*GEOLOGICA CARPATHICA, 55, 2, BRATISLAVA, APRIL 2004*
*147–153*

# CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY OF THE GRUND FORMATION (MOLASSE BASIN, LOWER AUSTRIA)

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*(Manuscript received June 5, 2003; accepted in revised form December 16, 2003)*

**Abstract:** The calcareous nannoplankton was studied in samples from the Grund Formation type locality (sections B, F, G and H). Samples from Grund-Windmühlberg (W1–W4) were further collected and investigated. The nannofossil assemblages are characterized by biostratigraphically important *Helicosphaera waltrans, H. walbersdorfensis* and the rare occurrence of discoasterids. Although the marker species *Sphenolitus heteromorphus* is absent in all samples, the composition of nannofossils enables specification of these deposits as Biozone NN5 of Martini (Lower Badenian). Regular presence of *H. waltrans*, which is usually limited to a short stratigraphic interval within nannoplankton Zone NN5, enables attribution of these sediments to the *Helicosphaera waltrans* Horizon (Švábenická 2002).

**Key words:** Badenian, Austria, Molasse Basin, Grund Formation, calcareous nannofossils, NN5 Nannoplankton Zone.

## Introduction

The Grund Formation is characterized by the change between sand and clay-silt sediments. Roetzel & Pervesler (2004) described the geological situation of the study area in detail. The sandy shell layers, with erosion surfaces at the base and graded bedding were interpreted as proximal tempestites (Zuschin et al. 2001), whereas intercalated clay-silt layers present products of quiet water paleoconditions. Biostratigraphic evaluation of the Grund Formation was the subject of investigations by many authors recently and earlier. Švábenická & Čtyroká (1998, 1999) investigated foraminiferal and nannoplankton contents of the Karpatian and Lower Badenian sediments in the Alpine-Carpathian Foredeep. They subdivided the equivalent deposits of the Grund Formation in a lower part (with *Helicosphaera waltrans*, *H. walbersdorfensis* and scarce *H. ampliaperta*) and an upper part (with relatively common *H. waltrans*). Calcareous nannofossil assemblages from fine clastic sediments from the excavation on the type locality Grund (organized by the Institute of Paleontology, Vienna) and from Grund-Windmühlberg were studied recently to clarify the stratigraphic position of the Grund Formation. Our attention was focused especially on the occurrence of the nannofossil species *Helicosphaera waltrans* and the importance of its stratigraphic range.

## Methods

Smear slides were analysed using a light microscope (1000× magnification) at normal and crossed nicols. Suspension slides were prepared by two different laboratory procedures. Before preparation, samples W1–W4 and sediments from section B were treated by ultrasound in distilled water for a few seconds. Suspension slides for sections F, G, and H were prepared using a decantation method (as mentioned in Švábenická 2002a).

Quantitative data were obtained under the microscope by counting specimens per view field. The term "Miocene *s.s.* (= *sensu stricto*) taxa" is used for nannofossil species the first occurrence of which is known in the Miocene. Long-ranging species that occur first in the Paleogene and extend to the Miocene are expressed under the term "taxa with their last occurrence mentioned during the Miocene". These nannofossils may belong to the autochthonous assemblage or they can be reworked from older strata.

For biostratigraphic determination, the standard NN zones of Martini (1971), Mediterranean nannofossil zones MNN of Fornaciari et al. (1996), and correlations of Young (1998) were applied.

Abundances of the calcareous nannoplankton are recorded in Table 1a,b for the section B and samples W1–W4, and Table 2 for the sections F, G and H (A = abundant: dominant species with more than 50 % of an assemblage; C = common: 10–50 %; F = few: <10 % of an assemblage; R = rare: only a few specimens were found; ? = questionable species; f = specimens mostly in fragments; B = barren: no specimen was found in a sample).

The preservation of the calcareous nannoplankton assemblage is characterized by the following terms: G = good, no evidence of etching or overgrowth; M = moderate, etching or overgrowth is apparent; P = poor, significant etching or overgrowth.

