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EARLY MIOCENE CALCAREOUS NANNOFOSSILS ASSEMBLAGES FROM TRANSYLVANIA

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Abstract. The calcareous nannofossil assemblages of the most representative sites from the Early Miocene formations in Transylvania, in the surrounding areas of Cluj and Dej, are presented and compared with other sites from the Central Paratethys. The paleoclimatologic – paleoecological significance is documented, too: the first significant Miocene warming episode in Eggenburgian, the Ottnangian cooling, a.o.

Keywords: Early Miocene, calcareous nannofossils, NN1–NN4 zones, paleoclimatology, paleoecology, Transylvania.

GENERAL CONSIDERATIONS CONCERNING THE EARLY MIOCENE CALCAREOUS NANNOFOSSILS

As a rule, the Chattian/Aquitanian (Oligocene/Miocene) boundary (Upper Egerian) is considered difficult to locate and correlate (Odin et al., 1997).

Generally, the Aquitanian (Late Egerian – Early Eggenburgian) contains fossil assemblages suggesting the presence of the calcareous nannofossil zone NN1–*Triquetrorhabdulus carinatus* Zone - of Martini (1971).

The early Burdigalian stage (Late Eggenburgian) is assumed to contain the complete calcareous nannofossil biozone NN2 – *Discoaster druggi* Zone - and the basal portion of NN3- *Sphenolithus belemnos* Zone - of Martini (1971).

Odin et al. (1997) mentioned the presence of assemblages characterizing Martini's biozone NN2 at the base and NN2 – NN3 in the upper part of the Burdigalian stage (Ottnangian–early Karpatian).

The Burdigalian/Langhian (Early/Middle Miocene) boundary is located within the calcareous nannofossil zone NN4–*Helicosphaera ampliaperta* Zone - of Martini (1971), the top of which is defined by the LCO of *Helicosphaera ampliaperta*. At a significant distance above the boundary, the LO of *Helicosphaera ampliaperta* is considered to be an important biosignal. The Burdigalian/ Langhian boundary stands within the late part of Martini's (1971) calcareous nannofossil zone NN4.

EARLY MIOCENE CALCAREOUS NANNOFOSSILS FROM TRANSYLVANIA

The studied Early Miocene (Eggenburgian, Ottnangian) sites are located on the western and northern borders of the Transylvanian Depression, in the surrounding areas of Cluj and Dej.

One of the best succesion for the Early Miocene is to be found in TRANSGEX H2 borehole – Feleac, Cluj-Napoca (Fig. 1).

The lithostratigraphic units from Transylvania are given according to the most recent revision (Filipescu, 2001).

Mărunțeanu (1999) considered that in general, in Romania, the Oligocene/Miocene boundary is represented by the FO of *Helicosphaera mediterranea*.

In the upper part of the **Vima Formation**, the calcareous nannofossils, containing assemblages which prove the NN1 Zone (Mészáros, 1991), plead for the location of the base of the Miocene within this formation.

Vima Formation consists of clays and limestones and is Late Oligocene to Early Miocene (Late Kiscellian – Eggenburgian or Late Rupelian – Burdigalian) in age.

Based on the FO of *Helicosphaera scissura* and *Helicosphaera mediterranea*, which are synchronous bioevents with the LO of *Dictyococcites bisectus* (Late Egerian – Early Eggenburgian) the previous authors have pointed out the NP25/NN1 boundary.

Representative sections are cropping out at Poiana Blenchii a. o. (Melinte in Rusu et al., 1996).

