ABHANDLUNGEN DER GEOLOGISCHEN BUNDESANSTALT

Abh. Geol. B.-A.	ISSN 0378-0864	ISBN 3-85316-007-7	Band 56/2	S. 553-565	Wien, Dezember 1999

Geologie ohne Grenzen Festschrift 150 Jahre Geologische Bundesanstalt	Redaktion: Harald Lobitzer & Pavol Grecula

The Ernstbrunn Limestone (Lower Austria): New data on Biostratigraphy and Applied Geology

BEATRIX MOSHAMMER*) & FELIX SCHLAGINTWEIT**)

1 Text-figure, 3 Tables and 2 Plates

Lower Austria
Waschberg Zone
Ernstbrunn Limestone
Microfacies
Stratigraphy
Dasycladales
Benthic Foraminifera
Microcoprolites
Mineral raw material
Geochemistry
Colorimetry
Brightness

Österreichische Karte 1: 50 000
Blätter 11, 24, 25

Contents

Der Ernstbrunner Kalk (Niederösterreich): Neue Ergebnisse zu Biostratigraphie und Rohstoffgeologie

Zusammenfassung

Im Rahmen der österreichischen Rohstofforschung wurden Proben des Ernstbrunner Kalks von verschiedenen Lokalitäten zwischen der österreichisch-tschechischen Grenze und Ernstbrunn übersichtsmäßig genommen. Geochemische Analysen und weißmetrische Bestimmung liefern Anhaltspunkte über Rohstoffqualität und mögliche industrielle Nutzung.

Eine stratigraphische Einstufung in den Zeitbereich Mittleres/Oberes Tithon bis Mittleres Berrias basiert auf benthonischen Foraminiferen und Dasycladaceen. Der erstmalige Nachweis von Unterkreide gestattet Vergleiche mit dem Stramberger Kalk in Nordmähren. Für die im nördlichen Teil zu beobachtende Dolomitisierung, die Wackestones der inneren Plattform betrifft, ist ein genetischer Zusammenhang mit der Regression im späten Tithon/Berrias denkbar, welche im Bereich von Bohrungen im östlichen süddeutschen Molassebecken mit vergleichbaren Faziestypen ("Purbeck") bekannt ist. In den südöstlichen Aufschlüssen von Brekzien ist eine Slope-Fazies nachweisbar, welche zu jurassischen Tiefwasserablagerungen der Tethys vermitteln könnte. Eine Neufassung bzw. erweiterte Definition des Begriffes "Ernstbrunner Kalk" erscheint aus stratigraphischen und faziellen Gründen erforderlich.

Addresses of the authors: *) Geological Survey of Austria, Rasumofskygasse 23, A-1030 Wien, Austria. **) Lerchenauerstraße 167, D-80935 München, Germany.

Abstract

In the framework of the Austrian mineral resource program, samples of the Ernstbrunn Limestone from various localities between the Austrian-Czech-border and Ernstbrunn have been investigated. Geochemistry and whiteness-measurement provide information of the quality and possible industrial usage of the limestone.

From the stratigraphic classification of benthic Foraminifera and dasycladales a Middle/Upper Tithonian to Middle Berriasian age is established. The evidence of Lower Cretaceous age allows comparisons with the Stramberk Limestone in Northern Moravia. The observed partial dolomitization of inner platform wackestones might be in causal connection to the late Tithonian/Berriasian regression, well known as "Purbeckian" from bore holes of the Eastern Molasse basin of S Germany with comparable microfacies types. Breccias referring to a platform talus facies have been evidenced in the south-eastern outcrops, probably marking the transition to deeper water environments in the Tethyan realm. Due to stratigraphical and facial reasons, the definition of the "Ernstbrunn Limestone" has to be adjusted.

1. Introduction

Within the mineral resource project ÜLG 38 (MOSHAMMER & LOBITZER 1998) dealing with the evaluation of pure and white limestones, marbles and subordinate dolomites from all over Austria investigations concerning the Ernstbrunn Limestone were carried out, too. With the aim of getting an overall view based on the distribution, size and lithologic, geochemical and physical properties, selected outcrops were sampled to enlighten the varieties of the rocks with special regard to purity and colour. An estimation of the Ernstbrunn Limestone's potential as an industrial mineral is based on these parameters. Thin slices of the samples were investigated for stratigraphic purposes.

2. Geological Setting

During Upper Jurassic times fossiliferous shallow water limestones without terrestrial influx known as Ernstbrunn Limestone reflect a differentiated carbonate platform (GRILL 1968). In the occurrences at Ernstbrunn an open marine platform is evidenced (HOFMANN 1990a), in Southern Moravia due to the Ernstbrunn Limestone the Pavlov Carbonate Platform, also separated from the European shelf, shows an inner and outer platform area (ELIAS & ELIASOVA 1984). A comparable evolution is proven for the Stramberk Limestone on the Baska Cordillera of the Silesian Unit (ELIAS & ELIASOVA 1984). Breccias of these shallow-water carbonates are thought to represent the talus facies on the corresponding slopes (ELIAS 1992). Basinwards the marly Klentnice Beds represent the deeper water facies. In the stratigraphical record the Ernstbrunn Limestone follows diachronously the Klentnice Beds and marks the regression of the post-Callovian sedimentary cycle. Until the Upper Cretaceous Klement Formation, consisting mainly of glauconitc sandstones and marls, no sedimentation is recorded (HOFMANN et al. 1999 this volume; SUMMESBERGER et al., 1999).

Due to Alpine movements nowadays the Ernstbrunn Limestone together with Klentnice Beds and the Klement Formation appear as klippen, i. e. thrust sheets within deformed Molasse sediments. This imbricated tectonic unit known as Waschberg Zone in Lower Austria corresponds to the Zdanice Zone of the Subsilesian Unit in Southern Moravia and occurs below the flysch-nappes and on top of the Autochthonous Mesozoic of the Bohemian massif (ELIAS & ELIASOVA 1984; ELIAS & WESSELY 1990; ZIMMER & WESSELY 1996, fig. 2).

The Ernstbrunn Limestone was encountered by the wells Staatz 3, Ameis 1 and Zistersdorf ÜT2A. In this well the upper part of the Ernstbrunn Limestone shows a block-structure containing different components of the Ernstbrunn level perhaps pointing to Lower Cretaceous age (WESSELY 1993). Within Czech wells an Albian oncoidic limestone ("Nove Mliny Limestone") has been proven (ADAMEK 1986).

The depositional area of the Autochthonous Mesozoic is situated to the northwest with regard to that of the Malmian klippen.

In the Autochthonous Mesozoic below the Molasse and the Alpine-Carpathian thrust units a complete section, in its upper part comparable to that of the klippen, is developed (BRIX et al., 1977, MALZER et al., 1993, especially fig. 136). A correlation and a joint schedule of Austrian and Czech stratigraphic formations was established by ELIAS & WESSELY 1990. According to these studies the Mikulov Marls and the Kurdejov Arenites correspond with the Klentnice Beds, and the "Upper Carbona-tic Horizon" or "Kobyli beds" correspond with the Ernstbrunn Limestone.

Towards the shoreline of the Bohemian massif to the west the basinal development of the Mikulov Marls grade diachronously (Lower to Upper Malmian) into a slope facies (Falkenstein Formation) fringing the western Altenmarkt Formation, which consists of bedded, partly cherty limestones and dolomites overlain by sponge- and finally coral reefs. Here sedimentation seems to stop, whereas in the area of the Mikulov Marls the sequence continues into the Upper Tithonian with calcarenites of the Kurdejov Formation marking a regression and passing into the Ernstbrunn Limestone.

The biogene elements of the addressed random shallow marine limestones along the European margin suggest a connection between S-Germany, Lower Austria and the Czech Republic (LADWEIN 1976, WIECZOREK 1998).

3. Description of sample locations

The insular occurrences of the klippen of the Ernstbrunn Limestone are documented in the Geological Map of the north-eastern Weinviertel, scale 1: 75 000 (GRILL 1961). The following occurrences, some of which were sampled, are arranged from NE to SW, see text–fig. 1.

The emphasis regarding sample locations was given on abandoned quarries within minor investigated areas. The Staatz Klippe was excluded due to preservation of rural amenities. From rather well known exposures at Oberleis – Dörfles near the active quarry ("Ernstbrunn-Kalkwerk II") one sample was taken for comparison.

