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EOCENE – OLIGOCENE CALCAREOUS NANNOFOSSILS FROM HUEDIN AREA, BETWEEN HODIŞ AND TETIŞ (TRANSYLVANIA, ROMANIA): BIOSTRATIGRAPHY AND PALEOECOLOGICAL DATA

CARMEN CHIRA[1], ALIN IGRIȚAN[1]

ABSTRACT. Eocene - Oligocene deposits from Huedin area, between the localities Hodiş and Tetiş, of the Transylvanian Basin, have been analysed. The assemblages of calcareous nannofossils are rich in the Brebi and Mera formations and relatively scarce in almost all other formations.

Keywords: Eocene, Oligocene; Transylvania: Huedin region, calcareous nannofossils, NP15 – NP23, biostratigraphy, paleoecology.

I. INTRODUCTION

In the investigated area of Huedin region, between the localities Tetiş and Hodiş, the Paleogene deposits are represented by Paleocene, Eocene and Oligocene sediments (Fig. 1). Until now these deposits have been studied regarding the calcareous nannofossils, in the neighborhood area of Huedin, at Morlaca, Văleni and other localities.

In the area of Hodiş and Tetiş, the previous studies concerned the molluscs, echinids, foraminifera, ostracods, a. o. groups of organisms.

This is the first study concerning the calcareous nannofossils from the mentioned sections of Tetiş and Hodiş.

The geological studies in the region of Huedin belong to Hauer & Stache (1863), Koch (1894), Moisescu (1975, 1978), Moisescu et al. (1991), Rusu (1970, 1977), Popescu (1978), Popescu et al. (1978), Gheța (1984), Mészáros (1957, 1960, 1991), Mészáros and Ianoliu (1989), Mészáros and Nicorici (1987, 1989), Mészáros et al. (1989, 1991), Mălan (1996), Chira (1989a, 1989b) Hosu (1999), a.o.

II. GEOLOGICAL SETTING

The lithostratigraphic units present in the Huedin area are given after the stratigraphical studies realized by Rusu (1970, 1977), Moisescu (1975), Popescu (1978), Bombiță (1963), Hosu (1999), a.o. and syntethized by Filipescu (2001).

The Jibou Formation (Late Maastrichtian – Late Lutetian) is a continental lithostratigraphic unit which consists of red siltic clays, sands and conglomerates.

The Foidaş Formation (Late Lutetian) is a marine lithostratigraphic unit represented by clays, dolomites, limestones and gypsum.

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[1] *“Babeş-Bolyai” University, Department of Geology , Str. Kogălniceanu 1, 3400 Cluj-Napoca, Romania.*

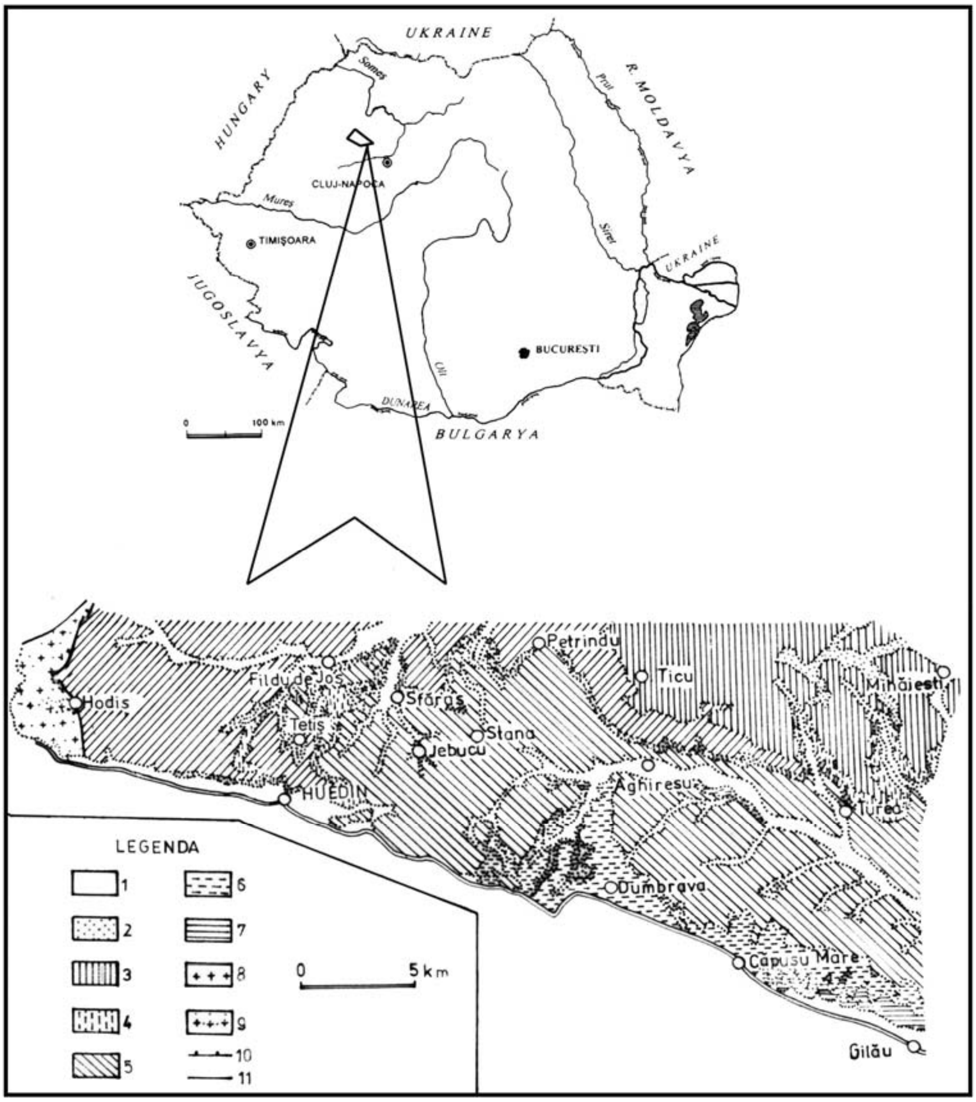

Fig. 1. Location map of the studied area (Hodiş - Tetiş). Legend: 1. Quaternary, 2. Badenian, 3. Chattian - Aquitanian, 4. Rupelian, 5. Priabonian, 6. Lutetian, 7. Ypresian, 8. Andesite - Early Paleogene, 9. Dacite - Early Paleogene, 10. Overthrust Fault, 10. Fault (after the geological maps 1:200.000 – Dumitrescu, 1968 and Patrulius et al., 1968, with modifications).

