ABHANDLUNGEN DER GEOLOGISCHEN BUNDESANSTALT

Abh. Geol. B.-A. | ISSN 0378-0864 | ISBN 3-85316-007-7 | Band 56/2 | S. 585-592 | Wien, Dezember 1999

Geologie ohne Grenzen
Festschrift 150 Jahre Geologische Bundesanstalt

Redaktion:
Harald Lobitzer & Pavol Grecula

Contributions to Facies and Fauna of the "Rudist-Coral-Brachiopod Limestone" of Weißenbachalm near Bad Aussee (Gosau Group, Upper Cretaceous, Austria)

István Szente, Felix Schlagintweit, Jiři Žítt & Harald Lobitzer

3 Text-Figures, 1 Table and 2 Plates

Northern Calcareous Alps
Salzkammergut
Gosau Group
Upper Cretaceous
Rudists
Echinoids
Microfacies

Österreichische Karte 1:50.000
Blatt 97

Contents

Abstract

The "rudist-coral-brachiopod limestone" of the Gosau Group of Aussee-Weißenbachalm is characterized by an impoverished microfauna/flora and a rudist assemblage poor in taxa, whereas the scleractinians show a comparatively higher diversity. The biostratigraphic age is considered tentatively as Upper Santonian (? Lower Campanian), equivalent to the Hochmoos Formation of Gosau locus classicus. However, a Turonian age cannot be ruled out completely due to the presence of the solenoporacean alga *Parachaetetes lichenoides* ELLIOTT. Also the description of the rare find of a regular echinoid *Salenia* sp., based on one specimen of corona, is presented.

Beiträge zur Fazies und Fauna des "Rudisten-Korallen-Brachiopoden Kalkes" der Ausseer Weißenbachalm (Gosau-Gruppe, Oberkreide, Österreich)

Zusammenfassung

Der "Rudisten-Korallen-Brachiopoden Kalk" der Ausseer Weißenbachalm-Gosau-Gruppe weist eine stark verarmte Mikrofauna/flora sowie Rudisten-Assoziation auf, während die Korallenfauna eine vergleichsweise höhere Diversität zeigt. Das biostratigraphische Alter konnte bislang nicht eindeutig geklärt werden. Mit Vorbehalt wird jedoch ein Obersantonium (? bis Untercampanium)-Alter, äquivalent der Hochmoos-Formation des Gosau locus classicus, angenommen. Ein Turon-Alter kann jedoch aufgrund des Auftretens der Solenoporacee *Parachaetetes lichenoides* ELLIOTT nicht gänzlich ausgeschlossen werden. Weiters wird der bislang einzige Fund eines regulären Seeigels der Gattung *Salenia* sp. systematisch beschrieben.

Addresses of the authors: Dr. István Szente, Eötvös University, Department of Palaeontology, Ludovika tér 2, 1083 Budapest, Hungary. Dr. Jiři Žítt, Institute of Geology, Academy of Sciences of the Czech Republic, Rozvojová 135, 16500 Prague 6, Czech Republic. Dr. Felix Schlagintweit, Lerchenauerstraße 167, 80935 München, Germany. Dr. Harald Lobitzer, Geologische Bundesanstalt, Rasumofskygasse 23, 1031 Vienna, Austria.

