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Badenian calcareous nannofossils from Semerovce ŠV-8 and Cífer-1 boreholes (Danube Basin)

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Abstract

The calcareous nannofossils in the Badenian sediments from the Semerovce ŠV-8 and Cífer-1 boreholes (Danube Basin) were studied for the biostratigraphical purpose.

Two nannoplankton zones NN5 – Sphenolithus heteromorphus and NN6 – Discoaster exilis were determined. The studied assemblage was quantitatively and qualitatively rich and included more than 40 % abundance from the species *Reticulofenestra minuta*, which indicated a good sea connection with an open ocean and rich nutrificant conditions in the sedimentary area.

Key words: Danube Basin, Badenian, calcareous nannofossils, biostratigraphy, paleoecology

Introduction

The Badenian sedimentary cycle started in the upper part of the Lower Badenian with transgressive pelitic sediments, corresponding to the nannoplankton zone NN5 – Sphenolithus heteromorphus sensu Martini (1971). This zone continued until the Middle Badenian. The base of this zone is defined by the FO (first occurrence) of the species *Helicosphaera waltrans* and by absenting species *Helicosphaera ampliaperta* (15.1 Ma in Berggren et al., 1995). According to Rögl (1998), the base of the "Middle" Badenian is placed at about 15 Ma.

The zone NN6, starting after Upper Badenian transgression, is characterized by the absence of the species *Sphenolithus heteromorphus* (13.5 Ma, Berggren et al., 1995) and terminated during the Sarmatian.

Following the study of the foraminifers the Badenian is divided into the lower and upper Lagenide zone (Lower Badenian), Zone Spiroplectamina carinata ("Middle" Badenian), Bulimino – Bolivine zone and Rotalia zone (Upper Badenian; Grill, 1941; Kováč et al., 2005).

The base of the Badenian in the Central Paratethys has an estimated geochronological age of 16.3 Ma and the end of Badenian has an age of 12.7 Ma sensu Harzhauser and Piller (2007).

Biostratigraphical research of Badenian sediments from the Danube basin on the basis of calcareous nannofossils was realized by Lehotayová and Halásová.

Lehotayová determined the nannoplankton zone NN5 in the following boreholes: Salka K–V, Chľaba ŠO-1, Bajtava (Lehotayová, 1977), zone NN6: Salka K–V, Lontov Ži-2, Gondovo PKŠ-1 – basicaly the presence (NN5) or the absence (NN6) and by appearance of the species *Triquetrorhabdulus rugosus* and the major abundance of the discoasters with the reduced central area and taper rays too, such as *Discoaster brouweri*, *Discoaster* cf. *bollii*, *Discoaster exilis* (Lehotayová, 1977).

Halásová defined the nannoplankton zones NN5 and NN6 in the Badenian sediments from the borehole Bruty VTB 1 (Halásová in Zlinská et al., 2002) that is defined as Lower and "Middle" Badenian, as well as zones NN5 and NN6 in the borehole Želiezovce HGŽ-3. Here was determined the calcareous assemblage from the zones NN4 and NN5 (Halásová in Fordinál et al., 2002).

Geological situation

Semerovce ŠV-8 and Cífer-1 boreholes are situated in Danube Basin, belonging among West Carpathian Neogene basins (Fig. 1).

The Lower Badenian deposits in the Danube Basin were represented by terrestrial sediments proceeding to marine sediments. In the Želiezovce Depresion the marine Bajtava succession on the margin is represented by transgressive conglomerates and by sandstones

Fig. 1. Location of the Semerovce ŠV-8 and Cífer-1 boreholes.

including volcaniclastics in the eastern part. In the centre of the depression the succession is represented mainly by calcareous clays, siltstones and sandstones (Kováč, 2000).

"Middle" and Upper Badenian sediments (15–13 Ma) extended over the whole Danube Basin. They were deposited in the lower to upper neritic conditions. The conditions of the sedimentation were marine with gradual trend of decrease of salinity and depth of sedimentary basin toward the end of this time.

The freshwater coal clays with lignite layers were deposited in the western part of the basin in the Upper