The Căpuş Formation (Late Lutetian – Bartonian) consists of clays, limestones, a *Pycnodonte brongnarti* level, a *Sokolovia eszterhazy*i biohorizon and a *Nummulites perforatus* level.

The Mortănuşa Formation is represented by:

- Inucu Member (Bartonian), a normal marine unit represented by marls and limestones, with a *Crassostrea bersonensis* biohorizon;
- Văleni Limestone (Bartonian);
- Ciuleni Member (uppermost Bartonian – lowermost Priabonian) is represented by marls, sands and a *Crassostrea orientalis* biohorizon.

The Viştea Limestone (Priabonian), with shallow marine deposits, is represented by calcarenites, biomicrites and dolomicrites with siliciclastic intercalations.

The Valea Nadăşului Formation represents the second continental lithostratigraphic unit which consists of a lower sandy sequence and an upper red clay sequence (Hosu, 1999).

The Jebuc Formation is represented by fresh-water and evaporitic deposits, represented by clays, limestones with *Anomia*, dolomicrites and gypsum.

The Cluj Limestone, which in the lower part is a porous skeletal wackestone and in the upper part a packstone with terrigenous grains, deposited on a carbonate platform, contains the following biohorizons: *Crassostrea transivanica,* then *Vulsella*, *Campanile* and echinoids biohorizons, and *Nummulites fabianii* biohorizon.

The Brebi Formation is a siliciclastic formation with bryozoans, limestones and *Pycnodonte gigantica* biohorizon, considered a marker for the boundary between the Priabonian and the Rupelian.

The Mera Formation is represented by clays, sands, sandstones and bioclastic limestones and is bounded by two levels with *Scutella subtrigona*.

The Hoia Limestone is a skeletal packstone which appear locally, in the lowermost part of the Mera formation.

III. EOCENE–OLIGOCENE CALCAREOUS NANNOFOSSILS ASSEMBLAGES FROM THE TRANSYLVANIAN BASIN AND ESPECIALLY FROM HUEDIN AREA: HODIŞ–TETIŞ

The investigated **Eocene** calcareous nannoplankton assemblages belong to NP15 – NP21 zones and the **Oligocene** ones belong to NP22 – NP23 zones, according to the Standard Nannoplankton Zonation (Martini, 1971).

At Hodiş, nearby Huedin, all the terms of the Eocene - Oligocene from Transylvania are present. The richest and most diversified calcareous nannofossils assemblages were found in the Brebi (NP21, NP22) and Mera formations (NP22, NP23).

On the Peşterii Valley, at Hodişu a tectonic semiwindow is present.

Along the Peşterii Valley, the Foidaş Formation (the equivalent of “Lower Gypsums”, after Popescu et al., 1978) is constituted of a 4 m thick sequence of dolomicrites stratified in decimetric beds with centimetric joints of greenish clays. The evaporite formation marks the first penetration of marine waters during the Eocene in the Transylvania Depression.

Within the Căpuş Formation, the calcareous nannofossils assemblage consists of: *Reticulofenestra hampdenensis, Micrantolithus basquensis, Pemma rotundum, Braarudosphaera bigelowii, Rhabdosphaera inflata, R. crebra, Blakites spinosus, Neococcolithes protenus, Zygrablithus bijugatus* (above the *Gryphaea* *brongniarti* level, according to Gheța in Popescu et al., 1978), and: *Reticulofenestra umbilica*, *R. hampdenensis, Neococcolithus dubius, Sphenolithus furcatolitoides* (one meter below the *Nummulites perforatus* level). It was mentioned that the assemblage is not varied specifically; the genera *Chiasmolithus* and *Discoaster*, utilised for the standard zonation of the Middle/Upper Eocene interval are lacking. As the most significant event within the "Lower Molluscan Marls" was mentioned the occurrence of *Reticulofenestra umbilica*, placed approximately towards the upper part of the Middle Eocene and corresponding to the upper half of the NP15 Zone (*Chiphragmalithus alatus* zone after Martini, 1971). Near Hodiş are mentioned two lumachelle beds with *Nummulites perforatus* separated by a sandy layer with molluscs, alveolinids and nummulits.

The Căpuş Formation (Late Lutetian – Bartonian) was included on the NP15 – NP16 biozones (Mészáros, 1991).

In the lower part of the Mortănuşa Formation ("Upper Molluscan Marls") the nannoplankton assemblage was considered resembling to that of the Căpuş Formation. Only *Reticulofenestra hampdenensis* has an increased frequency. This stratigraphic interval was also ascribed to the *Reticulofenestra umbilica* Zone, namely the Upper Middle Eocene (Gheța in Popescu et al., 1978).

The nannoplankton belongs to the NP16 – NP17 (Gheța, 1984, Mészáros, 1991); Ciuleni Member (uppermost Bartonian – lowermost Priabonian) is represented by marls, sands and a *Crassostrea orientalis* biohorizon (NP 17 – NP18) (Mészáros, 1991).

Within the lower half of the "Gray Clays and Marls" (Inucu Member of the Mortănuşa Formation), at Leghia, the nannoplankton assemblage was considered to be almost the same as the one from the "Lower Molluscan Marls"and to belong to the upper part of the *Reticulofenestra umbilica* Zone, more precisely to the *Discoaster saipanensis* subzone. The Middle/Upper Eocene boundary was placed in the upper half of the "Gray Clays and Marls" (Gheța in Popescu et al., 1978).

The "Leghia Limestone" (Văleni Limestone) is generally made up of two beds separated by a marly joint which at Hodiş reaches some 3 m in thickness (Fig. 2). It is a bioclastic calcarenite whose bioclasts are: corallinaceae, echinoderms, benthic microforaminifera and alveolinids. A nearshore fauna with a sandy substratum of an eurihaline marine basin was mentioned (Popescu et al., 1978).