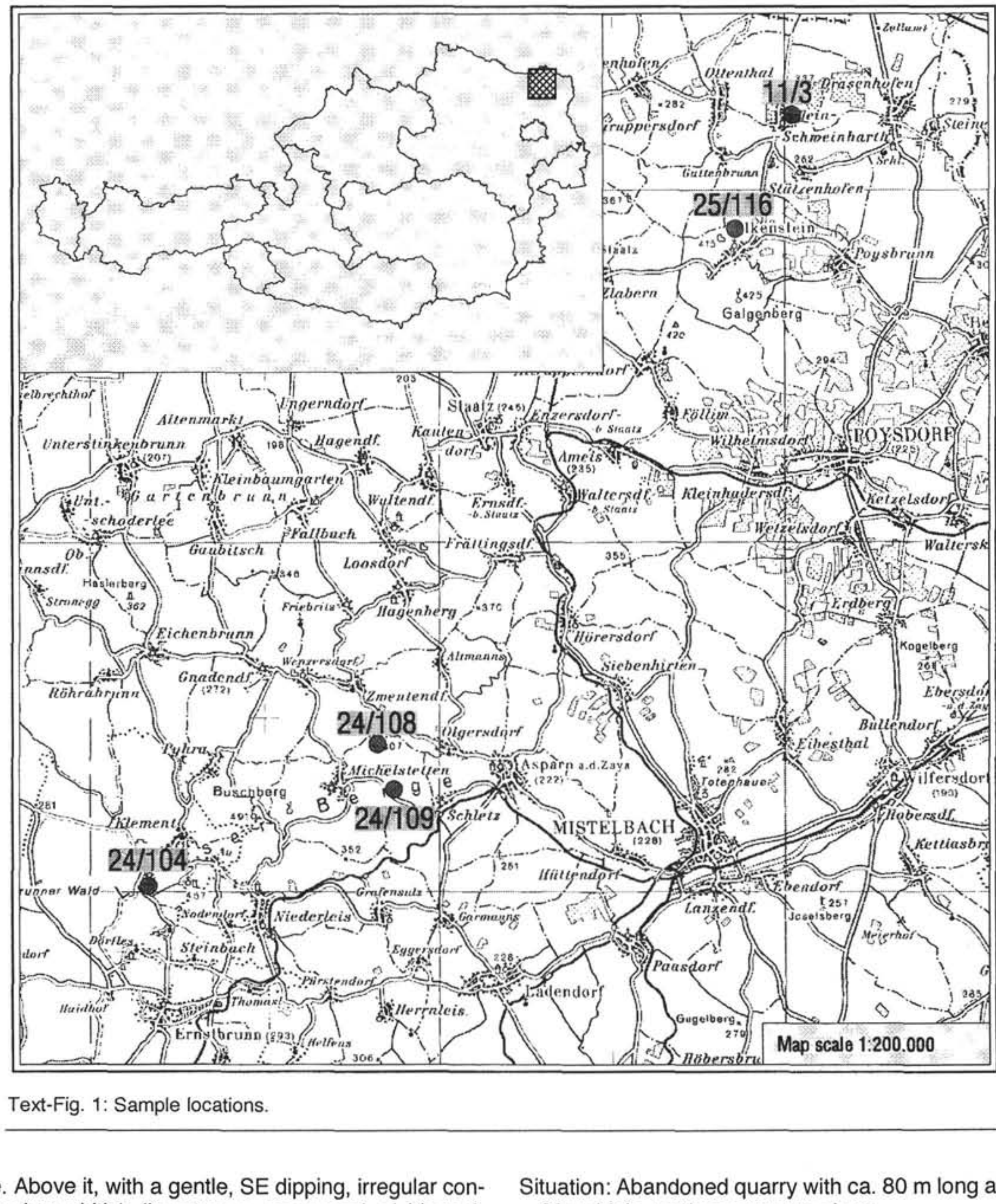
"Klein-Schweinbarth" (text–fig. 1 no. 11/3. Number refers to the raw materials archive of the Geological Survey):

Location: Locality Wachterberg and Fatima, north-east of Klein-Schweinbarth.

Situation: Two approximately 50 m long, abandoned and re-cultivated, half-round extraction-sites at the north-western (with Floriani-statue) and south-eastern flanks of a 10–20 m broad and ca. 10 m high limestone- and dolomite-rock.

Lithology: The north-western part (sample 11/3a-1) is built up by massive light-beige dolomites with numerous small-scale faults. The dolomite is fine crystalline and calcite-cemented. The south-eastern escarpment consists of dolomite at

Sample locations in Weinviertel / Lower Austria



Text-Fig. 1: Sample locations.

the base. Above it, with a gentle, SE dipping, irregular contact, *massive whitish limestones*, composed of biogeniferous micrite and detrital limestone made up of arenitic to ruditic onco- and intrasparite (sample 11/3b-7) follow.

"Ernstbrunner Wald 3" (text–fig. 1 no. 24/104):

Locality: East of a rounded turn-off in the road, 0,7 km south of the end of the village Klement.

Situation: Recultivated, cauldron-shaped quarry, ca. 80 m long, up to 60 m wide and 15 m high.

Lithology: Light-beige micritic limestone, showing a microfacies of pelsparite to -micrite with encrusting algae (sample 24/104-1).

"Am Galgenberg" (text–fig. 1 no. 24/108):

Locality: On the northern side of the rise Galgenberg (307 m) south of the Zaya-valley, 1,7 km north-east of Michelstetten.

Situation: Abandoned quarry with ca. 80 m long and up to ca. 20 m high, partly overgrown slope.

Lithology: Limestone-conglomerate to -breccia. The components are decimetre to 0,5 m^3 (max. up to some cubic metres) large and consist of light-beige, jointed limestones. The fabric is clast-supported with bad sorting showing major parts with coarse, angular, well fitting limestone-clasts and minor parts with well rounded limestone-clasts of centimetre to decimetre size. Greenish to ochre clay stone, marl and tectonically ground limestone form the more weathered matrix. The limestone-clasts show different facies like grain-, rudstone and micrites, which can also occur within one larger clast. Shells, corals and oncoids are observed. Calcite-filled voids are conspicuous. The samples 108-1, -2, -4 show reef-detritus-limestone (pack/floatstone) with relics of dasycladales, microproblematica, foraminiferes, sponges, hydrozoans, solitary corals, gastropods, thick-walled bivalves, filaments and echinoids.

"Am Steinbruchberg" (text–fig. 1 no. 24/109):

Locality: At the northern side of the road between Michelstetten and Schletz, 1,2 km west of Schletz.

Situation: Abandoned quarry with scarcely overgrown slope of medium steepness, ca. 40 m long and ca. 15 m high. The bottom is covered with shrubbery.

Lithology: Unsorted limestone-breccia with light-beige, angular to slightly rounded limestone-components of centimetre- to half-metre-size. The matrix is somewhat more clayey than the clasts and nearly similar light-beige coloured. The fabric is partly matrix-supported (sample 24/109-3 from the western part), yet predominantly clast-supported, sometimes appearing in-situ brecciated. The clasts consist of micrite (sample 24/109-1) and grainstone (sample 24/109-2). There are transitions from grain-, pack-, wacke- to floatstone within centimetres, accounting to intrapelbiomicrites, microsparrudites and oncolithes. The biogens, like microproblematica, cyanophycees, sponges, hydrozoans, bryozoans, serpulides ?, spongiostromata and foraminiferes are indicative of a reef-influenced platform. Calcite-cements and idiomorphic quartz are also observed. Subordinately and divergent from the former pelagic components of micrite (mudstone), intrabiopelmicrite and -microsparite, wacke- and packstone and graded laminites appear. Their mostly recrystallized biogene-content shows echinoderms, miliolid foraminiferes, radiolarians (?Spumellaria) and thick-walled bivalves.

"Stecher-Kalksteingrube" (text–fig. 1 no. 25/116):

Location: North of the village Falkenstein, 300 m northeast of the ruin, 300 m south of the peak of Höhlenstein (390 m).

Situation: Abandoned quarry with ca. 180 m long south-facing, ca. 25 m high wall. The quarry's width amounts to ca. 50 m; it is now used as a dumping-place for rubble.

Lithology: Altogether light-beige, massive carbonates with various lithologies. In the north-west corner main faults appear. The most frequent rocktype is a sandy, fairly weathered, biogeniferous, dolomitic limestone (samples 25/116-2, -3b, -5). It occasionally contains strongly weathered oncoids (up to 3 cm). Dark spots are made of ore-impregnated (Fe, Mn) dolomite-crystals. Yet, the dolomitic limestone-type is also apt of strong resistance, then showing dicerats and other frame-building organisms (sample 25/116-4). Another fault-bound rocktype is a likewise consolidated biomicrite (floatstone) containing again reef-building organisms (sample 25/116-6: solitary corals, sponges, hydrozoans, gastropodes, thick-walled bivalves, columnalia, benthic foraminiferes and microproblematica). Infrequently massive light-brown dolomites with fossil-solution-pores occur. Relics of a pure limestone of light-beige colour (sample 25/116-9: biomicrite) are exposed in the very low escarpments at the southern rim.

From this site, named "Gemeindesteinbruch", BACHMAYER (1954) provides an average chemical analysis with 75 % calcite, 25 % dolomite and <0,2 % insoluble residue.

4. General Remarks on the Facies

The first reference of the Ernstbrunn Limestone dates back to 1785 when Karl HAIDINGER, the father of the founder of the "k. k. geologische Reichsanstalt", described dicerats as "Gienmuscheln" (HAIDINGER 1785). In the following, BOUÉ (1830) for the first time used the terminus "calcaire d'ernstbrunn" and also mentioned the diceratids as typical fossils.

Investigating five abandoned quarries ("Dörfles I–V") of the Ernstbrunn Limestone in the area of Dörfles/Lower Austria HOFMANN (1990a, b) recognised five microfacies types corresponding to the internal and external platform: (1) wackestone facies, (2) packstone facies, (3) grainstone facies, (4) algae bindstone facies and (5) bafflestone facies (*Diceras* facies). Facies of the platform talus was not reported.

Although our material is coming from different localities with no longer profiles sampled, some observations on the microfacies are presented. Nearly all samples can be typically referred to a carbonate platform environment. Most of them belong to the external facies of moderately to well agitated water (grainstones). Typical foraminifera include trocholinids and protopeneroplids. It is worthy of emphasis that "reef" limestones have not been observed in our samples. Large debris of corals and pelecypods (rudstone) together with benthic foraminifera, mainly trocholinids *(T. odukpaniensis, T. cherchiae)* occur in the locality Galgenberg, sample 24/108-1. The matrix is sparite/microsparite. Noteworthy are also two representatives of the microcoprolite *Agantaxia biserialis* KRISTAN-TOLLMANN. From the locality Klein-Schweinbarth, sample 11/3B-3 represents a wackestone containing besides others *Salpingoporella annulata* CAROZZI and *Petrascula piae* (BACHMAYER), taxa characteristic of inner platform of shallow water lagoonal settings (e. g. BERNIER 1984: p. 500). From the locality at Falkenstein, sample 25/116-2 represents an oncoidal wackestone devoid of microbenthos (one thallus of *Clypeina parasolkani* FARINACCI & RADOICIC) and rich in idiomorphic dolomite ("Dolmitpflaster"). The microfacies features point to an intertidal depositional setting (e. g. FLÜGEL 1978). The dolomitization might indicate a shallowing of the depositional area possibly corresponding to the regression of the sea in early Berriasian times (see chapter 7). On the other hand, it could simply be a postsedimentary diagenetic effect, since this phenomenon is also reported from hemipelagic talus facies of the Ernstbrunn Limestone of Southern Moravia (REHANEK 1987). It is noted that the observed dolomitization is restricted to the northern sampled occurrences of the Ernstbrunn Limestone (11/3 and 25/116 in text–fig.1).

