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Fifty Years of Geological Cooperation between Austria, the Czech Republic and the Slovak Republic

The Lower Gosau Subgroup of the Kohlbachgraben and "Station Billroth" North of St. Gilgen (Turonian–?Coniacian, Salzburg, Austria)

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3 Text-Figures, 5 Plates

Österreichische Karte 1:50.000
Blatt 65 Mondsee

Northern Calcareous Alps
Calcareous nannofossils
Palaeoenvironment
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Die Untere Gosau-Subgruppe der Lokalitäten Kohlbachgraben und „Station Billroth" nördlich von St. Gilgen (Turonium–?Coniacium, Salzburg, Österreich)

Zusammenfassung

Aus grauen Mergeln der Unteren Gosau-Subgruppe des linken Kohlbach-Seitengrabens N von St. Gilgen wird eine schlecht erhaltene fossile Flora beschrieben. Foraminiferen, Nannofossilien und Palynomorphen erlauben eine Einstufung in das Turonium bzw. die Turonium/Coniacium-Grenze. Die grauen Mergel werden von einem mehrere Meter mächtigen Rudisten-Korallen-Riff überlagert, woraus sowohl die Bivalven-, als auch die Korallen-Vergesellschaftung beschrieben werden. Weiters wurden im Umfeld der historischen Lokalität „Billroth" an zwei Lokalitäten Proben von grauen Mergel entnommen. Sie lieferten schlecht erhaltene Mikrofossilien sowie eine mäßig diverse Vergesellschaftung von Kolonie bildenden Korallen mit Rudisten, die auf ein Turonium-Alter hindeuten.

Abstract

Grey marls of the Lower Gosau-Subgroup exposed in a left tributary of the Kohlbachgraben north of St. Gilgen have yielded foraminifers, calcareous nannofossils and palynomorphs as well as poorly preserved plant remains. The microfossils indicate a Turonian or Turonian/Coniacian boundary age. On top of the grey marls a several meters thick succession of marly limestone and marl follows, whose fossil fauna is dominated by radiolitid rudists. Grey marls sampled in two exposures situated near the long-known fossil locality „Billroth" yielded poorly preserved microfossils as well as a moderately diverse colonial coral and rudist assemblage, indicating a Turonian age. The most important findings of palynomorphs and macrofossils are briefly described and figured.

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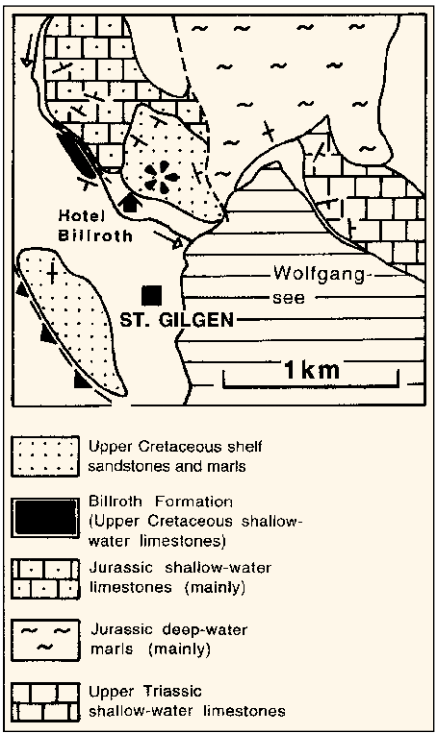
Introduction

Fossil-rich sediments of the Lower Gosau Subgroup cropping out in and around the village of Sankt Gilgen at the NW end of the Wolfgangsee have been known since the mid-19th century (see e.g. REUSS, 1854; ZITTEL, 1865–1866; UNGER, 1867a, b; DOUVILLÉ, 1897; KÜHN, 1967). Most of the fossils now housed in museums have been yielded by the former locality Billroth, named after the neighbouring post coach station "Station Billroth" (later Hotel Billroth), situated in the northern part of St. Gilgen, near the Bundesstraße "Mondseestraße". As it is usually the case of old collections, however, locality details are often lacking (e.g. STEUBER, 2004). The aim of this paper is, based on studies of recently collected material as well as of specimens housed in the Heimatkundliches Museum of St. Gilgen, to contribute to the knowledge of Gosau-type sediments and fossil assemblages of this classical area.

Geological Setting

Two main types of Gosau deposits can be distinguished in the region (PLÖCHINGER, 1964; SANDERS et al., 1999). An at least 30 m thick coral-rudist buildup (= Billroth Formation, as recently defined by SANDERS et al., 1999) is exposed along the right flank of the valley of Kohlbachgraben *sensu stricto*. To the east and to the south of the former a more than 100 m thick succession of shallow-water sediments, mainly sandstones and marls rich in corals, rudist bivalves and other molluscs, is known to crop out (Text-Fig. 1). The lowermost part of the sequence contains coal seams (Kohlbachgraben = Coal Creek, if translated) which were exploited in the past in small-scale mines (WOLDŘICH, 1868; GÜNTHER & TICHY, 1979). The siliciclastic sequence overlies the Billroth Formation. The exact stratigraphic relationship of the two types of successions is, however, unknown, due to intensive Neogene strike-slip deformation (SANDERS et al., 1999). According to the results of analyses of the strontium-isotope composition of rudist shells, rudist localities at St. Gilgen are Late Turonian in age (STEUBER, 2001, 2004). The geological map sheet 65 Mondsee (VAN HUSEN, 1989) shows in the surroundings of "Station Billroth" a sequence of the Lower Gosau Subgroup with "Bitumenschichten" on the base (grey marls and sandstone, Coniacian), rudist limestones (Coniacian–Santonian) and sandstones and marls (Campanian–Maastrichtian). In the light of results of recent studies, however, these ages should be revised.



Text-Fig. 1.
Geological map of St. Gilgen and its surroundings (after SANDERS et al., 1999).
The asterisk indicates the approximate position of studied localities.

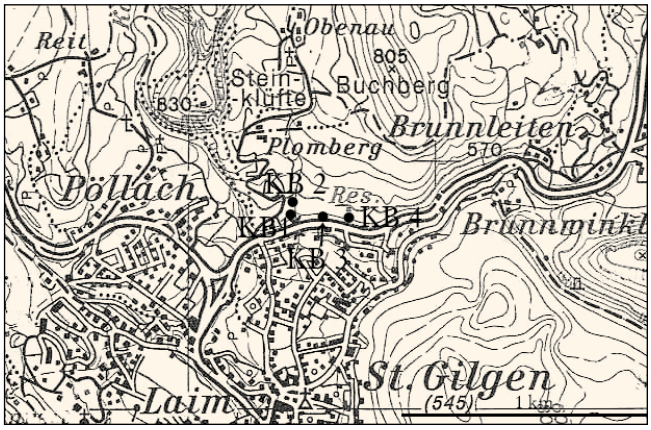
Localities

Four localities were sampled (Text-Fig. 2).