## Results

The material for nannofossil studies originates from silts and fine sands of the Grund locality, containing sections: B, F,

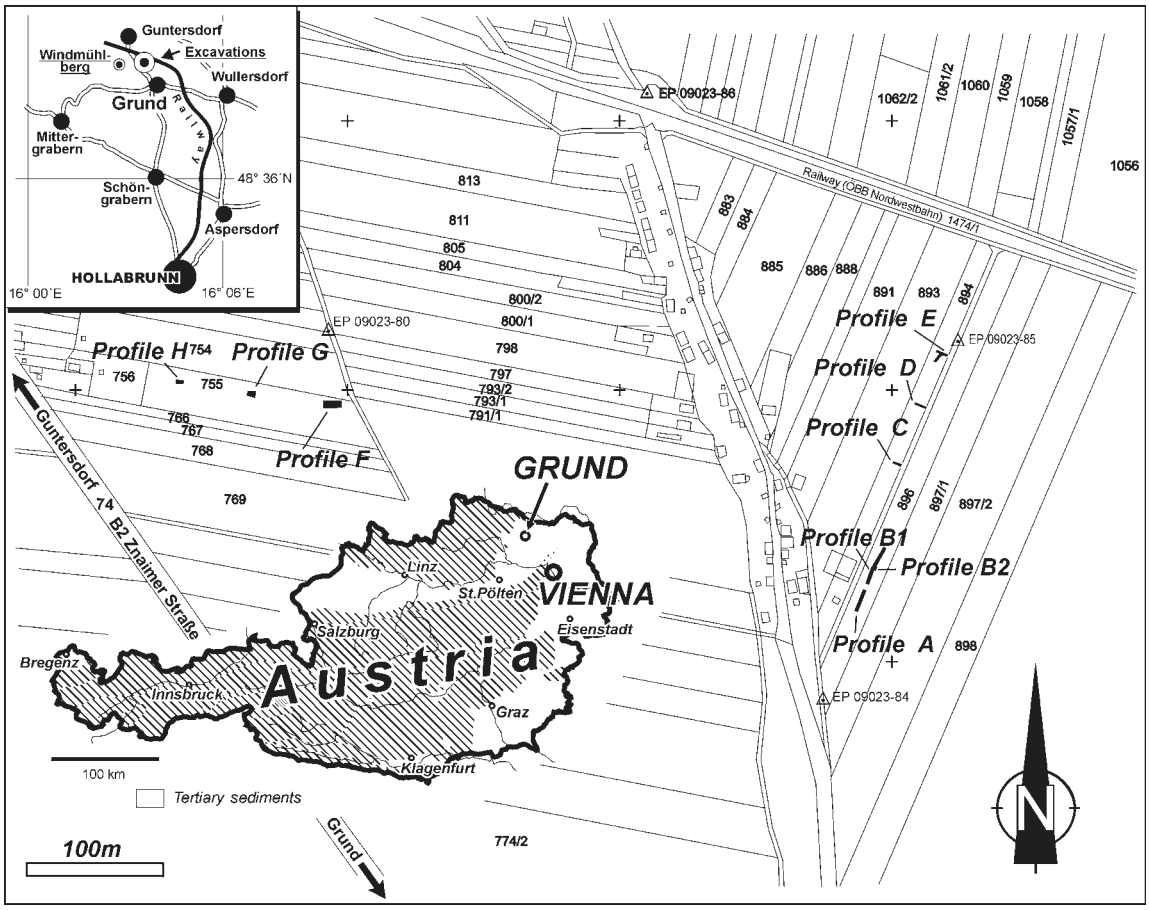


**Fig. 1.** Excavations at the type locality of the Grund Formation, Grund and Grund-Windmühlberg wine cellars (inserted map).

G, and H (Fig. 1). Samples W1–W4 were collected in old wine cellars, which are situated at Windmühlberg, approximately 900 m westwards of the excavation sections F, G and H.

Calcareous nannofossils are generally abundant and well preserved in the lower part of section B (samples GRU-B2-1a to GRU-B2-6) (Fig. 2). These samples are characterized by common to abundant *Reticulofenestra minuta.* The accompanying assemblage includes *Coccolithus pelagicus* and regularly found but rare *Helicosphaera carteri, H. walbersdorfensis, H. waltrans, H. vedderi, Reticulofenestra haqii*, and *Syracosphaera pulchra. Coronocyclus nitescens, Cyclicargolithus floridanus, Helicosphaera euphratis, H. granulata, H. mediterranea, Holodiscolithus macroporus, Pontosphaera multipora, Reticulofenestra gelida, R. pseudoumbilica, Rhabdosphaera sicca,* and *Sphenolithus moriformis* occur irregularly (Table 1a).