Rusu et al. (1996) have noticed a gradual transition from the marine to the marine brackish facies, from east to west, with the replacement of the fine-grained facies by coarse-grained facies types, as in Poiana Blenchii. Here, the calcareous nannofossils are represented by: *Pontosphaera enormis, Sphenolithus conicus, S. dissimilis, S. ciperoensis, Reticulofenestra minuta, R. lockeri, Helicosphaera recta, H.* cf. *ampliaperta, H. scissura, Triquetriorhabdulus carinatus, Coccolithus pelagicus, Cyclicargolithus floridanus, C. abisectus, Dictyococcites abisectus*, a. o. The boundary between NP25 and NN1 zones has been established at the *Helicosphaera scissura* FAD. (Melinte in Rusu et al., 1996).

Mărunțeanu (1999) established the Oligocene/ Miocene boundary at the FO of *Triquetrorhabdulus carinatus* and recently reconsidered it at the FO of *Helicosphaera mediterranea*.

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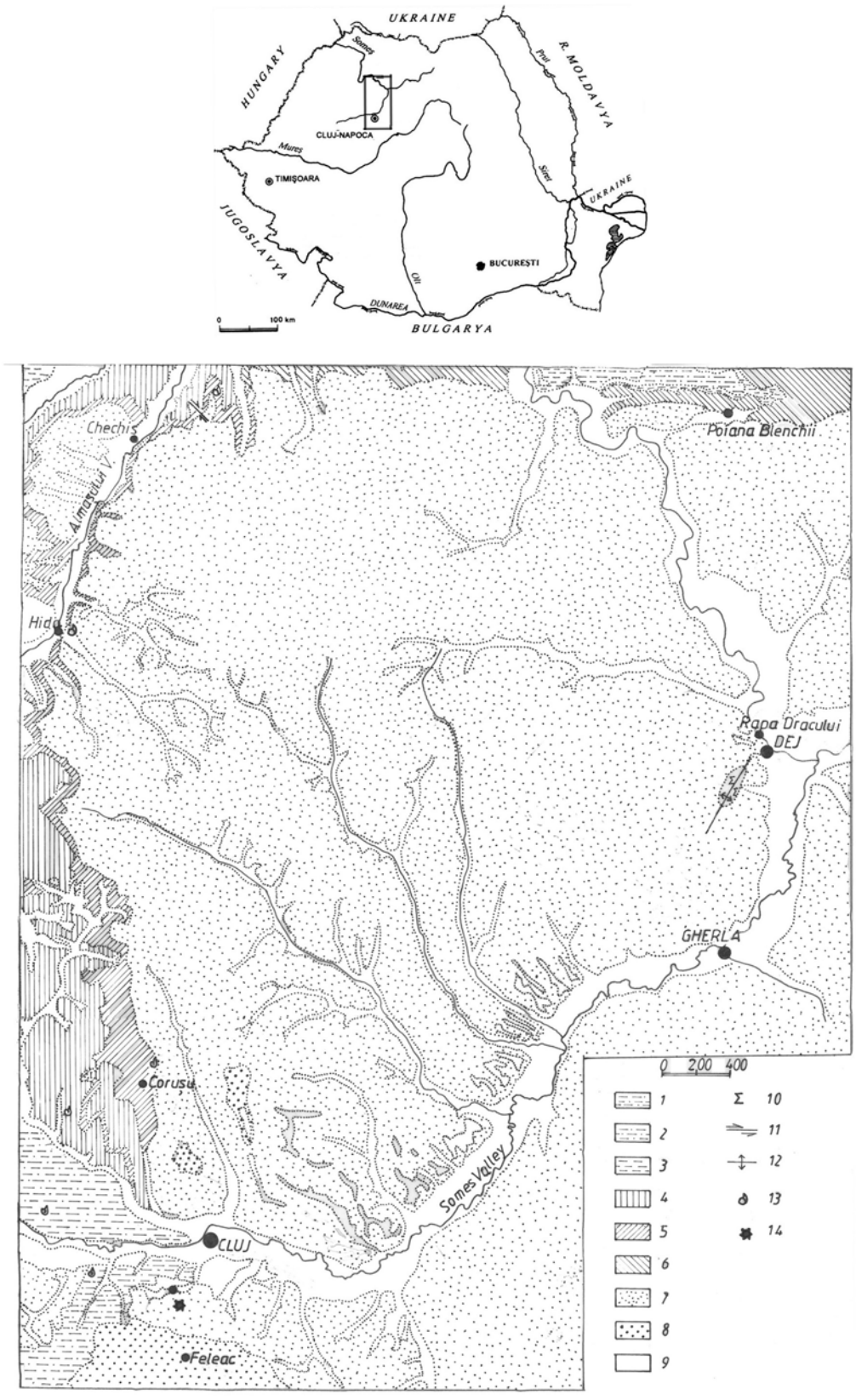