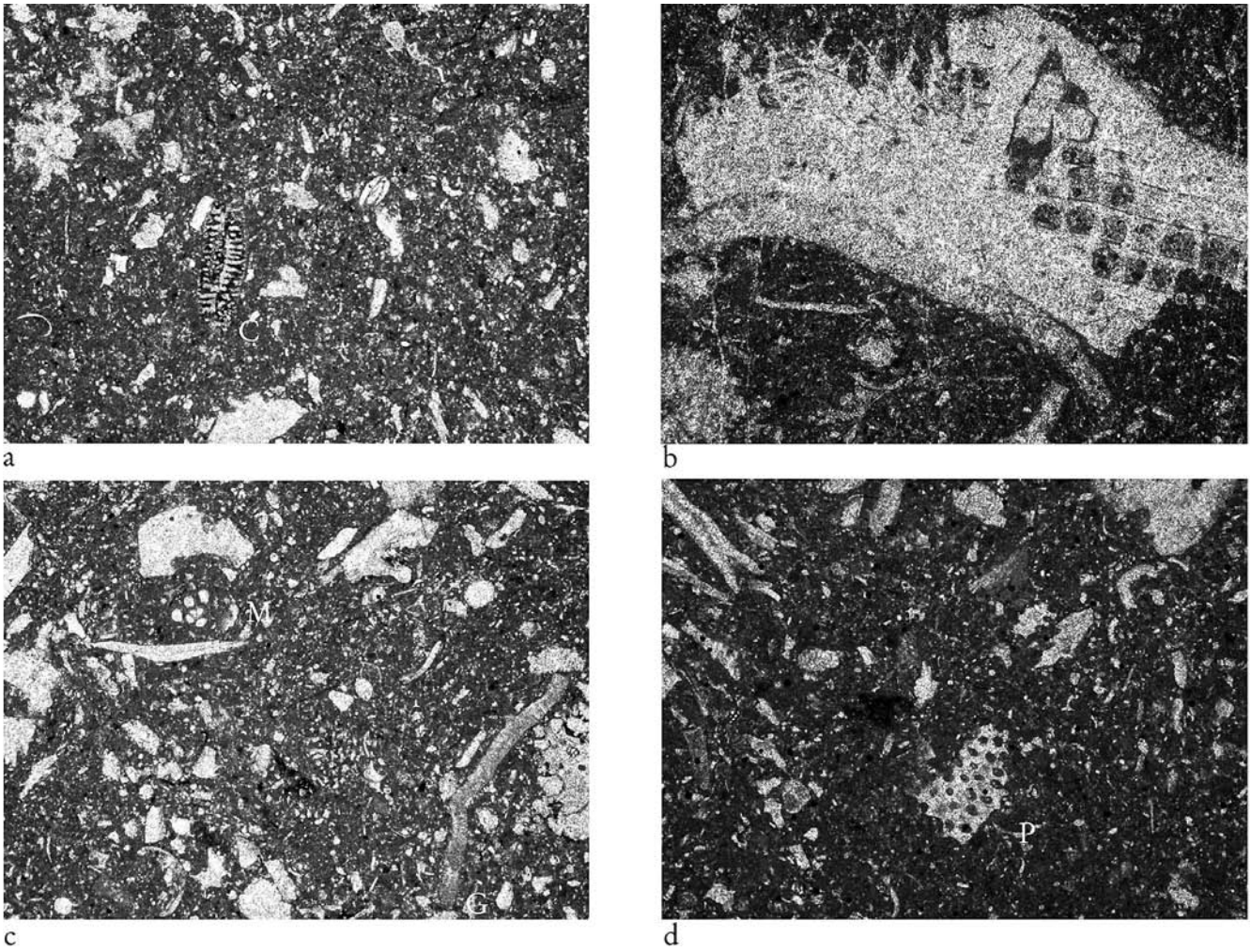
KB 1. A left tributary of the Kohlbachgraben *sensu stricto*, already reported by HRADECKÁ et al. (2008). The exposures extend to the N of the Bundesstraße "Mondseestraße". Near the bridge on the right flank of the ravine a rock wall is formed by marly limestone. Its microfacies is characterised by *Milanovicella hammudai* (RADOIČIĆ), which is rather common in the Late Turonian – Early Coniacian interval of the Lower Gosau Subgroup. Other microfossils include *Permocalculus gosaviensis* SCHLAGINTWEIT, *Neomeris mokragorensis* RADOIČIĆ & SCHLAGINTWEIT, debris of *Gosavisiphon paucimedullaris* (SCHLAGINTWEIT & EBLI), miliolid forams (e.g. *Vidalina hispanica* SCHLUMBERGER) and *Cuneolina*. Among other bioclasts, the coral *Pleurocora* sp. and debris of radiolitid rudists could be identified (Text-Fig. 3).

Immediately north of the rock wall a sequence of marls is exposed poorly on the right flank of the ravine, containing abundant although usually badly preserved radiolitid rudists, among which two types, *Radiolites* cf. *angeiodes* (LAPEIROUSE) and *Radiolites* sp. could be distinguished. Other rudists, such as *Vaccinites inaequicostatus* (MÜNSTER in GOLDFUSS) and *Plagioptychus uchauxensis* MENNESSIER occur only sporadically. A specimen of the colonial coral *Paraplacocoenia orbignyana* (REUSS) was also found there. The limestone-marl succession can not be identified with the Billroth Formation.

KB 2. Near the first waterfall of the creek light-coloured and partly dissolved bivalves were found in a seemingly displaced and disintegrated marl block. The taxa recorded are:



Text-Fig. 2.
Map showing the position of the studied localities.



Text-Fig. 3.
Characteristic microfacies and microfossils of marly limestone exposed at KB 1. a, *Cuneolina* sp. (C) ; b, shell fragment of radiolitid rudist bivalve; c, Miliolid foraminifera (M), *Gosavisiphon paucimedullaris* (G); d, *Permocalculus gosaviensis* (P). The width of pictures is 5 mm.

Crassatella macrodonta (J. SOWERBY), *Hippuritella resecta* (DEFRANCE). The plant fossils and microfossils (samples 2a and 2b) interpreted below were collected from the marl forming the bottom of the creek, below and near the waterfall.

KB 3. The road cutting of the Bundesstraße "Mondseestraße" exposes grey marls of the Lower Gosau Subgroup. Apart from some poorly preserved gastropods, bivalves and colonial corals these sediments yielded only microfossils. The foraminiferal assemblage, dominated by *Quinqueloculina angusta* (FRANKE) and *Spirillina cretacea* (REUSS) is clearly of shallow-water character. Ostracods, small gastropods, fragments of bivalves and rare Radiolaria were also found in the washed material. On the basis of comparison with foraminiferal assemblages of similar character (Weissenbachalm, Eisenbach [HRADECKÁ et al., 2006]) we can assume a Turonian age of the sample.

The poor and poorly preserved nannoflora with *Eiffellithus eximius* and *Lucianorhabdus maleformis* provides evidence of the Middle Turonian, zone UC8 (*sensu* BURNETT, 1998) and no evidence of a younger age. Rare occurrence of small specimens of *Braarudosphaera bigelowii* indicates shallow-water depositional environment.

The marl beds yielded corroded, pale yellow and very rare palynomorphs. Several triporate angiosperm pollen grains of the genera *Complexiopollis* sp. and *Trudopollis* sp., tricolporate pollen of *Retitricolporites* sp., spores of fungi (*Pluricellaesporites* sp.), broken dinocysts and foraminiferal linings were found. Despite of its low diversity, the assemblage was found to contain a form of some stratigraphical value: the angiosperm pollen *Trudopollis* appeared in the Middle Turonian. The presence of dinocysts and foraminifers gives evidence of marine environment.

KB 4. Some 200 m E of KB 1 blocks of fossil-rich marls can be found in the forest, below the water reservoir indicated as "Res." in the topographic map. The "archaeological finds" such as old-fashioned spades and beer bottles associated to the rocks and fossils suggest that the material came to the light when the reservoir was sunk.

The marl contains abundant colonial coral and rudist remains. Among corals, hemispherical ones of up to 20 cm diameter prevail, columnar and branching forms seem to be much less frequent. A preliminary survey has proved the presence of six taxa (see below).

The rudist assemblage is dominated by representatives of *Plagioptychus uchauxensis*. *Vaccinites* and other bivalves occur sporadically. No radiolitid rudists were found. Specimens of *Plagioptychus* are preserved almost exclusively with closed, conjoined and crushed right and left valves.

Short Description and Evaluation of Fossils Found at Localities KB 1, 2 and 4 During this Study

Nannofossils

Method

Nannofossils from KB 2 were investigated in the fraction of 2–30 μm, separated by decantation following the methodology described in SVOBODOVÁ et al. (2004). Simple smear-slides were mounted by Canada Balsam and inspected at 1000× magnification, using an oil-immersion objective on a Nikon Microphot-FXA transmitting light microscope. Biostratigraphic data and provincial preferences of nannofossil species were interpreted applying BOWN et al. (1998) and BURNETT (1998).