Calcareous nannofossil assemblages from the upper part of the Grund B section (samples GRU-B2-7 and GRU-B2-8) are generally scarce and poorly preserved. Only a few specimens of *Coccolithus pelagicus, Reticulofenestra minuta* and *Syracosphaera pulchra* could be identified.

Investigation of samples from Windmühlberg (W1–W4) yielded abundant, well preserved nannoplankton assemblages, similar to the lower part of the section B. Moreover, *Discoaster variabilis* and *D. challengeri* occur rarely in samples W3 and W4 (Table 1b).

Autochthonous assemblages were complemented by reworked nannofossils both in localities of Grund, section B and Grund-Windmühlberg. The allochthonous component forms up to 30 % of the entire assemblages in section B and in samples W1–W4. It is represented by Paleogene (*Reticulofenestra stavensis, R. bisecta, Cribrocentrum reticulatum, Chiasmolithus solitus, Zygrhablithus bijugatus, Discoaster multiradiatus* etc.) and Cretaceous taxa (*Cribrosphaerella ehrenbergii, Retacapsa* sp., *Watznaueria barnesae, W. manivitae* etc.).

Sediments from sections F and G provided assemblages (1–20 specimens per view field of the microscope at 1000×) of medium-well or poorly preserved calcareous nannofossils. Only scarce nannofossils were found in sediments of section H with the exception of the sample CI-H-1 taken from the excavation bottom. The overlying sediments either provided scarce specimens mostly reworked from older strata or they were barren of nannofossils.

The nannofossil assemblages of section F, G, and H are characterized by abundance of *Coccolithus pelagicus* and high numbers of reworked specimens. Miocene associations are formed by relatively common *Helicosphaera carteri* and *H. waltrans*. They are accompanied by small reticulofenestrids (*R. minuta, R. haqii, R. pseudoumbilica* < 5 μm), rare occurrences of *Discoaster variabilis, Syracosphaera* sp., *Pontosphaera multipora, Umbilicosphaera rotula,* and by the irregular occurrence of *Helicosphaera walbersdorfensis*.