Fig. 1. Geological map with the Lower Miocene sites (according Dumitrescu, 1968, scale 1:200.000). Legend: 1 – Late Eocene; 2, 3 – Oligocene; 4 – Chattian – Aquitanian; 5 – Burdigalian ; 6 - . Chattian – Burdigalian; 7 – Badenian; 8 – Sarmatian; 9 – Quaternary deposits; 10 – Salt diapir; 11 - Fault; 12 – Anticline axe; 13 – Fossiliferous Site; 14 – Borehole.

Species with Oligocene - Miocene ranges have been remarked in the Outer Moldavides: *Coccolithus pelagicus Coccolithus eopelagicus, Cyclicargolithus abisectus, C. floridanus, Discoaster adamanteus, D. deflandrei, Helicosphaera euphratis, H. intermedia, H. paleocarteri, Sphenolithus conicus, Reticulofenestra minuta, R. minutula. Helicosphaera mediterranea* has its FO, and (Mărunțeanu (1999) supposed that this bioevent marks the boundary between NP25 – NN1 zones, because the disappearance of *Helicosphaera recta, Sphenolithus ciperoensis* and *Zygrablithus bijugatus* are not simultaneous and consequently the lower boundary of NN1 Zone cannot be marked by these bioevents.

The **Coruş Formation**, a transgressive marine unit, with sands, sandstones and clays, contains calcareous nannofossils of the NN2 Zone (Mészáros, 1991) (Early Eggenburgian) (Late Aquitanian) and respectivelly NN2a (*Sphenolithus dissimilis* Subzone) (Mărunțeanu, 1991).

The subzone NN2a is defined from the FO of *Discoaster druggi* or *Reticulofenestra pseudoumbilicus* to the FO of *Helicosphaera ampliaperta* or LO of *Sphenolithus dissimilis*.

At the base of the Eggenburgian (NN2 Zone) the FO of *Discoaster druggi* and *Reticulofenestra pseudoumbilicus* are present.

In the Eggenburgian is located the FO of *Helicosphaera ampliaperta* (at the base of the Burdigalian). In the upper part of the Eggenburgian the FO of *Sphenolithus belemnos* is noticed, while its LO is located in the Ottnangian (NN3 zone).

Representative sections are cropping out at Coruş, Coasta Mare – Cluj (Mészáros, in Petrescu et al., 1979).

The Chechiş Formation is represented by clays, siltic clays and a glauconitic level.

The calcareous nannofossils of the **Chechiş Formation** belong to the NN2 - more preciselly NN2b (*Helicosphaera carteri* Subzone), and NN3 zones (Mészáros et al., 1976; Mészáros, 1991; Mărunțeanu, 1991; Chira, 2000), which suggest the presence of Late Eggenburgian (Early Burdigalian). Representative section: Chechiş.

The samples investigated for calcareous nannofossils from the TRANSGEX H2 borehole (Feleac Hill, south of Cluj-Napoca) (21 – 53.45 m) also indicate the presence of Eggenburgian – Ottnangian deposits (Chira, in Petrescu et al., 2002). Between meters 26 and 34, *Helicosphaera ampliaperta* (NN4) appears, while at 28 and 31 m *Sphenolithus belemnos* is present (NN3). This borehole provides one of the most representative and best preserved calcareous nannofossil assemblages for the Early Miocene.