Results

Calcareous nannofossils were extremely poorly preserved (mostly fragmented, partly extensively overgrown with calcite, partly etched). Nannofossil abundance was very low (1–2 identifiable specimens per 1 field of view of the microscope), the majority of specimens cannot be identified at all. The assemblage is characterized by a relatively large number of *Watznaueria barnesae* and by the presence of specimens (both coccoliths and nannoconids) reworked from older deposits of the Uppermost Jurassic – basal Cretaceous interval and from the Lower Cretaceous. Recorded taxa are listed in Appendix 1.

Stratigraphic Interpretations

Nannofossil thaphocoenose consists of three different assemblages at least:

Upper Cretaceous (Upper Turonian to ?Coniacian) with scarce *Micula staurophora* (1 badly preserved and questionable specimen), *Marthasterites furcatus* (3 strongly owergrown specimens), and *Lucianorhabdus quadrifidus.* The Coniacian may be indicated by the presence of a questionable, unfortunately fragmentary specimen of a polycyclolith (6 rays) probably of the genus *Lithastrinus* (?*L. grillii*) or ?*Hexalithus/Rucinolithus,* as well as of fragments of ?*Lucianorhabdus* ex gr. *cayeuxii*.

Lower Cretaceous (?Hauterivian) with *Micrantholithus hoschulzii, M. obtusus, Cruciellipsis cuvillieri, Lithaphidites bollii*, and nannoconids.

Uppermost Jurassic – basal Cretaceous interval with *Conusphaera mexicana* and *Faviococonus multicolumnatus.*

Palaeoenvironmental and palaeogeographic interpretations

The presence of calcareous nannofossils documents sea of normal salinity.

Upper Cretaceous (Upper Turonian to ?Coniacian, UC9–?UC10). Presence of *Braarudosphaera bigelowii* and *Lucianorhabdus* sp. reflects shallower marine conditions.

Lower Cretaceous. Presence of the predominantly Tethyan taxon *Cruciellipsis cuvillieri* (*sensu* BOWN et al., 1998) may document low latitudes. Nannoconids usually indicate shallow warmer waters and oligotrophic environment.

Discussion

The character of the nannofossil taphocoenoses, including the relatively large number of reworked specimens from older sediments of uppermost Jurassic and Lower Cretaceous age, is comparable to that of the sample collected at St. Gilgen Kühleitengraben.

The extremely poor preservation of specimens, especially carbonate dissolution and etching may be explained as a result of liberation of organic acids during decomposition of organic matter enclosed in the sediments (ŠVÁBENICKÁ et al., 2010). The large number of *W. barnesae* may be due to diagenetic processes.

Palynology

Preservation of the palynomorph assemblage is very poor. Almost all spores, pollen, organic-walled dinoflagellate cysts as well as foraminiferal linings are corroded by pyrite or pyrite crystals are found inside the grains (see e.g. Pl. 1, Fig. 2). Rare redeposited "early" angiosperm pollen, probably of Lower Cretaceous age, were also determined.

Chitinous microforaminiferal linings (Pl. 1, Figs. 8, 9) dominate the assemblage. Dinoflagellate cysts consist of *Kiokansium polypes, Pervosphaeridium pseudhystrichodinium, Oligosphaeridium complex, Circulodinium distinctum, Palaeohystrichophora infusorioides, Spiniferites ramosus, Dinogymnium* sp., aff. *Achomosphaera ramulifera* (Pl. 1, Fig. 7).

Spore-pollen taxa consist of triporate pollen of the *Normapolles* group – relatively most abundant are *Complexiopollis* sp., *Plicapollis* sp. and *Pseudovacuopollis* sp. (Pl. 1, Fig. 2). Rare reticulate tricolpate pollen *Retitricolpites* sp. (Pl. 1, Fig. 1), probably redeposited from the Lower Cretaceous, also appear.

Gymnosperm pollen consist of *Taxodiaceaepollenites hiatus, Corollina/Classopollis*, *Ephedripites* sp. associated with bisaccate *Pinuspollenites* sp. Pteridophyte spores are represented mainly by *Vadaszisporites urkuticus* (Pl. 1, Figs. 3, 4), *Stereisporites antiquasporites, Cyathidites minor.* Occasionally some fungal spores *Pluricellaesporites psilatus* occur. The palynofacies includes brown to black phytoclasts. Pyrite crystals are abundant.

The palaeoenvironment was warm and partly dry as evidenced by the presence of *Ephedripites* pollen and thick-walled pteridophyte spores. Sediments were probably deposited in shallow marine environment with lower oxygen content. It is documented also by common scolecodonts (jaw apparatus of Polychaeta worms) (Pl. 1, Figs. 5, 6). The composition of the triporate angiosperms as well as dinoflagellate cysts corresponds probably to the Turonian or Turonian/Coniacian age (GÓCZÁN et al., 1967; SIEGL-FARKAS, 1994; TSCHUDY, 1973). Redeposition of Lower Cretaceous miospores was also observed.

Recorded taxa are listed in Appendix 2.

Foraminifera

Two samples from layers 2a and 2b contain a relatively poor foraminiferal assemblage, which is composed only of about 10 benthonic species, plankton was not found. Specimen diversity of sample 2b is lower than that in 2a. Forms with agglutinated tests such as *Gaudryina trochus*

(D'ORBIGNY), *Gaudryina* sp., *Marssonella oxycona* (REUSS) and *Pseudotextulariella cretosa* (CUSHMAN) together with fine agglutinated sessile species of genera *Dictyopsella* and *Dictyopselloides* prevail. Among other agglutinated species, *Ammodiscus gaultinus* BERTHELIN and coarse agglutinated tests of *Ammobaculites* sp. and *Haplophragmoides* sp. are present.

Calcareous benthos is represented by frequent occurrence of *Quinqueloculina angusta* (FRANKE), *Quinqueloculina* sp., *Spirillina cretacea* (REUSS), *Trocholina* sp. and a few specimens of *Vaginulina robusta* (CHAPMAN).

Organic part of washed material of both samples is formed also by fragments of echinodermata (spines and small fragments), by green algae, fish teeth, fragments of bryozoa and corals, ostracoda and small pyritized gastropods. Pyrite is very frequent in sample 2a and less frequent in 2b.

Concerning the interpretation of palaeoenvironment we can suppose shallow-water conditions (*Vaginulina* and agglutinated species) with local fluctuation of salinity (occurrence of *Quinqueloculina*) and local dysoxic conditions. The benthos is represented by sessile or active epifaunal deposit feeders (*Trocholina* and *Spirillina*, etc.) with flat or conical tests, resting on and partially buried in the sediment-water interface.

On the basis of the character of foraminiferal assemblage the samples show a Turonian or Turonian/Coniacian boundary age.

Plant fossils

Already UNGER (1867a, b) reports about findings of fossil plant remains from the coal-bearing Bitumenschichten of the Kohlbachgraben. The flora has remained, however, largely undocumented until now.

Pinopsida

Brachyphyllum sp.

Pl. 2, Fig. 1

Material: K 962a.

Description: One coniferous twig No. K 962a was recorded. It shows a shoot with 3–4 branches arranged in one plane, bearing helically arranged poorly preserved leaves. They are intimately attached to branches including leaf apices. This can be caused also by poor preservation.

Discussion: In gross morphology *Brachyphyllum* sp. resembles *Brachyphyllum squamosum* from the Bohemian Cenomanian (VELENOVSKÝ, 1885a; KVAČEK, 2007). However its poor preservation does not allow closer comparison.

Gymnosperms *incertae sedis*

cf. *Dammarites albens* PRESL in STERNBERG

Pl. 2, Figs. 3, 4

Material: K 963, K 964, K 967, K 968, K 969.

Description: There are 5 specimens available in the collection of National Museum. They show fragments of entire margined leaves about 3 cm broad (Pl. 2, Fig. 3). The largest fragment showing basal part of leaf has 12 cm in length (Pl. 2, Fig. 4). The leaf fragments are coriaceous parallel-sided. Well pronounced parallel venation has density of 12 veins per 1 cm.