One of the most complete section for Valea Nadăşului Formation was remarked along Peşterii Valley from Hodiş, but some faults are fragmenting the sequence. A level bearing fresh water gastropodes crops out along this valley, near Hodiş. On the Peşterii Valley, at Hodiş, dolomicrites of only 20 cm thick, stratified as centimetric beds were remarked ("Upper Gypsum", respectivelly the Jebuc Formation).

Generally, within the Cluj – Huedin area, the Cluj Limestone begins with a sequence of marly limestone or sandy marls with *Anomia, Vulsella* and a typical molluscan fauna. Westwards, to Hodiş, at Peşterii Valley, the lumachellic level with *Crassostrea transilvanica* was not remarked. A Mediterranean molluscs fauna within which boreal elements occur, was mentioned (Gheța in Popescu et al., 1978). The nannoplankton assemblage is very poor. To the top of this formation, *Istmolithus recurvus* was found, which might have most probably appeared at a much lower level.

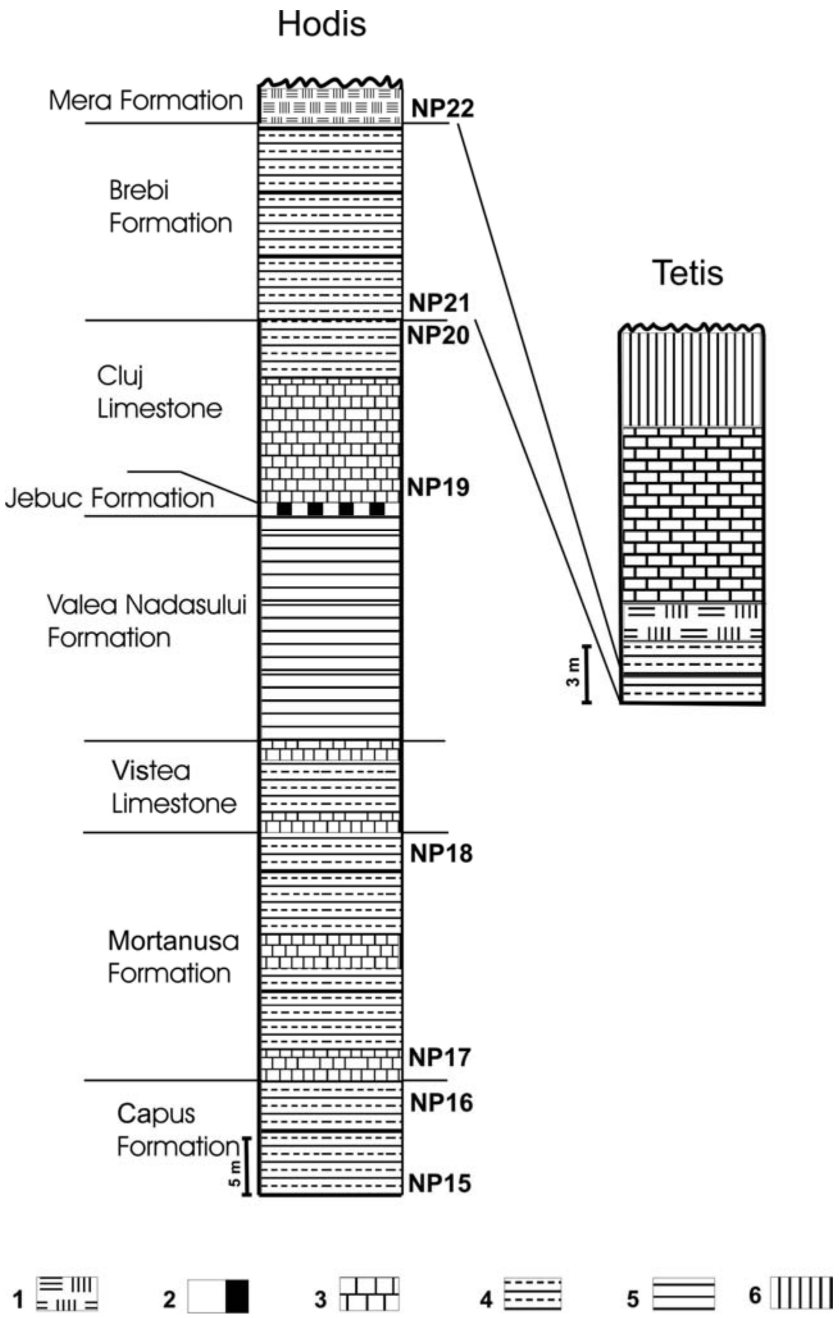

Fig. 2. Legend: 1 - Coralle limestone, 2 - Gypsum, 3 - Limestone, 4 - Marls, 5 - Sand, 6 - Sandstone.

The Cluj Limestone, which in the lower part is a porous skeletal wackestone and in the upper part a packstone with terrigenous grains, deposited on a carbonate platform, contains the following biohorizons: *Crassostrea transilvanica; Vulsella*, *Campanile* and echinoids; and *Nummulites fabianii.* The nannoplankton was included in the NP19 - NP20 zones (Mészáros, 1991).

Near the Hodiş village, along the Peşterii Valley a graded transition between the Brebi Formation and the Hoia Limestone was observed. Here, within a few centimeters, the "Brebi marls" turn into calcareous marls with tubular or palmate corals, then into a coraligenous limestone 20 cm thick. Some 200 m south along a stream parallel to the Peşterii Valley, the coraligenous Hoia Limestone, 45 cm thick, overlies without transition, the slightly sandy or silty "Brebi Marls".

The Brebi Formation nannoplankton assemblage is rich and quite varied.

In the upper part of the Cluj Limestone numerous specimens of *Istmolithus recurvus* were remarked (Gheța in Popescu et al., 1987). It was considered that it is possible that this species made its first appearance at a time corresponding to the Valea Nadăşului Formation or even older. From the nannoplankton assemblage of the Brebi Formation made up of about 40 species (Popescu and Gheța, 1972; Martini and Moisescu, 1974; Popescu et al., 1978), more frequent and important are: *Istmolithus recurvus, Sphenolithus predistentus, Reticulofenestra umbilica, Dictyococcites bisectus, Cyclicargolithus floridanus, Ericsonia subdisticha, Lanternitus minutus, Coccolithus formosus.* It was observed the lack of discoasterids in this Upper Eocene assemblage. This might be due to some local ecological or paleoenvironmental conditions. The nannofossil assemblages were included in the NP19 – NP21 biozones, ranging from the upper part of the Cluj Limestone to the *Pycnodonte gigantica* level of Brebi Formation (Gheța in Popescu et al., 1978). The *Coccolithus formosus* extinction above the *Pycnodonte gigantica* level marks the boundary between NP21 and NP22 zones, corresponding to the Priabonian/Rupelian boundary.

