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Biostratigraphy of Fissure Fillings in the Ernstbrunn Limestone of the Waschberg Zone (Lower Austria)

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2 Text-Figures and 3 Plates

Outer Western Carpathians
Waschberg Zone
Tithonian
Upper Cretaceous
Biostratigraphy
Foraminifera
Calcareous Nannofossils

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Inhalt

Stratigraphie von Spaltenfüllungen im Ernstbrunner Kalk der Waschbergzone (Niederösterreich)

Zusammenfassung

Die biostratigraphische Auswertung von Foraminiferen und Nannofossilien aus mergeligen Spaltenfüllungen im Ernstbrunner Kalk (Oberjura) der Waschberg Zone brachte folgende Ergebnisse: Im Steinbruch Ernstbrunn konnten Sedimente aus dem Tithon, als auch aus der Oberkreide (Santon und Oberes Campan) gefunden werden. Das tithone Alter der Spaltenfüllungen konnte mit einer Nannofloraassoziation, bei der *Watznaueria* dominiert, belegt werden. Santon ist durch *Rucinolithus wissei* und *Orastrum campanensis* des UC11c-UC12 Zonenintervals nachgewiesen. Diese Daten sind auch durch Foraminiferen aus dem Oberen Santon bis Unteren Campan untermauert. Oberes Campan ist durch die Globotruncanita calcarata Zone, bzw. durch UC15c-d^{TP} Zone mittels Nannofossilen nachgewiesen. In der Staatzer Klippe belegen Nannofossilien-Vergesellschaftungen mit *Rucinolithus* spp. und *Reinhardtites anthophorus* die UC11c Subzone des Unteren Santons. Das gemeinsame Auftreten von Nannoplanktonarten hoher und niedriger Breiten deutet auf einen Ablagerungsraum im Übergangsbereich der tethyalen-mediterranen Bioprovinz mit starkem borealen Einfluß hin.

Abstract

Biostratigraphic study (foraminifers and calcareous nannofossils) of marly sediments collected from the dissolution-dilated fractures in the Ernstbrunn Limestone (Upper Jurassic) of the Waschberg Zone provided the following information: In the Ernstbrunn Quarry, both Tithonian

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and Upper Cretaceous (Santonian and Upper Campanian) sediments were found. Tithonian deposits provided nannofossil association dominated by the genus *Watznaueria*. The Santonian is documented by nannofossils with *Rucinolithus wissei* and *Orastrum campanensis* of the UC11c-UC12 zone interval and by foraminifers of the Upper Santonian – Lower Campanian age. The Upper Campanian is confirmed by the Globotruncanita calcarata Zone and nannofossils of the UC15c-d^{TP} Zone. In the Staatz Klippe, nannofossil associations with *Rucinolithus* spp. and *Reinhardtites anthophorus* evidence the UC11c Subzone of the Lower Santonian age. The common occurrence of high- and low-latitude nannoplankton species indicates that the depositional area was situated within the Tethyan/Mediterranean province with a strong influence from the Boreal area.

1. Geological setting

The Waschberg Zone (Text–Fig. 1) represents the southern part of the Waschberg-Ždánice Unit of the Outer Western Carpathians. It is a highly tectonized zone in the north eastern part of Lower Austria and extends from the Waschberg (338 m) near Stockerau in northeastern direction to Southern Moravia. So, the Leiser Berge, the dominant Klippe of Staatz as well as the Mountains of Falkenstein are part of the Waschberg Zone. The zone also includes the mountains around Mikulov (Pavlovské vrchy Hills) N of the Austrian/Czech border. Due to the extension to the Czech Republic the Waschberg Zone is called Waschberg-Ždánice Unit, which expresses in better way its common features. This was made evident by ELIÁŠ et al. (1990, page 44): "The Waschberg Zone (GRILL 1953, 1968) is the only zone where the junction of the Eastern Alps with the Carpathians can be traced on surface. A relationship of the Waschberg Zone with the Ždánice Unit is evident by their lithostratigraphic and facies development."

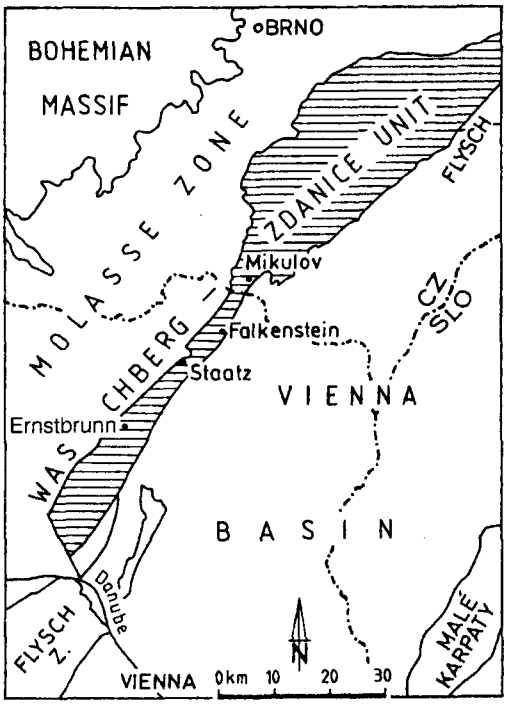
According to STEININGER et al. (1986) the Waschberg Zone is a part of the Molassezone. In detail the authors described it to the "allochthonous Molassezone" which was scraped from its footwall during late Alpine orogenic movements. As a result of this, Waschberg Zone is situated between the Molassezone in the west – where it is overthrust – and the Vienna Basin in the east. In the southern part the Flysch Zone is overthrust upon the Waschberg Zone. These overthrusts can be dated to the Lower Miocene (Karpatian). According to FUCHS (1980) various phases were determined within the period of the Eggenburgian and Karpatian in the Lower Miocene.

The most significant elements of the Waschberg Zone are the different isolated klippen composed of Jurassic sediments (Ernstbrunn Limestone and Klentnice Member). The Ernstbrunn Limestone represents a part of shallow Upper Jurassic carbonate platform fringing the southeastern part of the Bohemian Massif. After the sedimentation stopped in the Upper Jurassic-Lower Cretaceous (ELIÁŠ,1992) intensive karstification took place until a new transgression of the Upper Cretaceous Klement and Pálava formations (STRÁNÍK et al., 1996; SUMMESBERGER et al., 1999). As a result, Cretaceous and even Tertiary sediments have been known from fissures in the Ernstbrunn Limestone since the 19th century.

2. Fissure fillings in the Ernstbrunn Limestone of Lower Austria – an overview

BACHMAYER (1964) described a fissure filling (width 5.6 m) of Quaternary age with redeposited nannoflora (determined by E. KAMPTNER) from the Cretaceous and Tertiary, with some molluscs indicating the loess environment of Staatz.

As a result of an UNESCO-Course held at the Geological Survey of Austria, AL-SHAIBANI (1971) described Upper Cretaceous Foraminifera from "an old Quarry in Dörfles" (from which of the five quarries in Dörfles the material came is not clear). He presented a list with the following taxa indicating Maastrichtian age: *Globotruncana gansseri* BOLLI (= *Gansserina gansseri*), *Bolivinoides draco draco* MARSSON etc. Nevertheless, the presence of species such as *Reussella szajnochae* (GRYZBOWSKI) and *Globotruncana arca* (CUSHMAN) indicate rather Lower Maastrichtian age of sediments from Dörfles.



Text-Fig. 1.
Location of working area in Lower Austria.