Discussion: The leaf type is known from the locality St. Wolfgang road tunnel excavations (KVAČEK & LOBITZER, 2010). After inspection of the material from St. Wolfgang, which shows completely the same venation type and density, it is clear that the specimens earlier assigned to the genus *Monocotylophyllum* (HRADECKÁ et al., 2008) must be transfered to the genus *Dammarites*. The only known species of *Dammarites* from central Europe is *D. albens* described from the Bohemian Cretaceous (PRESL in STERNBERG, 1838; VELENOVSKÝ, 1885a; HLUŠTÍK, 1976). It shows the same type of leaf base and venation density. Its leaves are also typically coriaceous.

Magnoliopsida

Dicotylophyllum sp. 1

Pl. 2, Figs. 5, 6

Material: K 962b, K 966

Description: There are numerous, poorly preserved leaf fragments of entire-margined narrow, linear to elliptical coriaceous leaves. The best preserved leaf figured on it is a leaf impression with clearly pronounced mid vein and poorly preserved secondary venation. Some of the leaves are preserved as leaf compressions (Pl. 2, Fig. 5), but preparation of cuticle failed.

Discussion: The leaves are poorly preserved, they can be compared with *Dicotylophyllum proteoides* (UNGER) HERMAN & KVAČEK known from the Cretaceous flora of Grünbach (HERMAN & J. KVAČEK, 2010). They also may be compared with *Myrtophyllum angustum* (HEER) KNOBLOCH from the Bohemian Cenomanian (VELENOVSKÝ, 1885b; KVAČEK, 1992).

Dicotylophyllum sp. 2

Pl. 2, Fig. 2

Material: K 965

Description: One leaf fragment in the collection is nearly entire-margined, however, it shows very fine needle-like teeth. Venation is very poorly preserved, only the midvein is visible. This is a leaf compression, however preparation of its cuticle failed.

Discussion: There is no similar leaf known within the Central European Cretaceous, more and better preserved material is necessary for its interpretation.

Remarks on the plant assemblage

Together with this foliage various axes and fragments of roots co-occur on the same bedding plane. The whole assemblage is clearly allochthonous. Only coriaceous leaves survived long transport. The conifer twig and small entire-margined leaves with spines argue for mesophytic/xerophytic flora. This situation is very similar to the Häuselkogel flora collected near Bad Ischl. As already published by HRADECKÁ et al. (2008) the palaeoenvironment of the flora was probably quite dry and warm. Salt-marsh flora is represented here as well as in the St. Wolfgang tunnel assemblage (KVAČEK & LOBITZER, 2010) by the genus *Dammarites.* In the Bohemian Cenomanian it co-occurs with the genus *Frenelopsis* (ULIČNÝ et al., 1997; KVAČEK, 2000).

Scleractinian corals

(Coral and bivalve remains collected during this study are housed in the collection of Geologische Bundesanstalt, Vienna)

Abbreviations:
d: corallite diameter.
c–c: distance of corallite centers.
s: number of septa in corallite.
s/mm: number of septa per mm.

Family Faviidae Gregory, 1900

Genus Cladocora Ehrenberg, 1834

***Cladocora gracilis* (d'Orbigny, 1850)**

Pl. 3, Figs. 1, 2

Material: KB 3-3.

Diagnosis: Phaceloid-dendroid colony; gemmation intracalicinal (polystomodaeal) and extracalicinal; costosepta compact, finely granulated laterally, dentate marginally; paliform swellings in front of S1 and S2 can be present. Pseudo-columella formed by trabecular extension of axial septal ends, irregularly parietal, spongy to papillose, sublamellar deeper in corallum; wall septothecal and septoparathecal; endothecal dissepiments and epithecal wall thin; d = 3–4 mm; s = 24–40.

Family Agatheliidae L. & M. Beauvais, 1975

Agathelia Reuss, 1854

***Agathelia asperella* Reuss, 1854**

Pl. 3, Figs. 3, 4

Material: KB 3-9; -10; -11; -12; -13; -22.

Description: Massive, plocoid colonies; extracalicinal budding; costosepta compact, radially or bilaterally arranged in 6 systems, with small denticles marginally and granules laterally; columella feebly developed, parietal-spongy to lamellar; endothecal dissepiments vesicular to subtabulate; exothecal dissepiments vesicular, abundant; septothecal wall covered by concentrical perithecal lamellae; d (adult) = 3.5–6 mm; s (adult) = 30–40.

Multicolumnastraea Vaughan, 1899

***Multicolumnastraea cyathiformis* (Duncan, 1865)**

Pl. 3, Fig. 5

Material: KB 3-2; -21.

Diagnosis: Colony massive, plocoid; gemmation extracalicinal; costosepta compact, dentate marginally; columella formed by a small number of trabecular pillars; pali in front of S1 and S2; wall septothecal; endothecal and perithecal dissepiments thin, vesicular; auriculae rare; d = 1.8–3.5 mm; s = 18–24.

Family Actinacididae Vaughan & Wells, 1943

Genus Actinacis d'Orbigny, 1849

***Actinacis remesi* Felix, 1903**

Pl. 3, Fig. 6

Material: KB 3-24; -26.

Diagnosis: Plocoid colony; extracalicinal budding; corallites embedded in vermiculate coenosteum; costosepta have few, but large perforations, granular laterally; anastomosis present, synapticulothecal wall incomplete; columella parietal, substyliform, or formed by elongated segments; synapticulae abundant; endothecal dissepiments sparse, thin; d = 1.8–2.5 mm; s = 18–24.

Genus Elephantaria Oppenheim, 1930

***Elephantaria lindstroemi* Oppenheim, 1930**

Pl. 3, Fig. 7

Material: KB 3-25.

Diagnosis: Subthamnasterioid-subplocoid-subceriod colony; gemmation extracalicinal; corallites embedded in a porous-reticulate coenosteum, connected by irregularly confluent septa; nonconfluent septa common; costosepta reduced, subcompact to porous, granulate laterally; synapticulae and trabecular columella present; endothecal dissepiments thin, vesicular; c–c = 3–6.5 mm; s/mm = 6–9/2.

Family Placocoeniidae Alloiteau, 1952

Genus Paraplacocoenia M. Beauvais, 1982

***Paraplacocoenia orbignyana* (Reuss, 1854)**

Pl. 3, Fig. 8

Material: KB 1-2.

Diagnosis: Plocoid colony; gemmation extracalicinal; costosepta compact, radial, granular laterally, beaded marginally, and dissociate into trabecular structures in distal areas; perithecal wall tabulo-columnar; columella small, trabecular-lamellar; endothecal dissepiments thin, subtabulate, abundant; wall septoparathecal; d = 4–5 mm; c–c = 4.8–6 mm; s = 24 + s4.

Family Haplaraeidae Vaughan & Wells, 1943

Genus Pleurocora Milne Edwards & Haime, 1848

***Pleurocora* sp.**

Pl. 3, Fig. 9

Material: KB 1-1.

Diagnosis: Fragment of a branching (?subdendroid) colony; corallite subcylindrical; costosepta compact or subcompact, finely granulated laterally; pali irregularly occur opposite all but last cycle; wall dense, synapticulothecal; columella trabecular; endothecal dissepiments thin, vesicular; d = 5.6 mm; s = 24.

Genus Brachymeandra Alloiteau, 1957

***Brachymeandra leptophylla* (Reuss, 1854)**

Pl. 3, Figs. 10, 11

Material: KB 3-1; -23.

Diagnosis: Thamnasterioid colony, which is plocoid to submeandroid superficially; gemmation intracalicinal; costosepta subcompact or porous, subconfluent or confluent, beaded marginally, finely granulated laterally; columella parietal-papillose; paliform structures present; synapticulae abundant; endothecal dissepiments thin, subtabulate; perithecal wall can be present; generally no wall between the calices; d = 3–10 mm; s/mm = 8–11/3.