1. Introduction

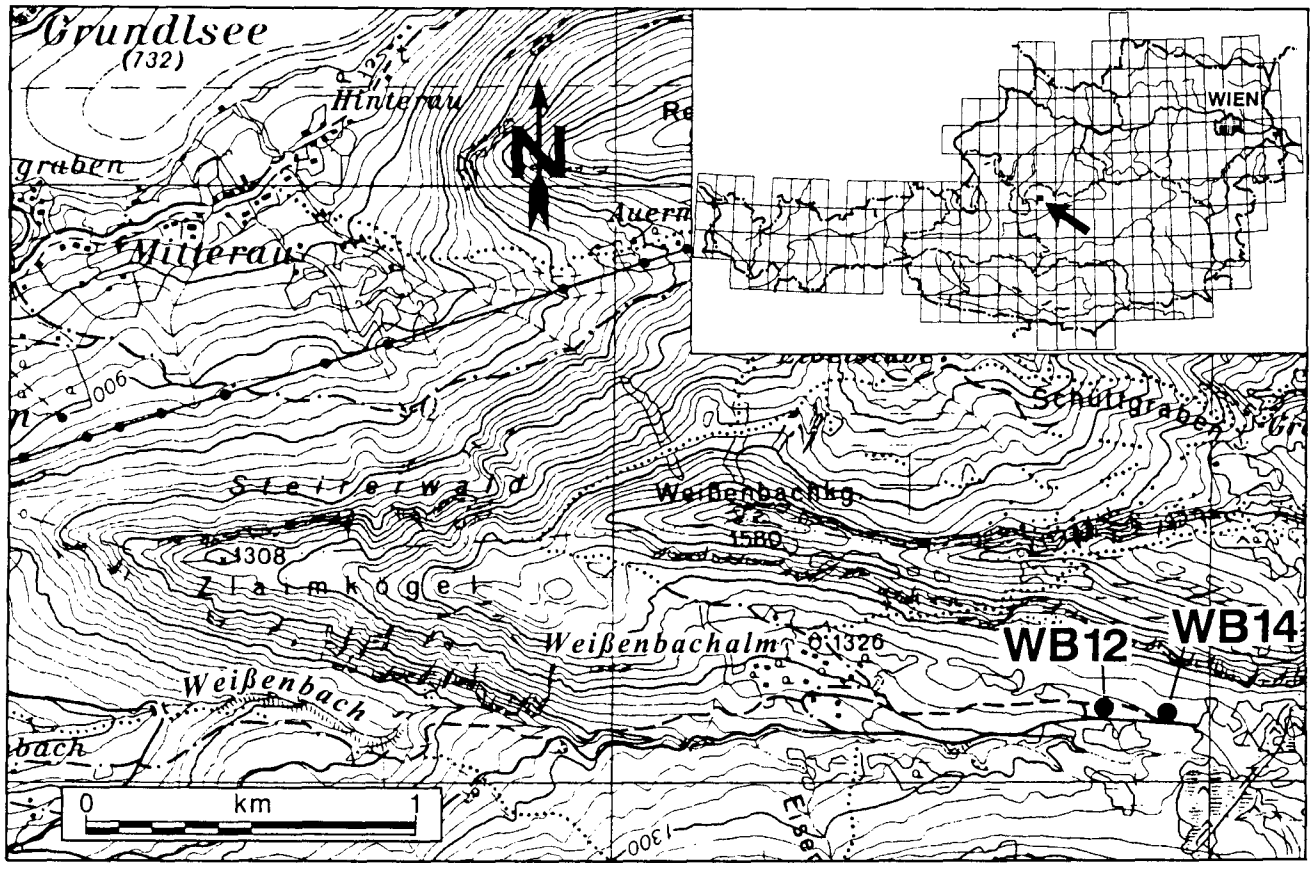
Exposures of marly limestone of the Gosau Group cropping out east of the Weißenbachalm near Bad Aussee (Text-Fig. 1) contain a moderately diverse rudist assemblage and a rather diverse coral assemblage. Brachiopods are also a conspicuous faunal element; they occur in rock forming quantities in dm-thick layers preferably in the higher part of the exposure. This "rudist-coral-brachiopod limestone" sensu KOLLMANN & SUMMESBERGER (1982) is exposed along a forest road and can be traced laterally for about 300 meters. At present nowhere the contact of the only approximately 6 m thick "rudist-coral-brachiopod limestone" to the underlying or overlying rock units is exposed and therefore the stratigraphic relations to the well dated grey marls (HRADECKA et al., 1999) is difficult to establish in the field. In spite of the fact that the locality has been known since the beginnings of the investigation of the Upper Cretaceous of the Northern Calcareous Alps (SEDGWICK and MURCHISON, 1831), the fauna has remained poorly studied and documented. While other rudist and coral occurrences attracted interest of several authors and were treated in descriptive and comprehensive publications (e. g. ZITTEL, 1864–1865; FELIX, 1908), the Weißenbachalm-fauna was comparatively neglected and seemingly only scarce data on this fauna were presented by PETERS (1852), REUSS (1854), STUR (1871), TOLLMANN (1960a, b), BEAUVAIS (1982) and KOLLMANN & SUMMESBERGER (1982). However, it has to be mentioned, that the outcrop situation of the rudist bearing limestones of Weißenbachalm Gosau was very poor till 1972, when a forest road was constructed. It allowed KOLLMANN & SUMMESBERGER (1982) to provide a list of rudist bivalves, which is quite similar to that one presented in this paper. According to KOLLMANN & SUMMESBERGER (l. c.) the marls of the Grabenbach Formation overly the "rudist-coral-brachiopod facies", which would mean, that this rudist limestone is older than Late Turonian. However, according to the present opinion (HRADECKA et al. 1999), it seems that the rudist limestone is younger than the Grabenbach Formation, that means younger than Early Santonian. More detailed work in the field and in respect to paleontology is still needed for a precise stratigraphic evaluation. Also the recent evaluation of the coral fauna by BARON-SZABO (1999) did not provide additional stratigraphical hints.

The main aim of this paper is to present new palaeontological findings, in particular in respect to microfacies (including microfauna/flora) and the first findings of echinoids.

2. Palaeontology

2.1. Microfacies and Microfauna/flora

The investigation of 15 thin sections of the rudist-coral-brachiopod limestone of Weißenbachalm shows several microfacies types, which are always characterized by the dominance of coral and rudistid fragments and a remarkably impoverished microfauna/flora. The texture of this bioclastic limestone is mostly matrix supported (marly) floatstone respectively wacke-/packstone, or more rarely shell supported rudstone, baffle- or boundstone. The bioclastic matrix in part is represented by bioturbated wacke- to packstone (Plate 1, Fig. 2), more rarely mudstone or grainstone. The clasts are poorly sorted. Biogenic encrusting of larger bioclasts by red algae, sessile arenaceous foraminifera and serpulids is common. Also micritic (? cyano-



Text-Fig. 1.
Location of sample points WB 12 and WB 14.