HOFMANN (1990) described two fissures with Tertiary sediments (marls of different ages) in the Dörfles region – abandoned quarries of Dörfles III and V. In the northwestern part of the Dörfles III quarry R. BRAUNSTEIN (in: HOFMANN, 1990, Fig. 9) determined rich, moderately preserved nannoflora with *Cruciplacolithus tenuis* and *Chiasmolithus danicus (=Sullivania danica)* of the Lower Paleocene age. In the nearby quarry, Dörfles V, (see Fig. 12 in: HOFMANN, 1990), an equally rich but poorly preserved floral association with *Isthmolithus recurvus* and *Dictyococcites bisectus* of the Upper Eocene age was found.

3. Description of the localities

3.1. Ernstbrunn Quarry

The quarry Ernstbrunn, which is known as "Kalkwerk II" or "Werk II" (BACHMAYER, 1940) is owned by the "Ernstbrunner Kalktechnik – Kalkgewerkschaft in Ernstbrunn Ges.m.b.H". The white limestone is used in the industry (BULLINGER, 1997). Five quarry levels are worked at present. At level 4

and 5 an appoximately 2 m intercalation of black (sample No. A/1998: very dark - grey to black claystone with silty admixture) to greenish, soft marly sediments with blocks of the Ernstbrunn Limestone striking from south to north dipping at 70° to 80° is found. This feature was documented by SAUER et al. (1992) in Figures 99, 103 and 104.

3.2. Staatz Klippe

A thin (approx. 50 cm) steeply inclined fissure of greenish marls and claystones (sample No. 3R/98) with breccia of Ernstbrunn Limestone within the Ernstbrunn Limestone is exposed in the middle part of northern wall in the abandoned quarry of Staatz, which is used as an open air theatre now (Text–Fig. 2).

In addition, some samples (3/1994, 1R/1998) were taken in the northern part where rock (limestones) is stabilized by shotcrete.

A large fissure with brownish marls and breccias of limestones is located in its southern part. Because of the large dimension, this could correspond with the fissure described by BACHMAYER (1964).

4. Material and Methods

Material was collected within the framework of the bilateral cooperation between the Czech and Austrian Geological surveys.

Samples for foraminiferal study were disintegrated at the laboratory of the Geological Survey in Vienna using standard washing method. Foraminifers were separated under binocular microscope and photographs of species were taken using scanning electron microscope in the Laboratory of Czech Geological Survey in Prague. Planktonic zonation of ROBASZYNSKI & CARON (1995) was used for correlation of Cretaceous sediments.

Samples for nannofossil research were processed in the Laboratory of Czech Geological Survey, Prague. Smear slides were prepared using standard method of decantation, samples were inspected under light microscope Nikon at 1,000x magnification. Cretaceous biostratigraphic data were correlated with the UC zones sensu BURNETT (1998). Data concerning province appurtenance of Cretaceous nannofossil species are interpreted mainly according to WIND (1979), WATKINS (1992), WATKINS et al. (1996) and BURNETT (1998).

5. Results

Samples were collected from marly sediments that were available in narrow dissolution fractures in Ernstbrunn Limestone of localities of Ernstbrunn, Staatz, Südmährenkreuz and Falkenstein. Sediments of Ernstbrunn Quarry provided both foraminifers and nannofossils, Staatz Klippe yielded only calcareous nannofossils and Falkenstein and Südmährenkreuz were free of both foraminifers and calcareous nannofossils.

5.1. Ernstbrunn Quarry

5.1.1. Foraminifera

Upper Cretaceous sediments, which were deposited in fissures in the Ernstbrunn Limestone (Ernstbrunn-Kalkwerk II, samples Nos. 1, 1A, 3, 4 and 5) contained foraminiferal assemblages with low diversity of species but with relatively well-preserved foraminiferal tests.

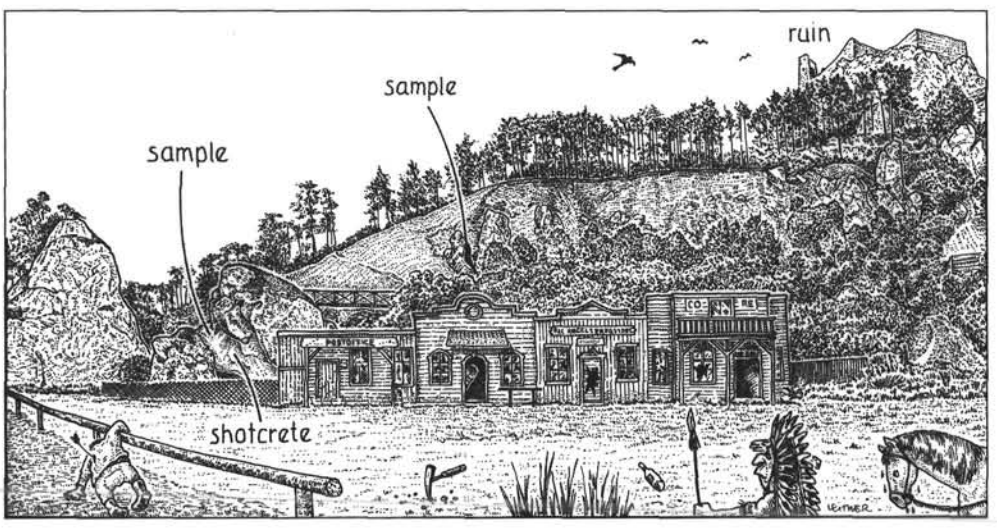
Ernstbrunn-Kalkwerk II, sample No. 1A:

Planktonic species were more abundant in comparison with other samples from this locality. Benthos was represented by important species such as *Bolivina incrassata* REUSS, *Gavelinella monterelensis* (MARIE), *G. stelligera* (MARIE), *G. pertusa* (MARSSON), *G. clementiana costata* (MARIE), *Bolivinoides delicatus* CUSHMAN, *B. decoratus* (JONES), *B. granulatus* HOFKER, *Stensioeina pommerana* BROTZEN, *Vaginulina trilobata* (D'ORBIGNY) and *Reussella szajnochae* (GRZYBOWSKI) etc. Especially three species of genus *Bolivinoides* are cosmopolitan in the Campanian sediments (HANZLÍKOVÁ 1972). Among planktonic foraminifers the following taxa dominated in the foraminiferal assemblage: *Globotruncana linneiana* (D'ORBIGNY), *Archaeoglobigerina cretacea* (D'ORBIGNY), *Rugoglobigerina rugosa* (PLUMMER), *Rosita fornicata* (PLUMMER) *Globotruncanita calcarata* CUSHMAN, *Heterohelix striata* (EHRENBERG), *H. navarroensis* LOEBLICH, *Globigerinelloides ultramicra* (SUBBOTINA) and *G. aspera* (EHRENBERG).

The foraminiferal assemblage from Ernstbrunn-Kalkwerk II, sample No. 1A belongs to the Globotruncanita calcarata total range zone sensu ROBASZYNSKI & CARON (1995) of the Upper Campanian age on the basis of the presence of *G. calcarata* CUSHMAN.

Ernstbrunn-Kalkwerk II, samples Nos.1, 3, 4 and 5

The studied samples contained poorly preserved tests of foraminifers (rolled, dissolved, mechanically damaged), fragments of echinodermata and sponges.



Text–Fig. 2.
Position of samples at the abandoned quarry of Staatz.