The Brebi Formation is a siliciclastic formation with bryozoans, limestones and *Pycnodonte gigantica* biohorizon - considered as a marker for the boundary between Priabonian and Rupelian (NP21 – NP22).

The Mera Formation is represented by clays, sands, sandstones and bioclastic limestones and it is bounded by two levels with *Scutella subtrigona* (NP22 – NP23).

The Hoia Limestone is a skeletal packstone which occurs locally, in the lowermost part of the Mera formation (NP22).

It was remarked that only the Călata (Racoczy) Group (Foidaş, Căpuş, Mortănuşa formations and Viştea Limestone or Racoczy Sandstone) (Lutetian – Bartonian – Early Priabonian) and the Turea (Cluj) Group (Jebuc Formation, Cluj Limestone, Brebi Formation, Hoia Limestone and Mera Formation) (Priabonian – Rupelian) yield calcareous nannofossils, with rich and well preserved assemblages, excepting the Vistea (Leghia) Limestone and the intervals containing gypsum (Gheța, 1984). For the rich and varied assemblages exhibited by the upper members of the Eocene sequence the standard zonation of Martini (1971) was used. For the lower members, where the index species are missing, Gheța (1984) had proposed another zonation, which consists of: *Reticulofenestra primitiva* zone – correlated with the NP16 zone - *Discoaster tani nodifer* zone; *Rhabdosphaera inflata* zone was correlated to the upper part of NP16; *Reticulofenestra bisecta* zone, equivalent to NP17 - *Discoaster saipanensis* zone; these are followed by NP18 - *Chiasmolithus oamaruensis* zone; the NP19 – *Istmolithus recurvus* zone was not recorded; NP20 – *Sphenolithus pseudoradians* zone; NP21 – *Ericsonia subdisticha* zone and NP22 – *Helicosphaera reticulata* zone – in the upper third of Brebi Formation, between the *Pycnodonte gigantica* level and the Mera Formation.

Middle Eocene/ Upper Eocene boundary could be established in the upper part of Mortănuşa Formation.

The Hoia Limestone ended the marine sedimentation of the Priabonian. The calcareous nannofossils belong to the NP22 zone.

In the Văleni area, south from Huedin, Mălan (1996) has identified three nannofloristic assemblages: the first one was included into the regional biozone *Reticulofenestra primitiva* proposed by Gheța (1984), for Transylvania and correlated with the subzone CP 14a (Okada and Bukry, 1980). It was considered to be specific for the terminal part of the Foidaş Formation and for the basis of the Căpuş Formation. The upper part of the Căpuş Formation and the Inucu Beds have been characterized by an assemblage assigned to the CP14a respectively NP16. The Mortănuşa Beds have been characterized by an assemblage assigned to the biozones CP14b (Okada and Bukry, 1980), respectively NP17 (Martini, 1971). The deposits were assigned to the terminal Lutetian (Foidaş and Căpuş Beds) and to the Bartonian (Inucu, Văleni and Mortănuşa Beds).

Table 1.

Representative calcareous nannofossils from Huedin area: Hodiş and Tetiş (according to the classification of Young & Bown, 1997).

NANNOFOSSIL SPECIES	Hodiş	Tetiş
CALCAREOUS NANNOPLANKTON: HETEROCOCCOLITHS		
Family Pontosphaeraceae		
Pontosphaera multipora (KAMPTNER, 1948) ROTH (1970)	x	X
Pontosphaera pulchra (ROMEIN, 1979)	x	
Pontosphaera latoculata (BUKRY & PERCIVAL, 1971) PERCH-NIELSEN, 1984	x	
Pontosphaera obliquipons (DEFLANDRE, 1959)	x	x
Pontosphaera lateliptica (BALDI-BEKE & BALDI, 1974) PERCH-NIELSEN, 1984	x	
Pontosphaera enormis (LOCKER, 1967 PERCH-NIELSEN, 1984)	x	x
Pontosphaera formosa (BUCKRY & BRAMLETTE, 1969) ROMEIN, 1979	x	
Pontosphaera bicaveata (PEARCH-NIELSEN,1967) ROMEIN, 1979	x	
Transversopontis obliquipons (DEFLANDRE IN DEFLANDRE & FERT, 1954) HAY, MOHLER & WADE, 1966	x	x
Transversopontis pulcheroides (SULLIVAN, 1964) BALDI-BEKE, 1971	x	x
Transversopontis pulcher (DEFLANDRE IN DEFLANDRE & FERT, 1954) PERCH-NIELSEN, 1967	x	x
Family Rhabdosphaeraceae		
Blakites tenuis (BRAMLETTE & SULLIVAN, 1961) SHERWOOD, 1979	x	x
Blakites spinosus (DEFLANDRE & FERT, 1954) HAY & TOWE, 1962	x	x
Rhabdosphaera creber (DEFLANDRE IN DEFLANDRE & FERT, 1954)	x	