The **Hida Formation** is bounded between two levels of conglomerates.

It preserves scarce nannofossils assemblages, which indicate the NN4 zone (Mészáros et al., 1977), possibly NN4a (*Discoaster deflandrei* subzone) (Ottnangian) (Burdigalian). Representative section: Dej (Râpa Dracului), Hida.

At Râpa Dracului – Dej, the NN4/ NN5 boundary is noticeable. Here, the species *Helicosphaera ampliaperta* is present, in the base of the section, 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 (Chira & Bălc, 2002).

The upper part of the Hida Formation, with *Calcidiscus leptoporus,* probably belongs to the Early Karpatian.

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

Calcareous nannoplankton from the type Ottnangian in the Central Paratethys indicates a correlation with the upper part of the zone NN3 (*Sphenolithus bemnos* Zone) and/or part of the NN4 Zone (*Helicosphaera ampliaperta* Zone) (Martini & Müller, 1975a) of the Standard Nannoplankton Zonation (Martini, 1971).

The calcareous nannoplankton is not very common in the type Ottnangian.

The most common species is *Coccolithus pelagicus*, then *Helicosphaera carteri, Cyclicargolithus floridanus, Reticulofenestra* sp. and *Helicosphaera ampliaperta* (Martini & Müller, 1975a).

The Karpatian in the Central Paratethys was studied from the Karpatian equivalents in Austria (Martini & Müller, 1975b).

The relatively well preserved nannofossil assemblage (Hole BL 503) is characterized by the presence of: *Calcidiscus leptoporus, C. tropicus, Coccolithus pelagicus, C. Miopelagicus, Coronocyclus nitescens, Helicosphaera ampliaperta, H. carteri, Pontospahera sp., Reticulofenestra haqii, R. minuta, R. pseudoumbilicus*, a.o. (Coric, in Spezzaferri & Coric, 2001).

Considering the Ottnangian nannoplankton assemblage, in which *Helicosphaera ampliaperta* is present, the lower part of the Karpatian was correlated with the upper part of the Zone NN4.

Sphenolithus heteromorphus seems to have invaded 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 noticed sometimes, but these are not associated with *Helicosphaera ampliaperta*, thus indicating that they belong to the NN5 Zone (*Sphenolithus heteromorphus* Zone).

From two boreholes in Moravia, Chicha et al. (1971) reported the presence of *Helicosphaera ampliaperta* Zone. The index fossil for NN4 appears

together with: *Braarudosphaera bigelowii, Coccolithus pelagicus, Pontosphaera multipora, Helicosphaera carteri, H. intermedia, Reticulofenestra pseudoumbilicus*, *Reticulofenestra* sp, *Sphenolithus* sp. The whole assemblage is considered to be identical with the nannoplankton assemblages from the Karpatian of Laa and Retznei, in Austria, which have been placed in the Zone NN4 (*Helicosphaera ampliaperta* Zone) (Martini & Müller, 1975b).

From the Korneuburg Basin, 12 species of Karpatian calcareous nannoplankton are documented (Müller, 1998): *Coccolithus pelagicus, Cyclicargolithus abisectus, C. floridanus, Discolithina desueta, D. multipora, Helicosphaera ampliaperta, H. carteri. H. euphratis, H. mediterranea, Reticulofenestra pseudoumbilicus, Sphenolithus abies, Sphenolithus* cf. *belemnos*.

PALEOCLIMATIC–PALEOECOLOGICAL SIGNIFICANCE OF THE EARLY MIOCENE CALCAREOUS NANNOFOSSILS

Environmental controls are broadly affecting the plankton, and perhaps even more the nannoplankton. Most nannoplankton species show more or less well- defined temperature control (Burnett et al., 2000).