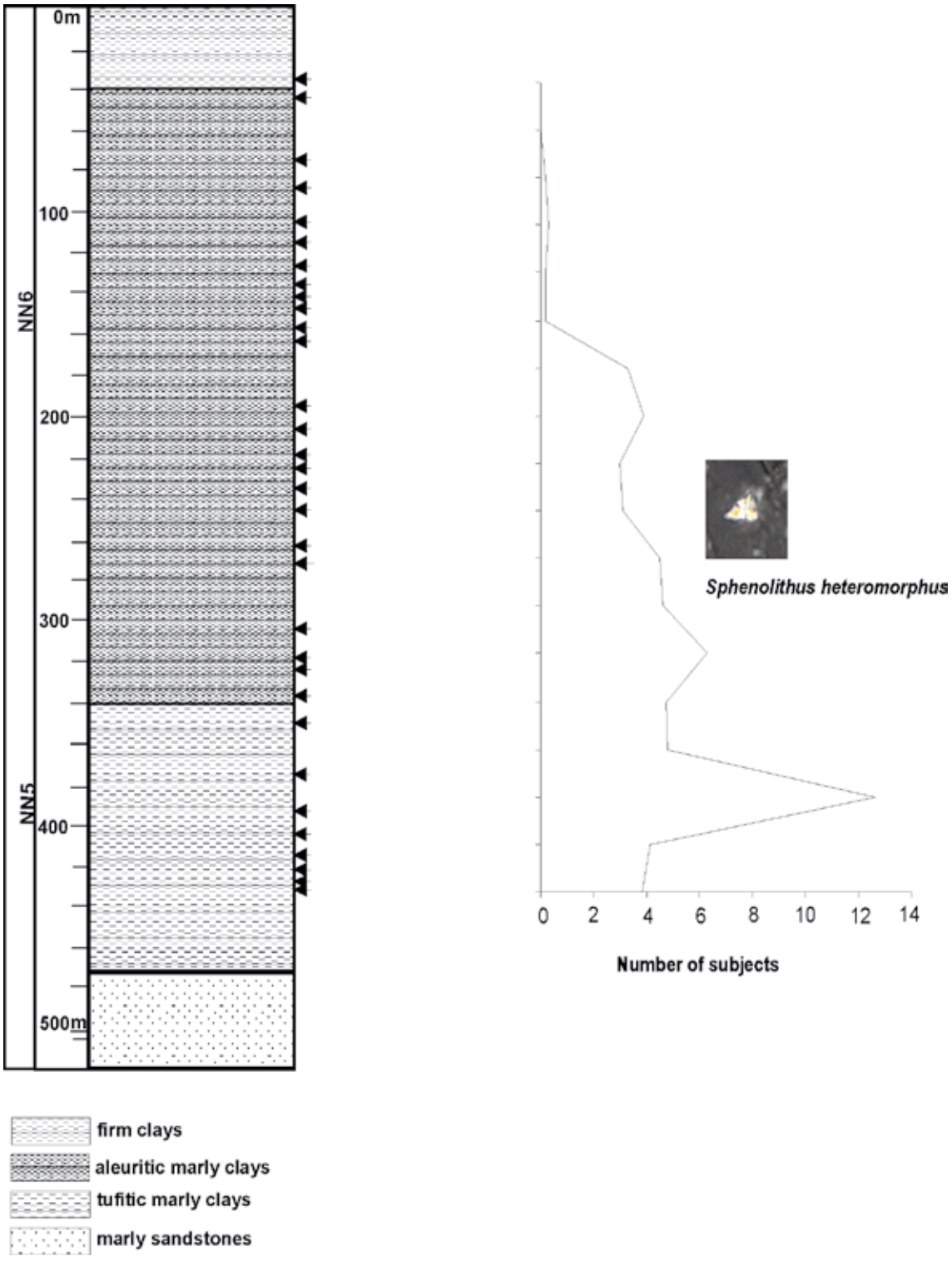


Fig. 2. Biostratigraphical evaluation of the Semerovce ŠV-8 borehole.

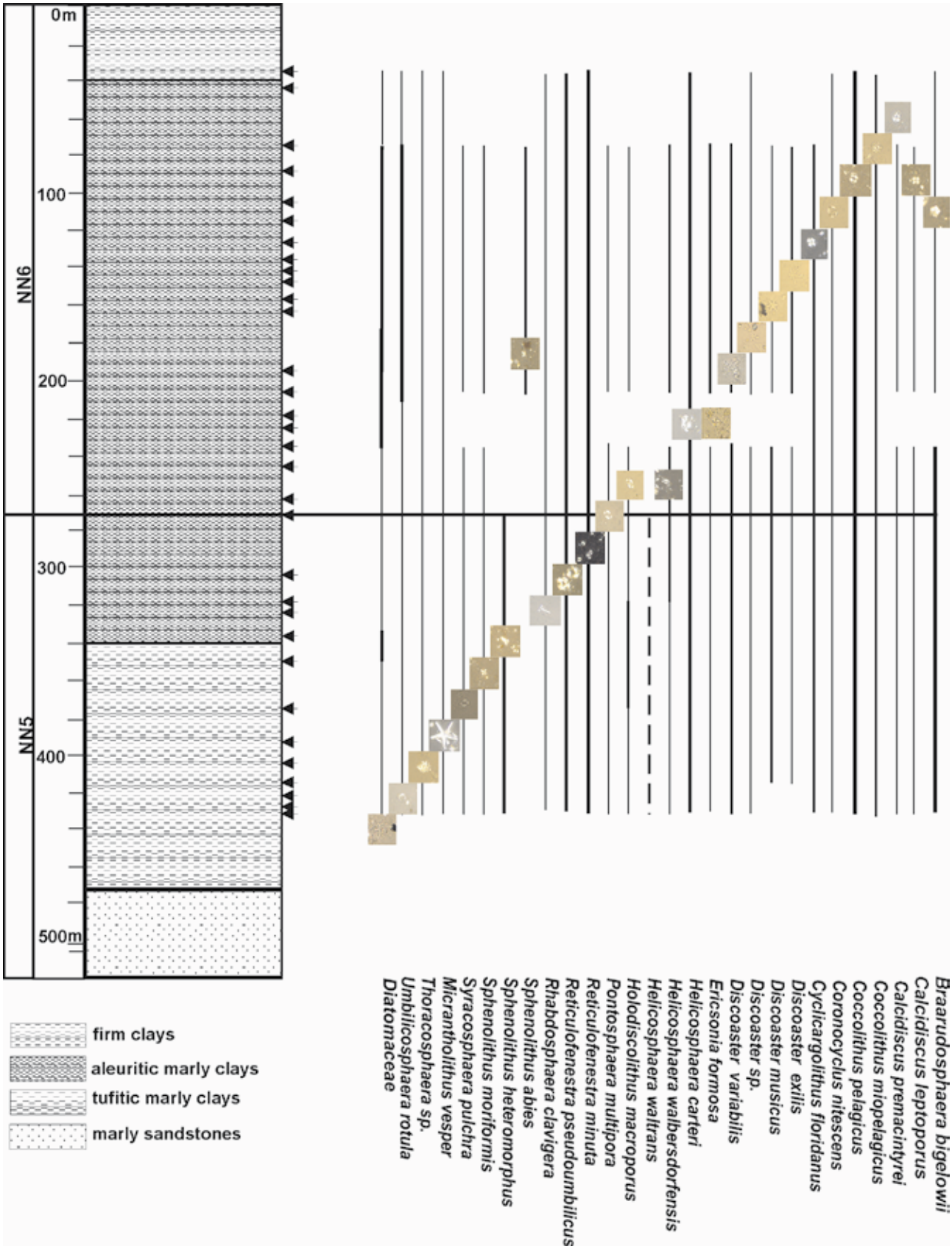


Fig. 3. List of species from Semerovce ŠV-8 borehole.

