Müller, 1975b). Consequently, the Langhian can be correlated with the Karpathian (partially or totally ?), and with the Early Badenian as also previously was mentioned by Mărunteanu & Chira (1998).

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

The stratigraphic distribution of the calcareous nanofossils 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 (Mărunteanu & 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 occurrences of *Discocoaster exilis*.

**CALCAREOUS NANOFOSILS**

**ASSEMBLAGES FROM DEJ – CICEURI – NEGRILEȘTI AREA –**

**BIOSTRATIGRAPHICAL IMPORTANCE**

The nanoplankton 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 Negriilești Valley, which could prove the Ottnangian age.

*Sphenolithus heteromorphus* Biozone (NN5) was marked 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 Negriilești was remarked the NN4/NN5 boundary and of the NN5a Subzone, with *Umbilicosphaera rotula* (= Calciscus 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 Early Badenian age, respectively 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 nanoplankton 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 mentipoged 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 nanofossil assemblages contain about 30 species (Table 1). The most frequent are: Reticulofenestra pseudoumbilicus, Syracosphaera histrica, Cyclicargolithus floridanus, Calcidiscus leptopus, Thoracosphaera cf. heimi. There are also relatively frequent *Sphenolithus heteromorphus*, Coelolithus pelagicus, Coelolithus miopelagicus, Sphenolithus moriformis. Rarely appear Sphenolithus abies, Holodiscolithus macroopus, Reticulofenestra minuta, R. gelida, Triquetrorhabdulus rugosus, Umbilicosphaera rotula, U. jafari, Calcidiscus macintyrei, Pontosphaera multipora, Helicosphaera ampliaperta, H. walbersdorfsensis, H. carteri, Discocoaster variabilis, D. exilis, D. cf. musici, D. brouveri.

In the Reteag – Ciceuri area, in the first two analysed samples the marker species are absent, and the nanofossil assemblages are scarce, containing about 8 species. From the samples 13, appear rarely *Sphenolithus*
| Table 1. Calcareous nanofoossils from Rapa Braculi - De' |
heteromorphus and Helicosphaera amphiaperta and the nanofossils 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 Mihăiaşti, Reteg and Mihăiaşti Valley. The nanofossils assemblages in the Reteg – Ciceu area contain 27 species (Table 2), more frequent being: Sphenolithus heteromorphus, Coccolithus pelagicus, Coccolithus miopelagicus, Cyclicargolithus florianus, Triquetrorhabdulus rugosus, Calcidiscus leptoporus, Umbilicosphaera rotula. Rarely appear the species of the genera: Braarudosphaera, Helicosphaera, Discoaster and Calciosolenia.

Table 2. Calcareous nanofossils from Reteg – Ciceu area.

<table>
<thead>
<tr>
<th>Species</th>
<th>Negreşte Valley</th>
<th>Reteg - Ciceu</th>
<th>Mihăiaşti Valley</th>
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</thead>
<tbody>
<tr>
<td>Sphenolithus heteromorphus</td>
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<td>Sphenolithus moriformis</td>
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<td>Sphenolithus abies</td>
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<td>Sphenolithus neobies</td>
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<td>Coccolithus miopelagicus</td>
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<td>Coccolithus pelagicus</td>
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<td>Cyclicargolithus floridanus</td>
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<td>Pacholofenestra pseudoumbilicus</td>
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<td>Pacholofenestra gelida</td>
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<td>Triquetrorhabdulus rugosus</td>
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<td>Rhabdosphaera poculi</td>
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<td>Syracosphaera histrica</td>
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<td>Calediscus leptoporus</td>
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<td>Umbilicosphaera rotula (=Calcidiscus annula)</td>
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<td>Umbilicosphaera jafari</td>
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<td>Pachyphora multipora</td>
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<td>Discoaster exilis</td>
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<td>Discoaster brouweri</td>
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<td>Discoaster variabilis</td>
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<td>Discoaster musculus</td>
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<td>Helicosphaera amphiaperta</td>
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<td>Helicosphaera scisura</td>
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<td>Helicosphaera carteri</td>
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<td>Helicosphaera walbersdorfensis</td>
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<td>Braarudosphaera bigelowii</td>
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<tr>
<td>Calciosolenia murray (= Scapholithus fossilis)</td>
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<tr>
<td>Thoracosphaera cf. helmii</td>
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PALAEOECOLOGICAL DATA

Calcareous nanoplankton/ nanofossils 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 Paratethys and the Mediterranean, the marine faunas are replaced by brackish or fresh-water faunas at the level of the Hida Formation.