Samples 24/109-1 and -2 of the south-eastern occurrence west of Schletz, can be referred to the platform talus with typical microbenthos (*Lenticulina, Spirilina,* small miliolids), remains of sponges, calcisphaerulids and microproblematica (*Tubiphytes morronensis* CRESCENTI and others). Analogous facies have been described by SCHLAGINTWEIT & EBLI (1999 this volume) from the Alpine Plassen Formation. Upper Jurassic siliceous sponge facies was described also from the drilling "Altenmarkt im Thale 1" in Lower Austria from a 666 m thick carbonatic sequence, reaching from Lower to Upper Malmian (LADWEIN 1976). A similar lithofacies was found by REHANEK (1987) from drillhole profiles of the Ernstbrunn Limestone in Southern Moravia.

In summary, it should be emphasised that further investigations on both, the lateral and vertical facies patterns of the Ernstbrunn Limestone, most desirable in a N–S profile, are strongly needed for further paleogeographic conclusions and reconstructions. Another topic of interest would be a comparison to the Plassen Formation from the Northern Calcareous Alps showing comparable facies (e. g. pl. 1, fig. 8, pl. 2, fig. 10, 12, 14).

5. Micropaleontology

In the micropaleontological part we refer to those taxa that are either poorly known or interesting from a stratigraphic point of view. The abbreviations used for the dimensions of the dasycladales are those from BASSOULLET et al. (1978). Since some taxa are only represented by a single section in our material, data on biometric parameters are limited. The calcareous algae, benthic foraminifera and other taxa are treated in alphabetic order. Whereas calcareous algae of the Ernstbrunn Limestone at Dörfles ("Dörfles I–V") had already been investigated by HOFMANN (1991, 93, 94), there are according to our knowledge no adequate papers dealing with the benthic foraminifera.

5.1. Calcareous algae

Genus ***Acicularia*** ARCHIAC, 1843
Acicularia ? aff. ***endoi*** PRATURLON, 1964
(Pl. 1, fig. 9–10)

*1964 *Acicularia endoi* n. sp. – PRATURLON: 189, figs. 25–26, Neocomian of Italy.
1987 *Acicularia endoi* PRATURLON – BARATTOLO & PUGLIESE: Pl. 9, fig. 7–8, 11–13, Oxfordian-Kimmeridgian of Capri Island/Italy.

Remarks: Representatives of *Acicularia* are usually defined by their diameter (D), number (N) and size (P) of the marginal sporangia. Our representatives with exclusively circular sections show affinities to both, *Acicularia* ? *endoi* PRATURLON and *Acicularia clapei* JAFFREZO. The latter is regarded as nomen nudem by GRANIER & DELOFFRE (1994) since no holotype has been designated. According to BARATTOLO & PUGLIESE (1987) *Acicularia endoi* should be assigned to the genus *Terquemella*. *A.* ? aff. *endoi* occurs in great abundance in grainstones together with *P. ultragranulata* (GORBATCHIK) and trocholinids. According to published literature, the stratigraphic range extends from the Oxfordian to the Aptian (BARATTOLO & PUGLIESE 1987; GRANIER & DELOFFRE 1994). Dimensions are given below (table).

Genus ***Chinianella*** OTT ex GRANIER & DELOFFRE, 1993
Chinianella* (?) *scheympflugi HOFMANN, 1994
(Pl. 1, fig. 1–2)

* 1994 *Chinianella* (?) *scheympflugi* nov. sp. – HOFMANN: 144, fig. 2, pl. 1, fig. 1–4, Upper Tithonian (?) of the Ernstbrunn Limestone of Dörfles (precisely the quarry "Dörfles V").

Remarks: *C.* (?) *scheympflugi* is so far only known from its type-locality, the Upper Tithonian (?) Ernstbrunn Limestone near Dörfles. HOFMANN (1994) mentions the association with *Clypeina solkani* CONRAD & RADOICIC and *Macroporella praturloni* DRAGASTAN, species that according to GRANIER & DELOFFRE (1993) and BUCUR et al. (1995) first appear later than the Upper Tithonian. This gives evidence that the type-level of the species may be Berriasian in age. In our material the occurrence of *Trocholina cherchiae* ARNAUD-VANNEAU et al. accounts for a (Lower ?) Berriasian age. The facies of the sample 11/3B-7, a grainstone with trocholinids, *Pseudocyclammina lituus* YOKOHAMA, *Arabicodium* sp. seems to be equivalent to the one described by HOFMANN (1994) from the type-locality of *Ch.* (?) *scheympflugi* of "Dörfles V".

Dimensions: D = 0,68–0,76 mm (0,6–0,89 mm), d = 0,15 mm (0,09–0,19 mm), d/D = 0,2 (0,14–0,25), p = 0,12–0,13 mm (0,12–0,15 mm). Data from HOFMANN (1994) in brackets.

Genus ***Clypeina*** (MICHELIN, 1845) BASSOULLET et al., 1978
Clypeina parasolkani FARINACCI & RADOICIC, 1991
(Pl. 1, fig. 3)

Remarks: One tangential section has been recovered from a dolomitized oncoidal wackestone without any other microbiota (sample 25/116-3). The stratigraphic range of *C. parasolkani* is Upper Tithonian-Valanginian (BUCUR et al., 1995).

Dimensions: D = 0,24 mm, h = 0,18 mm.

Genus ***Petrascula*** GÜMBEL, 1873
Petrascula piai (BACHMAYER, 1944) BERNIER 1979
(Pl. 1, fig. 4–5)

* 1944 *Petrascula piai* n. sp. – BACHMAYER: 238, fig. 2–4, Ernstbrunn Limestone.
1984 *Petrascula piai* (BACHMAYER) – BERNIER: 478, pl. 11, fig. 1–2, Tithonian of France.

Remarks: *P. piai* represents a poorly known dasycladale based on an inadequate original description. Detailed information on the thallus morphology has been provided by BERNIER (1979, 1984). According to BERNIER (1984: p. 500 and fig. 158) different representatives of the genus *Petrascula* show distinct variations in their paleoenvironmental distribution. While for example *P. bursiformis* is typically found in wellagitated external facies, *P. piai* occurs in very shallow and quiet water settings of the inner platform. The sample 11/3 B-3 is a grainstone where *P. piai* occurs within a clast of wackestone texture. The stratigraphy of *P. piai* is Tithonian (GRANIER & DELOFFE 1994). The questionable occurrence of *T. cherchiae* in our sample offers the possibility that the stratigraphic range could extend into the Berriasian.

Dimensions: Diameter of the stalk = about 1,8 mm (1,83–2,21 mm), diameter of the head = about 4,2 mm (4,05 mm), distance between two verticils (stalk) = about 0,5 mm, p' = about 0,08 mm (0,089–0,102 mm). Data from BERNIER (1984) in brackets.

	A.? *endoi* PRATURLON, 1964	*A.* ? aff. *endoi* PRATURLON, 1964	*Acicularia clapei* JAFFREZO, 1973 nom. nud.
Stratigraphic Occurrence	Barremian-Aptian of Italy	Berriasian, Ernstbrunn Limestone	Lower Cretaceous (?Aptian) of France
D P N	0,21–0,44 mm 0,05–0,09 mm 7–14	0,26–0,34 mm 0,03–0,04 mm 24–28	0,2–0,3 mm 0,025 mm 14–25

Genus ***Salpingoporella*** PIA in TRAUTH, 1918
Salpingoporella steinhauseri CONRAD, PRATURLON & RADOICIC, 1973
(Pl. 1, fig. 7)

* 1973 *Salpingoporella steinhauseri* n. sp. – CONRAD; PRATURLON & RADOICIC: 107, text–fig. 1, pl. 1, fig. 1–4, Berriasian of Switzerland.

Remarks: Small representative of *Salpingoporella* with uncompressed phloiophorous branches inclined towards the main axis. Facies are wackestones with dasycladales. Stratigraphy: Middle Berriasian (ARNAUD-VANNEAU et al., 1987; GRANIER & DELOFFRE 1994).

Dimensions: D = 0,22 mm (0,26–0,33 mm), d = 0,07 mm, d/D = 0,32 (0,35–0,4), p = 0,072, h = 0,08 mm (0,08–0,11 mm), L = 1,7 mm (1,25 mm). Data from CONRAD et al. (1972) in brackets.

5.2. Benthic foraminifera

Genus ***Protopeneroplis*** WEYNSCHENK, 1950
Protopeneroplis striata WEYNSCHENK, 1950
(Pl. 2, fig. 10, 12)

1967 *Protopeneroplis striata* WEYNSCHENK – SOTAK: Pl. 3, fig. 10, 11–12 (cf.) Middle/Upper Tithonian of Stramberk Limestone/Western Carpathians of Slovakia.

Remarks: See *Protopeneroplis ultragranulata.*

Protopeneroplis ultragranulata (GORBATCHIK, 1971)
(Pl. 2, fig. 11–14)

1987 *P. trochangulata* SEPTFONTAINE – SOTAK: 653, pl. 2, figs. 1–9, pl. 3, figs. 1–9, Lower/Middle Berriasian of Stramberk Limestone/Western Carpathians of Slovakia.

Remarks: *P. ultragranulata* differs from *P. striata* by its larger dimensions, the trochospiral coiling (instead of planispiral in *P. striata*) and a pustulated dorsal side. The latter feature, however, is not always well visible. Note that proteneroplide foraminifera, *P. striata* and *P. ultragranulata* respectively, have been demonstrated to possess stratigraphic importance in the Stramberk carbonate platform sequences (SOTAK 1987). The first occurrence of *P. ultragranulata* during the Middle Tithonian has been evidenced by HEINZ & ISENSCHMID (1988). Thus, both, *P. striata* and *P. ultragranulata*, co-occur during the Middle/Upper Tithonian interval (HEINZ & ISENSCHMID 1988; SEPTFONTAINE 1974; BUCUR 1993). On plate 2, fig. 10, 12 and 14 an example is shown from the Plassen Formation of Mount Untersberg/Salzburg.