Text-Fig. 2.
Type of coutcrop of "rudist-coral-brachiopod limestone" along Weißenbachalm forest road (sample point area WB 12). The exposure shows disintegrated rubble of locally reworked rudstone/bafflestone.

bacterial) envelopes can be observed. The rudist shells and also the corals are often bored by endolithic borings (? Clionids) and by lithophagid bivalves. Serpulids settle preferably on rudist shells. The aragonite layer of the rudist shells in general is replaced either by blocky calcite spar or by internal sediment. The internal sediment consists of bioclastic wacke- or packstone. Calcareous algae are represented by the rhodophyceans *Sporolithon gosaviense* (ROTHPLETZ) and *Pseudolithothamnium album* PFENDER. These coralline algae form spectacular rhodolithic encrustations preferably around hippuritids and corals. In addition, the solenoporaceae *Parachaetetes lichenoides* ELLIOTT occurs (Plate 1, Fig. 1). Calcareous green algae are extremely rare with occasional thallus fragments of *Neomeris circularis* BADVE & NAYAK and *Halimeda* sp. The microbenthos is represented by rare miliolids and encrusting arenaceous foraminifera (Plate 1, Fig. 3). A conspicuous and relatively abundant element is the microproblematicum *Pienina oblonga* BORZA & MIŠIK, which was interpreted by GRANIER (1987) as spiculae of octocorallia (Plate 1, Fig. 4). However, MIŠIK (1998) reported *P. oblonga* found inside the skeleton of sponges, probably Keratosa. MIŠIK discusses *P. oblonga* to represent skeletal parts or endoparasites of the sponges.

2.2. Rudist Bivalves

2.2.1. Material

Two exposures (Text-Fig. 1), namely WB 12 and WB 14 were found to contain rudists. Since both of them yielded seemingly the same assemblage, the Weißenbachalm-fauna is treated here as a whole. The material consists of more than 100 specimens in various states of preservation, many of them showing signs of abrasion. Shell cavities are infilled with micritic/microsparitic sediment or are replaced by sparry calcite. Some *Vaccinites* shells are densely bored. Remains of encrusting organisms were also encountered, however, only comparatively rarely. The specimens are housed in the collections of the Geologische Bundesanstalt (Vienna), inventory-nos. 1999/23.

2.2.2. Systematic Part

***Vaccinites inaequicostatus* (MÜNSTER, 1840)**
(Plate 2, Figs. 1, 3)

Material: Two specimens, both of them with closed valves.

Remarks: The specimens reach a maximum diameter of 8 cm. Outer surface of the specimen in Fig. 3. is ornamented with weak longitudinal costae. The ligamental crest is elongated, rounded at its extremity, exceeding both pillars in length. The first pillar, slightly pinched, is wider and shorter than the second one. The posterior myophore, as revealed by a more adapical section of the specimen shown in Fig. 3. (not figured), is triangular and sharply pointed, running parallel with the first pillar. Anterior teeth of the left valve lying in the continuation of the ligamental crest. The triangular posterior tooth is smaller than the anterior one and parallel with the ligamental crest. The Weißenbachalm-specimens correspond well with those previously described from the peri-Mediterranean region (e. g. POLŠAK, 1959, 1967; LUPU, 1976; KOLLMANN et al., 1985).