The foraminiferal assemblages had a similar but not identical character and the age of sediments from these samples is probably Campanian. Planktonic species were not present in high quantities as it was the case in Ernstbrunn-Kalkwerk II, sample No. 1A. Several species found in the foraminiferal assemblage from Ernstbrunn-Kalkwerk II, sample No. IA such as *Gavelinella clementiana costata* (MARIE), *G. monterelensis* (MARIE), *Bolivina incrassata* REUSS, *Bandyella greatvalleyensis* (TRUJILLO), *Rosita fornicata* (PLUMMER) etc. were found in these four samples too.

Nevertheless, stratigraphic important taxa such as *G. calcarata* CUSHMAN and benthic species such as *Reussella szajnochae* (GRZYBOWSKI) and *Stensioeina pommerana* BROTZEN (GASINSKI et al., 1999) were missing. Representatives of the family Nodosariidae *(Frondicularia, Nodosaria)* were more frequent. On the basis of the occurrence of *Arenobulimina d'orbignyi* (REUSS) and *Stensioeina exsculpta* (REUSS) in Ernstbrunn-Kalkwerk II, samples Nos. 1 and 5, an older age (Upper Santonian – Lower Campanian) is supposed for these samples (HANZLÍKOVÁ 1972) than for sample Ernstbrunn-Kalkwerk II, sample No. 1A.

Unfortunately, stratigraphically important planktonic species could not be identified. Hence, it was not possible to define an exact stratigraphic range of these samples.

5.1.2. Calcareous Nannofossils

Samples obtained from marly sediments transgressing the Ernstbrunn Limestone provided the following nannofossil assemblages:

1. Monogeneric association of Tithonian age dominated by *Watznaueria barnesae* and also containing *W. biporta, W. britannica, W. manivitae* and *Cyclagelosphaera margerelii* was found in grey to black claystones with silty admixture (Kalkwerk II, level No. 5, sample No. A/1998).

2. Association with abundant *Watznaueria barnesae* (> 10 %) and relative high numbers of *Rucinolithus wissei, R. hayi, Orastrum campanensis* and *Micula decussata* (1–5 %) which is associated by *Kamptnerius magnificus, Gartnerago obliquum, Reinhardtites anthophorus, Cylindralithus nudus, Grantarhabdus coronadventis, Arkhangelskiella specillata* and others gives evidence for the Lower Santonian, the UC11c – UC12 (lower part) zones interval (Kalkwerk II, level No. 5, sample No. 1). Nannofossil preservation (overgrowth) is very similar to another one observed in the Santonian sediments of the locality of Staatz Klippe.

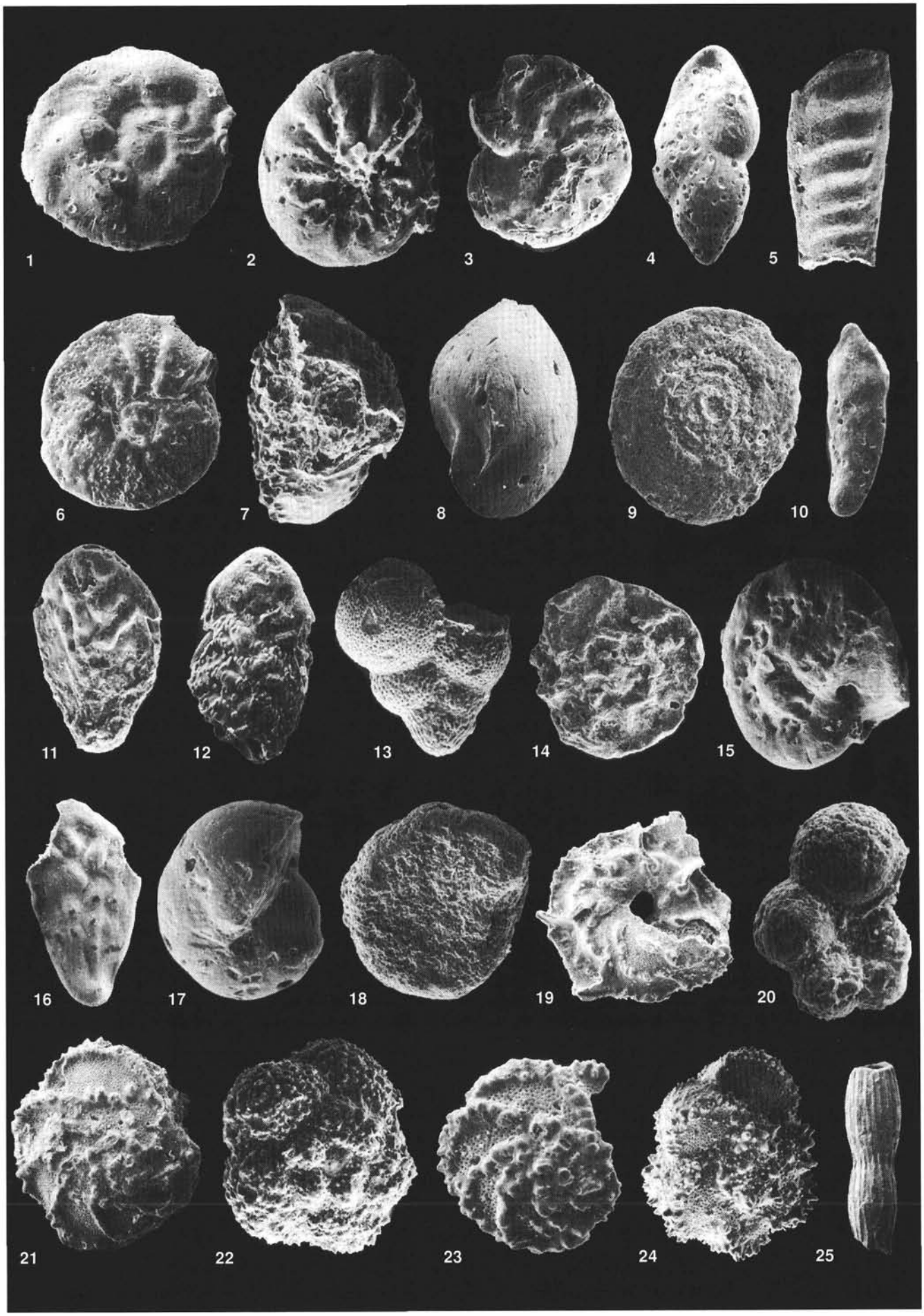
3. Rich and well preserved nannofossils of the Upper Campanian age. Assemblages of high species diversity with *Broinsonia parca constricta, Arkhangelskiella cymbiformis, Staurolithites aachenus, Angulofenestrellithus snyderi, Reinhardtites anthophorus, R. levis, Eiffellithus eximius, Micula swastica, Prediscosphaera grandis, Petrarhabdus copulatus, Markalius inversus* and others were found in the fissure fillings in Kalkwerk II, samples Nos. 1A and 4. High number of low-latitude species, such as *Uniplanarius sissinghii, Ceratolithoides aculeus, C. quasiarcuatus* and *C. sesquipedalis* indicates that the depositional area was situated within the Tethyan/ Mediterranean bioprovince. Nevertheless, common occurrence of high-latitude species, among others *Orastrum campanensis, Biscutum magnum, Prediscosphaera stoveri, Neocrepidolithus watkinsii* or *Monomarginatus quaternarius* gives evidence for strong influence from the Boreal bioprovince. By virtue of the common occurrence of high- and low-latitude species, both Boreal and Tethyan zonation was used for biostratigraphical correlations: the UC15d^{BP} Zone and UC15c^{TP} Zone, respectively, which points to the lower part of Upper Campanian. The above mentioned nannofossil association is similar in its character to those of the same age from the type locality of the Pálava Formation, Ždánice Unit, Outer Western Carpathians (ŠVÁBENICKÁ in STRÁNÍK et al., 1996). Furthermore, the assemblage of Kalkwerk II, sample No. 3 yielded species *Uniplanarius trifidus* which gives evidence for the younger UC15d^{TP} Zone within the lower part of Upper Campanian.