Genus ***Trocholina*** PAALZOW, 1922
Trocholina odukpaniensis DESSAUVAGIE, 1968
(Pl. 2, fig. 1, 9)

1988 *Trocholina odukpaniensis* DESSAUVAGIE – ARNAUD-VANNEAU et al.: 361, pl. 5, fig. 7–22.

1994 *Trocholina odukpaniensis* DESSAUVAGIE – CHIOCCHINI et al.: Taf. 30, fig. 3, Berriasian of Central-Southern Apennines/Italy.

Remarks: *T. odukpaniensis* is a low conical *Trocholina* characterised by thick calcareous walls delimiting the chamber lumina from the outer surface, best visible at the apex of the test. According to ARNAUD-VANNEAU et al. (1988) it has a stratigraphic range from the Berriasian to basal Cenomanian. The clear identification of *T. odukpaniensis* in the Plassen Formation of the Trisselwand (SCHLAGINTWEIT & EBLI 1999, this volume), makes it possible that the species already appears in the uppermost Tithonian as already presented by ALTINER (1991: Fig. 3) in his stratigraphic table of Jurassic-Lower Cretaceous carbonate successions in North-western Anatolia/Turkey.

Dimensions: Diameter of the test = 0,52–0,92 mm (0,44–1,15 mm), height of the test = 0,4–0,6 mm (0,31–0,98 mm), D/H = 1,3–1,5. Data from ARNAUD-VANNEAU et al. (1988) in brackets.

Trocholina cherchiae ARNAUD-VANNEAU, BOISSEAU & DARSAC, 1988
(Pl. 2, fig. 1–2, 4)

* 1988 *Trocholina cherchiae* n. sp. – ARNAUD-VANNEAU et al.: 357, fig. 2, pl. II, fig. 9–21, Berriasian-Valanginian of Sardegna (Italy and S-France).

1994 *Trocholina cherchiae* ARNAUD-VANNEAU et al. – CHIOCCHINI et al.: Pl. 30, fig. 4, 6?, Valanginian of the Central-Southern Apennines/Italy.

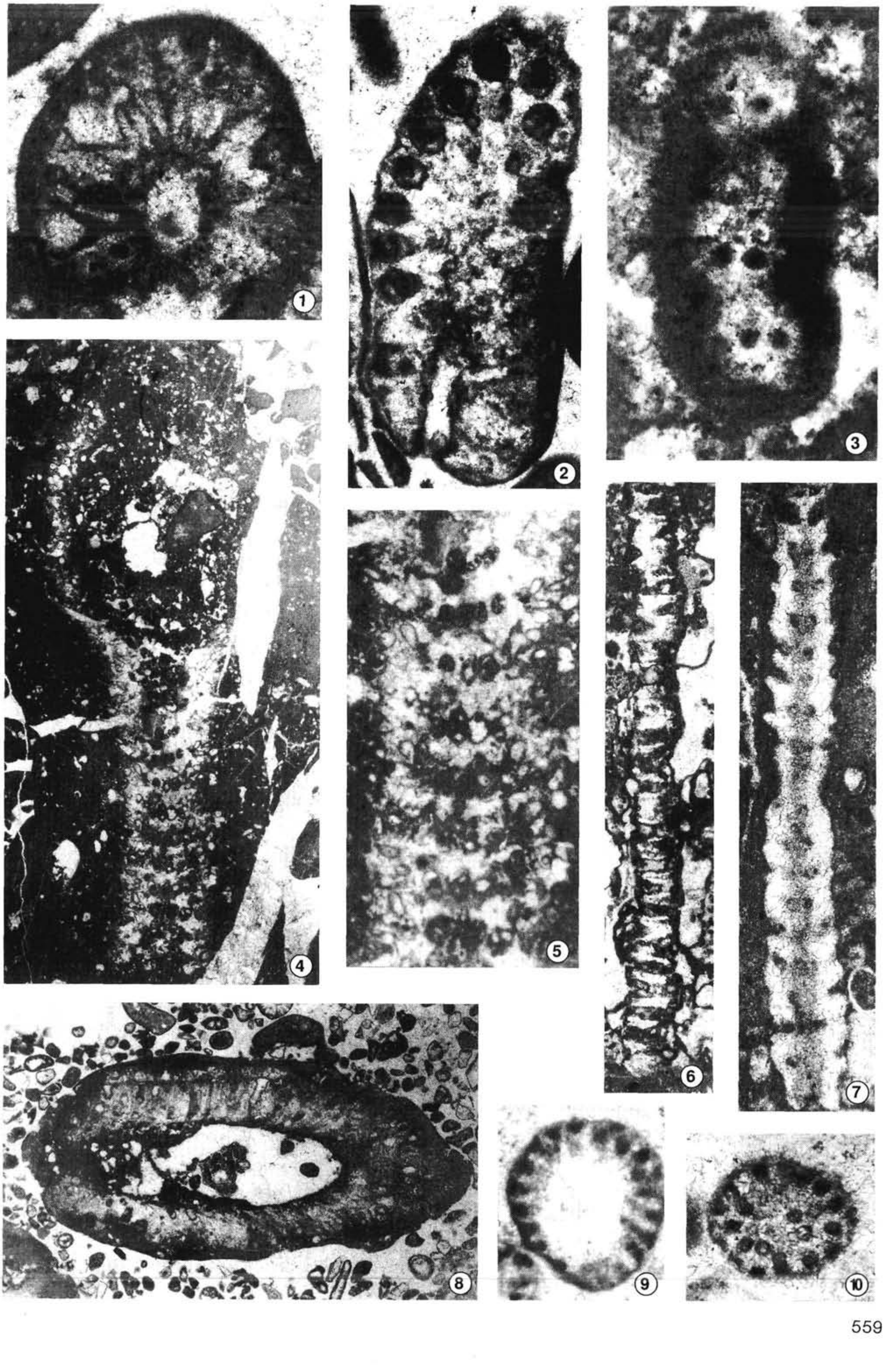
1995 *Trocholina cherchiae* ARNAUD-VANNEAU et al. – BUCUR et al.: Pl. II, fig. 3, 11, Valanginian of Eastern Serbia.

Remarks: High conical representative of *Trocholina* with a distinctly convex ventral side displaying a well developed reticulum. Stratigraphy: (Lower) Middle Berriasian – Valanginian (ARNAUD-VANNEAU et al. 1988; BUCUR et al., 1995).

Dimensions: D = 0,37–0,56 mm, H = 1,1–1,2 mm, D/H = 0,33–0,5, number of whorls = 7–8

Plate 1: Calcareous Algae

Fig. 1–2: ***Chinianella scheympflugi*** HOFMANN. Fig. 1: Oblique transverse section, sample 11/3 B-7 (x 62); Fig. 2: Oblique section, sample 11/3 B-7 (x 55).
Fig. 3: ***Clypeina parasolkani*** FARINACCI & RADOICIC, tangential section, sample 25/116-3 (x 87).
Fig. 4–5: ***Petrascula piai*** (BACHMAYER). Fig. 4: Axial section of the head and the stalk, sample 11 / 3 B-3 (x10); Fig. 5: Detail of Fig. 4 of the stalk showing higher order branches (x 23).
Fig. 6: ***Epimastoporella jurassica*** (ENDO), sample 24/108-4 (x 24).
Fig. 7: ***Salpingoporella steinhauseri*** CONRAD & RADOICIC, shallow tangential section, sample 24/108-4 (x 71).
Fig. 8: ***Linoporella gigantea*** (CAROZZI) FARINACCI & RADOICIC, oblique section, sample 93/19, Plassen Formation of Mount Untersberg/Salzburg (x 13).
Fig. 9–10: ***Terquemella*** ? aff. ***endoi*** PRATURLON, sample 24/108-2 (x 100).


1
2
3
4
5
6
7
8
9
10

Genus ***Troglotella*** WERNLI & FOOKES, 1992
Troglotella incrustans WERNLI & FOOKES, 1992
(Pl. 2, fig. 5)

1997 *Troglotella incrustans* WERNLI & FOOKES – KOLODZIEJ: 251, Fig. 2 A-E, ? fig. 3, Tithonian-Lower Berriasian of the Polish Carpathians ("boulders of the Stramberk-type limestone").

Remarks: Nothing new can be added to the exhaustive descriptions and discussions by SCHMID & LEINFELDER (1996) and KOLODZIEJ (1997). *T. incrustans* may occur alone (endolithic stage) or with the typical association of *Lithocodium aggregatum* ELLIOTT (e.g. pl. 6, fig. 7).

5.3. Microcoprolites

Genus ***Agantaxia*** KRISTAN-TOLLMANN, 1989
Agantaxia ? biserialis KRISTAN-TOLLMANN, 1989
(Pl. 2, fig. 3, 6)

* *Agantaxia biserialis* n. gen. n. sp. – KRISTAN-TOLLMANN: 24, fig. 2–4, Tithonian Plassen Formation of Mount Plassen.

Remarks: This microcoprolite (about 0,4 mm in diameter) is characterised by 6 longitudinal channels elongate in shape and arranged bilateral-symmetrically in two rows. The latter feature has also been evidenced by *Palaxius montemeranoensis* BLAU & GRÜN, 1989. Thus, only the shape of the channels remains as a main difference to the genus *Palaxius* BRÖNNIMANN & NORTON. Here, the channels are said to be "sichelförmig", but the shape may be highly variable within the genus. For example, in *Palaxius salataensis* BRÖNNIMANN, CROS & ZANINETTI the channel can also be elongated (e. g. SENOWBARI-DARYAN et al. 1992). Consequently, *A. biserialis* might perhaps be transferred to the genus *Palaxius*, which has already been mentioned by KRISTAN-TOLLMANN (1989) to be nearest to the genus *Agantaxia*. As concerns stratigraphy, our sample with *A. biserialis*, can be referred to the Berriasian due to the occurrence of *Trocholina cherchiae* ARNAUD-VANNEAU et al. The Tithonian age of the type-locality is not evidenced clearly, since the original description lacks information on the accompanying biota. In the Ernstbrunn Limestone the richness of crustaceans is noteworthy (BACHMAYER 1957; TOLLMANN 1985).