***Vaccinites sulcatus* (DEFRANCE, 1821)**
(Plate 2, Figs. 2, 4–8)

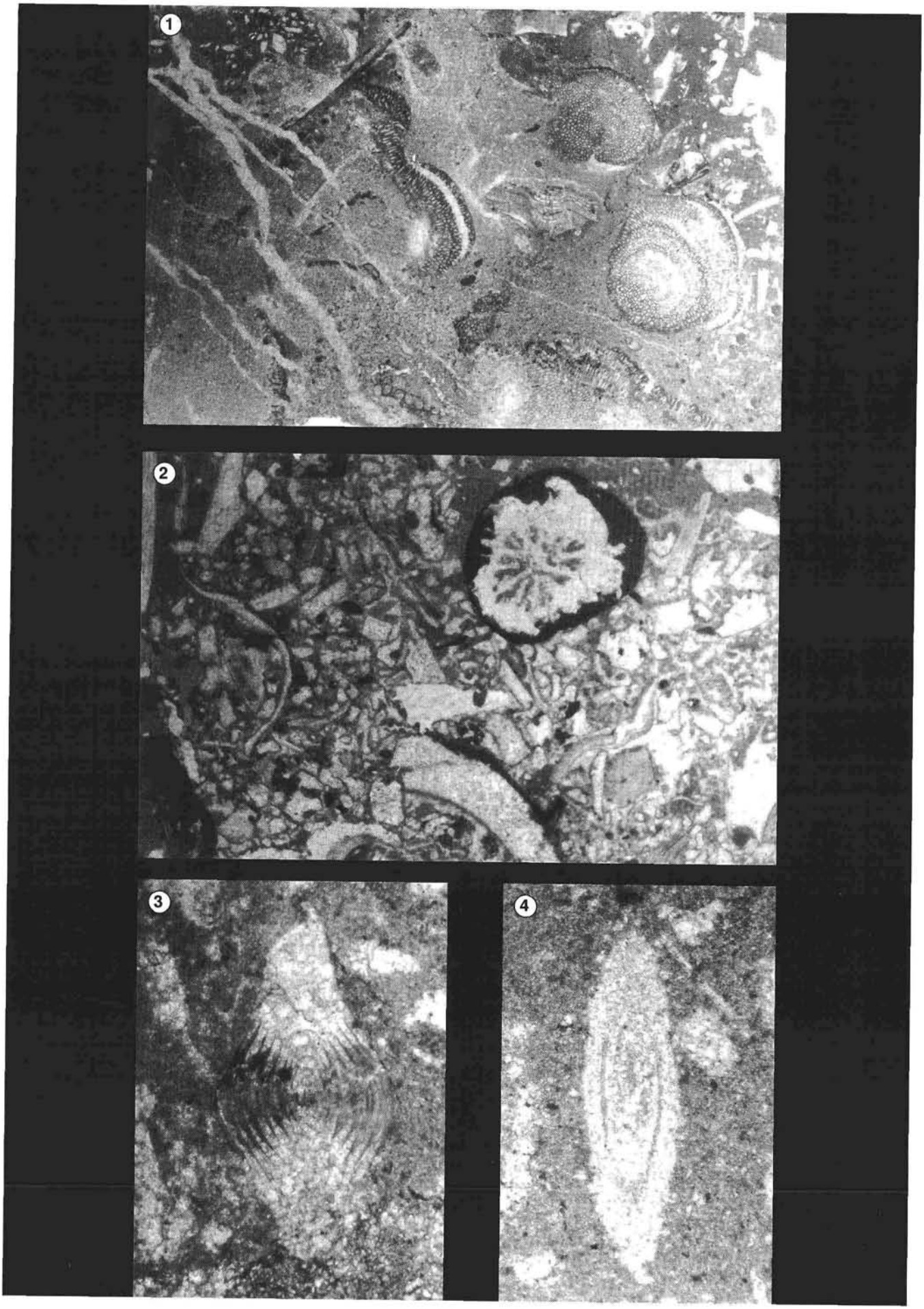
Material: 48 specimens, predominantly isolated lower valves.
Remarks: Two morphotypes of *V. sulcatus* can be distinguished in the collection. The more frequent one is represented by 28 slender, straight or slightly curved, cylindrical right valves not exceeding 2 cm in diameter (e. g. Plate 2, Figures 4, 8). They are probably identical with *V. "sulcatus"*, recorded by SANDERS & BARON-SZABO (1997) from the Haidach section. Conical right valves reaching a maximum diameter of 5 cm are thought to belong to the other morphotype (e. g. Plate 2, Figures 2, 5–7). All of them, however, display outer surface ornamentation by longitudinal, in some places spiny costae and well-defined sulci, as well as internal features characteristic of this widespread species. The latter include triangular, truncated ligamental crest and wide first pillar shorter than the second one. The angle between the ligamental crest and the second pillar is about 90°. These features agree well with those of *V. sulcatus*, recently reviewed by VICENS (1992).

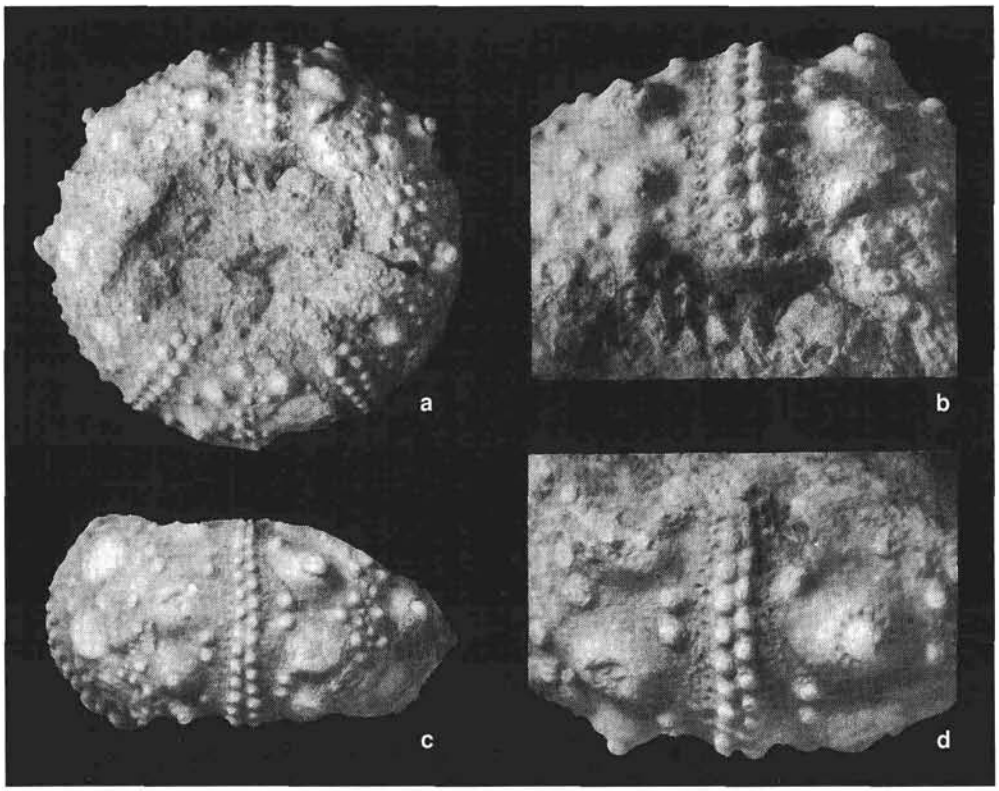
***Plagioptychus toucasi* MATHERON, 1842**
(Plate 2, Figs. 9, 11, 13)