Bivalves

Limaria? *sp.* cf. *marticensis* (Matheron, 1843)

Pl. 4, Fig. 1

A single fragment of a left valve bearing well defined radial ribs resembles the specimens of *"Lima" marticensis* as figured by Zittel (1866, Pl. 16, Figs. 1, 1a) from the Hofergraben of Gosau.

Curvostrea madelungi (Zittel, 1866)

Pl. 4, Fig. 2

Remarks: the marl of KB 1 contains fragments of oyster shells similar to *"Ostrea" madelungi* Zittel (1866, p. 125, Pl. 19, Figs. 7a–c). Inner characters of the valves can not be studied. Zittel (l. c.) compared *O. madelungi* to *O. tetragona* Bayle, 1849, a species described from the Upper Cretaceous of North Africa, from which the Gosau specimens were found to differ by their smaller size and by the lack of commarginal growth lamellae. *"O." tetragona* was designated as the type species of *Quadrostrea* Vialov, 1936, which later was, however, considered as uncertain by Stenzel (1971) and was synonymised with *Curvostrea* Vialov, 1936 by Malchus (1990). It is possible that *C. madelungi* represents an ecophenotypical variety of *C. tetragona*.

Crassatella macrodonta (J. Sowerby, 1832)

Pl. 4, Fig. 3

The single specimen found clearly falls within the morphological range of *C. macrodonta* as illustrated by Zittel (1865, Pl. 8, Figs. 2, 3). According to Dhondt (1987), this variable species is an endemic element of the Gosau fauna. The specimen recorded here indicates, however, that its stratigraphic range is considerably longer than it was previously supposed (i. e. Santonian; Dhondt, 1987).

Plagioptychus uchauxensis Mennessier, 1957

Pl. 4, Figs. 4–8

Material: Two specimens from KB 1, 6 specimens from KB 3.

Description: inaequivalve forms of up to 70 mm commissural diameter. The right valve is relatively flat, gyropleuriform. About 11 primary pallial canals can be counted in the shell wall of the posterior part of the left valve. The walls of canals display three bifurcations. The tooth of the right valve is prominent, occupying the dorsal part of the posterior shell cavity.

Remarks: On the basis of the branching pattern of the wall of pallial canals and the dimensions of the shell the specimens are assigned to the Turonian species *P. uchauxensis*. The mode of preservation of the specimens found during this study is strikingly similar to those reported by Steuber (2004) from an unknown locality of St. Wolfgang.

Hippuritella resecta (Defrance, 1821)

Pl. 4, Figs. 9–13

Material: 8 right valves from KB 2.

Description: slender shells bearing fine ribs. The ligamental crest is triangular, wide and short. The pillar S is short and wide, the pillar E is longer than S.

Remarks: There is no general agreement in the literature on the generic assignment of *H. resecta*. Some authors (e.g. Pleničar & Jurkovšek, 2001; Pleničar, 2005) consider it as belonging to *Hippurites* Lamarck, 1801. As it was pointed out by Pleničar (2005), the right valve of *H. resecta* is similar to that of *Vaccinites sulcatus* (Defrance, 1821) (see e.g. Szente et al., 1999). The species is widely distributed in the Turonian of the peri-Mediterranean region (Steuber, 1993).

Vaccinites inaequicostatus (Münster in Goldfuss, 1840)

Pl. 4, Figs. 14–16

Material: 3 specimens from KB 1.

Remarks: The dimensions of the shell as well as the shape and arrangement of pillars correspond well to *V. inaequicostatus* recently described in detail by Steuber (1999). The species, which was already recorded from St. Gilgen – Billroth by Douvillé (1897), is a characteristic element of the Upper Turonian – Lower Coniacian rudist associations of the Gosau-type formations (Steuber, 2001).

Vaccinites cf. *cornuvaccinum* (Bronn, 1831)

Pl. 5, Fig. 1

Remarks: A right valve belonging to the collection of H. Schiemer, displayed at the Heimatkundliches Museum of Sankt Gilgen differs considerably from *V. inaequicostatus* both in shape and arrangement of pillars and shows characteristic features of *V. cornuvaccinum*. On the label of the specimen St. Gilgen/Billroth is indicated as locality. According to Steuber (2003), however, *V. cornuvaccinum* is restricted to the Coniacian, thus its occurrence at St. Gilgen somewhat contradicts the Turonian age of the Gosau successions of this area. Other *Vaccinites* species of similar shape and spacing of pillars, such as *V. chaperi* (Douvillé, 1897) and *V. ultimus* (Milovanović, 1935) are also younger than Turonian.

Radiolites cf. *angeiodes* (Lapeirouse, 1781)

Pl. 5, Figs. 2–5

Material: 11 more or less worn and crushed specimens from KB 1.

Description: Conical right valves ornamented with sharp and rarely interrupted longitudinal ribs. Details of the region of radial bands can not be studied on the specimens available. Shell lamellae are regularly plicated. Cells of the outer shell layer are usually hexagonal, rarely exceeding 0.5 mm in diameter. Possible structural modifications could be observed only in the ventral radial band.

Remarks: the specimens collected during this study as well as those collected previously at Billroth and now housed in the Heimatkundliches Museum of Sankt Gilgen, correspond well to *"Sphaerulites" angeiodes* as described and figured from various localities of the Northern Calcareous Alps by Zittel (1866, p. 150; Pl. 25, Figs. 4–12; Pl. 26, Figs. 1–4). The St. Gilgen specimens are, however, somewhat larger and less regularly conical than most of *R. angeiodes* described and figured in the literature (e.g. Lupu, 1976; Czabalay, 1982; Steuber, 1999; Pleničar, 2005). According to the valuable rudist database developed and maintai-

ned by STEUBER (www.paleotax.de/rudists/s392.htm) the species has been hitherto recorded from the Coniacian to Campanian interval of the Gosau-type successions. Thus, if the St. Gilgen specimens are conspecific, they represent the stratigraphically oldest occurrence of *R. angeiodes* in the Gosau-type formations of the Northern Calcareous Alps.

***Radiolites* sp.**

Pl. 5, Figs. 6–8

A single, strongly worn specimen with closed valves from KB 1 appears to differ from *R.* cf. *angeiodes* by its larger size, more cylindrical shape and less continuous ribs.

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Plate 1

Organic-walled microfossils. Scale bar 10 µm.

Fig. 1: *Retitricolpites* sp. (redeposition from the Lower Cretaceous).
Fig. 2: *Pseudovacuopollis* sp. (small pyrite crystals inside miospore).
Figs. 3, 4: *Vadaszisporites urkuticus* (DEÁK) DEÁK & COMBAZ.
Figs. 5, 6: Scolecodonts.
Fig. 7: aff. *Achomosphaera ramulifera* (DEFLANDRE) EVITT
Figs. 8, 9: Chitinous foraminiferal linings (Fig. 9: degradation by pyrite crystals).

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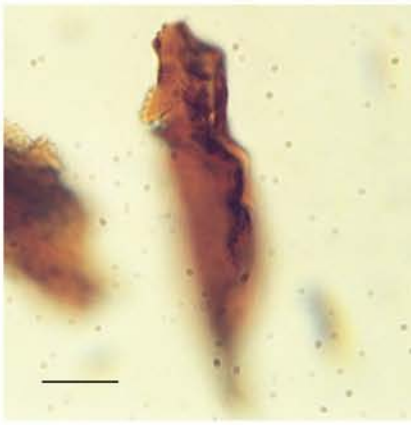

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Plate 2

Plant remains

Fig. 1: *Brachyphyllum* sp.
Branched twig, 3×.

Fig. 2: *Dicotylophyllum* sp. 2.
Basal part of leaf, 3×.

Fig. 3: cf. *Dammarites albens*.
Leaf fragment with parallel venation , 1.5×.

Fig. 4: cf. *Dammarites albens*.
Basal part of leaf, 2×.

Fig. 5: *Dicotylophyllum* sp. 1.
Fragment of entire-margined leaf, 2×.

Fig. 6: *Dicotylophyllum* sp. 1.
Fragment of entire margined leaf, 2×.