Badenian. The north-western part of the Danube Basin was represented by the grey calcareous clays, claystones and siltstones with beds from the sands and sandstones of the Špačince and Madunice formations, which exceeded a thickness of 3000 m. The Komjatice Depression contained the Pozba Formation sediments thick 2000 m. They are characterized by the sedimentary sequence of calcareous clays, claystones, siltstones with abundant volcaniclastics and bioherms of limestones (Kováč, 2000).

Material and methods

The study samples were taken from pelitic rocks with contents of $CaCO_3$.

The methods of gravitational setting were applied to produce the microscopic preparations. 3 g of rock were mixed with distilled water in a tube. The suspension had sedimented for 1–2 min. and after the liquid was decanted above the settled fraction to the second tube this

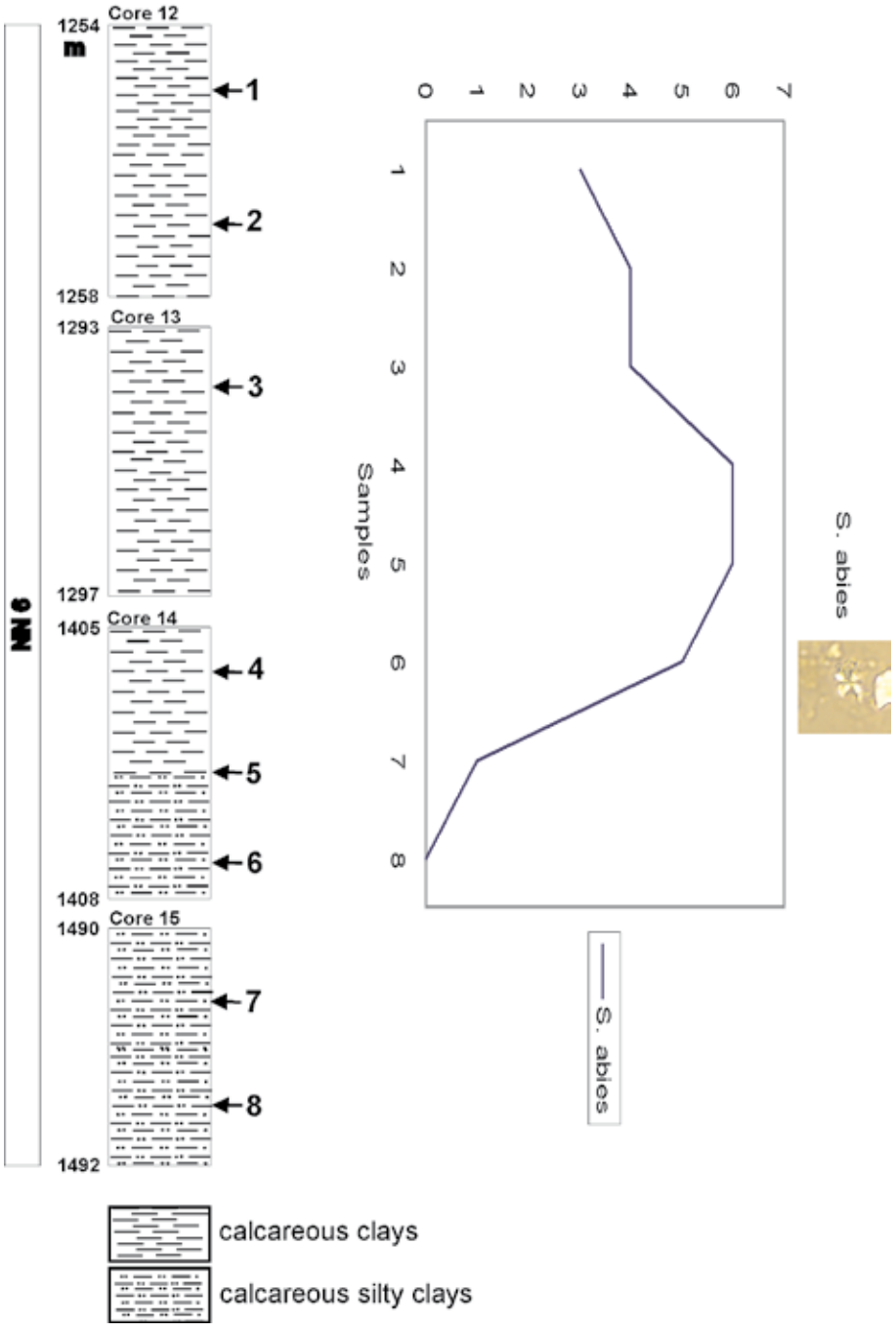


Fig. 4. Biostratigraphical evaluation of Cífer-1 borehole.