Material: 43 specimens.
Remarks: Shells assigned to the genus *Plagioptychus* MATHERON, 1842 are conspicuous elements of the Gosau-faunas. *"Caprina partschii"* of HAUER (1847) included forms both with conical and gyropleuriform right valves. REUSS (1853), on the other hand, distinguished two species: *"Caprina exogyra"* was proposed for large shells with gyropleuriform right valve, while the name *C. exiqua* was applied to small-sized forms. Later on, all of them were synonimised with *"C. aguilloni* d'ORBIGNY" by ZITTEL (1865). MENNESSIER (1957) interpreted *P. exogyra* as a distinct species, and regarded the type specimen of *exiguus* as a juvenile valve of *exogyra*.
The Weißenbachalm-specimens clearly represent two morphotypes differing in size and in the shape of the right valve. Larger forms with low, twisted right valve are thought to represent *P. toucasi* MATHERON (=*P. aguilloni* d'ORBIGNY auctt). Internal features including hinge morphology and shell structure of the left valve agree with those of *P. toucasi* described in the literature (e. g. LUPU, 1976).

***Plagioptychus* aff. *paradoxus* MATHERON 1842**
(Plate 2, Figs. 10, 12)

Material: 10 specimens.
Remarks: The specimens reach a maximum height of 30 cm. Left valves are low, strongly inaequilateral, and bear fine


1
2
3
4



Text–Fig. 3.
Salenia sp., Upper Cretaceous, Weißenbachalm. a – test viewed adorally, x 3.3; b – peristomial region with a part of ambulacrum and adjacent interambulacra, x 6.0; c – test in lateral view, x 3.3; d – apical extremity of an ambulacrum and adjacent interambulacra (apical system unpreserved), x 6.0. Photograph J. Žitt.

radial striae. The shell-structure could not be studied. Right valves are more or less distorted, semicircular in cross-section. The form described above is provisionally identified as *P.* aff. *paradoxus*.

***Radiolites?* sp.**
(not figured)

Material: 8 specimens, 3 of them forming a small bouquet.
Remarks: The specimens are small-sized lower valves, not exceeding 2 cm in diameter. The shell displays a cellulo-prismatic structure, composed of quadrangular prisms.

2.3. Echinoids

2.3.1. Material

In 1998, two specimens belonging to two different species of regular echinoids have been found in the Late Cretaceous "rudist-coral-brachiopod limestone" of the Weißenbachalm locality by M. Siblík, Institute of Geology AS CR, Prague. While the first specimen is preserved only as an internal mould of the corona and lacks any reliable taxonomic features, the second specimen, though incomplete as well, could be studied in detail and it is described here. The so far known Gosau echinoid fauna consisting of a relatively large number of both regulars and irregulars (Lambert 1907, Kühn 1925) is very important from the point of view of interbasinal relationships (e. g. with the Bohemian Late Cretaceous). Modern taxonomic revisions of this fauna would therefore be desirable.

2.3.2. Systematic Part

Order Salenioida
Delage & Hérouard, 1903
Family Saleniidae
Agassiz, 1838
Genus *Salenia* Gray, 1835