NANNOFOSSIL SPECIES	Hodiş	Tetiş
Family Noelaerhabdaceae		
Reticulofenestra umbilica (LEVIN, 1965) MARTINI & RITZKOWSKI, 1968	x	x
Reticulofenestra hillae (BUKRY & PERCIVAL, 1971)	x	
Reticulofenestra reticulata (GARTNET & SMITH, 1967) ROTH & THIERSTEIN, 1972		
Reticulofenestra dictyoda (DEFLANDRE IN DEFLANDRE & FERT, 1954) STRADNER IN STRADNER & EDWARDS, 1968	x	x
Dictyoccoccites bisectus (HAY, MOHLER, WADE, 1966) BUKRY & PERCIVAL, 1971	x	x
Dictyococites danicus (BLACK, 1967)	x	
Cyclicargolithus abisectus (Muller, 1970) WISE, 1973	x	
Cyclicargolithus floridanus (ROTH & HAY *in* HAY *et al.*, 1967) BUKRY (1971)	x	x
Cyclicargolithus rupeliensis	x	x
Cyclicargolithus robustus	x	
Cyclicargolithus luminis	x	x
Family Coccolithaceae		
Coccolithus formosus (KAMPTER, 1963) WISE, 1973	x	x
Coccolithus pelagicus (WALLICH, 1877) SCHILLER (1930)	x	x
Coronocyclus prionion (DEFLANDRE & FERT, 1954) STRADNER in STRADNER & EDWARDS, 1968	x	
Coronocyclus nitiscens (KAMPTER, 1963) BRAMLETTE & WILCOXON, 1967	x	
Chiasmolithus gigas (BRAMLETTE & SULLIVAN, 1961) RADOMSKI, 1968	x	
Chiasmolithus grandis (BRAMLETTE & SULLIVAN, 1954) RADOMSKI, 1968	x	
Cribrocentrum reticulatum (GARTNER & SMITH, 1967) PERC-NIELSEN, 1971	x	
Ericsonia fenestrata (DEFLANDRE & FERT, 1954) STRADNER IN STRADNER & EDWARDS, 1968	x	
Ericsonia subdisticha (ROTH & HAY in HAY et al.,1967) ROTH in BAUMANN & ROTH, 1969	x	
Cenozoic heterococolith genera incertae sedis		
Markalius inversus (DEFLANDRE IN DEFLANDRE & FERT, 1954) BRAMLETTE &MARTINI, 1964	x	
HOLOCOCCOLITHS **Family Calyptrosphaeraceae**		
Zygrablithus bijugatus (DEFLANDRE IN DEFLANDRE & FERT, 1954) DEFLANDRE, 1959	x	x
Corannulus germanicus (STRADNER, 1962)	x	
Lanternitus minutus (STRADNER, 1962)	x	x
Istmolithus recurvus (STRADNER, 1954)	x	
NANNOLITHS **Family Braarudosphaeraceae**		
Braarudosphaera bigelowii (GRAN & BRAARUD, 1935) DEFLANDRE (1947)	x	x
Micrantholithus inequalis (MARTINI, 1961)	x	x
Family Discoasteraceae		
Discoaster cf. tani BRAMLETTE & RIEDEL (1954)	x	
Discoaster tani nodifer BRAMLETTE & RIEDEL (1954)	x	
Family Sphenolithaceae		
Sphenolithus pseudoradians (BRAMLETTE & WILCOXON, 1967)	x	
Sphenolithus predistensus (BRAMLETTE & WILCOXON, 1967)	x	

NANNOFOSSIL SPECIES	Hodiş	Tetiş
Family Lithostromationaceae		
Lithostromation perdurum (DEFLANDRE, 1942)	x	
Genera incertae sedis		
Tribrachiathus bramlettei (BROENNIMANN & STRADNER, 1960) PROTO DECIMA et al., 1975	x	
Family Lapideacassaceae **Genera incertae sedis**		
Biantholithus sparsus (BRAMLETTE & MARTINI, 1964)	x	x
CALCAREOUS DINOFLAGELLATES		
Thoracosphaera sp.	x	x

IV. PALEOECOLOGICAL DATA

By analogy with the present-day climatologically diferentiated nannoplankton assemblages, Hay and Lohmann (1976) attributed the early Cenozoic latitudinal differentiation to climatic control. They inferred two marked cooling episodes during the Paleocene – Eocene interval: the first during the middle Paleocene and the second during the middle Eocene, as well as a marked warming event during the late Paleocene and early Eocene, and a second less pronounced warming in the late Eocene.

The exact intervals for the Atlantic Ocean, when the middle Paleocene cooling episode took place, as shown by the migratory patterns of the high latitude *Prinsius martinii* Assemblage were precised. The same for the late Paleocene – early Eocene warming episode – with a warming peak when *Toweius craticulus* Assemblage showed its maximum poleward extent. The middle Eocene cooling occurred when discoasters retreated from relatively mid to high latitudes towards low latitudes. A synchronous slight withdrawal of the Reticulofenestrid Assemblage from higher latitudes was also noticed during interval. A less pronounced warming episode in the late – middle Eocene was characterised by the discoasters return to mid and lower high latitudes in significant number (Haq and Lohmann, 1979).

For the Atlantic Ocean it was remarked that the Eocene reticulofenestrid assemblage appeared once again in the early Oligocene mainly at high latitudes (Haq et al., 1977). Among the other assmblages of the Oligocene the sphenolith – discoaster assemblage dominated the low latitudes. The *Cyclicargolithus floridanus* and *Dictyococcites hesslandii* assemblages were both cosmopolitan assemblages occuring throughout the Oligocene. Thus, in the early Oligocene a marked cooling episode was indicated by the Oligocene high – latitude nannofloral assemblages (reticulofenestrid and *Coccolithus pelagicus*, which extended their range equatorward. The last important Paleogene climatic event was a warming trend in the latest Oligocene, when the low latitude sphenolith – discoaster nannofloral assemblage extended its range into the mid – latitudes, while the high – latitude nannofloral assemblages withdrew from the low latitudes (Haq et al., 1977).

The disapearance in the Paratethys of *Coccolithus formosus, Istmolithus recurvus,* and *Clausicoccus* during the Early Oligocene may be due to their low tolerance of the paleoenvironmental changes occuring then: strong temperature lowering, increased seasonality, decrease in salinity or increase nutrient supply. Eutrophication was considered to be one of the determinant agents of the Early Oligocene nannofossil extinctions by Aubry (1992).

The grouping of *Discoaster tani, D. nodifer* and *Reticulofenestra umbilica* may characterize open-sea conditions – i. e. low nutrient content and normal salinity. *R. umbilica* had a a higher resistance to dissolution, too (Krhovsky et al., 1992).

Several species occur more frequently in near-shore waters: *Pontosphaera multipora, Transversopontis pulcheroides, Zygrablithus bijugatus and Dictyococcites bisectus*. These require increased nutrient contents and can tolerate greater variations in ecologic conditions: salinity, temperature changes a. o. (Krhovsky et al., 1992).

Chiasmolithus is more frequent at higher latitudes and in shelf sediments (Beckmann et al., 1981).