The first significant palaeoclimatical events can be recorded during Early Miocene. The warming of the climate at the level of the Vima Formation was followed by a more important warming during Eggenburgian, imprinted in the fossil record of the Corus Formation. During Ottnangian, a cooling episode was recorded in the Hida Formation, probably related with Atlantic and Boreal influences (Chira et al., 2000).

Due to their Mediterranean character, the first calcareous nannofossils assemblage, belonging to the Miocene from the Vima Formation, suggests a warming of the climate at this level. During the Eggenburgian, the first warming Miocene episode in the Transylvanian Depression was recorded.

However, *Helicosphaera ampliaperta*, the index species for NN4, seems to prefer cooler waters (Müller, 1977). This species is present in the NN2b subzone (Eggenburgian) (Chechiş Formation). The NN4 zone was recorded by Mészáros et al. (1977) in the Hida Formation.

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

Dumitrică et al. (1975) assumed the presence of the NN4 Zone at the base of the "Ciceu – Giurgeşti Beds", too, despite the absence of *Helicosphaera ampliaperta*. The absence of this species in the upper NN4 may be explained by Indo-Pacific influences (Mărunțeanu, 1991).

As Aubry (1984) already mentioned, there is considerable evidence that *Discoaster* – producing organisms were essentially restricted to warm water masses. One of their most extended diversification, during the Early Miocene, corresponds to warmer climatic conditions.

Coccolithus pelagicus, which is a subpolar species today, evolved in the tropical area during the Early Cenozoic and migrated towards the poles during the Mid – Cenozoic. Other species, like most of the *Sphenolithus* and some *Helicosphaera* seem to have avoided boreal waters (Martini, 1971).

The increase in abundance of *Helicosphaera carteri* and *Coccolithus pelagicus* may reflect higher nutrient contents (Findlay & Giraudeau, 2002).

The living species *Helicosphaera carteri* from the Atlantic Ocean and from the Pacific Ocean has a geographic distribution which has been interpreted as depending on water temperature. *Helicosphaera carteri* is eurythermal. Although more common in tropical and subtropical nannofloral provinces, rarely it is also recorded in transitional, arctic and subarctic assemblages where it 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 yet clearly understood.

Usually, high frequency of cribriliths in fossil assemblages is considered indicative of shallower marine environments (Aubry, 1990, a. o.). The genus *Pontosphaera* shows a greater variety in the near shore than in the oceanic samples.

Pontosphaera multipora is considered a nearshore environment species, as well as *Helicosphaera* group (Perch-Nielsen, 1985).

Cool surface waters in the Paratethys were considered to have characterized the Karpatian stage (Spezzaferri & Coric, 2001).

CONCLUSIONS

The Oligocene/Miocene boundary in Transylvania is marked by the FO of *Helicosphaera mediterranea*.

The base of the Miocene – NN1 – *Triquetrorhabdulus carinatus* Zone is located in the upper part of the Vima Formation.

The Coruş Formation belongs to the Eggenburgian.

Early Eggenburgian (Late Aquitanian) corresponds to NN2 - *Discoaster druggi* Zone, more preciselly to NN2a – *Sphenolithus dissimilis* Subzone. It is marked by the FO's of *Discoaster druggi* and *Reticulofenestra pseudoumbilicus*.

In the Eggenburgian the FO of *Helicosphaera ampliaperta* took place (at the base of Burdigalian).

The Late Eggenburgian (Early Burdigalian) corresponds to the Chechiş Formation: NN2, respectivelly NN2b – *Helicosphaera carteri* Subzone

and NN3 – *Sphenolithus belemnos* Zone. In NN3, the LO of *Sphenolithus belemnos* is noticed.

The Hida Formation corresponds to the Ottnangian. It is scarce in nannofossil assemblages. It belongs to NN4 – *Helicosphaera ampliaperta* Zone, respectivelly NN4a – *Discoaster deflandrei* Subzone.