The occurrence of species *Petrarhabdus copulatus*, which is only rarely mentioned from the northern hemisphere, was reported by ŠVÁBENICKÁ (1998). This species was observed in low numbers in the Outer Western Carpathians, forming characteristic component of assemblages where mixing of low- and high-latitude nannofossils is evident. Here, it can be even used for biostratigraphic conclusions in the Upper Campanian.

4. Finally, intercalations of grey-green claystones (Kalkwerk II, level No. 5, sample No.B/1998) which were found

Plate 1: Foraminifers from Ernstbrunn

Fig. 1: *Gavelinella monterelensis* (MARIE); dorsal view, Ernstbrunn-Kalkwerk II, sample No. 1A, x60.
Figs. 2, 3: *Gavelinella stelligera* (MARIE); 2 – ventral view, 3 – dorsal view, Ernstbrunn-Kalkwerk II, sample No. IA, x120.
Fig. 4: *Bandyella greatvalleyensis* (TRUJILLO); sample Ernstbrunn-Kalkwerk II, sample No. 1A, x80.
Fig. 5: *Vaginulina trilobata* (D'ORBIGNY); Ernstbrunn-Kalkwerk II, sample No. 1A, x40.
Fig. 6: *Gavelinopsis bembix* (MARSSON); Ernstbrunn-Kalkwerk II, sample No. 1A, x70.
Fig. 7: *Stensioeina pommerana* BROTZEN; lateral view, Ernstbrunn-Kalkwerk II, sample No. 1A, x120.
Fig. 8: *Astacolus cretaceus* (CUSHMANN); Ernstbrunn-Kalkwerk II, sample No. 1A, x90.
Fig. 9: *Patelina subcretacea* CUSHMANN-ALEXANDER; Ernstbrunn-Kalkwerk II, sample No. 5, x120.
Fig. 10: *Bolivina incrassata* REUSS; Ernstbrunn-Kalkwerk II, sample No. 3, x70.
Fig. 11: *Bolivinoides delicatulus* CUSHMANN; Ernstbrunn-Kalkwerk II, sample No. 1A, x120.
Fig. 12: *Bolivinoides granulatus* HOFKER; Ernstbrunn-Kalkwerk II, sample No. 1A, x110.
Fig. 13: *Heterohelix striata* (EHRENBERG); Ernstbrunn-Kalkwerk II, sample No. 1A, x110.
Fig. 14: *Stensioeina exsculpta* (REUSS); Ernstbrunn-Kalkwerk II, sample No.1, x120.
Fig. 15: *Gavelinella clementiana costata* (MARIE); Ernstbrunn-Kalkwerk II, sample No. 4, x100.
Fig. 16: *Bolivinoides decoratus* (JONES); Ernstbrunn-Kalkwerk II, sample No. 1A, x120.
Fig. 17: *Pullenia cretacea* CUSHMANN; Ernstbrunn-Kalkwerk II, sample No. 4, x170.
Fig. 18: *Gavelinella thalmanni* (BROTZEN); Ernstbrunn-Kalkwerk II, sample No. 5, x140.
Fig. 19: *Globotruncanita calcarata* CUSHMANN; Ernstbrunn-Kalkwerk II, sample No. 1A, x100.
Fig. 20: *Globigerinelloides prairiehillensis* PESSAGNO; Ernstbrunn-Kalkwerk II, sample No. 5, x100.
Fig. 21: *Globotruncanita subspinosa* (PESSAGNO); Ernstbrunn-Kalkwerk II, sample No. 1A, x100.
Fig. 22: *Archaeoglobigerina cretacea* (D'ORBIGNY); Ernstbrunn-Kalkwerk II, sample No. 1A, x100.
Fig. 23: *Rosita fornicata* (PLUMMER); Ernstbrunn-Kalkwerk II, sample No. 4., x120.
Fig. 24: *Globotruncana linneiana* (D'ORBIGNY); Ernstbrunn-Kalkwerk II, sample No. 1A, x120.
Fig. 25: *Nodosaria* sp.; Ernstbrunn-Kalkwerk II, sample No. 4, x60.
Microphotographs by Ananda Gabašová, Laboratory of the Czech Geological Survey.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nearby sample No. A/1998 did not provide any calcareous nannofossils.

Species *Biantholithus sparsus* was recorded as an accessory in Kalkwerk II, sample No. 1A (see Plate 3, Figs. 37, 38). The presence of *B. sparsus* in an assemblage which otherwise is of the Upper Campanian age and where no contamination by the Upper Maastrichtian or Tertiary nannofossils was observed remains a mystery. *B. sparsus* is usually supposed to be a marker species for the base of the Tertiary. Even though this species was observed in the uppermost Maastrichtian sediments of the Outer Western Carpathians (ŠVÁBENICKÁ in BUBÍK et al., 1999 and SUMMESBERGER et al., 1999), no indications of its occurrence are known from stratigraphically older sediments by now.

5.2. Staatz Klippe

5.2.1. Calcareous Nannofossils

Samples provided mostly poorly preserved and markedly overgrown and/or dissolved calcareous nannofossils. Nannofossil associations are characterized by the dominance of species *Watznaueria barnesae* and relatively high abundance of *Rucinolithus* spp. and *Gartnerago obliquum* where overgrowth is evident. In contrast, specimens of genera *Prediscosphaera* and *Cribrosphaerella* occur rarely here and show strong dissolution. Furthermore, many nannofossil species which usually form assemblages of Coniacian and Santonian age were not recorded probably due to the specific paleoenvironmental conditions in the depositional area.

Marly sediments obtained from narrow dissolution fractures in the Ernstbrunn Limestone (samples Nos. 3/1994 and 1R/1998) yielded poorly preserved and markedly overgrown nannofossil association represented by species *Watznaueria barnesae* (quantitatively prevailing), *W. biporta, W. britannica, Rucinolithus hayi, R.* wissei, *Gartnerago obliquum,* rare *Kamptnerius magnificus, Reinhardtites anthophorus, Quadrum gartneri, Q. gartneri* ssp. 2 (sensu CRUX, 1982), *Eprolithus floralis, Eiffellithus eximius, E. gorkae, Retacapsa angustiforata, Chiastozygus litterarius, Prediscosphaera cretacea, P. columnata, Manivitella pemmatoidea, Staurolithites* cf. *imbricatus* which gives evidence for the Lower Santonian age, the upper part of the UC11c Subzone. It is interesting that the solution-resistant species *Micula staurophora* was absent from both the above mentioned samples.

Sediments obtained from an about 0.5 m wide fissure (middle part of northern wall) in the limestones provided the following nannofossil associations (sample No. 3R/1998):

1. Markedly overgrown nannofossils of Santonian age where preservation of coccoliths is comparable with that mentioned in sample No. 3/1994): *Micula staurophora, Gartnerago obliquum, Reinhardtites anthophorus, Kamptnerius magnificus, Rucinolithus wissei, R. hayi, Cylindralithus biarcus, C. nudus* and others.