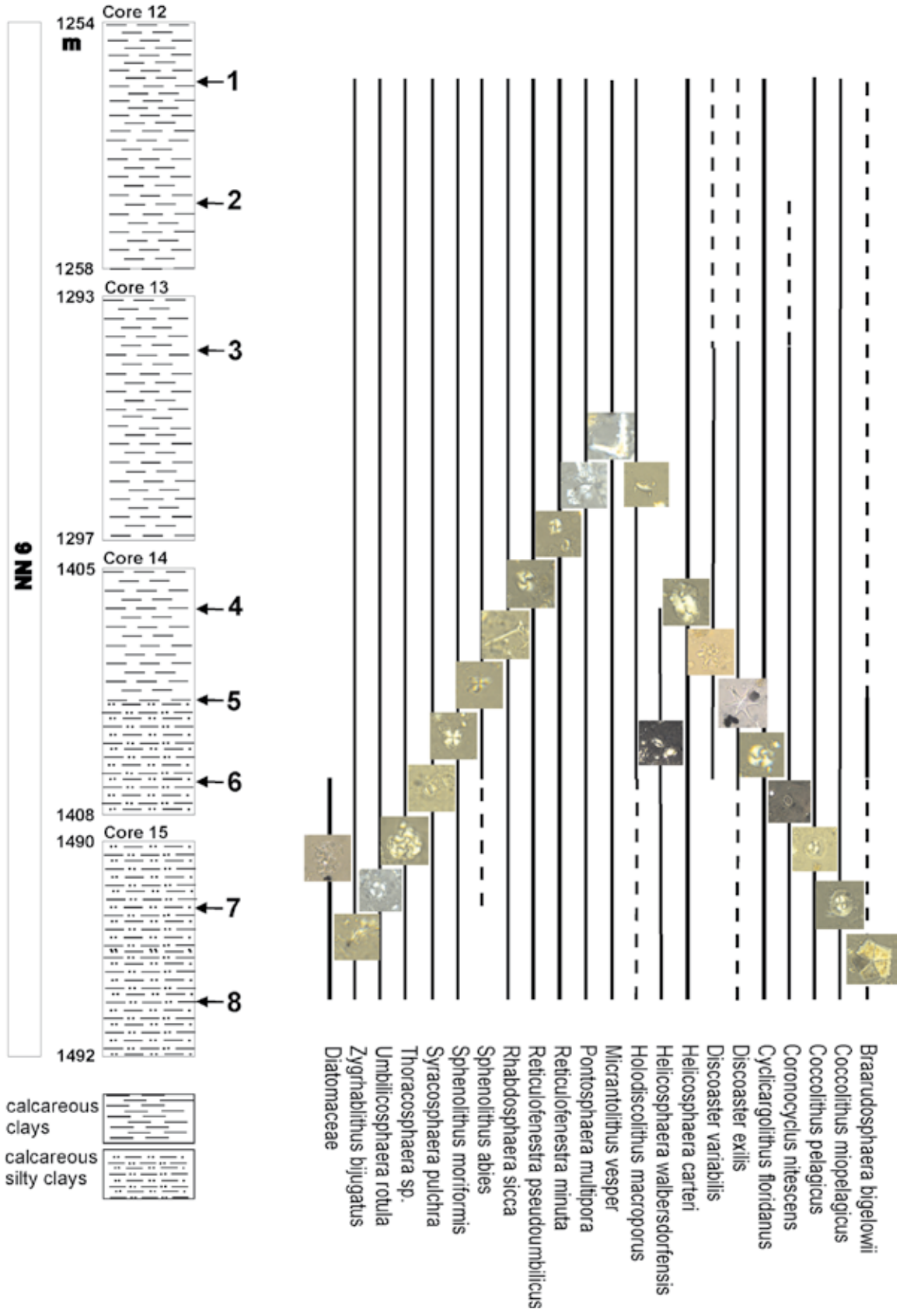


Fig. 5. Borehole list of species from Cífer-1 borehole.

sedimented for 45 minutes by 45 mm water column. Next the liquid was decated above the settled fraction and from this fraction were made the microscopic samples.

The microscopical preparates were studied by the light microscope and by the SCAN (Raster electron microscope).

Biostratigraphical results

Semerovce ŠV-8

Two nannoplankton zones NN5 and NN6 were determined in the borehole Semerovce ŠV-8 (Fig. 2). Stratigraphical important species such as *Sphenolithus heteromorphus*, *Calcidiscus premacintyrei*, *Discoaster musicus*, *Discoaster exilis*, *Discoaster variabilis* were recognized in the Zone NN5 (305–432 m), while *Helicosphaera waltrans*, which has its LO in this zone, appeared sporadically. The species *Helicosphaera walbersdorfensis* had its LCO in the boundary of the zones. The beginning of zone NN6 (273–143 m) is indicated by the absence of species *Sphenolithus heteromorphus* and by the appearance of *Sphenolithus abies*. The lower part of this zone contained frequent occurrence of discoasters (Fig. 3).

The major part of the assemblage from nannoplankton zone NN5 was composed of the species *Coccolithus pelagicus*, *Reticulofenestra pseudoumbilicus*, *Cyclicargolithus floridanus*, *Helicosphaera carteri*. However, the most dominant species (more than 40 % from the nannofossil assemblage) was *Reticulofenestra minuta*. This species continued into zone NN6 and had the dominant position here as well.

Cífer-1

The Cífer-1 borehole contained a rather rich assemblage of the calcareous nannofossils from zone NN6 – Discoaster exilis (Fig. 4). This zone was determined in the interval 1254–1408 m, mainly on the basis of the absence of the species *Sphenolithus heteromorphus*. The samples contained the species typical for the zone NN6 like *Sphenolithus abies*, *Discoaster exilis*. The species *Cyclicargolithus floridanus* occurred most frequently in this zone. The species *Reticulofenestra minuta* has in samples more than 40 % abundance of the assemblage. Together with other species *Coccolithus pelagicus*, *Reticulofenestra pseudoumbilicus* and *Helicosphaera carteri* they compose the major part of the assemblage (Fig. 5).

Paleoecological results

Semerovce ŠV-8

The assemblage of calcareous nannofossils was rather rich and well diversified and showing good nutrificant conditions in the marine sedimentary area and active connection with the open ocean. The change in paleoarea is evident in the interval 273–218 m, where small subjects and an increase of *Diatomaceae* were found, indicating continental stream. The large percentual abundance of the species *Reticulofenestra minuta* in the some intervals from borehole (432 m, 421–392 m, 349–318 m) is related to open sea conditions and high nutrificant index in the sedimentary area (Fig. 6).

Cífer-1

The calcareous nannofossils found in the samples were quantitatively and qualitatively rich, and included Paleogene species. From the paleoecological aspect the more than 40 % abundance of the species *Reticulofenestra minuta* is important (Fig. 7). A similar event was recognized in the Semerovce borehole and it is probably typical for the Badenian Danube Basin and is an argument for high nutrificant conditions in the basin.

An increase from the species *Braarudosphaera bigelowii* was recognized in the samples from interval 1405–1408 m. This could indicate a change of salinity in the basin. *Diatomaceae* were also observed in the borehole (1490–1492 m). This is an argument for a larger terrestrial stream to the marine basin.