Based on paleoecological observations, the Paleogene calcareous nannoplankton was subdivided into seven groups by Baldi-Beke (1984), for the Transdanubian region, which indicate the paleotemperature and the distance from the shore, especially: group 1 containing the genera: *Thoracosphaera, Scyphosphaera, Sphenolithus, Discoaster, Trochoaster and Lithostromation*, which characterize oceanic forms of open sea, preferring mainly warmer climate; Group 2 contains the genera *Coccolithus*, *Cyclicargolithus*, *Cyclococcolithus*, *Cribrocentrum*, *Reticulofenestra*, *Chiasmolithus* and *Cruciplacolithus*, which are considered oceanic forms, characterizing mainly open sea; Group 3 is represented by *Lanternitus minutus*, *Zygrablithus bijugatus*, *Istmolithus recurvus*, a.o. species. All the species are considered only marine, preferring the near-shore facies; Group 4 contains the genera *Rhabdosphaera* and *Blackites*, which are marine near-shore forms; Group 5 contains the genera *Braarudosphaera*, *Micrantolithus* and *Pemma*, characteristic only for near-shore and with tolerance to decreasing salinity; Group 6 with *Pontosphaera* (= *Discolithina*), *Transversopontis*, *Neococcolithes dubius* are considered typical for the near-shore environment, capable to tolerate a stronger decrease in salinity; Group 7 is characterized by *Reticulofenestra tokodensis* considered characteristic to slightly hyposaline water.

V. CONCLUSIONS

In conclusion, in the Huedin area, the calcareous nannofossils allow us to evidence the presence of the Eocene - Oligocene deposits, belonging to NP 15 – NP23 biozones.

Only for the late Eocene – early Oligocene deposits the marker species from the standard zonations have been identified (Martini's zonation, 1971). For the other formations, the content in calcareous nannofossils is very scarce, and the possibility to integrate the nannoplankton assemblages into the standard zonation is reduced.

At Hodiş, all the terms of Eocene – Oligocene from Transylvania are present. The richest and most diversified calcareous nannofossils were found in the Brebi (NP21, NP22) and Mera formations (NP22, NP23).

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PLATE CAPTIONS

Plate I Fig. (x 2.000):

1a, 1b – *Ericsonia subdisticha* Roth & Hay in Hay et al., 1a - NII; 1b - N+; Hodiş.
2a, 2b – *Istmolithus recurvus* Stradner. 2a - NII; 2b - N+; Hodiş.
3a, 3b – *Markalius inversus* Deflandre in Deflandre & Fert. 3a - NII; 3b - N+ Hodiş.
4a, 4b – *Markalius sp.*.4a - NII; 4b - N+;.
5a, 5b – *Biantholithus sparsus* Bramlette & Martini. 5a – NII; 5b – N+; Hodiş.
6a, 6b – *Zygrhablithus bijugatus* Deflandre in Deflandre & Fert. 6a - NII; 6b - N+; Hodiş.

Plate II Fig. (x 2.000):

1 – *Discoaster tani* Bramlette & Riedel. NII; Hodiş
2, 3 – *Discoaster tani nodifer* Bramlette & Riedel. NII; Hodiş.
4 – *Corannulus germanicus* Stradner. NII; Hodiş.
5 – *Lithostromation perdurum* Deflandre. NII; Hodiş.
6 – *Tribrachiatus bramlettei* Broennimann & Stradner. NII; Hodiş.
7a, 7b – *Pontosphaera lateliptica* Baldi-Beke & Baldi. 7a - NII; 7b – N+; Hodiş.
8a, 8b – *Pontosphaera formosa* Bukry & Bramlette. 8a - NII; 8b – N+; Hodiş.
9a, 9b – *Pontosphaera bicaveata* Pearch-Nielsen. 9a – NII; 9b - N+; Hodiş.

Plate III Fig. (x 2.000):

1a, 1b – *Pontosphaera enormis* Locker. 1a - NII; 1b - N+; Hodiş.
2a, 2b – *Helicosphaera cf. reticulata* Baldi-Beke. 2a - NII; 2b - N+; Hodiş.
3a, 3b – *Pontosphaera pulchra* Romein. 3a - NII; 3b - N+; Hodiş.
4a, 4b – *Reticulofenestra dictyoda* Deflandre in Deflandre & Fert. 4a - NII; 4b - N+; Tetiş.
5a, 5b – *Dictyococites cf. danicus* Black. 5a - NII; 5b – N+; Hodiş.
6a, 6b – *Chiasmolithus gigas* Bramlette & Sullivan. 6a - NII; 6b - N+; Hodiş.

Plate IV Fig. (x 2.000):

1a, 1b – *Lanternitus minutus* Stradner. *Sphenolithus pseudoradians* Bramlete & Wilcoxon; 1a - NII; 1b - N+; Hodiş.
2a, 2b – *Sphenolithus pseudoradians* Bramlete & Wilcoxon. 2a - NII; 2b - N+; Hodiş.
3a, 3b – *Rabdosphaera creber* Deflandre in Deflandre & Fert. 3a - NII; 3b - N+; Hodiş.
4a, 4b – *Dictiococites bisectus* Hay, Mohler, Wade. 4a - NII; 4b - N+; Hodiş.
5a, 5b – *Braarudosphaera bigelowii* Gran & Braarud. 5a - NII; 5b – N+ Tetiş.
6a, 6b – *Blakites spinosus* Deflandre & Fert. 6a - NII; 6b - N+; Hodiş.

Plate V Fig. (x 2.000):

1a, 1b – *Cyclicargolithus luminis* . 1a - NII; 1b - N+; Hodiş.
2a, 2b – *Reticulofenestra reticulata* Gartnet & Smith. 2a – NII; 2b - N+; Hodiş.
3a, 3b – *Coccolithus eopelagicus* Bramlette & Riedel. 3a - NII; 3b - N+; Hodişu.
4a, 4b – *Coccolithus formosus* Kampter. 4a – NII; 4b – N+; Tetişu.
5 – *Reticulofenestra hillae* Bukry & Percival. N+; Hodişu.
6 – *Reticulofenestra umbilica* Levin. N+; Hodişu.
7a, 7b – *Thoracosphaera cf. heimii* Lohmann. 7a – NII; 7b – N+; Hodişu