The upper part of the Hida Formation, with the FO of *Calcidiscus leptoporus*, probably belongs to the Lower Karpatian.

For the Transylvanian Depression, the first significant warming episodes in the Miocene have been established at the level of the Eggenburgian. During the Ottnangian, a cooling episode was recorded in the Hida Formation.

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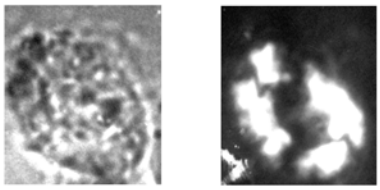
PLATES

PLATE I: Early Miocene calcareous nannofossils from Transylvania.

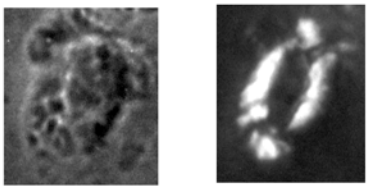
1a, 1b – *Helicosphaera mediterranea* Müller, 1981. 1a – NII; 1b – N+; x 2.000.
2a, 2b – *Helicosphaera ampliaperta* Bramlette & Wicoxon, 1967. 2a – NII; 2b – N+; x 2.000.
3a - 5b – *Helicosphaera scissura* Miller, 1981. 3a, 3c, 4a, 4c – NII; 3b, 3d, 4b, 4d – N+; x 2.000.
6a, 6b – *Helicosphaera paleocarteri* Theodoridis, 1984. 6a - NII; 6b - N+; x 2.000.
7a, 7b - *Cyclicargolithus floridanus* (Roth & Hay, 1967) Bukry, 1971. 7a - NII; 7b - N+; x 2.000.
8a, 8b - *Coccolithus pelagicus* (Wallich 1877) Schiller 1930. 8a - NII; 8b - N+; x 2.000.

PLATE II: Early Miocene calcareous nannofossils from Transylvania.

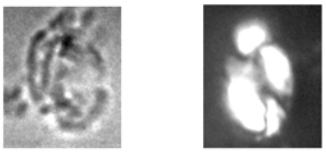
1a – 2b – *Sphenolithus belemnos* Bramlette & Wicoxon, 1967. 1a,2a – NII; 1b, 2b – N+; x 2.000.
3a, 3b – *Sphenolithus dissimilis* Bukry & Percival, 1971. N+; x 2.000.
4a – 5b – *Sphenolithus moriformis* (Brönnimann & Stradner 1960) Bramlette & Wilcoxon 1967. 4a, 5a – NII; 4b, 5b – N+. x 2.000.
6a, 6b – *Pontosphaera multipora* (Kamptner 1948) Roth 1970. 6a - NII; 6b - N+; x 2.000.
7a, 7b – *Discoaster deflandrei* Bramlette & Riedel, 1954. NII; x 2.000.
8 – *Discoaster adamanteus* Bramlette & Wicoxon, 1967. NII; x 2.000.
9a, 9b – *Discoaster* cf. *druggi* Bramlette & Wilcoxon, 1967. NII; x 2.000.
10, 10 b – *Reticulofenestra pseudoumbilicus* (Gartner 1967) Gartner 1969. 10a – NII; 10b – N+; x 2.000.



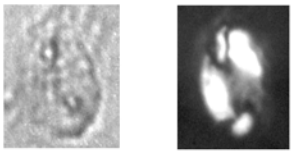
1a 1b



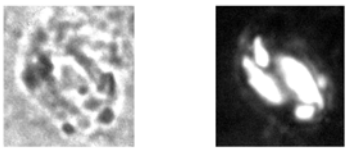
2a 2b



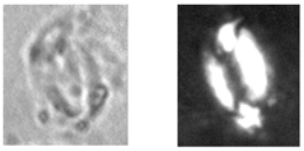
3a 3b



3c 3d



4a 4b



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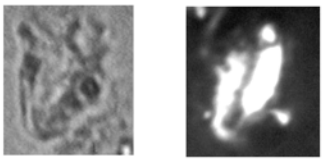