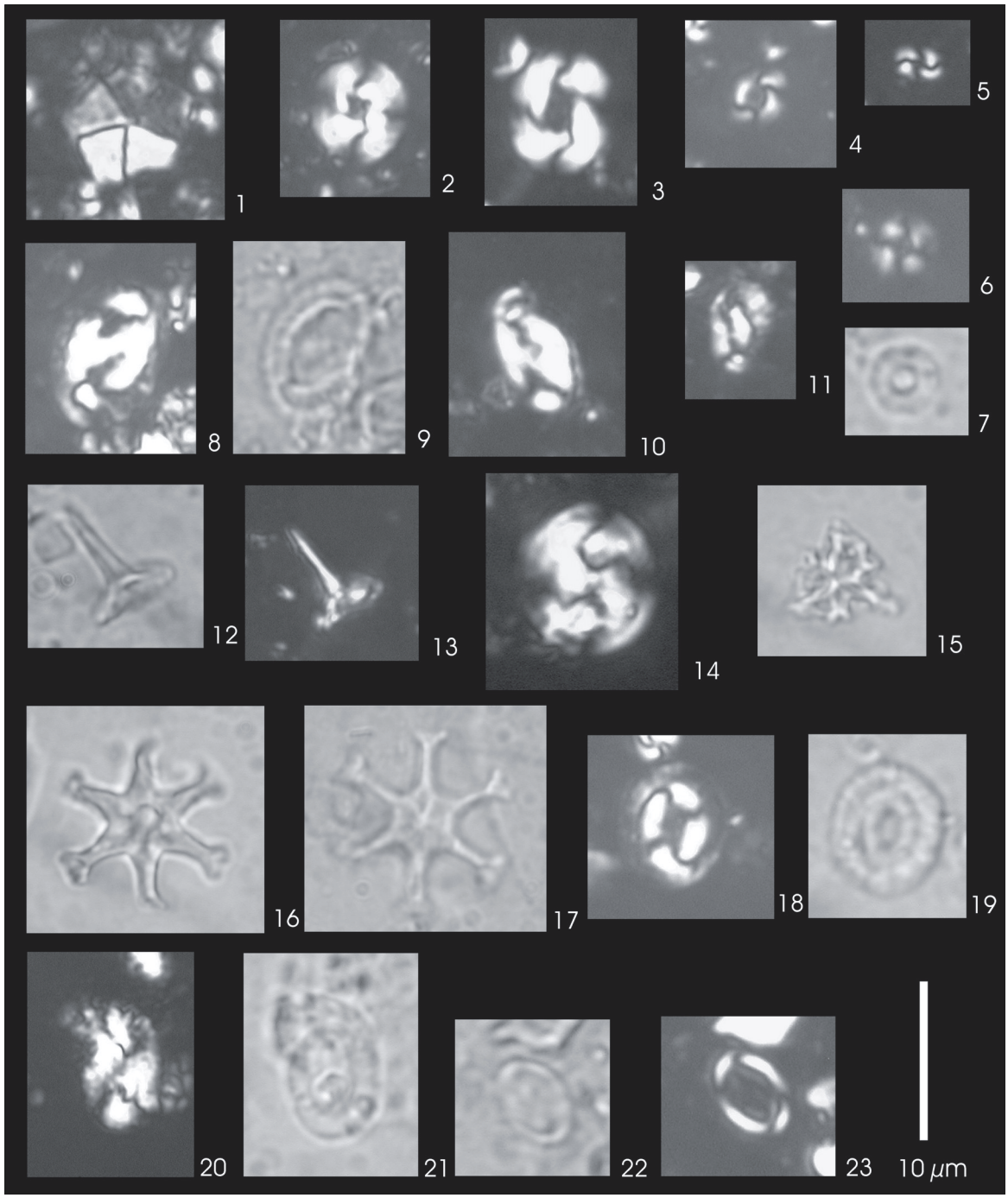


**Fig. 2.** Light microscope photographs of calcareous nannofossils from Grund excavations and Grund–Windmühlberg. **1** — *Braarudosphaera bigelowii* (Gran et Braarud, 1935) Deflandre, 1947; Sample B-2-1b, crossed polarized light. **2** — *Reticulofenestra gelida* (Geitzenauer, 1972) Backman, 1978; Sample B-2-1b, crossed polarized light. **3** — *Reticulofenestra pseudoumbilica* (Gartner, 1967) Gartner 1969; Sample B-2-1b, crossed polarized light. **4** — *Reticulofenestra haqii* Backman, 1978; Sample B-2-1b, crossed polarized light. **5** — *Reticulofenestra minuta* Roth, 1970; Sample B-2-1b, crossed polarized light. **6, 7** — *Umbilicosphaera jafari* Müller, 1974; Sample B-2-1b. 6. crossed polarized light; 7. parallel light. **8–10** — *Helicosphaera waltrans* Theodoridis, 1984; 8. Sample B-2-1b, crossed polarized light. 9. Sample B-2-1b, parallel light. 10. Sample W-3, crossed polarized light. **11**— *Helicosphaera walbersdorfensis* Müller 1974; Sample B-2-1b, crossed polarized light. **12, 13** — *Rhabdosphaera sicca* Stradner, 1963; Sample B-2-1b; 12. parallel light; 13. crossed polarized light. **14** — *Reticulofenestra bisecta* (Hay et al., 1966) Roth, 1970; reworked specimen, sample B-2-1b, crossed polarized light. **15** — *Lithostromation perdurum* Deflandre, 1942; Sample B-2-1b, parallel light. **16** — *Discoaster variabilis* Martini et Bramlette, 1963; Sample W-3, parallel light. **17** — *Discoaster challengeri* Bramlette et Riedel, 1954; Sample W-4, parallel light. **18, 19** — *Coccolithus pelagicus* (Wallich, 1871) Schiller, 1930; Sample W-3. 18. crossed polarized light; 19. parallel light. **20, 21** — *Helicosphaera carteri* (Wallich, 1877) Kamptner, 1954; Sample B-2-1b. 20. crossed polarized light; 21. parallel light. **22, 23** — *Syracosphaera pulchra* Lohmann, 1902; Sample B-2-1b. 22. parallel light; 23. crossed polarized light.