PLATE I

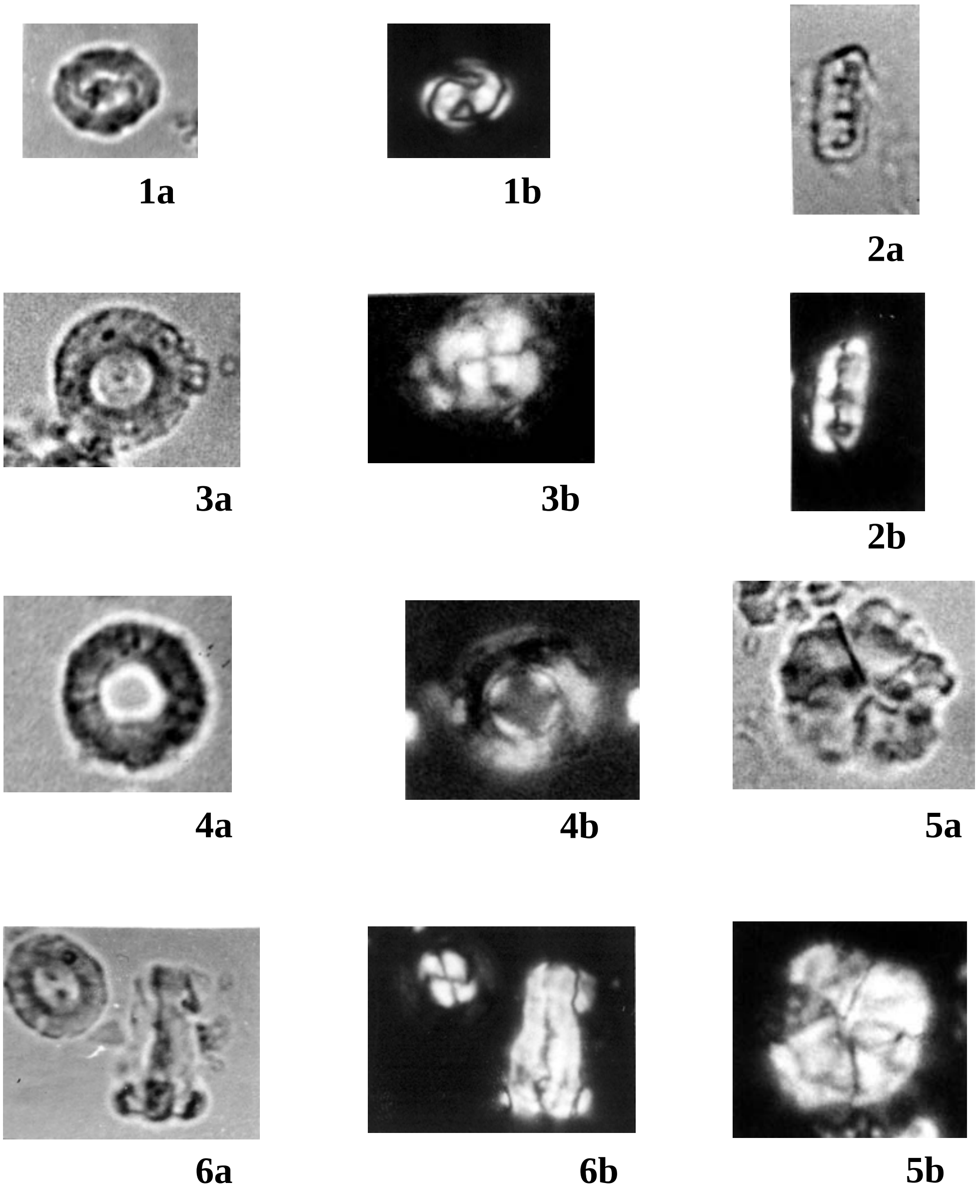


PLATE II

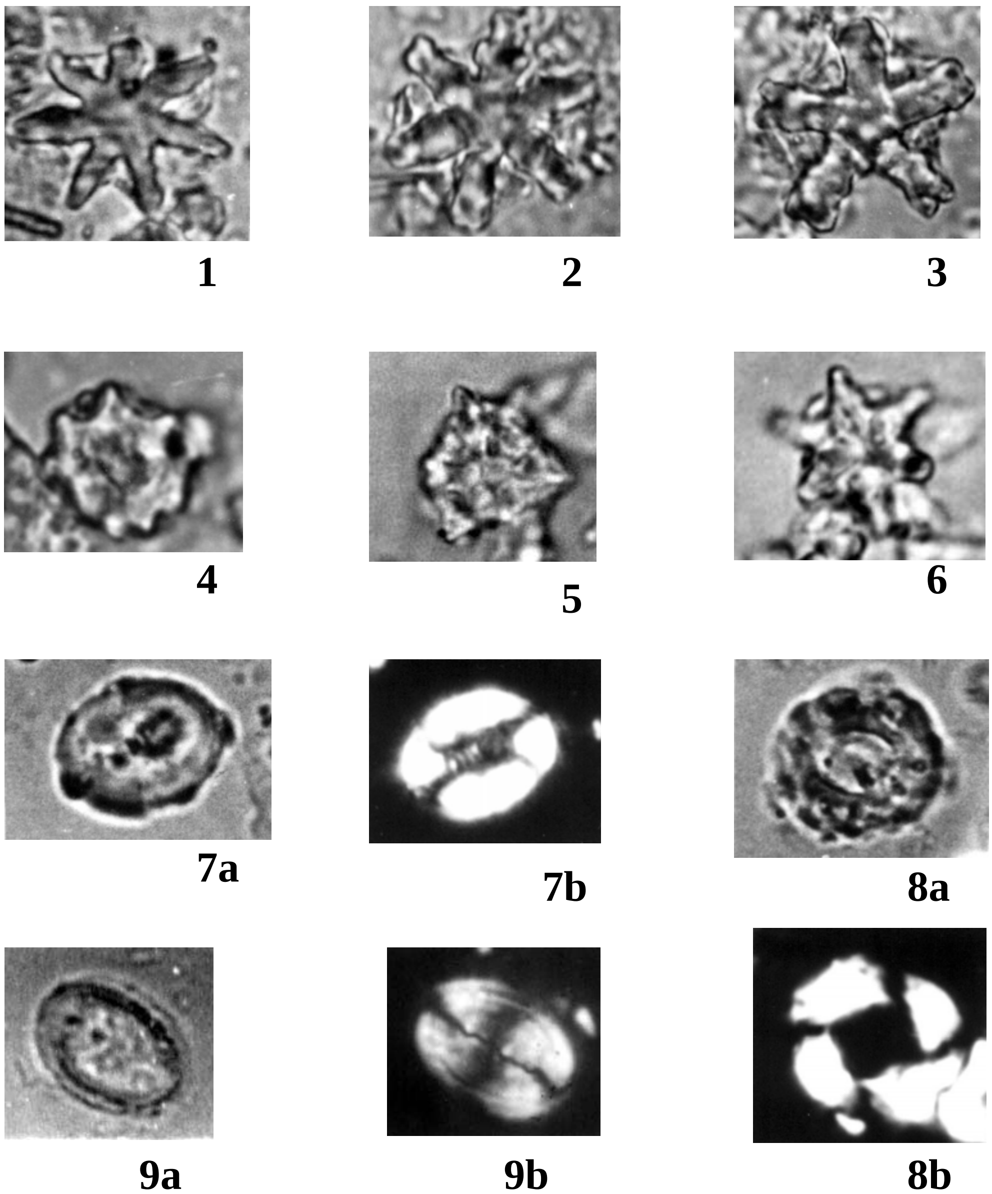
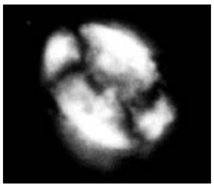