2. Calcareous nannofossils without marked overgrowths evidencing the following stratigraphical horizons:

- Association with species *Arkhangelskiella cymbiformis, Broinsonia parca constricta, Biscutum magnum, Calculites obscurus, Reinhardtites levis, Lithraphidites praequadratus* evidencing the Upper Campanian.
- Association with *Markalius apertus, M. astroporus, Cruciplacolithus primus, C. tenuis* and *Biantolithus hughesii* evidencing the Lower Danian.
- Association with *Helicosphaera carteri, Pontosphaera multipora, Reticulofenestra coenura, R. hillae, Dictyococcites bisectus, Coccolithus pelagicus, C. formosus* etc. evidencing the Oligocene – Lower Miocene age.

Although the above mentioned species form a negligible part of the nannofossil association, their presence needs further discussion: younger nannofossils here indicate either the Miocene age of sediments or the contamination of Cretaceous sediments by younger ones caused e. g. by solifluction. The Miocene age can be supported by the youngest species found here: *Helicosphaera carteri.* High proportion (over 90 %) of Upper Cretaceous reworked nannofossils is a typical phenomenon of the Miocene thanatocoenoses in the Alpine-Carpathian Foredeep (ŠVÁBENICKÁ & ČTYROKÁ, 1998). This observation is similar to BACHMAYER (1964) who described Cretaceous and Tertiary nannofossils from fissure filling which otherwise are Quaternary.

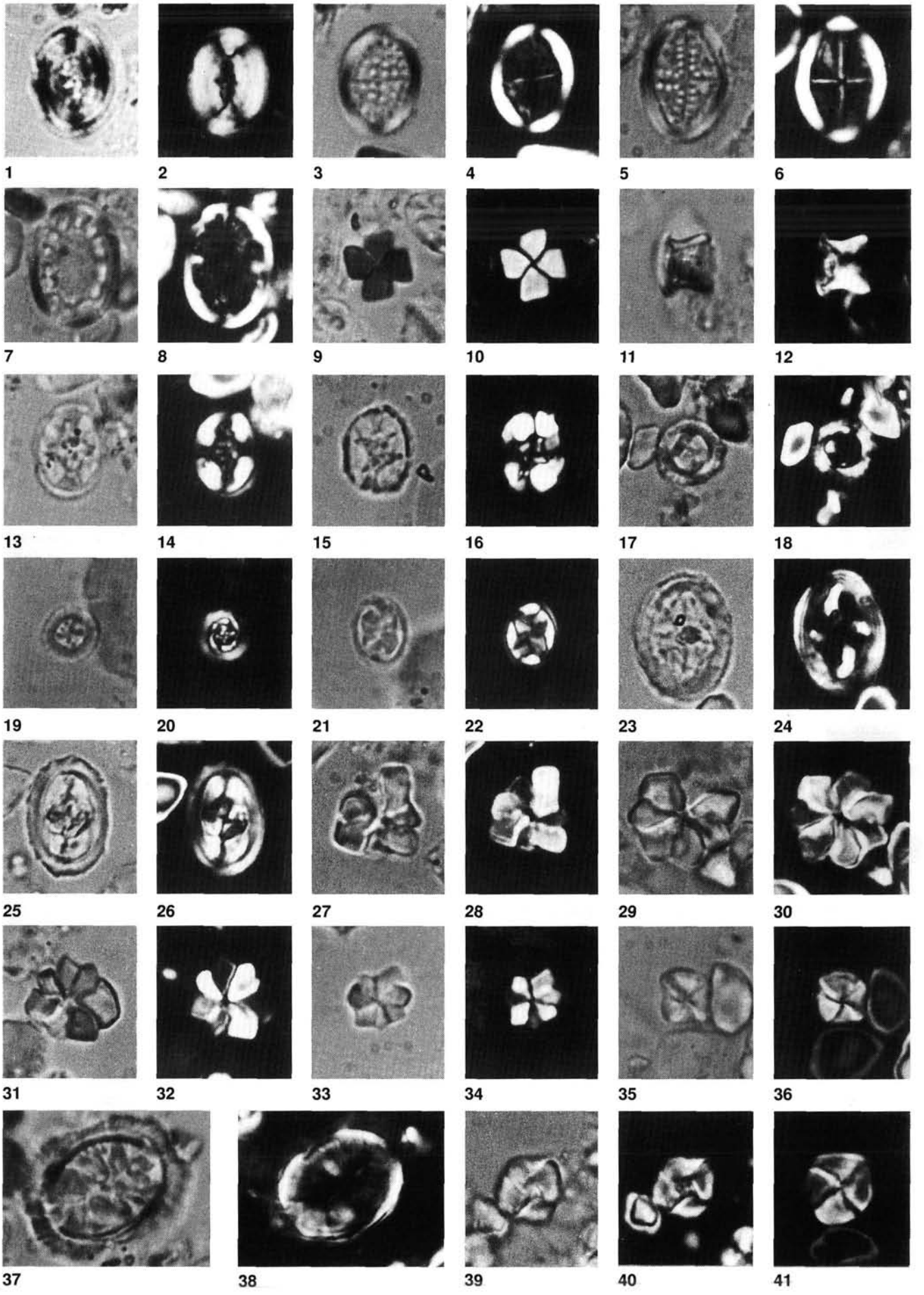
6. Conclusions

Ernstbrunn Quarry

- Grey to black clay (Kalkwerk II, level 5, sample No. A/1998) provided the monogeneric nannofossil association of

Plate 2: Calcareous Nannofossils from Ernstbrunn and Staatz

Figs. 1, 2: *Broinsonia parca constricta* HATTNER et al.; Ernstbrunn-Kalkwerk II, sample No. 3.
Figs. 3, 4: *Arkhangelskiella specillata* VEKSHINA; Ernstbrunn-Kalkwerk II, sample No. 1.
Figs. 5, 6: *Arkhangelskiella cymbiformis* VEKSHINA; Ernstbrunn-Kalkwerk II, sample No. 1A.
Figs. 7, 8: *Dodekapodorhabdus noeliae* PERCH-NIELSEN; Ernstbrunn-Kalkwerk II, sample No. 3.
Figs. 9, 10: *Petrarhabdus copulatus* (DEFLANDRE) WIND and WISE; Ernstbrunn-Kalkwerk II, sample No. 3.
Figs. 11, 12: *Cylindralithus serratus* BRAMLETTE & MARTINI; Ernstbrunn-Kalkwerk II, sample No. 4.
Figs. 13, 14: *Eiffellithus eximius* (STOVER) PERCH-NIELSEN; Staatz Klippe, sample No. 1R/1998.
Figs. 15, 16: *Eiffellithus turriseiffelii* (DEFLANDRE) REINHARDT; Staatz Klippe, sample No. 1R/1998.
Figs. 17, 18: *Cylindralithus* cf. *nudus* BUKRY; Staatz Klippe, sample No. 3R/1998.
Figs. 19, 20: *Prediscosphaera columnata* (STOVER) PERCH-NIELSEN; Staatz Klippe, sample No. 1R/1998.
Figs. 21, 22: *Helicolithus trabeculatus* (GÓRKA) VERBEEK; Staatz Klippe, sample No. 3R/1998.
Figs. 23, 24: *Gartnerago obliquum* (STRADNER) NOËL; Staatz Klippe, sample No. 1R/1998.
Figs. 25, 26: *Zeugrhabdotus embergeri* (NOËL) PERCH-NIELSEN; Staatz Klippe, sample No. 1R/1998.
Figs. 27, 28: *Rucinolithus* cf. *wisei* THIERSTEIN; Staatz Klippe, sample No. 1R/1998.
Figs. 29, 30: *Rucinolithus wisei* THIERSTEIN; Staatz Klippe, sample No. 1R/1998.
Figs. 31, 32: *Rucinolithus* cf. *hayi* STOVER; Staatz Klippe, sample No. 1R/1998.
Figs. 33, 34: *Rucinolithus hayi* STOVER; Staatz Klippe, sample No. 1R/1998.
Figs. 35, 36: *Micula staurophora* (GARDET) STRADNER, Staatz Klippe, sample No. 3R/1998.
Figs. 37, 38: *Kamptnerius magnificus* DEFLANDRE, Staatz Klippe, sample No. 3R/1998.
Figs. 39, 40: *Quadrum gartneri* ssp. 2 sensu CRUX (1982); Staatz Klippe, sample No. 1R/1998.
Fig. 41: *Micula-Quadrum*; Staatz Klippe, sample No. 3R/1998 .
Microphotographs by L. Švábenická, magnification 1,000x.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Tithonian age which is dominated by *Watznaueria barnesae*.