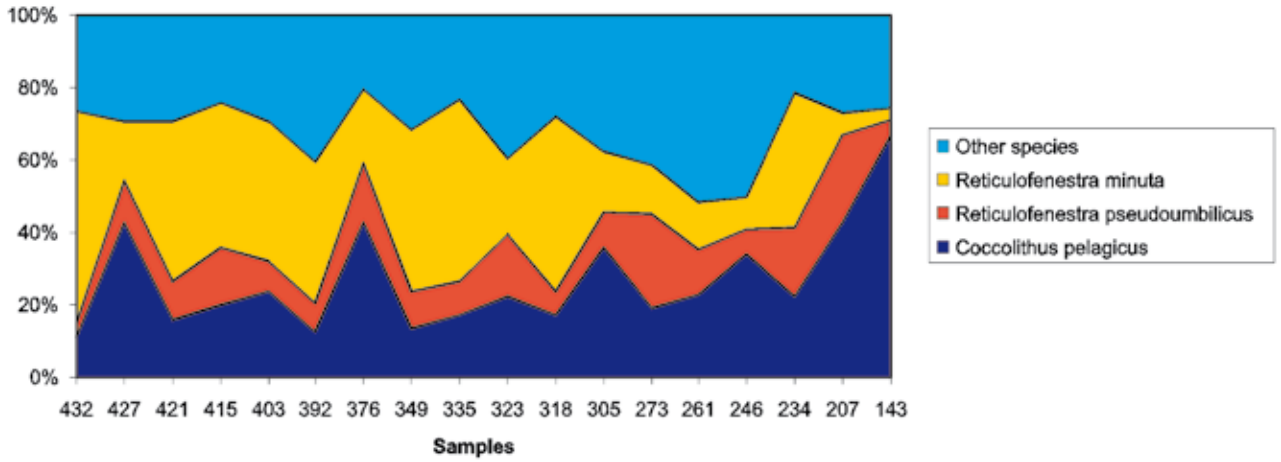
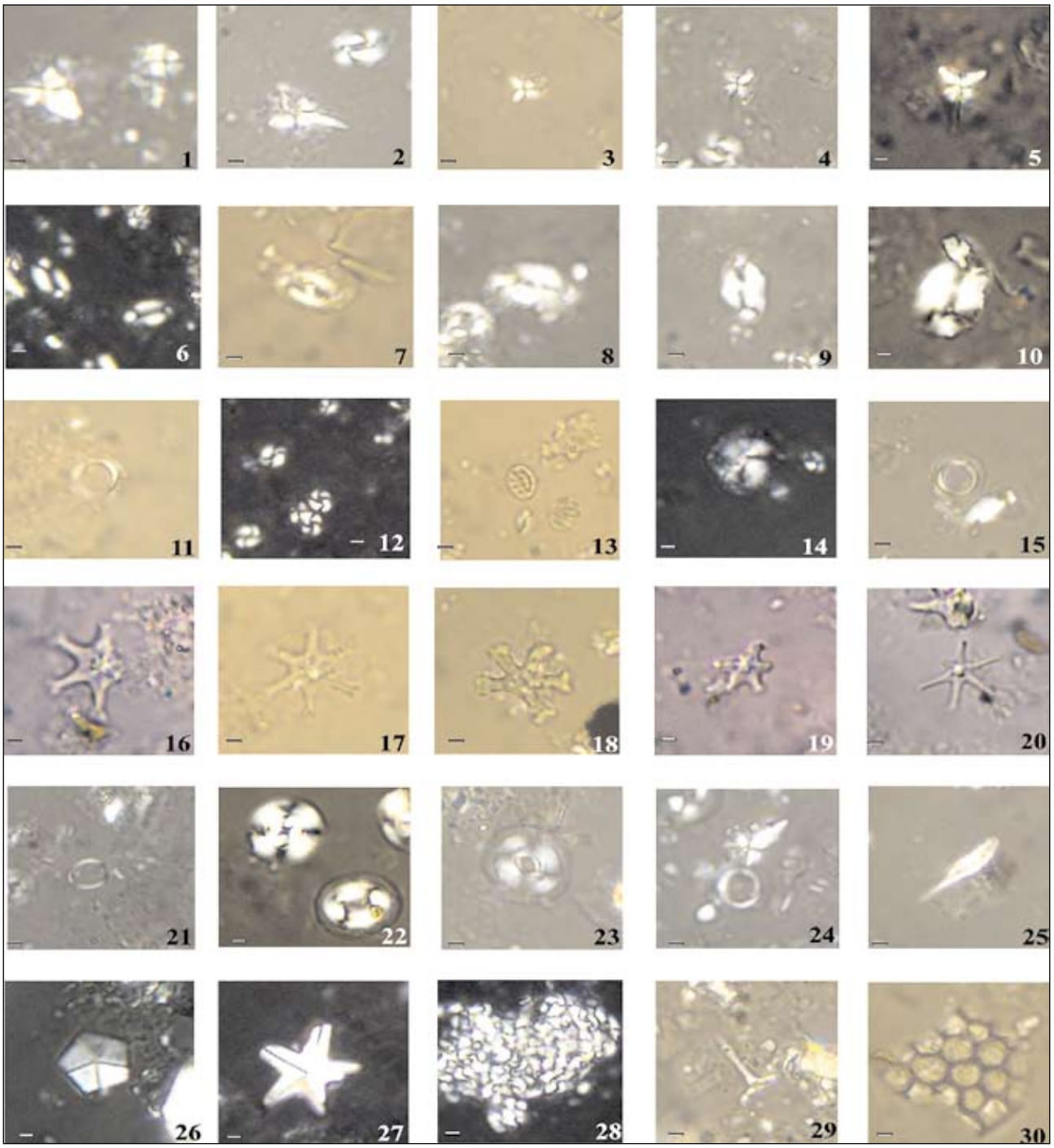
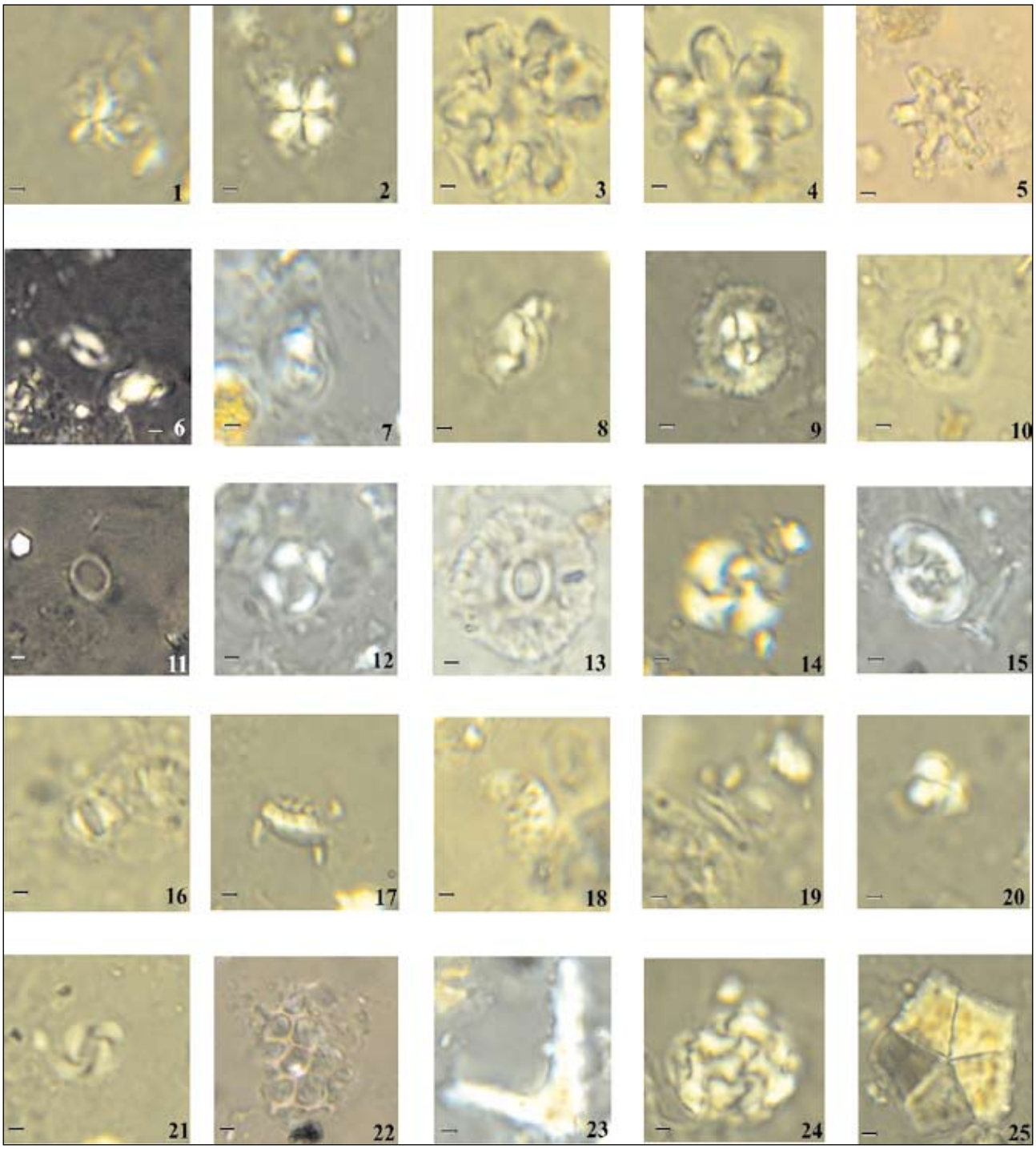