6. Stratigraphy

The stratigraphy of the Austrian Ernstbrunn Limestone is generally accepted as (Middle/Upper) Tithonian (e. g. ZEISS & BACHMAYER 1989; REHANEK 1987; ELIAS & WESSELY 1990).

The stratigraphic table of the Autochthonous Mesozoic on the eastern flank of the Bohemian Massif presented by ELIAS & WESSELY (1990) shows the top parts of the Ernstbrunn Limestone at the end of the Tithonian. So far no indications for the Lower Cretaceous have been made available (TOLLMANN 1985: p. 421). In the region of the Outer Carpathians shallow water limestones, analogous to the Austrian Ernstbrunn Limestone, are known as the Stramberk Limestone (e. g. MISIK 1974). The latter is divided into the Stramberk carbonate platform (Lower Tithonian), the Stramberk reef complex (mainly Upper Tithonian) and the Stramberk carbonate platform in the uppermost Tithonian up to the Hauterivian (ELIAS & ELIASOVA 1986). The Lower Berriasian age has been recorded by means of calpionellids (HOUSA 1990) and ammonites (ELIAS & VASICEK 1995).

Recent investigations of the calcareous algae, namely dasycladales, of the Ernstbrunn Limestone were carried out by HOFMANN (1991, 1993, 1994) reinstating the (Upper) Tithonian age. The author compiled a list of the algal flora using own observations and literature data (HOFMANN 1993: p. 6–7). Herein, one can find besides others
Salpingoporella steinhauseri CONRAD & RADOICIC (Middle Berriasian acc. to ARNAUD-VANNEAU et al., 1987; GRANIER & DELOFFRE 1993)
Clypeina solkani CONRAD & RADOICIC (Berriasian – Hauterivian, ? Aptian acc. to BUCUR, CONRAD & RADOICIC 1995) and
Macroporella praturloni DRAGASTAN (Berriasian – p. p. Valanginian, acc. to GRANIER & DELOFFRE 1993).

In addition, the fossil list of HOFMANN contains species not known to co-occur due to differences in their stratigraphic ranges. The dasycladales that have so far been mentioned in the literature from the Ernstbrunn Limestone evidence both, the Tithonian and Berriasian stages. In our material the Berriasian age for parts of the Ernstbrunn Limestone can be deduced from the occurrence of *Trocholina cherchiae* ARNAUD-VANNEAU and of the dasycladale *Salpingoporella steinhauseri* CONRAD et al. Although the stratigraphic range of *T. cherchiae* is Berriasian-Valanginian, a Lower/Middle Berriasian age for our samples is most likely.

7. Stratigraphic Conclusions

The stratigraphy of the Ernstbrunn Limestone is so far generally accepted as comprising the Middle/Upper Tithonian. Our samples evidence the Middle/Upper Tithonian and the Lower/Middle Berriasian on the basis of dasycladales and benthic foraminifera. For the Czech equivalent of the Ernst-brunn Limestone, the Stramberk Limestone, it is already well known that the carbonate platform, fringing the Bohemian Massif persisted till the karstification started in the Berriasian (see chapter 6).

Plate 2: Benthic Foraminifera, Microcoprolites

Fig. 1: Grainstone facies with ***Trocholina cherchiae*** ARNAUD-VANNEAU et al. (left two specimens) and ***Trocholina odukpaniensis*** DESSAUVAGIE, sample 24/108-1 (x 42).
Fig. 2, 4: ***Trocholina cherchiae*** ARNAUD-VANNEAU et al., sample 24/108-1 (x 70).
Fig. 3, 6: Microcoprolite ***Agantaxia biserialis*** KRISTAN-TOLLMANN, sample 24/108-1 (x 65).
Fig. 5: Foraminifer ***Troglotella incrustans*** WERNLI & FOOKES within tissue of ***Lithocodium aggregatum*** ELLIOTT, sample 11/3B-4 (x 31).
Fig. 7: ***Mohlerina basiliensis*** (MOHLER), sample 11/3B-6 (x 60).
Fig. 8, 15: ***Pseudocyclammina lituus*** (YOKOYAMA). Fig. 8: Sample 24/108-2; Fig. 15: Sample 11/3B-6 (x 40).
Fig. 9: ***Trocholina odukpaniensis*** DESSAUVAGIE, sample 24/108-2 (x 64)
Fig. 10: ***Protopeneroplis striata*** WEYNSCHENK, sample 93/19, Plassen Formation of Mount Untersberg/Salzburg, (x 79).
Fig. 11, 13, 14: ***Protopeneroplis ultragranulata*** (GORBATCHIK). Fig. 11, 13: Sample 24/108-2 (x 87). Fig. 14: Sample 93/19, Plassen Formation of Mount Untersberg/Salzburg, (x 96).
Fig. 12: Grainstone facies with ***Protopeneroplis striata*** WEYNSCHENK *(P. s.)* and ***Protopeneroplis ultragranulata*** (GORBATCHIK) *(P. u.)*, sample 93/19, Plassen Formation of Mount Untersberg/Salzburg (x 29).

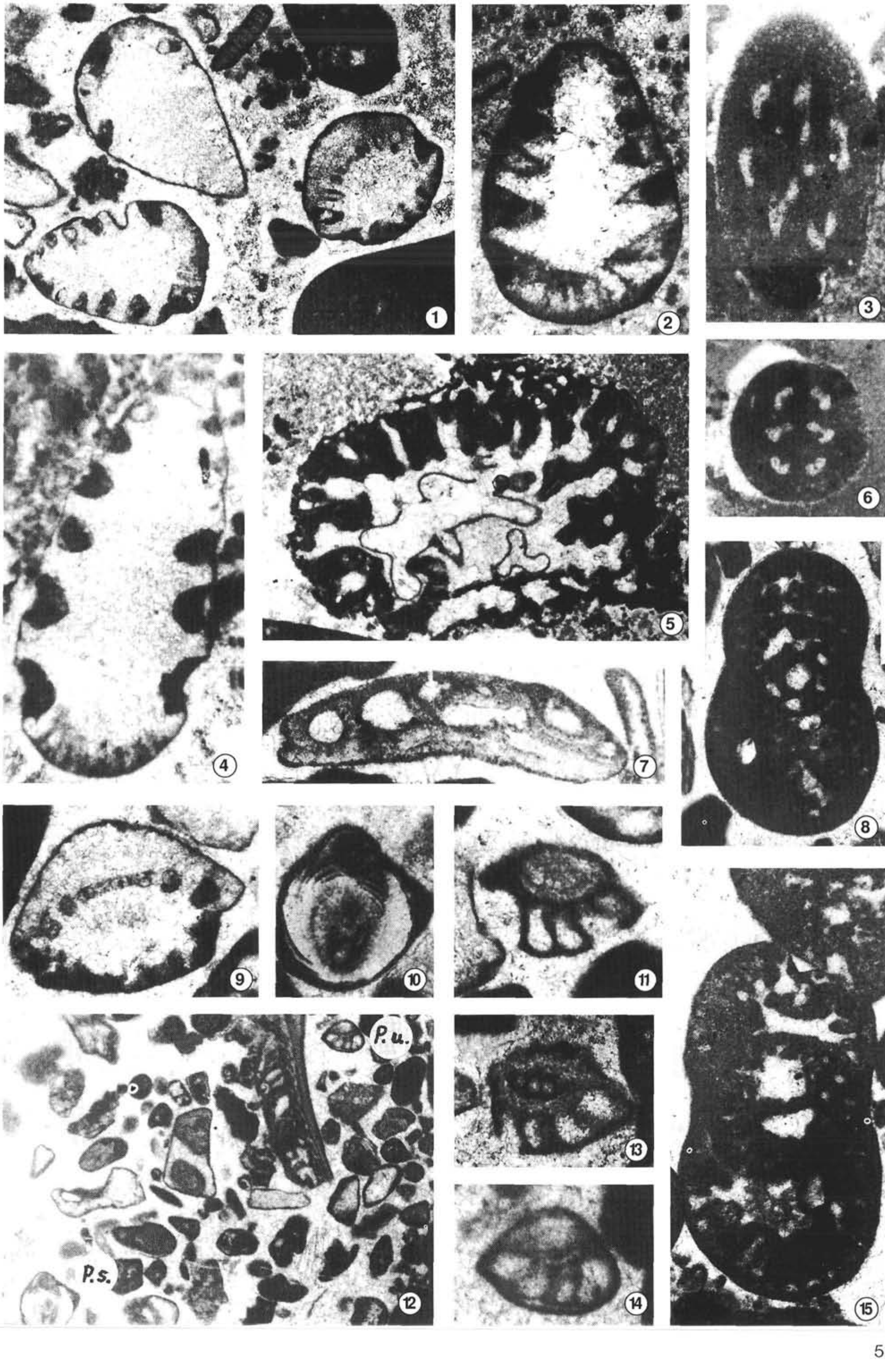

1
2
3
4
5
6
7
8
9
10
11
P.u.
P.s.
12
13
14
15

Table 1:
Distribution of the benthic foraminifera, calcareous algae, microproblematica and other biogenic groups in the samples studied.