• Santonian is proved by nannofossil assemblage with *Rucinolithus* spp. and *Orastum campanensis* of the UC11c-UC12 zone interval which is supported by poorly preserved foraminifers of the Upper Santonian-Lower Campanian age with *Arenobulimina d'orbignyi* (REUSS) and *Stensioeina exsculpta* (REUSS).

• Upper Campanian is documented by foraminiferal assemblage of the Globotruncanita calcarata total range zone and by nannofossils of the UC15c-d^{TP} Zone.

• Common occurrence of high- and low-latitude nannofossil species in the Upper Campanian sediments indicates that the depositional area was probably situated within the Tethyan/ Mediterraneaen province with a strong influence from the Boreal area.

• Upper Campanian nannofossil associations are similar in their character to those of the same age from the Pálava Formation in the Ždánice Unit, Outer Western Carpathians.

Staatz Klippe

Two different nannofossil associations were observed:

1. Association with *Rucinolithus hayi, R. wissei* and *Reinhardtites anthophorus* which gives evidence for the UC11c Subzone of Lower Santonian age.

2. Mixture of nannofossil species of the Oligocene-Lower Miocene, Lower Danian, Upper Campanian and Santonian age which can be explained either by contamination of Cretaceous sediments by younger ones or by reworking older nannofossils into the Miocene sediments.

To conclude, nannofossil preservation (overgrowth) in sediments of locality Staatz Klippe is very similar to another one observed in the Santonian sediments of the Ernstbrunn Quarry.

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References

AL-SHAIBANI, S. K. (1971): An Upper Maastrichtian Foraminiferal Fauna from Dörfles, Lower Austria. – Jahrb. Geol.-B.A., Sdbd. 17, 105–119, Wien.

BACHMAYER, F. (1940): Beiträge zur Kenntnis der Tithonfauna aus dem Raume von Ernstbrunn (Niederdonau). – Unpuplished PhD. Thesis, Univ. Vienna, 73 p., Wien.

BACHMAYER, F. (1964): Untersuchung einer Kluftfüllung im Steinbruch Staatz (Kautendorf), nördliches Niederösterreich. – Ann. Naturhistor. Mus. Wien, 67, 181–187, Wien.

BUBÍK, M., BAK, M. & ŠVÁBENICKÁ, L. (1999): Biostratigraphy of the Maastrichtian to Paleocene distal flysch sediments of the Rača Unit in the Uzgruň section (Magura Group of nappes, Czech Republic). – Geologica Carpathica, 50, 1, 33–48, Bratislava.

BULLINGER, E. (1997): Die Bedeutung des Ernstbrunner Kalkes für die Industrie. – ÖGG Exk. Führer 17, 37–38, Wien.

BURNETT, J. (1998): Upper Cretaceous. In: BOWN, P. R. (Ed.): Calcareous Nannofossil Biostratigraphy. – Cambridge University Press, 132–199, Cambridge.

CRUX, J. A. (1982): Upper Cretaceous (Cenomanian to Campanian) calcareous nannofossils. In: LORD, A. R. (Ed.): A Stratigraphical Index of Calcareous Nannofossils. – British Micropalaeontological Society Series, Ellis Horwood Limited, 81–135, Chichester.

ELIÁŠ, M. (1992): Sedimentology of the Klentnice Formation and the Ernstbrunn Limestone (Ždánice–Subsilesian unit of the Outer West Carpathians). – Věst. Čes. geol. Úst., 67, 3, 179–193, 6 figs., 2 pls., Praha.

ELIÁŠ, M., SCHNABEL, W. & STRÁNÍK, Z. (1990): Comparison of the Flysch Zone of the Eastern Alps and the Western Carpathians based on recent observations. – In: MINAŘÍKOVÁ & LOBITZER (Eds.) Thirty Years of Geological Cooperation between Austria and Czechoslovakia, 37–46, Vienna/Praha.

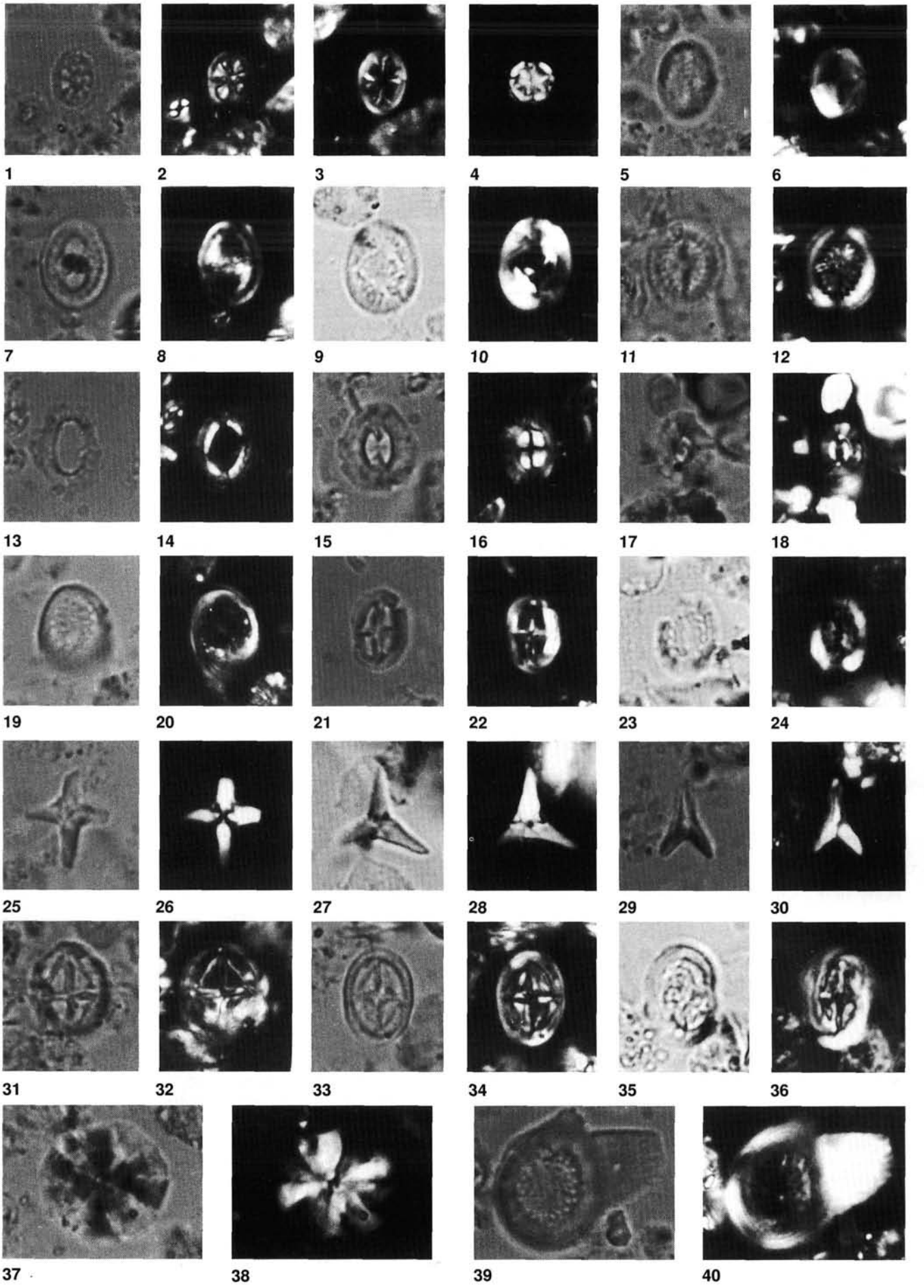
FUCHS, W. (1980): Das Jungalpidikum (Die geologische Entwicklung vom Obereozän bis in die Gegenwart), 49–55, Abb.14.– In: OBERHAUSER, R. (Ed.): Der geologische Aufbau Österreichs, 700 S., Wien – New York.