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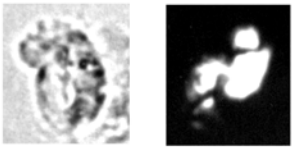
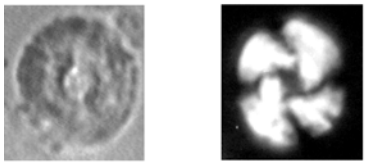


6a 6b



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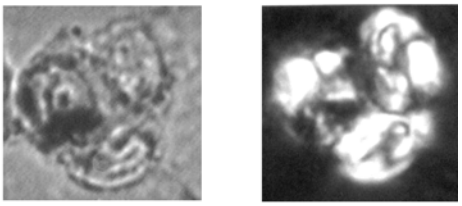

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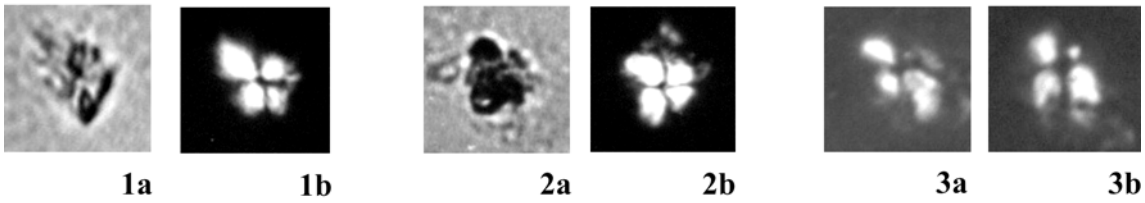

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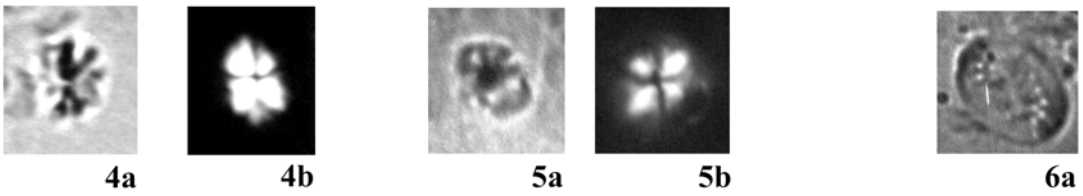

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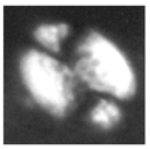

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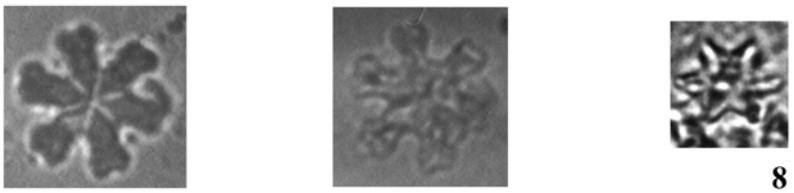
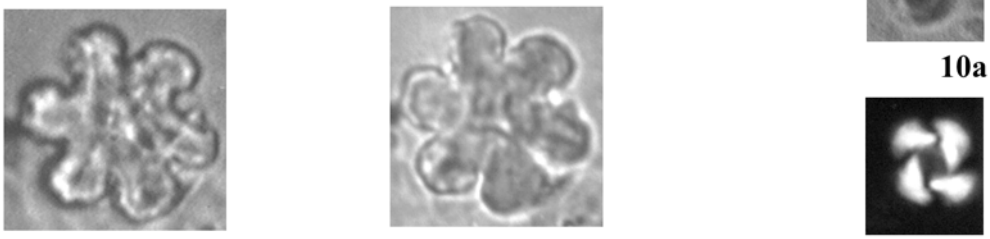


7a 7b 8



9a 9b 10a

10b