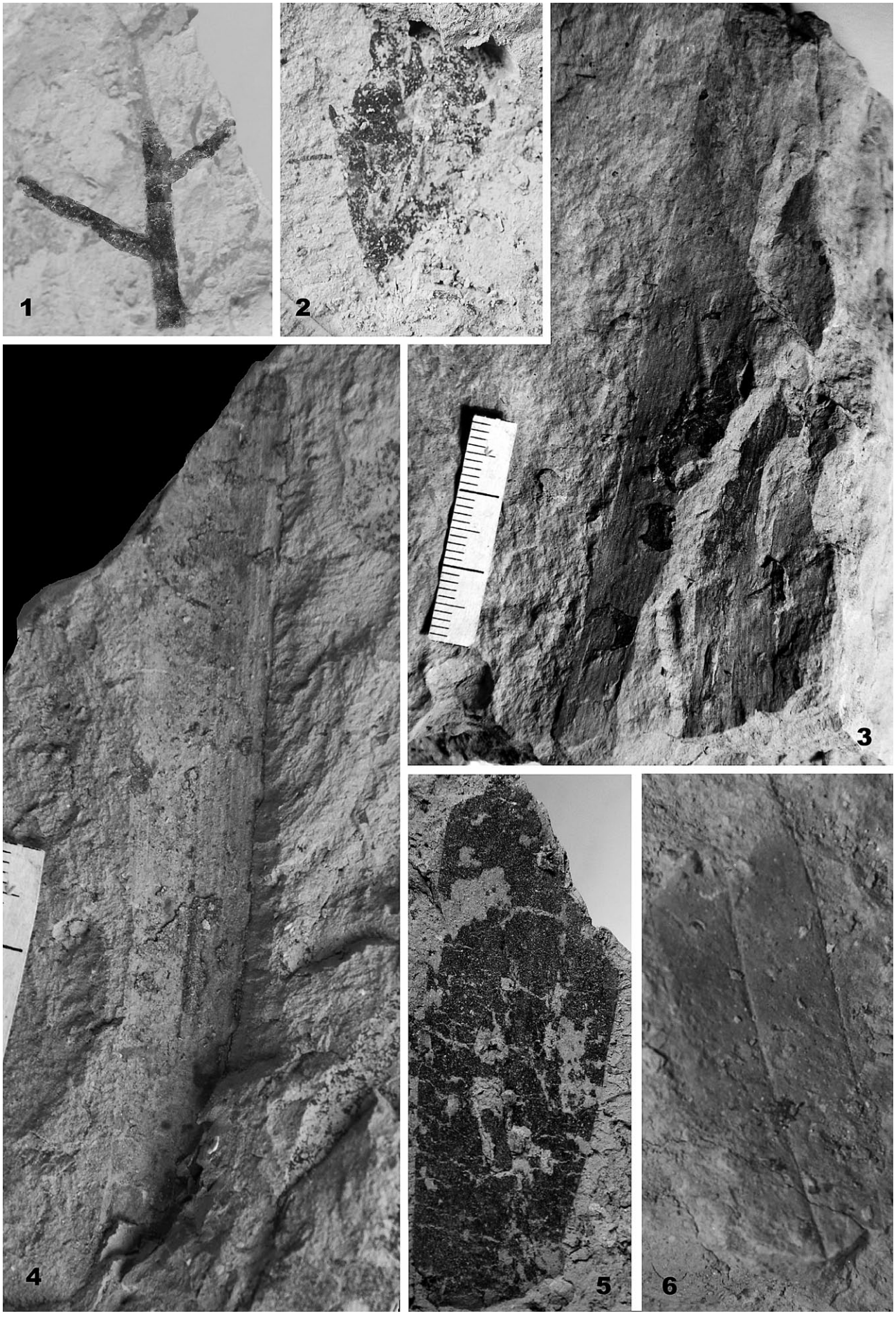
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Plate 3

Corals

The specimens in Figs. 1, 4 and 10 are coated with ammonium-chloride.

The scale-bar represents 3 mm in Figs. 2, 3, 5–9 and 11.

Figs. 1, 2: *Cladocora gracilis* (D'ORBIGNY, 1850).
Sample KB 3-3.
Fig.1: lateral view of colony.
Fig. 2: cross-section.

Figs. 3, 4: *Agathelia asperella* REUSS, 1854.
Fig. 3: Sample KB 3-22, cross-section.
Fig. 4: sample KB 3-13, upper surface of colony, 1,5×.

Fig. 5: *Multicolumnastraea cyathiformis* (DUNCAN, 1865).
Sample KB 3-2, cross-section.

Fig. 6: *Actinacis remesi* FELIX, 1903.
Sample KB 3-26, cross-section.

Fig. 7: *Elephantaria lindstroemi* OPPENHEIM, 1930.
Sample KB 3-25, cross-section.

Fig. 8: *Paraplacocoenia orbygniana* (REUSS, 1854) .
Sample KB 1-2, cross-section.

Fig. 9: *Pleurocora* sp.
Sample KB 1-1, cross-section.

Figs. 10, 11: *Brachymeandra leptophylla* (REUSS, 1854) .
Sample KB 3-1.
Fig. 10: upper surface of colony, 2×.
Fig. 11: cross-section.

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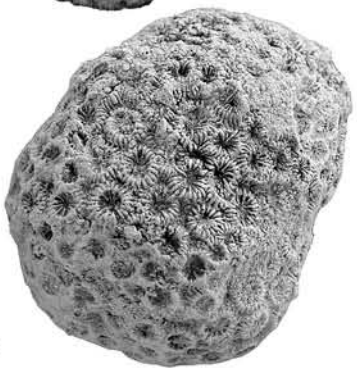

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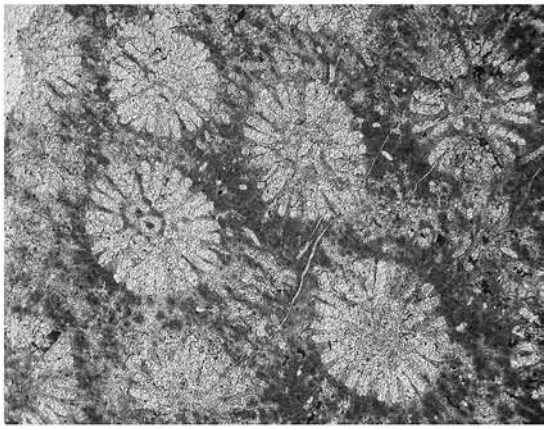

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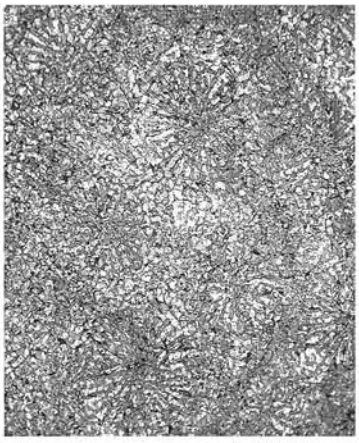

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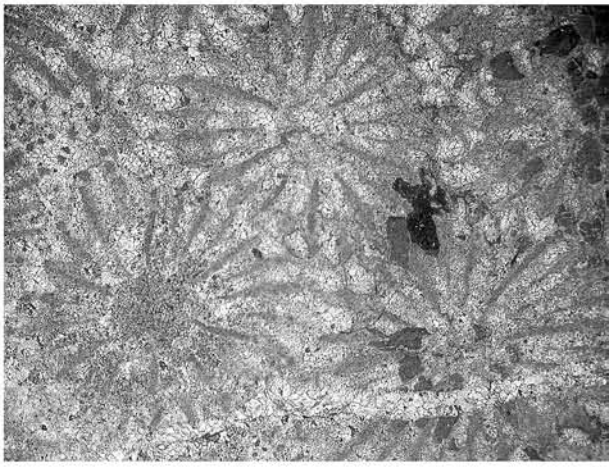