Fig. 6. Structure of nannoassemblage of Semerovce ŠV-8 borehole.



Pl. 1. 1–2 – *Sphenolithus heteromorphus* Deflandre, Semerovce ŠV-8, 376 m, 1 – 349 m, 2 – 305 m; **3, 4, 5** – *Sphenolithus abies* Deflandre, Semerovce ŠV-8, 3 – 305 m, 4 – 207 m, 5 – 127 m; **6** – *Helicosphaera walbersdorfensis* Müller, Semerovce ŠV-8, 376 m; **7, 8, 9, 10** – *Helicosphaera mediterranea* Müller, Semerovce ŠV-8, 7 – 376 m, 8, 9 – 305 m, 10 – 421 m; **11, 15** – *Coronocyclus nitescens* (Kamptner) Bramlette et Wilcoxon, Semerovce ŠV-8, 11 – 305 m, 15 – 207 m; **12** – *Reticulofenestra minuta* Roth, Semerovce ŠV-8, 349 m; **13** – *Holodiscolithus macroporus* (Deflandre) Roth, Semerovce ŠV-8, 376 m; **14** – *Cyclicargolithus floridanus* (Roth et Hay) Bukry, Semerovce ŠV-8, 349 m; **16, 17** – *Discoaster exilis* Martini et Bramlette, Semerovce ŠV-8, 16 – 305 m, 17 – 415 m; **18** – *Discoaster variabilis* Martini et Bramlette, Semerovce ŠV-8, 415 m; **19** – *Discoaster musicus* Stradner, Semerovce ŠV-8, 305 m; **20** – *Discoaster hamatus* Martini et Bramlette, Semerovce ŠV-8, 305 m; **21** – *Syracosphaera pulchra* Lohmann, Semerovce ŠV-8, 349 m; **22** – *Reticulofenestra pseudoumbilicus* (Gartner) Gartner, Semerovce ŠV-8, 376 m; **23** – *Calcidiscus premacintyrei* Theodoridis, Semerovce ŠV-8, 376 m; **24** – *S. heteromorphus* Deflandre, *C. nitescens* (Kamptner) Bramlette et Wilcoxon, Semerovce ŠV-8, 305 m; **25** – *Triquetrorhabdulus* sp., Semerovce ŠV-8, 207 m; **26** – *Braarudosphaera bigelowii* (Gran et Braarud) Deflandre, Semerovce, ŠV-8, 234 m; **27** – *Micrantolithus vesper* Deflandre, Semerovce, ŠV-8, 234 m; **28** – *Thoracosphaera operculata* Bramlette et Martini, Semerovce, ŠV-8, 376 m; **29** – *Rhabdosphaera clavigera* Murray et Blackman, Semerovce, ŠV-8, 235 m; **30** – diatom, 234 m.