**Table 1: a** — Abundance of calcareous nannofossils at the type locality of the Grund Formation — section B. **b** — Abundance of calcareous nannofossils in samples from Windmühlberg.

a

| Samples | preservation | abundance | *Braarudosphaera bigelowii* | *Calcidiscus leproporus* | *Calcidiscus tropicus* | *Coccolithus miopelagicus* | *C. pelagicus* | *Coronocyclus nitescens* | *Cyclicargolithus floridanus* | *Discoaster* sp. | *Geminilithella rotula* | *Helicosphaera carteri* | *H. euphratis* | *H. granulata* | *H. mediterranea* | *H. walbersdorfensis* | *H. waltrans* | *H. vedderi* | *Holodiscolithus macroporus* | *Lithostromation perdurum* | *Pontosphaera discopora* | *P. multipora* | *Pontosphaera* sp. | *Reticulofenestra gelida* | *R. haqii* | *R. minuta* | *Reticulofenestra pseudoumbilica* | *Reticulofenestra* sp. | *Rhabdosphaera sicca* | *Scyphosphaera* sp. | *Sphenolithus moriformis* | *Sphenolithus* sp. | *Syracosphaera histrica* | *Syracosphaera pulchra* | *Thoracosphaera heimii* | *Thoracosphaera* sp. | *Triquetrorhabdulus* sp. | *Umbilicosphaera jafari* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GRU-B2-8 | P | R | | | | | x | | | | | | | | | | | | | | | | | | | x | | | | | | | x | | | | |
| GRU-B2-7 | P | R | | | | | x | | | | | | | | | | | | | | | | | | | x | | | | | | | | | | | |
| GRU-B2-6 | M | F | | | | | f | | | | | r | | | | | | r | | | | | | | | f | | | | r | | | r | | | | r |
| GRU-B2-5 | G | C | | | | r | f | r | | r | | r | r | r | | r | r | r | | | | r | | r | r | c | r | | | | | | r | | | r | |
| GRU-B2-4 | G | F | | | | | f | | | | | r | | | | r | r | | | | | | | r | r | c | r | | | r | | | r | | | | |
| GRU-B2-3 | G | F | | r | | | f | | | | | r | | | | | r | r | | | r | | | | r | c | | | | r | | r | | r | | | | |
| GRU-B2-2 | G | C | | | | r | f | | r | | | r | | | | r | r | r | | | | r | r | | r | a | r | | | | | | r | | | | r |
| GRU-B2-1c | G | A | | | | r | f | r | | | | r | | r | r | r | | r | r | | | r | r | r | | c | | | r | | | | r | r | | | r |
| GRU-B2-1b | G | A | r | | r | | r | r | r | | r | r | | | | r | r | r | r | r | | r | r | r | r | a | r | r | r | | r | | r | r | | | r |
| GRU-B2-1a | G | A | | | | r | r/f | r | r | | | r | r | | | r | r | r | r | | r | r | | r | r | a | | | r | | r | | r | | r | r | r |

b

| Sample | preservation | abundance | *Calcidiscus tropicus* | *Coccolithus miopelagicus* | *C. pelagicus* | *Coronocyclus nitescens* | *Cyclicargolithus floridanus* | *Discoaster challengeri* | *Discoaster variabilis* | *Discoaster* sp. | *Helicosphaera carteri* | *H. walbersdorfensis* | *H. waltrans* | *H. vedderi* | *Holodiscolithus macroporus* | *Lithostromation perdurum* | *P. multipora* | *Reticulofenestra gelida* | *R. haqii* | *R. minuta* | *Reticulofenestra pseudoumbilica* | *Reticulofenestra* sp. | *Rhabdosphaera procera* | *Rhabdosphaera sicca* | *Syracosphaera histrica* | *Syracosphaera pulchra* | *Thoracosphaera saxea* | *Thoracosphaera* sp. | *Triquetrorhabdulus* sp. | *Umbilicosphaera jafari* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W4 | G | A | | | r | | r | r | r | | r | | | | | | | r | r | a | | | | | | r | | | | | |
| W3 | G | A | | | c | r | r | | r | r | | r | r | r | r | | | r | | a | r | | r | r | r | r | | r | r | | r |
| W2 | G | A | r | r | r | | r | | | r | r | r | r | r | | r | | r | f | a | r | r | | | | r | r | | | | r |
| W1 | G | A | | | r | | r | | | r | r | r | r | r | | | r | r | r | a | | r | | | r | r | | | | | r |