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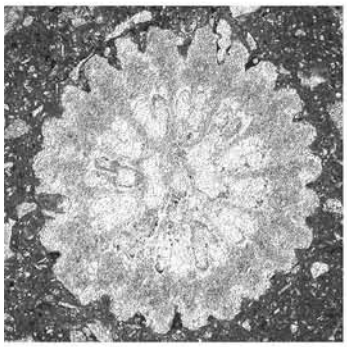

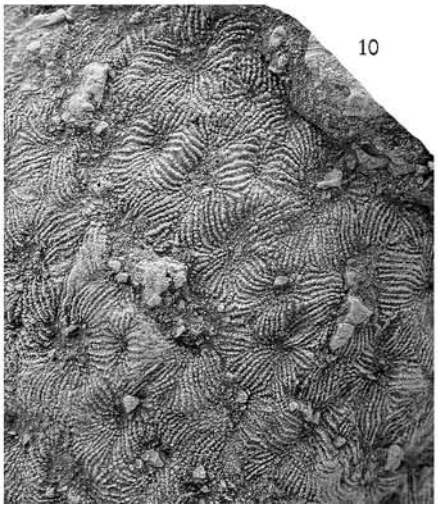

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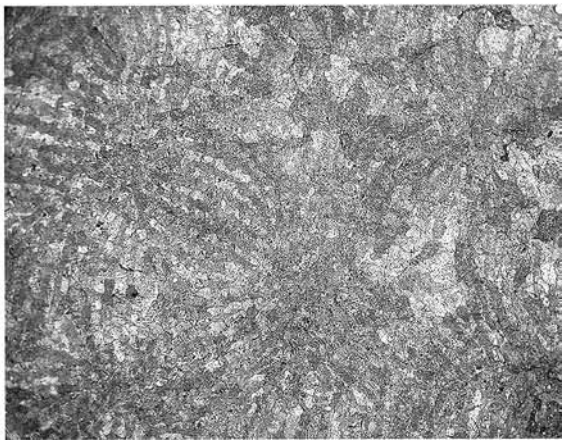

Plate 4

Bivalves
(The specimens in Figs. 1–3, 11 and 15 are coated with ammonium-chloride).

Fig. 1: *Limaria*? sp. cf. *marticensis* (MATHERON, 1843), sample KB 3-5.
Fig. 2: *Curvostrea madelungi* (ZITTEL, 1866), sample KB 1-3.
Fig. 3: *Crassatella macrodonta* (J. SOWERBY, 1832), sample KB 2-1.
Figs. 4–8: *Plagioptychus uchauxensis* MENNESSIER, 1957.
Figs. 4, 5: sample KB 3-4.
Figs. 6, 7: sample KB 3-6.
Fig. 8 (mirror image): sample KB 1-4.
Figs. 5, 7: 2×.
Figs. 9–13: *Hippuritella resecta* (DEFRANCE, 1821).
Fig. 9: sample KB 2-2.
Figs. 10, 11: sample KB 2-3.
Figs. 12, 13: sample KB 2-4.
Figs. 9, 12: 2×, Fig. 13: 4×.
Figs. 14–16: *Vaccinites inaequicostatus* (MÜNSTER in GOLDFUSS, 1840).
Fig. 14: sample KB 1-5.
Figs. 15, 16: sample KB 1-6.

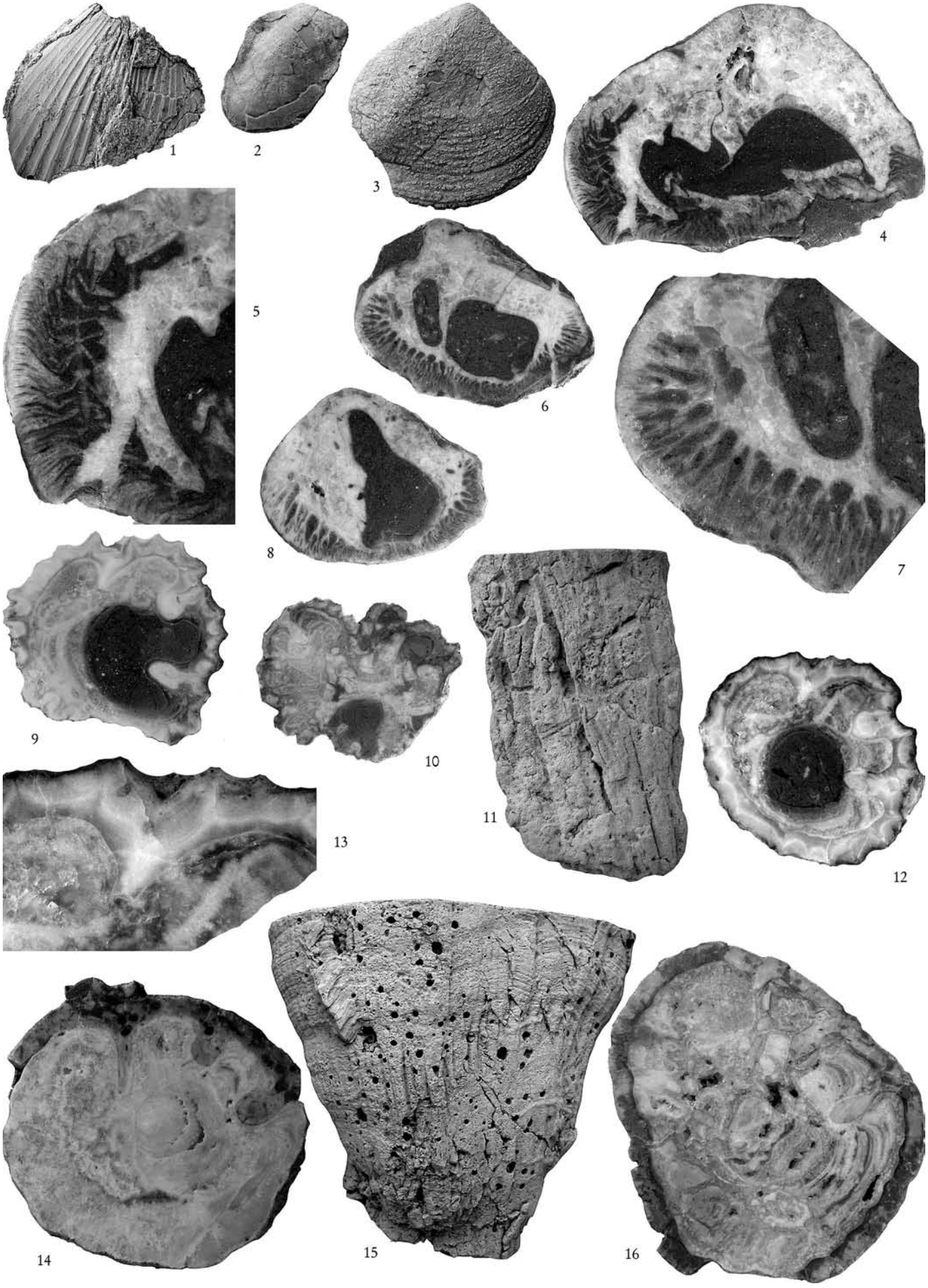
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Plate 5

Bivalves

(The specimens in Figs. 2 and 6 are coated with ammonium-chloride).

Fig. 1: *Vaccinites* cf. *cornuvaccinum* (BRONN, 1831).
Specimen at display at the Heimatkundliches Museum of St. Gilgen (mirror image).

Figs. 2–5: *Radiolites* cf. *angeiodes* (LAPEIROUSE, 1781).
Sample KB 1-7.

Fig. 2: ventral view.

Fig. 4: region of posterior radial band.

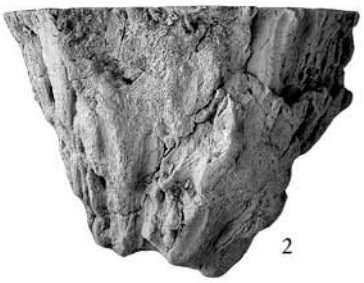
Fig. 4: 2×.
The scale bar in Fig. 5 represents 3 mm.

Figs. 6–8: *Radiolites* sp.
Sample KB 1-8.