GASINSKI, M., JUGOWIEC, M. & SLACZKA, A. (1999): Late Cretaceous foraminiferids and calcareous nannoplankton from the Wenglówka Marls (Subsilesian Unit, Outer Carpathians, Poland). – Geologica Carpathica, 50, 1, 63–73, Bratislava.

GRILL, R. (1953): Der Flysch, die Waschbergzone und das

Plate 3: Calcareous Nannofossils from Ernstbrunn and Staatz

Figs. 1, 2: *Ahmuellerella regularis* (GÓRKA) REINHARDT; Ernstbrunn-Kalkwerk II, sample No. 3.
Fig. 3: *Ahmuellerella octoradiata* (GÓRKA) REINHARDT; Ernstbrunn-Kalkwerk II, sample No. 3.
Fig. 4: *Corollithion exiguum* STRADNER; Ernstbrunn-Kalkwerk II, sample No. 4.
Figs. 5, 6: *Orastrum campanensis* (CEPEK) WIND & WISE; Ernstbrunn-Kalkwerk II, sample No. 3.
Figs. 7, 8: *Reinhardtites anthophorus* (DEFLANDRE) PERCH-NIELSEN; Ernstbrunn-Kalkwerk II, sample No. 4.
Figs. 9, 10: *Reinhardtites levis* PRINS & SISSINGH; Ernstbrunn-Kalkwerk II, sample No. 3.
Figs. 11, 12: *Cretarhabdus conicus* BRAMLETTE & MARTINI; Ernstbrunn-Kalkwerk II, sample No. 4.
Figs. 13, 14: *Biscutum magnum* WIND & WISE; Ernstbrunn-Kalkwerk II, sample No. 4.
Figs. 15, 16: *Biscutum coronum* WIND & WISE; Ernstbrunn-Kalkwerk II, sample No. 3.
Figs. 17, 18: *Biscutum ellipticum* (GÓRKA) GRÜN; Staatz Klippe, sample No. 3R/1998.
Figs. 19, 20: *Angulofenestrelithus snyderi* BUKRY; Ernstbrunn-Kalkwerk II, sample No. 1A.
Figs. 21, 22: *Staurolithites imbricatus* (GARTNER) BURNETT; Staatz Klippe, sample No. 3R/1998.
Figs. 23, 24: *Tortolithus* cf. *hallii* (BUKRY) CRUX; Ernstbrunn-Kalkwerk II, sample No. 3.
Figs. 25, 26: *Uniplanarius sissinghii* PERCH-NIELSEN; Ernstbrunn-Kalkwerk II, sample No. 1A.
Figs. 27, 28: *Uniplanarius trifidus* (STRADNER) HATTNER & WISE; Ernstbrunn-Kalkwerk II, sample No. 3.
Figs. 29, 30: *Ceratolithoides sesquipedalis* BURNETT; Ernstbrunn-Kalkwerk II, sample No. 1A.
Figs. 31, 32: *Monomarginatus quaternarius* WIND & WISE; Ernstbrunn-Kalkwerk II, sample No. 3.
Figs. 33, 34: *Neocrepidolithus watkinsii* POSPÍCHAL & WISE; Ernstbrunn-Kalkwerk II, sample No. 3.
Figs. 35, 36: *Neocrepidolithus watkinsii* POSPÍCHAL & WISE; Ernstbrunn-Kalkwerk II, sample No. 3.
Figs. 37, 38: *Biantholithus sparsus* BRAMLETTE & MARTINI (?contamination from Tertiary deposits or the autochthonous component of the Upper Campanian association); Ernstbrunn-Kalkwerk II, sample No. 1A.
Figs. 39, 40: *Kamptnerius magnificus* DEFLANDRE; Ernstbrunn-Kalkwerk II, sample No. 1A.
Microphotographs by L. Švábenická, magnification 1,000x.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Jungtertiär um Ernstbrunn (Niederöstereich). – Jahrb. Geol. B.-A., 96, 65–116, Wien.
GRILL, R. (1968): Erläuterungen zur Geologischen Karte des nordöstlichen Weinviertels und zu Blatt Gänserndorf. – 155 p., Geol. B.-A., Wien.
HANZLÍKOVÁ, E. (1972): Carpathian Upper Cretaceous Foraminiferida of Moravia (Turonian-Maastrichtian). – Rozpravy Ústř. Úst. geol. 39, 1–160, Praha.
HOFMANN, T. (1990): Der Ernstbrunner Kalk im Raum Dörfles (Niederösterreich) Mikrofazies und Kalkalgen. – Unpubl. Diplom, Univ. Vienna, 164 p., Wien.
ROBASZYNSKI, F. & CARON, M. (1995): Foraminiferes planctoniques du Crétacé: commentaire de la zonation Europe – Méditerranée. – Bull. Soc. Géol. France, 166, 6, 681–692, Orleans.
SAUER, R. SEIFERT, P. & WESSELY, G. (1992) Guidebook to Exkursions in the Vienna Basin and the Adjacent Alpine – Carpathian Thrustbelt in Austria. – Mitt. Österr. Geol. Ges., 85, 239 p., 200 figs., Wien.
STEININGER, F. F., WESSELY, G., RÖGL, F. & WAGNER, L. (1986): Tertiary sedimentary history and tectonic evolution of the eastern Alpine Foredeep. – Giorn. di Geol., 3, 48/1–2, 285–297, Bologna.
STRÁNÍK, Z., BUBÍK, M., ČECH, S. & ŠVÁBENICKÁ, L. (1996): The Upper Cretaceous in South Moravia. – Věst. Čes. geol. Úst., 71, 1, 1–30, Praha.
SUMMESBERGER, H., ŠVÁBENICKÁ, L., ČECH, S., HRADECKÁ, L. & HOFMANN, T. (1999): New palaeontological Data on the Klement and Pálava Formations (Late Cretaceous) in Austria (Waschberg-Ždánice Unit). – Ann. Naturhistor. Mus. Wien, 100, 39–79, 2 figs., 3 tab., 6 pls., Wien.
ŠVÁBENICKÁ, L. (1998): Occurrence of *Petrarhabdus copulatus* (Deflandre) Wind and Wise in the Outer Western Carpathians. – Věst. Čes. geol. Úst., 73, 2, 89–97, Praha.
ŠVÁBENICKÁ, L. & ČTYROKÁ, J. (1998): Foraminifera and nannofossil biostratitigraphic correlation of the Karpatian and Lower Badenian sediments in the Carpathian Foredeep of Moravia (Preliminary results). – Zprávy o geologických výzkumech v roce 1997, 166–170, Praha.
WATKINS, D. K. (1992): Upper Cretaceous nannofossils from Leg 120, Kerguelen Plateau, Southern Ocean. – Proceedings of the ODP, Scientific Results, 120, 343–370, Washington.
WATKINS, D. K., WISE, S. W., POSPÍCHAL, J. J. & CRUX, J. (1996): Upper Cretaceous calcareous nannofossil biostratigraphy and paleoceanography of the Southern Ocean. In: MOGUILEVSKY, A. & WHATLEY, R.: Microfossils and Oceanic Environments. – University of Wales, Aberystwyth Press, 355–381, Aberystwyth.
WIND, F. H. (1979): Maestrichtian-Campanian nannofloral provinces of the southern Atlantic and Indian Oceans. In: TALWANI, M. HAY, W. W. & RYAN, W. B. F. (Eds.): Deep drilling results in the Atlantic Ocean: Continental Margins and Paleoenvironment. – Am. Geophys. Union, 123–137, Washington.