***Salenia* sp.**
(Text-Fig. 3)

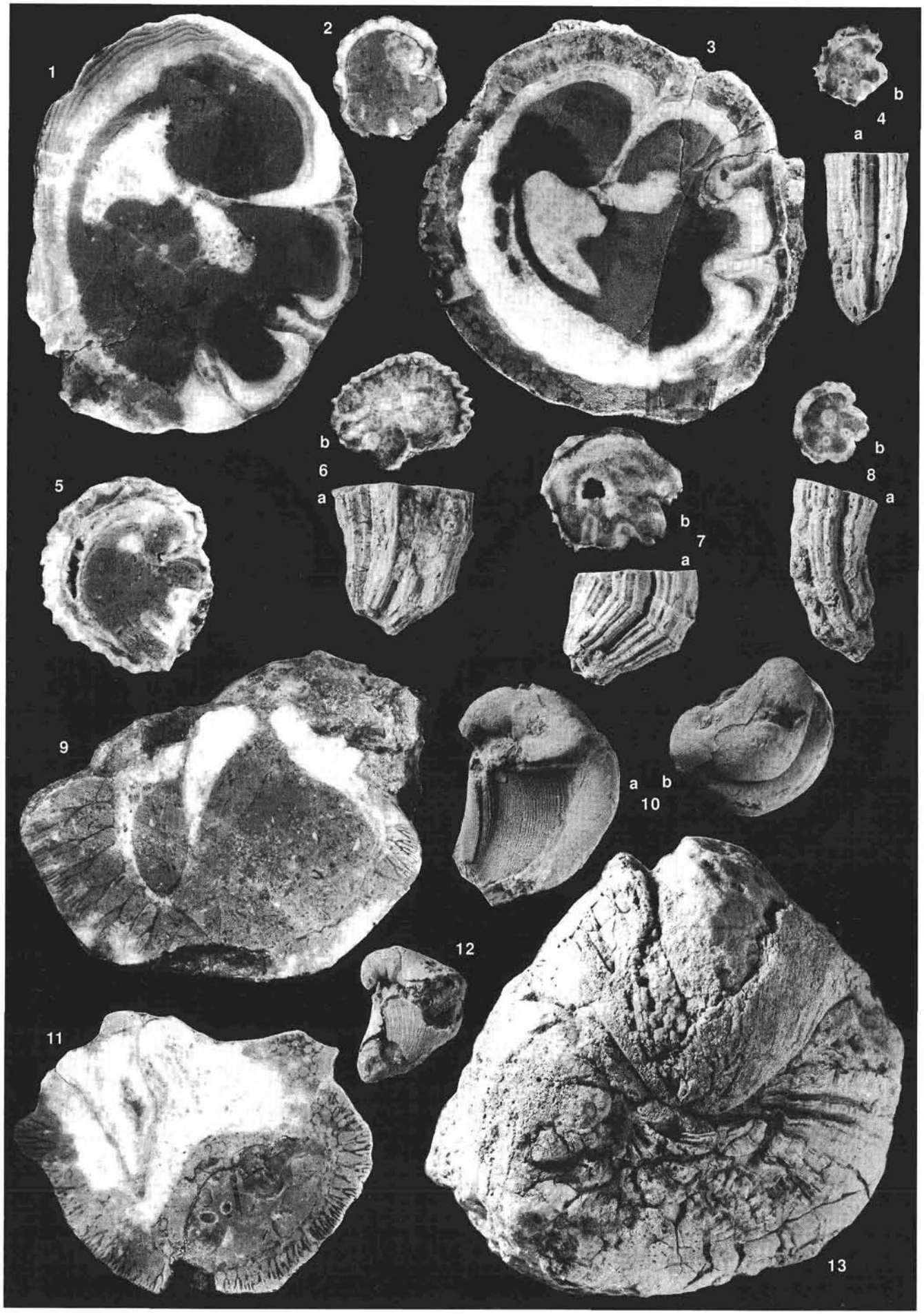
Material: One specimen represented by corona with broken off apical system.

Description

Shape and size: The test is circular in outline, medium sized, with diameter (DT) equaling 17.0 mm. However, partly broken off interambulacral primary tubercles a little reduces this dimension. The test sides are convex, the base is slightly flattened.
Apical system: Apical system is unpreserved but it was doubtless large, covering the major part of dorsal test surface as shown by location of visible adapical ends of some ambulacra.
Ambulacra: Slightly sinuous adapically but more or less straight subambitally. They are very narrow adapically (7.6 % DT), slightly expanding ambitally (12.3 % DT) as far as the peristome (14.7 % DT). Ambulacral plates are compound with one primary tubercle to every two plates. Sutures between plates are invisible. Ambulacral pores arranged uniserially throughout the ambulacra. Near the peristome they are a little crowded. Width of the pore zone near apex is 46.0 %, at ambitus 38.0 % and near the peristome 44.0 % of the width of the half-ambulacrum. Number of pore pairs in a pore zone is 33–34. About 17 primary ambulacral tubercles are present in a column. They are arranged in a single, superambitally slightly sinuous line in each plate column and are imperforate, non-crenulate. Smaller miliary tubercles rim the radial sutures.
Interambulacra: Their width next to the apex is 32.4 %, at ambitus 50.0 %, and next to the peristome 23.5 % DT.