Sample	**Calcareous Algae**	*Acicularia ? aff. endoi*	*Arabicodium sp.*	*Chinianella scheymptlugi*	*Clypeina parasolkani*	*Clypeina jurassica*	*Lithocodium aggregatum*	*Petrascula piai*	*Rivulariaceae*	*Salpingoporella steinhauseri*	*Salpingoporella annulata*	*Salpingoporella gr. pygmaea*	*Terquemella ? aff. endoi*	*Thaumatoporella parvo.*	**Benthic Foraminifera**	*Charentia cuvillieri*	*Coscinophragma cribrosum*	*Lenticulina sp.*	*Mohlerina basiliensis*	*Protopeneroplis striata*	*Protopeneroplis ultragranulata*	*Pseudocyclammina cf. lituus*	*Spirillina sp.*	*Trocholina cherchiae*	*Trocholina odukpaniensis*	*Trocholina alpina*	*Troglotella incrustans*	*Valvulina lugeoni*	**Other**	*Agantaxia ? biserialis*	*Bryozoa*	*Calcisphaerulidae*	*Koskinobullina socialis*	*Mercierella ? dacica*	*Sponges*	*Tubiphytes morronensis*
11 / 3B-3							X	X	X		X			X										?		X										
11 / 3B-4							X		X											X							X									
11 / 3B-7			X	X					X										X			X		X	X	X	X									
11 / 9 B-6							X		X					X					X			X		X			X									
24 / 108-1				X					X													X		X	X	X				X						
24 / 108-2		X											X					X			X				X	X										
24 / 108-4						X				X		X				X	X									X	X									
24 / 109-1																		X					X												X	X
24 / 109-2																		X					X								X	X		X	X	X
24 / 109-3																															X	X	X			
25 / 116-2							X		X																											
25 / 116-3B					X															?						X										
25 / 116-5							X		X																											
25 / 116-6																																				
25 / 116-7																																				
25 / 11-8A							X												X								X				X					
25 / 116-8B																																				
25 / 116-9							X		X			?		X					X		X						X	X								

The microfacies of our samples comprise the inner and outer platform as well as the platform talus. The strong dolomitization of inner platform (oncoidal) wackestones of presumably Berriasian age, could be evidence for influences of the late Tithonian/early Berriasian regression. The latter caused the saliniferous facies of the Purbeckian that is well recorded from several boreholes of the Eastern Molasse Basin of South-Germany (e. g. MEYER 1994) and Upper Austria (e. g. drilling site Oberhofen 1, EGGER et al., 1997). It is emphasized that further studies should therefore be undertaken to elucidate the stratigraphic succession of the facies zones of the Ernstbrunn Limestone in a north-south cross section and its correlation with time-equivalent profiles coming from bore-holes of the Austrian Molasse basin. The stratigraphy of these limestones can be worked out by means of dasycladales and benthic foraminifera (e. g. EBLI & SCHLAGINTWEIT 1998).

8. Geochemistry

The chemical analyses were carried out with atomic absorption spectroscopy, the determination of mercury content was done with a Mercury-Analyser AMA-254. H_2O^+ was determined at about 1000 °C, H_2O^- at 110 °C.

For the calculation of the magnesium- and calciumcarbonate-contents the analyses are corrected to a sum of 100. For the calculation of $MgCO_3$ the MgO-bound carbon dioxide is calculated. The remaining carbon dioxide is taken for the calculation of calciumcarbonate. This means: If there is sufficient CO_2, then $MgCO_3 = 2{,}0919 * MgO$ and $CaCO_3 = 1{,}7848 * CaO$. In the other case $CaCO_3 = 2{,}2742 * CO_2 - 2{,}4832 * MgO$.

The results in table 2 show very pure carbonates. The amount of insoluble residues does not exceed 1 %. Except for one analysis (sample 11/3B-7) the calculations show a surplus of CaO (CaO-rest* in table 2), which is not bound to CO_2. Moreover an increased sulphur-content is characteristic for the analyses. This could be explained by a small amount of anhydrite or gypsum. Further particularities, compared to other analyses of the project, comprehend slightly increased amounts of potassium-oxide (24/109-1: 0,03 %), nickel (25/116-5: 8 ppm), zinc (25/116-3B: 14 ppm) and chromium (average amount 16,5 ppm).

The most striking fact, however, is the content of dolomite, which should be fairly low for the calcination process. It can be seen that the sample with the lowest amount of MgO comes from the occurrence near Dörfles (24/104).

The analyses, which are derived from the limestone- or dolomite-clasts only, do not reflect the probable contamination from the clayey matrix in some deposits. This means that analyses of the average raw material of the localities Galgenberg (24/108) and west of Schletz (24/109) would show higher amounts of contaminating oxides than our results do. The amount of quartz in the presented analyses is very low, the maximum (0,1 %) is found in the dolomitic part of the occurrence of Klein-Schweinbarth (11/3).

9. Colorimetry

The method is described in MOSHAMMER & LOBITZER (1998, in press). The measurements of pulverized samples (grain-size < 0,063 mm), formed into tablets, are made by means of a ZEISS-spectrophotometer (calibrated with bariumsulphate, diffuse/0°-geometry, 5 mm aperture, gloss-absorption). The results are given in table 3. On the basis of the spectral reflectance curves, the tristimulus values (X, Y (syn. luminous reflectance) and Z) and the coordinates of the CIELAB Colour Space (L*a*b*) are calculated for the CIE 1964 observer and

Table 2:
Chemical Analyses.

Sample	Karbges*	$CaCO_3$*	$MgCO_3$*	Dolomit*	CaO rest*	SiO_2	TiO_2	Al_2O_3
011/003A-1	98,38	60,03	38,35	83,88	0,87	0,10	0,04	0,19
011/003B-7	99,26	98,15	1,12	2,45	0	0,04	0,01	0,17
024/104-1	99,46	98,85	0,61	1,33	0,04	0,04	0,04	0,24
024/108-2	99,29	97,87	1,42	3,12	0,38	0,08	< 0,005	< 0,05
024/109-1	99,23	98,13	1,11	2,43	0,21	0,08	< 0,005	0,25
025/116-3B	98,99	90,38	8,62	18,85	0,34	0,06	0,04	0,13
025/116-5	99,45	82,43	17,02	37,22	0,07	0,04	0,03	0,19
025/116-9	99,32	98,23	1,09	2,38	0,39	0,06	0,01	< 0,05

Main elements are given in percent

* $CaCO_3$-calculation on base of the CO_2, left over after the calculation of $MgCO_3$

Sample	Fe_2O_3	FeO	MnO	MgO	CaO	SrO	BaO	Li_2O	Na_2O
011/003A-1	0,13	0,03	0,065	18,34	34,52	0,013	0,006	< 0,005	0,04
011/003B-7	< 0,01	0,03	0,009	0,53	54,61	0,021	< 0,005	< 0,005	0,03
024/104-1	0,04	< 0,03	0,014	0,29	55,28	0,009	< 0,005	< 0,005	0,02
024/108-2	0,01	0,06	0,016	0,68	55,36	0,021	< 0,005	< 0,005	0,03
024/109-1	< 0,01	0,04	0,005	0,53	55,28	0,016	0,026	< 0,005	0,03
025/116-3B	0,01	< 0,03	0,010	4,12	50,99	0,020	0,277	< 0,005	0,02
025/116-5	0,02	0,03	0,010	8,09	45,99	0,014	< 0,005	< 0,005	0,03
025/116-9	< 0,01	0,03	0,006	0,52	55,36	0,015	< 0,005	< 0,005	0,04

Sample	K_2O	P_2O_5	CO_2	C	H_2O^+	F	S	H_2O^-	Sum
011/003A-1	0,05	0,019	46,43	< 0,01	< 0,01	0,031	0,03	0,150	100,16
011/003B-7	0,03	0,006	43,76	< 0,01	< 0,01	0,022	0,03	0,130	99,42
024/104-1	0,02	0,007	43,67	< 0,01	0,02	0,013	0,02	0,130	99,87
024/108-2	0,01	0,028	43,89	< 0,01	< 0,01	0,040	0,03	0,115	100,39
024/109-1	0,04	0,029	43,80	< 0,01	< 0,01	0,035	0,03	0,110	100,28
025/116-3B	0,02	0,021	44,25	< 0,01	< 0,01	0,022	0,02	0,100	100,12
025/116-5	0,04	0,008	44,87	< 0,01	< 0,01	0,016	0,03	0,100	99,50
025/116-9	0,03	< 0,005	43,71	< 0,01	< 0,01	0,038	0,03	0,085	99,95

Sample	Ag	As	Cd	Co	Cr	Cu	Hg	Mo	Ni	Pb	Zn	V
011/003A-1	< 0,8	0,23	< 0,8	< 5	20	8	< 0,01	< 5	< 5	< 10	5	< 15
011/003B-7	< 0,8	< 0,10	< 0,8	< 5	17	7	< 0,01	< 5	< 5	15	3	< 15
024/104-1	< 0,8	0,23	< 0,8	6	15	6	< 0,01	< 5	< 5	20	5	< 15
024/108-2	< 0,8	0,93	< 0,8	< 5	16	7	< 0,01	< 5	6	16	4	< 15
024/109-1	< 0,8	< 0,10	< 0,8	< 5	15	7	< 0,01	< 5	< 5	16	9	< 15
025/116-3B	< 0,8	0,11	< 0,8	< 5	17	7	< 0,01	< 5	7	28	14	< 15
025/116-5	< 0,8	0,17	< 0,8	< 5	17	6	< 0,01	< 5	8	15	6	< 15
025/116-9	< 0,8	0,29	< 0,8	< 5	6	2	< 0,01	< 5	< 5	23	4	< 15

Trace elements are given in ppm

Table 3:
Parameters of whiteness measurements.

Sample		X D65/10°	Y D65/10° %	Z D65/10°	L* D65/10°	a* D65/10°	b* D65/10°	Tappi Brightness 457 nm	Yellowness Index
11/3A-1	Average	78,57	82,46	79,96	92,78	0,79	6,22	75,04	12,55
	St.dev.	0,17	0,18	0,22	0,08	0,01	0,04	0,21	0,09
11/3B-4	Average	82,25	86,44	87,15	94,50	0,58	3,91	81,53	7,95
	St.dev.	0,23	0,24	0,24	0,10	0,01	0,04	0,22	0,08
11/3B-7	Average	83,71	88,01	89,14	95,17	0,51	3,66	83,40	7,38
	St.dev.	0,65	0,68	0,65	0,29	0,01	0,04	0,60	0,05
24/104-1	Average	86,63	91,23	92,37	96,50	0,27	3,72	86,43	7,22
	St.dev.	0,11	0,12	0,18	0,05	0,01	0,05	0,16	0,09
24/108-2	Average	82,59	86,79	86,42	94,65	0,57	4,70	80,95	9,39
	St.dev.	0,30	0,33	0,30	0,14	0,02	0,06	0,28	0,10
24/109-1	Average	83,02	87,37	87,96	94,90	0,35	4,02	82,34	7,95
	St.dev.	0,06	0,05	0,07	0,02	0,02	0,05	0,06	0,09
25/116-3B	Average	82,44	86,61	86,50	94,57	0,63	4,50	81,06	9,07
	St.dev.	0,25	0,27	0,27	0,11	0,01	0,01	0,26	0,02
25/116-5	Average	81,71	85,87	85,51	94,26	0,57	4,68	80,15	9,38
	St.dev.	0,08	0,08	0,09	0,04	0,01	0,02	0,08	0,04
25/116-9	Average	82,28	86,43	86,56	94,49	0,64	4,33	81,02	8,78
	St.dev.	0,61	0,64	0,80	0,28	0,02	0,10	0,73	0,21

Number of measured tablets per sample: 3

the standard illuminants D65 (AGOSTON 1979). The table is completed with the TAPPI-Brightness, which is comparable to the ISO-Brightness, and the Yellowness-Index DIN 6167.