Appendix

List of calcareous nannofossil taxa mentioned in this study, in the alphabetical order of generic epithets:

Cretaceous taxa

Ahmuellerella octoradiata (GÓRKA, 1957) REINHARDT, 1966
Ahmuellerella regularis (GÓRKA, 1957) REINHARDT & GÓRKA, 1967
Angulofenestrellithus snyderi BUKRY, 1969
Arkhangelskiella cymbiformis VEKSHINA, 1959
Arkhangelskiella specillata VEKSHINA, 1959
Biscutum coronum WIND & WISE in WISE & WIND, 1977
Biscutum ellipticum (GÓRKA, 1957) GRÜN in GRÜN & ALLEMANN, 1975
Biscutum magnum WIND & WISE in WISE & WIND, 1977
Broinsonia parca constricta HATTNER et al., 1980
Calculites obscurus (DEFLANDRE, 1959) PRINS & SISSINGH in SISSINGH, 1977
Ceratolithoides aculeus (STRADNER, 1961) PRINS & SISSINGH in SISSINGH, 1977
Ceratolithoides quasiarcuatus BURNETT, 1998
Ceratolithoides sesquipedalis BURNETT, 1998
Chiastozygus litterarius (GÓRKA, 1957) MANIVIT, 1971
Corollithion exiguum STRADNER, 1961
Cretarhabdus conicus BRAMLETTE & MARTINI, 1964
Cyclagelosphaera margerelii NOËL, 1965
Cylindralithus biarcus BUKRY, 1969
Cylindralithus nudus BUKRY, 1969
Cylindralithus serratus BRAMLETTE & MARTINI, 1964
Dodekapodorhabdus noeliae PERCH-NIELSEN, 1968
Eiffellithus eximius (STOVER, 1966) PERCH-NIELSEN, 1968
Eiffellithus gorkae REINHARDT, 1965
Eiffellithus turriseiffelii (DEFLANDRE in DEFLANDRE & FERT, 1954) REINHARDT, 1965
Eprolithus floralis (STRADNER, 1962) STOVER, 1966
Gartnerago obliquum (STRADNER, 1963) NOËL, 1970
Grantarhabdus coronadventis (REINHARDT, 1966) GRÜN in GRÜN & ALLEMANN, 1975
Helicolithus trabeculatus (GÓRKA, 1957) VERBEEK, 1977
Kamptnerius magnificus DEFLANDRE, 1959
Lithraphidites praequadratus ROTH, 1978
Manivitella pemmatoidea (DEFLANDRE in MANIVIT, 1965) THIERSTEIN, 1971
Markalius inversus (DEFLANDRE in DEFLANDRE & FERT, 1954) BRAMLETTE & MARTINI, 1964
Micula staurophora (GARDET, 1955) STRADNER, 1963
Micula swastica STRADNER & STEINMETZ, 1984
Monomarginatus quaternarius WIND & WISE in WISE & WIND, 1977
Neocrepidolithus watkinsii POSPÍCHAL & WISE, 1990
Orastrum campanensis (CEPEK, 1970) WIND & WISE in WISE & WIND, 1977
Petrarhabdus copulatus (DEFLANDRE, 1959) WIND & WISE in WISE, 1983
Prediscosphaera columnata (STOVER, 1966) PERCH-NIELSEN, 1984
Prediscosphaera cretacea (ARKHANGELSKY, 1912) GARTNER, 1968
Prediscosphaera grandis PERCH-NIELSEN, 1979
Prediscosphaera stoveri (PERCH-NIELSEN, 1968) SHAFIK & STRADNER, 1971
Quadrum gartneri PRINS & PERCH-NIELSEN in MANIVIT et al., 1977
Reinhardtites anthophorus (DEFLANDRE, 1959) PERCH-NIELSEN, 1968
Reinhardtites levis PRINS & SISSINGH in SISSINGH, 1977
Retacapsa angustiforata BLACK, 1971
Rucinolithus hayi STOVER, 1966
Rucinolithus wisseI THIERSTEIN, 1971
Staurolithites aachenus (BUKRY, 1969) BURNETT, 1998
Staurolithites imbricatus (GARTNER, 1968) BURNETT, 1998
Tortolithus hallii (BUKRY, 1969) CRUX in CRUX et al., 1982
Uniplanarius sissinghii PERCH-NIELSEN, 1986
Uniplanarius trifidus (STRADNER in STRADNER & PAPP, 1961)
Watznaueria barnesae (BLACK, 1959) PERCH-NIELSEN, 1968
Watznaueria biporta BUKRY, 1969
Watznaueria britannica (STRADNER, 1963) REINHARDT, 1964
Watznaueria manivitae BUKRY, 1963
Zeugrhabdotus embergeri (NOËL, 1958) PERCH-NIELSEN, 1984

Tertiary taxa

Biantholithus hughesii VAROL, 1989
Biantholithus sparsus BRAMLETTE & MARTINI, 1964
Coccolithus formosus (KAMTNER, 1963) WISE, 1973
Coccolithus pelagicus (WALLICH, 1871) SCHILLER, 1930
Cruciplacolithus primus PERCH-NIELSEN, 1977
Cruciplacolithus tenuis (STRADNER, 1961) HAY & MOHLER in HAY et al., 1967
Dictyococcites bisectus (HAY et al., 1966) BUKRY & PERCIVAL, 1971
Helicosphaera carteri ((WALLICH, 1877) KAMPTNER, 1954
Isthmolithus recurvus DEFLANDRE in DEFLANDRE & FERT, 1954
Markalius apertus PERCH-NIELSEN, 1979
Markalius astroporus (STRADNER, 1963) HAY & NOHLER in HAY et al., 1967
Pontosphaera multipora (KAMPTNER, 1948) ROTH, 1970
Reticulofenestra coenura (REINHARDT, 1966) ROTH, 1970
Reticulofenestra hillae BUKRY & PERCIVAL, 1971
Sullivania danica (BROTZEN, 1959) VAROL, 1992