Fig. 6: ventral view.

Fig. 7: dorsal region with ligamental ridge, 2×.

1



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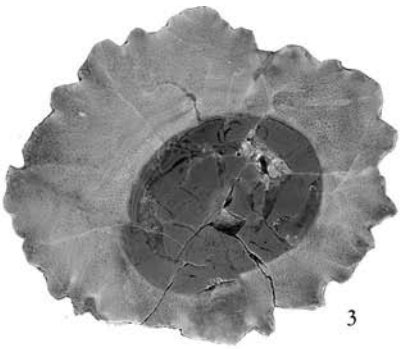

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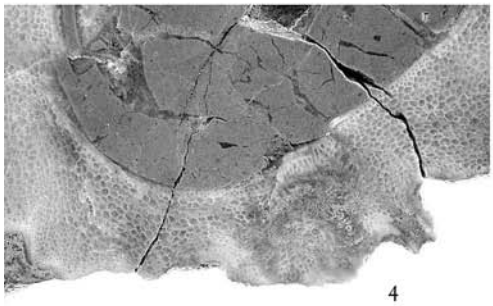

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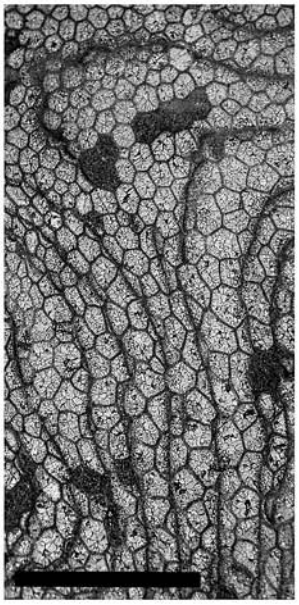

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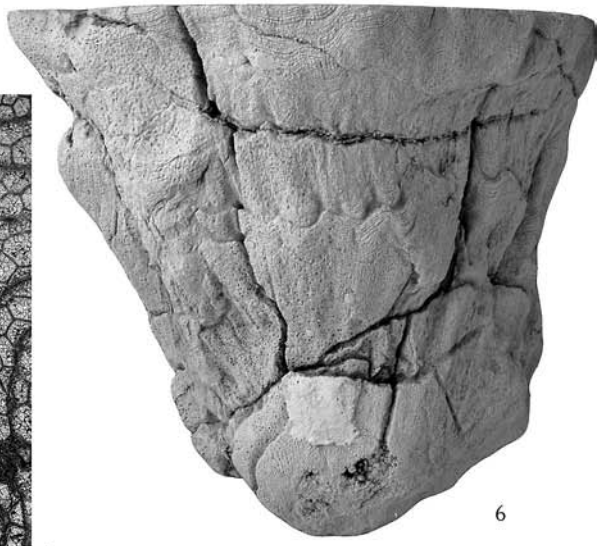

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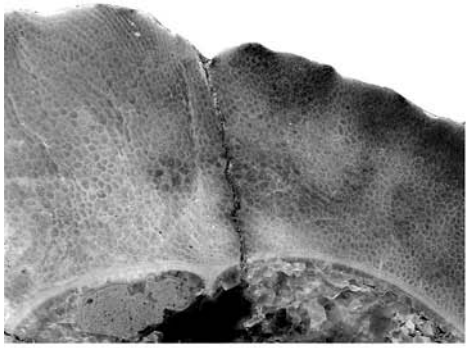

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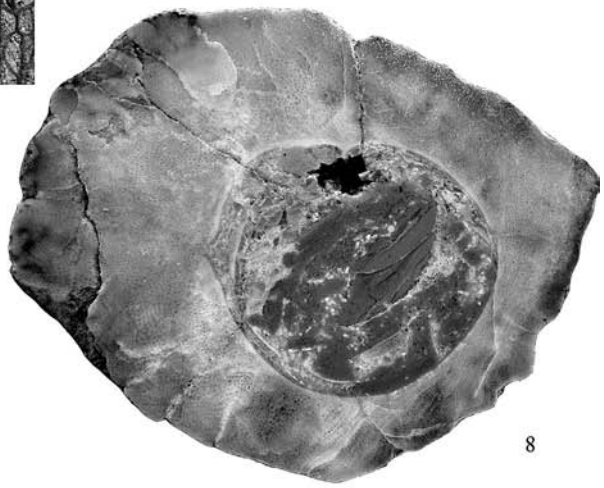

8

Appendix 1

List of calcareous nannofossils found in sample St. Gilgen Kohlbachgraben, in alphabetical order of generic epithets:

Aptian-Albian and Upper Cretaceous:

Amphizygus brooksii Bukry
Braarudosphaera bigelowii (Gran & Braarud) Deflandre
Calculites ovalis (Stradner) Prins & Sissingh
Cribrosphaerella ehrenbergii (Arkhangelsky) Deflandre
Eiffellithus eximius (Stover) Perch-Nielsen
Eiffellithus gorkae Reinhardt
Eiffellithus turriseiffelii (Deflandre) Reinhardt
Eiffellithus turriseiffelii-eximius
Lithastrinus grillii Stradner
Lucianorhabdus cayeuxii Deflandre
Lucianorhabdus maleformis Reinhardt
Lucianorhabdus quadrifidus Forchheimer
Marthasterites furcatus (Deflandre) Deflandre
Micula staurophora (Gardet) Stradner
Nannoconus ex gr. *truitti* Brönnimann
Prediscosphaera cretacea (Arkhangelsky) Gartner
Prediscosphaera ponticula (Bukry) Perch-Nielsen
Prediscosphaera spinosa (Bramlette et Martini) Gartner
*Rhagodiscus angustus (*Stradner) Reinhardt
Russellia-Octolithus
Tranolithus orionatus (Reinhardt) Reinhardt

Lower-Upper Cretaceous (long-ranging species):

Helenea chiastia Worsley
Lithraphidites carniolensis Deflandre
Manivitella pemmatoidea (Deflandre) Thierstein
Retacapsa angustiforata Black
Retacapsa crenulata (Bramlette et Martini) Grün
Zeugrhabdotus diplogrammus (Deflandre) Burnett

Jurassic and Lower-Upper Cretaceous (long-ranging species):

Biscutum ellipticum (Górka) Grün
Cyclagelosphaera margerelii Noël
Watznaueria barnesae (Black) Perch-Nielsen
Watznaueria britannica (Stradner) Reinhardt
Watznaueria manivitiae Bukry

Lower Cretaceous:

Cruciellipsis cuvillieri (Manivit) Thierstein
Lithraphidites bollii (Thierstein) Thierstein
Micrantholithus hoschulzii (Reinhardt) Thierstein
Nannoconus kamptnerii Brönnimann
Nannoconus steinmannii Kamptner

Uppermost Jurassic-lowermost Cretaceous interval

Conusphaera mexicana Trejo
Faviococonus multicolumnatus Bralower

Appendix 2

Palynoflora taxa mentioned in the text (in alphabetical order):

aff. *Achomosphaera ramulifera* (Deflandre) Evitt
Circulodinium distinctum (Deflandre & Cookson)
Complexiopollis sp.
Corollina torosa (Reissinger) Klaus emend. Cornet & Traverse
Cyathidites minor Cooper
Dinogymnium sp.
Ephedripites sp.
Kiokansium polypes (Cookson & Eisenack) Below
Oligosphaeridium complex (White) Davey & Williams
Palaeohystrichophora infusorioides Deflandre
Pervosphaeridium pseudhystrichodinium (Deflandre) Yun
Pinuspollenites sp.
Plicapollis sp.
Pluricellaesporites psilatus van der Hammen
Pseudovacuopollis sp.
Spiniferites ramosus (Ehrenberg) Loeblich & Loeblich
Stereisporites antiquasporites (Wilson & Webster) Kremp
Taxodiaceaepollenites hiatus (Potonié) Kremp
Vadaszisporites urkuticus (Deák) Deák & Combaz

Redeposition from the Lower Cretaceous:

Retitricolpites sp.

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