In general, limestones do not reach the high brightness resp. whiteness that is possible for marbles. According to the luminous reflectance Y, which is standardized within the range of 0 % for ideal black and 100 % for ideal white, the Ernstbrunn limestone-samples show an average of 87 %, whereas white marbles can show Y-values above 95 % or at least above 90 %. Among the other accredited light-coloured limestones in Austria, the Ernstbrunn Limestone-samples take an intermediate position, below the highest ranking Plassen Limestone and similar to the Wetterstein Limestone. Colour (hue) results from certain colouring elements like iron, manganese and chromium. However, our colour measurements do not correspond to the chemical analyses, except for iron, which primarily contributes to the yellow tinge. For example the highest Yellowness Index (12,5) appears with the dolomite-sample 11/3A-1, which shows the highest amount of Fe(III).

10. Mineral raw material aspects

Due to the fact that the Ernstbrunn Limestone-outcrops appear as "white" rocks in the landscape, and due to considerations that stratigraphic equivalents in other tectonic units, like the very pure and light coloured Plassen and Sulzfluh Limestone appear in large quantities (MOSHAMMER & LOBITZER 1997), the Ernstbrunn Limestone was included for an overall view in the before-mentioned raw materials project. The emphasis was laid on the northern deposits of it's occurrences, which are lesser known and not quarried today like the large deposit in the vicinity of Ernstbrunn ("Kalkwerk Ernstbrunn II").

From field observations and laboratory results it emerged that the limestone-dolomite distribution in the localities Klein-Schweinbarth (11/3) and Falkenstein (25/116) appears too irregularly within small areas to provide enough material for a large extraction. Especially in Falkenstein, the light limestone extraction seems completed.

The deposits west of Schletz (24/109) and Galgenberg (24/108) belong to a lithologically different group. These mass-flow deposits, which appear as breccias/conglomerates contain undesirable clayey impurities within the matrix, even if the clasts comprise pure limestones, as shown in the analyses. In the outcrops the amount of clay in the matrix varies. Field observations suggest a much higher clayey contamination in the locality of Galgenberg (24/108), perhaps up to 15 volumetric %, than in the locality west of Schletz (24/109) where a calcareous matrix predominates.

Near Dörfles (24/104) the limestone appears geochemically homogeneous, without dolomitic parts, and continuously light-coloured. Within this large deposit, the limestone of the large quarry "Ernstbrunn Kalkwerk II" of the enterprise Kalkgewerkschaft Ernstbrunn consists predominantly of patch reefs, whereas the small quarries "Dörfles I–V" on the western half of the Steinberg reveal a more lagoonal development (HOFMANN 1990a).

The quarried limestone of "Ernstbrunn Kalkwerk II", where only little overburden is encountered, undergoes crushing and classifying and is used for the production of mortars and for quicklime, the latter going mainly to the construction, the chemical, and environmental industries (BULLINGER 1998). These applications show the possibility of this raw material to be used by a well founded lime-industry for products for which the light-yellow colour is suitable.

Acknowledgements

G. Wessely, Th. Hofmann and H. Lobitzer are gratefully acknowledged for discussion and amendments on the manuscript. The limestone-project ÜLG 38 has been carried out in the framework of the national raw materials research program of the BM f. Wissenschaft und Verkehr and the Oberste Bergbehörde, Sektion VII des BM f. wirtschaftliche Angelegenheiten in Vienna. We are grateful to S. Pfleiderer for English language corrections.

References

ADAMEK, J. (1986): Geologické poznatky o stavbe mezozoika v úseku JTH jihovýchodních svahů Českého masívu. – Zem. Plyn Nafta, **XXXI**, 4, Hodonín.

AGOSTON, G. A. (1979): Color Theory and Its Application in Art and Design. – 137 p., Springer Berlin Heidelberg New York.

ARNAUD-VANNEAU, A., ARNAUD, H., ADATTE, T., ARGOT, M., RUMLEY, G. & THIEULOY, J. P. (1987): The lower Cretaceous from the Jura Platform to the Vocontian Basin (Swiss Jura, France). – Field trip guide book, Excursion D, 3rd. Int. Cret. Symp. 26.8.–8.9.87, 1–128, Tübingen.

ARNAUD-VANNEAU, A., BOISSEAU, T. & DARSAC, C. (1988): Le genre *Trocholina* et ses principales espèces au Crétacé. – Rev. Paléobiol., Vol. spéc., **2**, 353–377, Geneva.

ARNAUD-VANNEAU, A., CONRAD, M. A., LUPERTO SINNI, E., MASSE, J. P., PEYBERNES, B., RADOICIC, R., SOKAC, B. & VELIC, I. (1991): Distribution of Lower Cretaceous Foraminifera and Dasyclad algae of the Adriatic plate. In: VELIC, I. & VLAHOVIC, L. (Eds.), Abstracts 2nd. Int. Symp. On the Adriatic carbonate platform, Zadar, 12.–18.05.91, 22–26.

BACHMAYER, F. (1944): Zwei neue Siphoneae verticillatae aus dem Jurakalk von Dörfles und Klafterbrunn (Nieder-Donau). – Verh. Zool.-bot. Ges., **LXXXVIII-LXXXIX**, 237–240, Wien.

BACHMAYER, R. (1954): Bericht über Kartierungsarbeiten im Bereiche der Waschbergzone (Jura-Kreide-Klippen) auf den Blättern Mistelbach (24) und Poysdorf (25). – Verh. Geol. B.-A., **1**, 19–21, Wien.

BARATTOLO, F. & PUGLIESE, A. (1987): Il Mesozoico dell'Isola di Capri. – Quad. Accad. Pont., **8**, 1–172, Naples.

BASSOULLET, J. P., BERNIER, P., CONRAD, M. A., DELOFFRE, R. & JAFFREZO, M. (1978): Les algues dasycladales du Jurassique et du Crétacé. – Geobios, Mém. Spéc., **2**, 1–330, Lyon.

BERNIER, P. (1979): Le genre *Petrascula* GÜMBEL 1873, Algue Dasycladacée: Emendation, révision des espèces du genre, création de nouvelles espèces. – Géobios, **12**/6, 839–861, Lyon.

BERNIER, P. (1984): Les formations carbonatées du Kimmeridgien et du Portlandien dans le Jura méridional. Stratigraphie, micropaléontologie, sédimentologie. – Doc. Lab. Geol., **92**/1, 1–803, Lyon.

BLAU, J. & GRÜN, B. (1989): *Palaxius montemeranoensis* n. sp., ein Anomuren-Koprolith aus roten Kalken der "Serie Toscana" (Lias, Italien). – N. Jb. Geol. Paläont. Mh., **8**, 467–473, Stuttgart.

BOUÉ, A. (1830): Resumé des observations sur l'âge relatif dés depôts secondaires dans les Alpes autrichiennes. – Journ. Géol., **1**, 50–86, Paris.

BRIX, F., KRÖLL, A. & WESSELY, G. (1977): Die Molassezone und deren Untergrund in Niederösterreich. – Erdöl-Erdgas-Zeitschrift, **93**, 12–35, Hamburg Wien.

BUCUR, I. I. (1993): Les représentants du genre *Protopeneroplis* WEYNSCHENK dans les dépots du Crétacé inférieur de la zone de Resita-Moldova Noua (Carpathes mériodionales, Roumanie). – Rev. Micropaléont., **36**/3, 213–223, Paris.

BUCUR, I. I., CONRAD, M. A. & RADOICIC, R. (1995): Foraminifers and Calcareous Algae from Valanginian limestones in the Jerma River Canyon, Eastern Serbia, – Rev. Paléobiol., **14**/2, 349–377, Geneva.

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

CHIOCCHINI, M., FARINACCI, A., MANCINELLI, A., MOLINARI, V. & POTETTI, M. (1994): Biostratigrafia a foraminiferi, dasicladali e calpionelle delle successioni carbonatiche Mesozoiche dell'Appennino Centrale (Italia). – Studi Geol. Camerti, vol. spec., 9–129, Camerino.

CONRAD, M. A., PRATURLON, A. & RADOICIC, R. (1973): Reinstatement of the genus *Salpingoporella* PIA (Dasycladaceae), followed by *Salpingoporella steinhauseri*, n. sp. – Compte Rend. Sci. Soc. Phys. D'Hist. nat. Genève, **7**/2–3, 103–111, Geneva.

EGGER, H., POLESNY, H. & WAGNER, L. R. (1997): Cretaceous of the Rhenodanubian Flysch and Ultrahelvetikum. Core storage display of rocks from the Molasse basement and the Molasse. – AAPG International Conference & Exhibition, 7.–10.09.97, Field Trip Notes, 86–104, Wien.

EBLI, O. & SCHLAGINTWEIT, F. (1998): On some biostratigraphic important microfossils (benthic foraminifera, dasycladales) from subsurface Late Jurassic-Early Cretaceous shallow water limestones of S-Germany. – Mitt. Bayer. Staatsslg. Paläont. hist. Geol., **38**, 9–23, München.

ELIAS, M. (1992): Sedimentology of the Klentnice Formation and the Ernstbrunn Limestone (Zdanice – Subsilesian unit of the Outer West Carpathians). – Vestnik Ceskeho geologickeho ustavu, **67**, 3, 179–193, Praha.