Scarce specimens of *Helicosphaera mediterranea, H. euphratis*, *H. granulata,* and reworked *Helicosphaera ampliaperta* were recorded (Table 2).

Miocene *s.s.* specimens from section F, G and H represent about 30 % of the oryctocoenoses, and are complemented by numerous reworked nannofossils from the Upper Cretaceous and Paleogene strata.

The absence or scarcity of discoasterids in investigated sediments, which indicate open ocean conditions, confirms shallow paleoenvironment documented by other fossil groups. Relatively high number of reworked specimens especially in samples from sandy beds does not allow satisfactory paleoecological interpretation.

## Discussion

Theodoridis (1984) highlighted the short phase of the *Helicosphaera waltrans* occurrence and correlated it with Zone NN5 (*sensu* Martini 1971). In the Mediterranean, *H. waltrans* is restricted to the short interval that spans the upper part of Subzone MNN5a and the lower part of MNN5b attributed to the Langhian (Fornaciari et al. 1996), which corresponds to the middle part of Zone NN5 (Young 1998). There is no doubt that *H. waltrans* also forms a significant and short horizon in the Alpine-Carpathian Foredeep; nevertheless, its precise stratigraphic correlation is still under discussion. The rare presence of *Helicosphaera ampliaperta* may be explained here as a reworked component in oryctocoenoses from the older strata. Zone NN5 is correlated with the Lower Badenian of the regional stratigraphic classification of the Central Paratethys (Rögl 1998). The presence of *Helicosphaera waltrans* and the scarcity of reworked *H. ampliaperta* in samples from section B, F, G and H as well as in four samples from Windmühlberg (W1–W4) indicate nannoplankton Zone NN5 although the stratigraphically very important species *Sphenolithus heteromorphus* is absent in all samples.

**Table 2:** Abundance of calcareous nannofossils at the type locality of the Grund Formation: Profiles F, G and H.

| | GRUND | Horizon Helicosphaera waltrans | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | sample No. | CI-F-1 | CI-F-2 | CI-F-3 | CI-F-4 | CI-F-5 | CI-F-6 | CI-G-1 | CI-G-2 | CI-G-3 | CI-G-4 | CI-G-5 | CI-G-6 | CI-H-1 | CI-H-2 | CI-H-3 | CI-H-4 | CI-H-5 |
| | sample abundance | C | C | R | R | V | R | C | C | C | C | B | R | C | B | B | R | B |
| | nannofossil preservation | M | M | P | P | M | P | P | M | P | M | | P | M | | | P | |
| Miocene s.s. nannofossil taxa | *Coccolithus miopelagicus* | R | | | | | | R | | | | | | R | | | | |
| | *Discoaster druggi* | | | | | ? | | | ? | | | | | | | | | |
| | *Discoaster exilis* | | | | | | | | R | | | | | | | | | |
| | *Discoaster variabilis* | R | R | R | | R | | | | R | R | | | | | | | |
| | *Helicosphaera ampliaperta* | | | R | | R | | | | | | | | | | | | |
| | *Helicosphaera carteri* | C | C | C | | C | R | F | C | C | | | | C | | | F | |
| | *Helicosphaera mediterranea* | | | | | | | R | | | | | | | | | | |
| | *Helicosphaera scissura* | R | R | | | | | R | R | | | | | | | | | |
| | *H. scissura-ampliaperta* | | | | | | | | | R | | | | | | | | |
| | *Helicosphaera walbersdorfensis* | | F | | | R | | | R | | F | | | R | | | | |
| | *Helicosphaera waltrans* | C | C | C | | C | | F | F | C | C | | | C | | | R | |
| | *Reticulofenestra haqii* | F | R | | | R | | | | R | R | | | R | | | | |
| | *Reticulofenestra minuta* | F | F | | | | | | F | F | | | | | | | | |
| | *Reticulofenestra minutula* | | R | | | F | | | | | F | | | R | | | | |
| | *Reticulofenestra pseudoumbilicus* | | | R | | F | | | R | | R | | | | | | | |
| | *Syracosphaera* sp. | | F | | | F | | | R | R | F | | | R | | | | |
| | *Umbilicosphaera rotula* | | R | | | | | | F | R | F | | | R | | | | |
| Taxa their last occurrence is mentioned during the Miocene | *Braarudosphaera bigelowii* | | R | | | | | R | | | | | | | | | R | |
| | *Coccolithus pelagicus* | C | A | C | R | A | F | A | A | C | A | | F | C | | | A | |
| | *Cyclicargolithus floridanus* | C | F | F | R | | | R | F | | F | | | F | | | | |
| | *Dictyococcites daviesii* | | F | | | | | | | | F | | | | | | | |
| | *Discoaster deflandrei* | | | | | | | | | R | | | | | | | | |
| | *Helicosphaera euphratis* | | | | | | | R | | | | | | | | | | |
| | *Pontosphaera discopora* | | | | | | | | | R | | | | | | | | |
| | *Pontosphaera multipora* | F | F | R | f | F | | R | F | | F | | | | | | | |
| | *Rhabdosphaera* sp. (fragments) | | | | | | | | | R | | | | | | | | |
| | *Sphenolithus moriformis* | R | | | | R | | | R | | | | | F | | | | |
| | *Thoracosphaera* sp. | | R | | | F | | | F | | | | | R | | | | |