Helicosphaera amphiaperta 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 dominant 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 amphiaperta. 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 nanofossil assemblage, rather a single species.

As precised (Chira in Chira et al., 2000), the warm nanoplankton taxa, Sphenolithus heteromorphus – the index species for the NN5 Zone, Helicosphaera carteri, Umbilicosphaera rotula (=Calciscus 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 throughout 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 this 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 frequency 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 characterized 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 controlled only by the depth of water.

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

Usually, high frequency of cibertii 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 nanofloral 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 helicosphaths 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 – Ciceu – Reteag – Negriștei, prove the presence of the Miocene deposits, and especially from the boundary Early Miocene/ Middle Miocene.

Two nanoplankton biozones are present: Helicosphaera ampliaperta Zone (NN4) and Sphenolithus heteromorphus Zone (NN5). The first one was remarked nearby Dej and Negriștei, 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 indicated 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* (= *Calciscus annula*).

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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 walbersdorffensis 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 Kampnerr (=Calcidiiscus annulata) (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 fossils Deflandre), 9a – NII; 9b – N+; x 2.000, Râpa Dracului – Dej.
Figures 10 a,b Pontosphera 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 Calcidiiscus cf. macintyrei (Bukry & Bramlette) Loeblich & Tappan. S.E.M., x 14,000, Râpa Dracului – Dej.
Figure 13 Calcidiiscus macintyrei (Bukry & Bramlette) Loeblich & Tappan. S.E.M., x 14,000, Râpa Dracului – Dej.

Plate II

Figures 1, 2, 3 Discoaster musculus 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 heimi (Lohmann) Kampnerr, 7a – NII; 7b – N+; x 2.000, Râpa Dracului – Dej.
Figures 8 a,b Helicosphaera carteri (Wallich) Kampnerr; 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; Reteg – Ciceurii.
Figures 2 a,b Helicosphaera carteri (Wallich) Kampnerr, 2a – NII; 2b – N+; x 2.000, Reteg – Ciceurii.
Figure 3 Braurudsworthia bigelowi (Gran & Braarud) Deflandre, 3 – NII; x 2.000; Reteg – Ciceurii.
Figures 4 a,b Sphenolithus heteromorphus Deflandre, 4a – NII; 4b – N+; x 2.000, Reteg – Ciceurii.
Figures 5 a,b Sphenolithus moniformis (Brönnum & Stradner) Bramlette & Wilcoxon. 5a – NII; 5b – N+; x 2.000, Reteg – Ciceurii.
Figures 6 a,b Sphenolithus abies Deflandre. 6a – NII; 6b – N+; x 2.000, Reteg – Ciceurii.
Figures 7 a,b Coccolithus micropelagicus Bukry, 7a – NII; 7b – N+; x 2.000, Reteg – Ciceurii.
Figures 8 a,b Coccolithus pelagicus (Wallich) Schiller, 8a – NII; 8b – N+; x 2.000, Reteg – Ciceurii.
Figures 9 a,b Calcisicdiscus leptoporus (Murray & Blackman) loeblich & Tappan. 9a – NII; 9b – N+; x 2.000, Reteg – Ciceurii.
Figure 10 Discoaster cf. exilis Martini & Bramlette, NII; x 2.000, Reteg – Ciceurii.
Figure 11 Discoaster brouweri Tan emend. Bramlette & Riedel, NII; x 2.000, Reteg – Ciceurii.
Figures 12 a,b Cyclicargolithus floridanus (Roth & Hay) Bukry. 12a – NII; 12b – N+; x 2.000, Reteg – Ciceurii.
Figures 13 a,b Umbilicosphaera jafari Müller, 13a – NII; 13b – N+; x 2.000, Reteg – Ciceurii.
Figures 14 a,b Triguerthabulus rugosus Bramlette & Wilcoxon. 14a – NII; 14b – N+; x 2.000, Reteg – Ciceurii.
Figures 15 a,b Reticulofenestra pseudoumbilicus (Gartner) Gartner, 15a – NII; 15b – N+; x 2.000, Reteg – Ciceurii.
Figures 16 a,b Syracosphaera histrica Kampnerr, 16a – NII; 16b – N+; x 2.000, Reteg – Ciceurii.