ELIAS, M. & ELIASOVA, H. (1984): Facies and palaeogeography of the Jurassic in the western part of the Outer Flysch Carpathians in Czechoslovakia. – Sbor. Geol. Ved, Geologie, **39**, 105–170, Praha.

ELIAS, M. & ELIASOVA, H. (1986): Elevation facies of the Malm in Moravia. – Geol. Zbor. Geol. carpath., **37**/4, 533–550, Bratislava.

ELIAS, M. & VASICEK, Z. (1995): Early Berriasian ammonites from the Stramberk Limestone of Kotouc quarry (Outer Carpathians, Silesian Unit, Stramberk, Czech Republic). – Véstnik Ces. Geol. Ust., **70**, 1–32, Bratislava.

ELIAS, M. & WESSELY, G. (1990): The autochthonous Mesozoic on the Eastern flank of the Bohemian Massif – An object of mutual geological efforts between Austria and CSSR. – In: MINARIKOVA, D. & LOBITZER, H. (Eds.), Thirty years of Geol. Coop. Between Austria and Czechoslovakia, Ustr. Ustav geol., Festive Volume, 78–83, Prag.

FLÜGEL, E. (1978): Mikrofazielle Untersuchungsmethoden von Kalken. – 454 p., Berlin, Heidelberg, New York (Springer).

GRANIER, B. & DELOFFRE, R. (1993): Inventaire critique des Algues dasycladales fossiles. II° Partie – Les Algues Dasycladales du Jurassique et du Crétacé. – Rev. Paléobiol., **12**/1, 19–65, Geneva.

GRILL, R. (1961): Geologische Karte des nordöstlichen Weinviertels. 1: 75 000. – Geol. B.-A., Wien.

GRILL, R. (1968): Erläuterungen zur Geologischen Karte des nordöstlichen Weinviertels und zu Blatt Gänserndorf. – 155 p., Geol. B.-A., Wien.

HAIDINGER, K. (1785): Beschreibung einer seltenen Versteinerung aus dem Geschlechte der Gienmuscheln. – Physik. Arbeiten der einträchtigen Freunde in Wien (Aufgesamm. Von Ignaz Edlen von Born). – 1. Jahrg., 3. Quart., Wien.

HEINZ, R. A. & ISENSCHMID, C. (1988): Mikrofazielle Untersuchungen im Massivkalk (Malm) der Préalpes médianes. – Eclogae geol. Helv., **81**/1, 1–62, Basel.

HOFMANN, T. (1990a): Der Ernstbrunner Kalk im Raum Dörfles (Niederösterreich): Mikrofazies und Kalkalgen. – Diplarb. Univ. Vienna, 164 p., Wien.

HOFMANN, T. (1990b): Der Ernstbrunner Kalk (Tithon) im Raum Dörfles (Niederösterreich): Mikrofazies und Kalkalgen. – Nachr. dt. geol. Ges., **43**, 45–46, Hannover.

HOFMANN, T. (1991): Some aspects on the classification of *Salpingoporella pygmaea* (Calcareous algae) from the Ernstbrunn Limestone (Tithonian) of Lower Austria. – In: KOVAR-EDER, J. (Ed.): Palaeovegetational Development of Europe: Pan-European Palaeobotanical Conference 19.–23. September 1991.– 281–285, Wien.

HOFMANN, T. (1993): Jurassic of the Eastern Alps. In: HÖFLING, R. et al. (Eds.): Facial development of algae-bearing carbonate sequences in the Eastern Alps. – Field Trip Guidebook (Alpine Algae 1993), A2, 1–14, Munich.

HOFMANN, T. (1994): *Chinianella* (?) *scheympflugi*, a new Dasyclad alga (green algae) from the Tithonian Ernstbrunn Limestone in Lower Austria. – Beitr. Paläont., **19**, 143–147, Wien.

HOFMANN, T., SVABENIKA, L. & HRADECKA, L. (1999): Biostratigraphy of Fissure Fillings in the Ernstbrunn Limestone of the Waschberg Zone (Lower Austria). – Abh. Geol. B.-A., Wien.

HOUSA, W. (1990): Stratigraphy and calpionellid zonation of the Stramberk Limestone and associated Lower Cretaceous beds. Atti II Conv. Inv. Fossili, Evoluzione, Ambiente, Pergola, 1987, 365–370.

JAFFREZO, M. (1976): Les algues calcaires du Jurassique supérieur et du Crétacé inférieur des Corbières. – Rev. Micropal., **16**/2, 75–88, Paris.

KOLODZIEJ, B. (1997): Boring foraminifera from exotics of the Stramberk-type limestones (Tithonian-Lower Berriasian, Polish Carpathians). – Ann. Soc. Geol. Pol., **67**, 249–256, Warschau.

KRISTAN-TOLLMANN, E. (1989): *Agantaxia biserialis* n. g. n. sp., ein Anomuren-Koprolith aus dem tithonen Plassenkalk von Ober-Österreich. – N. Jb. Geol. Paläont. Mh., **1**, 23–29, Stuttgart.

LADWEIN, H. W. (1976): Sedimentologische Untersuchungen an Karbonatgesteinen des autochthonen Malm in Niederösterreich (Raum Altenmarkt-Staatz). – Diss. Univ. Innsbruck, 154 p., Innsbruck.

MALZER, O., RÖGL, F., SEIFERT, P., WAGNER, L., WESSELY, G. & BRIX, F. (1993): Die Molassezone und deren Untergrund. – In: BRIX, F. & SCHULTZ, O. (Eds.): Erdöl und Erdgas in Österreich. – 281–292, Verlag Naturhistorisches Museum Wien und F. Berger, Horn.

MEYER, R. K. F. (1994): "Moosburg 4", die erste Kernbohrung durch den Malm unter der bayerischen Molasse. – Erlanger geol. Abh., **123**, 51–81, Erlangen.

MISIK, M. (1974): Paleogeographic outline of the Tithonian in the Czechoslovakian Carpathians. – Acta geol. Polonica, **24**/3, 485–503, Warschau.

MOSHAMMER, B. & LOBITZER, H. (1997): Oberjura-Plattformkarbonate in Österreich: Eine Gegenüberstellung der Ernstbrunner Kalke, Plassenkalke und Sulzfluhkalke in geochemischen und weißmetrischen Analysen. – ÖGG Exk. Führer **17**, 57–60, Wien.

MOSHAMMER, B. & LOBITZER, H. (1998): Nutzungsoptionen ausgewählter österreichischer Vorkommen von hochreinen Karbonatgesteinen (Kalkstein, Marmor, Dolomit z. T.) – Lagerstättenkundliche Detailuntersuchungen.- Unveröff. Bericht Bund-/Bundesländer Rohstoffprojekt Ü-LG-038-F/1996, 184 p., Wien.

MOSHAMMER, B. & LOBITZER, H. (in press): Weißmetrik und Geochemie ausgewählter österreichischer Kalkstein- und Marmor-Vorkommen. – Mitt. Österr. Geol. Ges., Wien.

PRATURLON, A. (1964): Calcareous algae from Jurassic-Cretaceous Limestone of Central Apennines (Southern Latium-Abruzzi). – Geol. Romana, **III**, 171–202, Rome.

REHANEK, J. (1987): Facial development and biostratigraphy of the Ernstbrunn Limestones (Middle to Upper Tithonian, Southern Moravia) (English summary). – Geol. Prace, Stravy, **87**, 27–60, Bratislava.

SCHLAGINTWEIT, F. & EBLI, O. (1999): New Results on Microfacies, Biostratigraphy and Sedimentology of Late Jurassic – Early Cretaceous platform carbonates of the Northern Calcareous Alps. Part I: Tressenstein Limestone, Plassen Formation. – Abh. Geol. B.-A., Wien.

SENOWBARI-DARYAN, B., WEIDLICH, O. & FLÜGEL, E. (1992): Erster Nachweis von "Favreien" (Crustaceen-Koprolithen) aus dem Perm: Oberperm, Oman-Berge. – Paläont. Z., **66**/1–2, 187–198, Stuttgart.

SEPTFONTAINE, M. (1974): Présence de *Protopeneroplis trochangulata* sp. nov. (Foraminifère) dans le Crétacé inférieur du Jura méridional et révision de *Protopeneroplis* WEYNSCHENK, 1950. – Eclogae geol. Helv., **67**/3, 605–628, Basel.

SOTAK, J. (1987): Protopeneroplide foraminifers from lowermost Cretaceous of the Stramberk carbonate platform (Outer Western Carpathians). – Geol. Zbor. Geol. carpath., **38**/6, 651–667, Bratislava.

SUMMESBERGER, H., SVABENICKA, L., ČECH, S., HRADECKA, L. & HOFMANN, T. (1999): New palaeontological Data on the Klement and Palava Formations (Late Cretaceous) in Austria (Waschberg-Zdanice Unit). – Ann. Naturhistor. Mus. Wien, **100**, Wien.

TOLLMANN, A. (1985): Geologie von Österreich. Band 2. – 710 p., Verlag Franz Deuticke, Wien.

WESSELY, G. (1993): Das autochthone Stockwerk unter dem Wiener Becken. – In: BRIX, F. & SCHULTZ, O. (Eds.): Erdöl und Erdgas in Österreich. – 276–280, Verlag Naturhistorisches Museum Wien und F. Berger, Horn.

WIECZOREK, J. (1998): Nerinaceans from the Ernstbrunn Limestone (Tithonian, Austria): – Ann. Naturhist. Mus. Wien, **99A**, 311–329, Wien.

ZEISS, A. & BACHMAYER, F. (1989): Zum Alter der Ernstbrunner Kalke (Tithon; Niederösterreich). – Ann. Naturhist. Mus. Wien, **90**/A, 103–109, Wien.

ZIMMER, W. & WESSELY, G. (1996): Exploration results in thrust and subthrust complexes in the Alps and below the Vienna Basin in Austria. – In: WESSELY, G. & LIEBL, W. (Eds.): Oil and Gas in Alpidic Thrustbelts and Basins of Central and Eastern Europe, EAGE Special Publication **5**, 81–107, Oxford.