Therefore the assemblages belong to the upper part of the *Helicosphaera waltrans* Horizon (Švábenická 2002a,b). This horizon, marked by relatively common *H. waltrans* and by the rare presence or absence of *Sphenolithus heteromorphus* was described in the Moravian part of the Carpathian Foredeep, Czech Republic. Švábenická (2000) studied sediments from the Grund Formation and briefly discussed problems of biostratigraphic correlation in the classic Mediterranean area and the Central Paratethys.

Calcareous nannofossil assemblages from the Lower Badenian sediments of the Gaindorf Formation (Mühlbach Beds), which replaces the Grund Formation westwards, are also characterized by the occurrence of *H. waltrans* and scarce *S. heteromorphus* (Ćorić 2003).

According to Ćorić (in Rögl et al. 2002), the upper part of the nannoplankton Zone NN4 is recorded in the lowermost Badenian of the Styrian and Vienna Basins. Study of the calcareous nannoplankton and foraminiferal assemblages from the drill site Roggendorf-1 (Ćorić & Rögl 2004) yielded identical results for the Molasse Basin.

The foraminiferal fauna investigations of sediments from the Grund sections F and G also confirm the Lower Badenian age (Spezzaferri 2004).

Qualitative and quantitative expansion of genus *Helicosphaera*, scarce discoasters and the absence of *Sphenolithus heteromorphus* indicate shallow epicontinental sea (Báldi-Beke 1980).

## Conclusion

The nannofossil assemblages of the excavations at Grund (sections B, F, G, H) and from Grund-Windmühlberg outcrop (W1–W4) are characterized by:

— presence of *Helicosphaera waltrans* (if present, it is relatively common),
— irregular occurrence of *Helicosphaera walbersdorfensis*,
— relative abundance of *Helicosphaera carteri,*
— absence of *Sphenolithus heteromorphus,*
— high numbers of small reticulofenestrids (*Reticulofenstra minuta, R. haqii, R. pseudoumbilica* — forms < 5 μm in diameter),
— scarce occurrence of reworked *Helicosphaera ampliaperta* and *H. mediterranea*,
— rare occurrence of discoasters, and specimens of genera *Umbilicosphaera* and *Pontosphaera*.

This study of nannofossil assemblages indicates that the Grund Formation belongs to nannoplankton Zone NN5 (Martini 1971) and is comparable to the *Helicosphaera waltrans* Horizon (Švábenická 2002a,b).

The character of the nannofossil assemblages, especially higher numbers of helicosphaers, scarce discoasters and absence of *Sphenolithus heteromorphus* indicates shallow epicontinental sea.