Plate 1

Fig. 1: Numerous thalli of the solenoporaceae *Parachaetetes lichenoides* Elliott. Sample WB 14-2D (x 8).
Fig. 2: Packstone composed of debris of rudistids and corals. Sample WB 12-2G (x 15).
Fig. 3: Benthic foraminifera *Vidalina hispanica* Schlumberger, axial section. Sample WB 12-A (x 88).
Fig. 4: Microproblematicum *Pienina oblonga* Borza & Misik, longitudinal section slightly oblique. Sample WB 12-2C (x 68).


1
2
3
4
a
b
5
6
a
b
7
a
b
8
a
b
9
10
a
b
11
12
13

Four to five plates per column are present. Each of them has a single primary tubercle which is largest at and immediatelly above the ambitus. They are imperforate, crenulate. The width of areole is largest near the ambitus, where it equals 77.8 % of the plate width (measured horizontally). Areolae are rimmed by about 5 secondary tubercles. Extrascrobicular surface of the plate is covered by the secondary tubercles of similar size with smaller miliary tubercles in between. The plates are widest near the ambitus; adjacent pore zone consists of 9–11 pore-pairs.

Peristome: More or less circular in outline. Its diameter is 44.2 % DT. Buccal slits are distinct but shallow. They are rimmed by a low lip.

Remarks: The specimen studied may not be determined as for the species because of the missing apical system. The corona doubtless belongs to an adult individual. As regards *Salenia* sp. described by LAMBERT (1907) from the Gosau Upper Cretaceous and later mentioned by FELIX (1908) and KÜHN (1925), its relationship to the present species may not be discussed without systematic revision of the original material.

Table 1

sample	*Vermiporella tenuipora* CONRAD	*Halimeda* sp.	*Parachaetetes lichenoides* ELLIOTT	*Sporolithon* sp.	*Sporolithon gosaviense* (ROTHPLETZ)	*Pseudolithothamnium album* PFENDER	*Plenina oblonga* BORZA & MISIK	*Vidalina hispanica* SCHLUMBERGER	encrusting foraminifera	miliolids	textulariids
WB / 12-2A				X			X	X		X	
WB / 12-2B				X			X		X		
WB / 12-2C				X			X		X		
WB / 12-2D				X			X			X	
WB / 12-2E			X	X			X			X	
WB / 12-2F					X		X		X	X	
WB / 12-2G					X		X				
WB / 14-2A				X							
WB / 14-2B				X			X		X		
WB / 14-2C					X			X	X	X	X
WB / 14-2D			X	X		X			X		
WB / 14-2E		X		X				X	X	X	
WB / 14-2F				X		X	X		X		X
WB / 14-2G				X			X		X		
WB / 14-2H	X			X		X	X				

3. Biostratigraphy

All former authors (e. g. SEDGWICK & MURCHISON, 1831; PETERS, 1852; KOLLMANN & SUMMESBERGER, 1982) considered the "rudist-coral-brachiopod limestone" of Weißenbachalm as stratigraphically older than the grey marls (Grabenbach Formation). Unfortunately, nowhere the under- or overlying strata are cropping out in contact with the "rudist-coral-brachiopod limestone" and the well dated grey marls (HRADECKA et al., 1999) are separated from the "rudist-coral-brachiopod limestone" by the Weißenbach stream, which is considered to represent a tectonic fault line (GEYER, 1915; TOLLMANN, 1985).

Benthic foraminifera occur only sporadically and show no stratigraphic value. Only the algae observed could prove stratigraphically somehow promising. *Halimeda* sp. is known in the Calcareous Alps in the Turonian-Santonian. *Vermiporella tenuipora* CONRAD is known from the Gosau Group of Strobl-Weißenbach and *Parachaetetes lichenoides* ELLIOTT from the Branderfleck Formation loc. class. (SCHLAGINTWEIT, 1992). The solenoporacean alga *P. lichenoides* was described by ELLIOTT from Turonian and ? Campanian units. POIGNANT (1982) considers *P. lichenoides* as marker fossil for the Turonian, however, no sufficient data exist to prove this ranging.

Rudists are valuable index fossils in the Gosau Group (KÜHN, 1965). According to PHILIP (1998) both *Vaccinites inaequicostatus* and *V. sulcatus* appeared in the Late Santonian and persisted into the Early Campanian. KOLLMANN et al. (1985), however, presumed a longer, Coniacian to Lower Campanian, range of both taxa. *Plagioptychus* species are reportedly of shorter range. According to MENNESSIER (1957) and LUPU (1976) *P. toucasi* is confined to the Santonian. DECHASEAUX and PERKINS (1969), however, mentioned this species from the Turonian.

Most probably the "rudist-coral-brachiopod limestone" of the Aussee Weißenbachalm resembles the Hochmoos Formation of Gosau locus classicus respectively of the Nussensee-Bad Ischl Gosau Group, which is Upper Santonian in age (WAGREICH, 1998).