Pl. 2. 1, 2 – *Sphenolithus moriformis* (Bronnimann et Stradner) Bramlette et Wilcoxon, Cífer-1, 1254 m; **3** – *Discoaster deflandrei* Bramlette et Riedel, Cífer-1, 1293 m; **4** – *Discoaster druggi* Bramlette et Wilcoxon, Cífer-1, 1293 m; **5** – *Discoaster variabilis* Martini et Bramlette, Cífer-1, 1293 m; **6** – *Helicosphaera walbersdorfensis* Müller, Cífer-1, 1254 m; **7** – *Helicosphaera mediterranea* Müller, Cífer-1, 1294 m; **8** – *Helicosphaera carteri* (Wallich) Kamptner, Cífer-1, 1294 m; **9, 10** – *Coccolithus pelagicus* (Wallich) Schiller, Cífer-1, 1405 m; **11** – *Coronocyclus nitescens* (Kamptner) Bramlette et Wilcoxon, Cífer-1, 1405 m; **12** – *Umbilicosphaera rotula* (Kamptner) Varol, Cífer-1, 1408 m; **13** – *Calcidiscus premacintyrei* Theodoridis, Cífer-1, 1406 m; **14** – *Cyclicargolithus floridanus* (Roth et Hay) Bukry, Cífer-1, 1406 m; **15** – *Chiasmolithus solitus* (Bramlette et Sullivan), Cífer-1, 1406 m; **16** – *Syracosphaera pulchra* Lohmann, Cífer-1, 1293 m; **17** – *Holodiscolithus macroporus* (Deflandre) Roth, Cífer-1, 1406 m; **18** – *Pontosphaera multipora* (Kamptner) Roth, Cífer-1, 1293 m; **19** – *Triquetrorhabdulus* sp., Cífer-1, 1408 m; **20** – *Zygrhablithus bijugatus* (Deflandre) Deflandre, Cífer-1, 1294 m; **21** – *Reticulofenestra pseudoumbilicus* (Gartner) Gartner, Cífer-1, 1294 m; **22** – diatom, Cífer-1, 1490 m; **23** – *Micrantolithus vesper* Deflandre, Cífer-1, 1408 m; **24** – *Cyclicargolithus floridanus* (Roth et Hay) Bukry, coccosphere, Cífer-1, 1405 m; **25** – *Braarudosphaera bigelowii* (Gran et Braarud) Deflandre, Cífer-1, 1294 m.

Discussion

Zone NN5 was recognized in both boreholes on the basis of the presence of the species *Sphenolithus heteromorphus* and other species typical for this zone: *Helicosphaera walbersdorfensis*, *Calcidiscus premacintyrei*, *Discoaster musicus*, *Discoaster variabilis*. The beginning of zone NN6 may be characterized by the absence or only a low number *Sphenolithus heteromorphus*. In this zone the species *Cyclicargolithus floridanus* is most frequent and the species *Triquetrorhabdulus rugosus* appears. Other typical species in this zone are *Discoaster exilis*, *Discoaster variabilis*, *Sphenolithus abies*.

No other fossils have been studied in the Cífer borehole so we cannot compare our results with other results.

Foraminifers were studied in the Semerovce borehole (Lehotayová, 1981) and the results are comparable with the results from my study. In the interval 470–350 m Lehotayová (l.c.) recognized Lower Badenian with the species *Uvigerina*, *Bolivina*. In the interval 350–300 m she recognized Middle Badenian with basically mixing Lower and Upper Badenian species, but zone Spiroplectamina carinata continues to the Upper Badenian. In the interval 350–229 m she recognized the Spiroplectamina carinata zone. In the interval 229–35 m the Upper Badenian and Bulimino – Bolivina zone were recognized. Some difference between the results from nannofossils and foraminiferal study zone NN5 was recognized in the interval 305–432 m, which is defined from the upper part of Lower Badenian to the Middle/Upper Badenian boundary. The zone NN6 was assigned to the interval 273–143 m and this zone occurs from the Upper Badenian to Sarmatian (Kováč et al., 2005). These differences are caused by the new biostratigraphical study and new biostratigraphical time scales, generated during the last 20 years.

Conclusions

Two nannoplankton zones NN5 – Sphenolithus heteromorphus and NN6 – Discoaster exilis were recognized in the Semerovce and Cífer boreholes on the basis of the presence or absence of biostratigraphical marker *Sphenolithus heteromorphus* and other species important for these zones.

The Paleoecological environments from the study of marine sediments show good nutrificant conditions in the ancient sea, normal salinity and a connection with the open ocean. In the same interval, where the paleoenvironmental condition changed, we observed an increase of the species *Braarudosphaera bigelowii* and Diatomaceae.

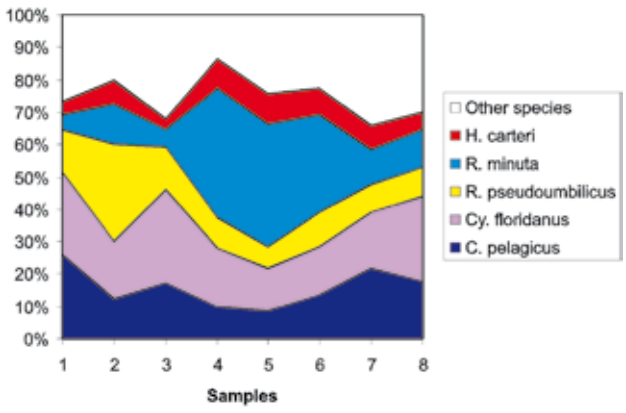


Fig. 7. Structure of nannoassemblage in Cífer-1 borehole.