PLATE III


1a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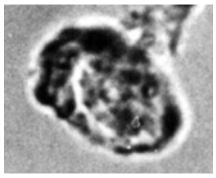
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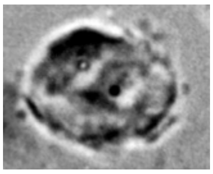
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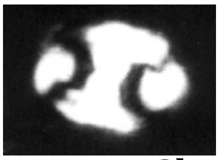
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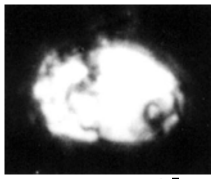
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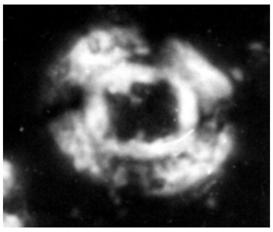
4a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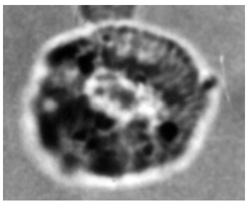
5a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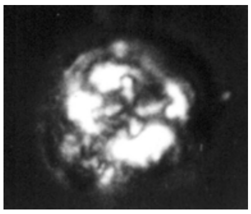
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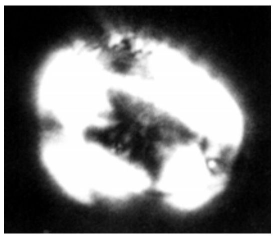
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PLATE IV

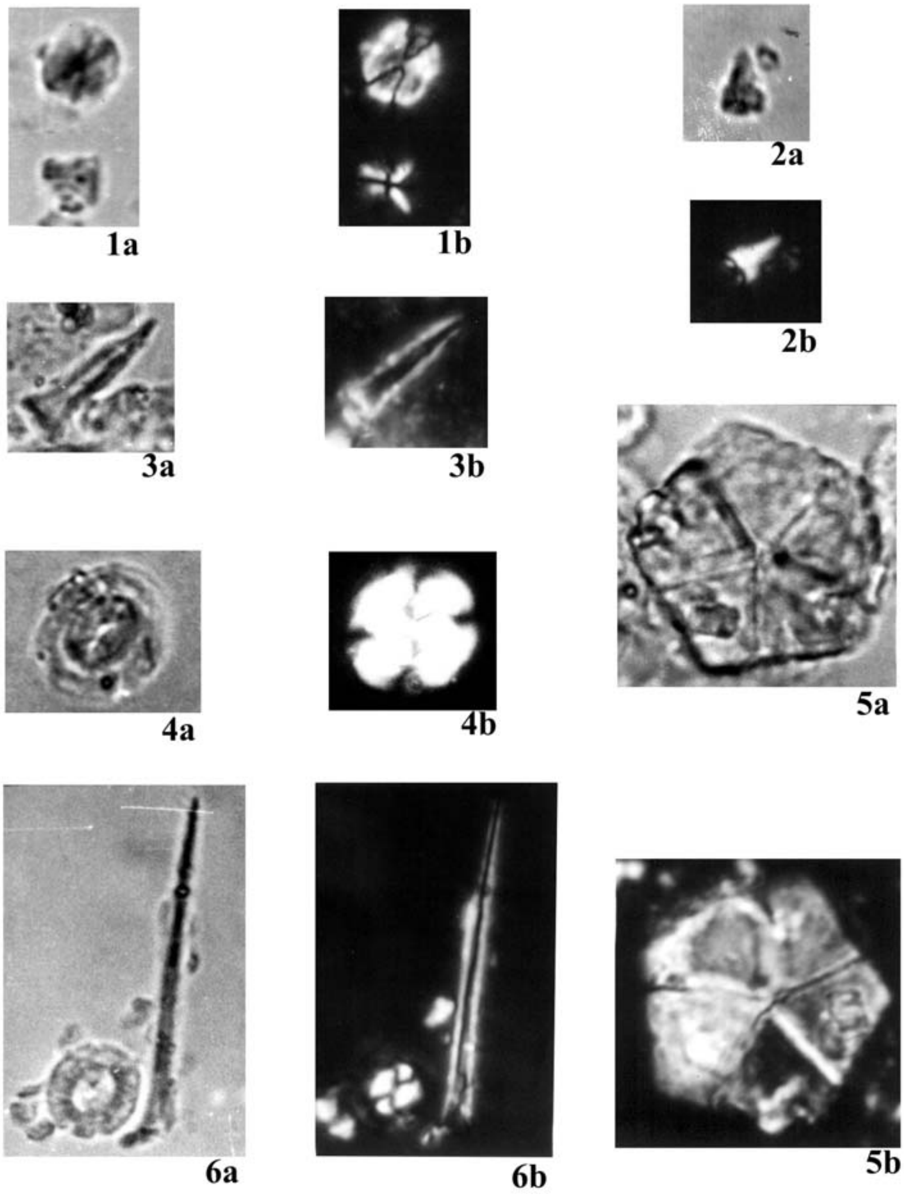

PLATE V