**Acknowledgments:** This study was supported by the Austrian Science Fund Project P13743-BIO (Project leader Prof. J. Hohenegger), which was focused on investigations of the paleoecology of the marine Miocene in Austria and by the Grant Agency of the Czech Republic (Grant No. 205/98/0694 "Biostratigraphy and sedimentology of the Lower and Middle Miocene in the Alpine-Carpathian Foredeep, Lower Austria and Moravia", project leader I. Cicha). We thank J. Hohenegger, (University of Vienna), M. Melinte (National Institute of Marine Geology and Geoecology, Bucharest), A. Nagymarosy (Eötvös University, Budapest) and F. Rögl (Museum of Natural History, Vienna) for the review of this paper. For the provision of the samples, discussion and additional information we are grateful to I. Cicha (Geological Survey, Praha), P. Pervesler (University of Vienna), and to R. Roetzel (Geological Survey, Vienna).

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## Appendix

Nannofossil taxa mentioned in this work in alphabetical order of genera epithets:

*Braarudosphaera bigelowii* (Gran et Braarud, 1935) Deflandre, 1947
*Calcidiscus leptoporus* (Murray et Blackman, 1898) Loeblich et Tappan, 1978
*Calcidiscus tropicus* Kamptner, 1956
*Coccolithus miopelagicus* Bukry, 1971
*Coccolithus pelagicus* (Wallich, 1871) Schiller, 1930
*Coronocyclus nitescens* (Kamptner, 1963) Bramlette et Wilcoxon, 1967
*Cyclicargolithus floridanus* (Roth et Hay, 1967) Bukry, 1971
*Dictyococcites daviesii* (Haq, 1968) Perch-Nielsen, 1971
*Discoaster challengeri* Bramlette et Riedel, 1954
*Discoaster deflandrei* Bramlette et Riedel, 1954
*Discoaster druggi* Bramlette et Wilcoxon, 1967
*Discoaster exilis* Martini et Bramlette, 1963
*Discoaster variabilis* Martini et Bramlette, 1963
*Discoaster* sp.
*Geminilithella rotula* Kamptner, 1956
*Helicosphaera ampliaperta* Bramlette et Wilcoxon, 1967
*Helicosphaera carteri* (Wallich, 1877) Kamptner, 1954
*Helicosphaera euphratis* Haq, 1966
*Helicosphaera granulata* (Bukry et Percival, 1971) Jafar et Martini, 1975
*Helicosphaera mediterranea* Müller, 1981
*Helicosphaera scissura* Miller, 1981
*Helicosphaera vedderi* Bukry, 1981
*Helicosphaera walbersdorfensis* Müller, 1974
*Helicosphaera waltrans* Theodoridis, 1984

*Holodiscolithus macroporus* (Deflandre, 1954) Roth, 1970
*Lithostromation perdurum* Deflandre, 1942
*Pontosphaera discopora* Schiller, 1925
*Pontosphaera multipora* (Kamptner, 1948) Roth, 1970
*Pontosphaera* sp.
*Reticulofenestra gelida* (Geitzenauer, 1972) Backman (1978)
*Reticulofenestra haqii* Backman, 1978
*Reticulofenestra minuta* Roth, 1970
*Reticulofenestra minutula* (Gartner, 1967) Haq et Berggren, 1978
*Reticulofenestra pseudoumbilica* (Gartner, 1967) Gartner, 1969
*Reticulofenestra* sp.
*Rhabdosphaera procera* Martini, 1969
*Rhabdosphaera sicca* Stradner, 1963
*Rhabdosphaera* sp.
*Scyphosphaera* sp.
*Sphenolithus moriformis* (Brönnimann et Stradner, 1960) Bramlette et Wilcoxon, 1967
*Sphenolithus* sp.
*Syracosphaera histrica* Kamptner, 1941
*Syracosphaera pulchra* Lohmann, 1902
*Syracosphaera* sp.
*Thoracosphaera heimii* (Lohmann, 1919) Kamptner, 1941
*Thoracosphaera* sp.
*Triquetrorhabdulus* sp.
*Umbilicosphaera jafari* Müller, 1974
*Umbilicosphaera rotula* (Kamptner, 1956) Varol, 1982