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Badenian calcareous nannofossils from Semerovce ŠV-8 and Cífer-1 boreholes (Danube Basin)

Semerovce ŠV-8 borehole (Danube Basin) has the depth of 1204 m and the interval 505–35 m is of the Badenian age. The calcareous nannoplankton was found in the interval 446–45 m. The nannoplankton assemblage was qualitatively and quantitatively rich and consists mainly of the species *Reticulofenestra minuta, Reticulofenestra pseudoumbilicus, Cyclicargolithus floridanus* and *Coccolithus pelagicus*. The Nannoplankton zone NN5 was determined mainly on the basis of the occurrence of *Sphenolithus heteromorphus* (in the interval 305–432 m), and NN6 (in the interval 273–143 m), where this species is absent.

Paleoecological interpretation. The changes in the paleoenvironment were determined in the interval 273–218 m on the basis of growth of the *Diatomaceae*. It was due to the inflow of the terrestrial stream to the marine paleoenvironment.

High abundance of the species *Reticulofenestra minuta* (40 %) indicates an unrestricted sea connection with open ocean and eutrophic conditions in the sedimentary area.

Cífer-1 borehole (Danube Basin) has the depth 1842 m and the interval 1408–990 m was determined to be of the Badenian age. The zone NN6 was defined in the interval 1254–1408 m, mainly on the basis of the absence of the species *Sphenolithus heteromorphus*. In the nannoplankton assemblage were *Sphenolithus abies* and *Discoaster exilis*, representing species typical for this zone. The species *Cyclicargolithus floridanus* has the highest abundance in this zone. The species *Reticulofenestra minuta*, together with other species *Coccolithus pelagicus, Reticulofenestra pseudoumbilicus* and *Helicosphaera carteri* compose the major part of the assemblage.

Paleoecological interpretation. The calcareous nannoplankton in the studied samples is qualitatively and quantitatively rich and also contains some Paleogene species. The dominant species are *Reticulofenestra minuta, Reticulofenestra pseudoumbilicus, Cyclicargolithus floridanus* and *Coccolithus pelagicus*. High abundance of *Reticulofenestra minuta* is of paleoecological importance. A similar event was recorded in the Semerovce ŠV-8 borehole and indicates eutrophic conditions in the sedimentary area. In the samples from the interval 1405–1408 m there was found an increase of the occurrence the species *Braarudosphaera bigelowii*, which indicates a salinity changes in the marine area. The terrestrial stream is recorded by high abundance of the *Diatomaceae*, mainly in the interval 1490–1492 m.

Bádenské vápnité nanofosílie z vrtu Semerovce ŠV-8 a vrtu Cífer-1 (podunajská panva)

Vrt Semerovce ŠV-8 (podunajská panva) má hĺbku 1204 m a bádenský vek sa stanovil v rozpätí 505–35 m. Vápnitý nanoplanktón sa našiel v hĺbke 446–45 m, jeho spoločenstvo bolo bohaté kvantitatívne aj kvalitatívne a prevažnú zložku v ňom tvoril druh *Reticulofenestra minuta, Reticulofenestra pseudoumbilicus, Cyclicargolithus floridanus* a *Coccolithus pelagicus*. Zastúpenie *Reticulofenestra minuta* miestami dosahovalo 40 %. Nanoplanktónová zóna NN5 (305–432 m) sa určila najmä podľa výskytu druhu *Sphenolithus heteromorphus* a NN6 (273–143 m), ale hlavne na základe jeho absencie.

Paleoekologické hodnotenie. Zmena paleoprostredia je viditeľná v rozpätí 273–218 m, a to na základe rastu podielu rozsievok pod vplyvom vyššieho prísunu terestrického materiálu do morského prostredia. Vysoké zastúpenie druhu *Reticulofenestra minuta* v istých úsekoch vrtu (432, 421–392 a 349–318 m) pravdepodobne súvisí s veľkým prísunom živín podmieneným prepojením s otvoreným oceánom.

Vrt Cífer-1 (podunajská panva) dosiahol hĺbku 1842 m a bádenské sedimenty sa určili v rozpätí 1299–990 m. Obsahoval pomerne bohaté spoločenstvo vápnitého nanoplanktónu nanoplanktónovej zóny NN6 *Discoaster exilis*, ktorá je definovaná pre vrchný báden až sarmat.

Zóna NN6 sa stanovila v rozpätí 1254–1408 m podľa chýbania indexovej fosílie *Sphenolithus heteromorphus*. Vo vzorkách sa vyskytovali aj druhy typické pre zónu NN6 *Sphenolithus abies* a *Discoaster exilis*. Hojne je zastúpený druh *Cyclicargolithus floridanus* a v tejto zóne má najväčší výskyt. Vo vrte sa v nadmernom množstve vyskytoval druh *Reticulofenestra minuta*, ktorý vo vzorkách dosahoval takmer 40 %, a spolu s druhom *Coccolithus pelagicus, Reticulofenestra pseudoumbilicus* a *Helicosphaera carteri* tvoril majoritnú časť nanospoločenstva.

Paleoekologické hodnotenie. Vápnitý nanoplanktón bol v študovaných vzorkách bohatý kvantitatívne aj kvalitatívne a boli v ňom aj paleogénne druhy. Z paleoekologického hľadiska je významné zastúpenie druhu *Reticulofenestra minuta* (takmer 40 %). Podobný jav sa pozoroval vo vrte Semerovce ŠV-8 a môže svedčiť o vysokonutričnom prostredí. Vo vzorke z rozpätia 1405–1408 m sa zistil vyšší výskyt druhu *Braarudosphaera bigelowii*, ktorý môže byť dôkazom o zmene salinity v paleoprostredí. Vo vrte sa ako výsledok väčšieho prísunu terestrického materiálu do sedimentačnej panvy vyskytovali aj rozsievky (najmä v rozpätí 1490–1492 m).