4. Conclusions

The "rudist-coral-brachiopod limestone" of the Aussee Weißenbachalm Gosau Group can be laterally followed for about 300 m and shows an exposed thickness of six meters only. The under- and overlying rocks are nowhere exposed at present and therefore the stratigraphic relationship to the Upper Turonian-Lower Santonian grey marls (Grabenbach Formation) is not yet solved. Due to its lithologic characteristics the "rudist-coral-brachiopod limestone" is predestined to surficial weathering. A large part of the outcrop looks more or less like a loose heap of rubble showing mounds of boundstones to floatstones, where scleractinian corals evidently grew in close association with rudists. Most of the rudists lack the upper valve. Due to slightly changing siliciclastic input, a repeated vertical change from a matrix of friable silty marly limestones to a matrix of bioclastic limestone (wacke- to floatstone) can be observed. It seems, that the exposure shows a vertical trend from coral-rudist mounds to occasional local hippuritid biostromes higher up-section. The succession may represent a "Type A carbonate-dominated cycle" sensu SANDERS and PONS (1999). Also the brachiopods are enriched preferably in dm-thick layers in the upper part of the exposure. Scarce densely packed autochthonous *Vaccinites* clusters in growth position can be observed only in the higher part of the section, which may indicate a shallowing of the environment. Besides the brachiopods and non-rudist bivalves the large *Plachioptychus* sp. are characteristic dwellers, they do not act as framework constructors.

Plate 2

Figs. 1, 3: *Vaccinites inaequicostatus* (MÜNSTER, 1840). Cross sections of the right valve.
Figs. 2, 4–8: *Vaccinites sulcatus* (DEFRANCE, 1821). a: lateral view, b: cross sections of the right valve.
Figs. 9, 11, 13: *Plagioptychus toucasi* MATHERON, 1842. 9, 11: cross sections of the left valve, 13: both valves from a dorsal view.
Figs. 10, 12: *Plagioptychus* aff. *paradoxus* MATHERON, 1842, lateral view, 1.5x .

The specimens are coated with ammonium-chloride except the sectioned surfaces. All figures are in natural size unless otherwise indicated.

Echinoids are extremely rare dwellers. However, some of the microbial organisms, coralline algae and encrusting arenaceous foraminifera (see chapter 2.1.) can be considered as important framework-binders. It seems characteristic for this inner-neritic ("lagoonal") environment, that the microfauna/flora and also the rudist assemblage is impoverished in taxa-diversity. It has been stated in several studies (e. g. HÖFLING, 1997; SANDERS, 1998), that the rudist fauna of the Northern Calcareous Alps is considerably impoverished in comparison to contemporaneous rudist assemblages of the southern Tethys. However, the scleractinian assemblage shows a taxonomically diverse faunal spectrum (BARON-SZABO, 1999) dominated by coral heads and relatively scarce branched taxa. The brachiopods so far were not determined, however, the assemblage looks almost monospecific to paucispecific. Among hundreds of smooth shelled specimen only one ribbed specimen has been collected so far (leg. Jana SIBLÍK).

Acknowledgements

Field work for this study was funded by Austrian Geological Survey in the framework of bilateral cooperation with the Czech and Hungarian Geological Survey. The rudist bivalves were collected by Lenka HRADECKA, Jana and Milos SIBLIK (Prague), Ágnes SIEGL-FARKAS (Budapest) and Harald LOBITZER (Vienna). The research of István SZENTE was partly supported by the Hungarian Science Foundation (OTKA Grant-No. T 019456).

References

BARON-SZABO, R. Ch. (1999): Taxonomy of Upper Cretaceous scleractinian corals of the Gosau Group (Weißenbachalm, Steiermark, Austria). – Abh. Geol. B.-A., 56/2, 441–464, 6 Text-Figs., 6 Tabs., 8 Pls., Wien.

BEAUVAIS, M. (1982): Révision systématique des Madréporaires des Couches de Gosau (Crétacé supérieur, Autriche). – 5 Volumes, Paris.

DECHASEAUX, C. & PERKINS, B. F. (1969): Family Caprinidae. – In: MOORE, R. C. (ed.): Treatise on Invertebrate Paleontology Part N, Mollusca 6 Bivalvia, 787–799, Lawrence.

FELIX, J. (1908): Studien über die Schichten der oberen Kreideformation in den Alpen und den Mediterrangebieten. – Palaeontographica, 54, 251–344, Pls. 25, 26, Stuttgart.

GEYER, G. (1915): Aus den Umgebungen von Mitterndorf und Grundlsee im steirischen Salzkammergut. – Jb. Geol. R.-A., 65, 177–238, Wien.

GRANIER, B. (1986): Les *Pienina oblonga* BORZA & MISIK, 1976, sont-elles des sclérites d'Alcyonaires? – Rev. Micropaléont., 29/2, 103–108, Paris.

HAUER, F. v. (1847): Ueber *Caprina Partschii*; eine neue Bivalve a. d. Gosauschichten der österreichischen Alpen. – Haidingers naturw. Abhandl., 1, 1–8, Pl. 3, Wien.

HOFLING, R. (1997): Eine erweiterte Riff-Typologie und ihre Anwendung auf kretazische Biokonstruktionen. – Abh. Bayer. Akad. Wiss., N.F., mathem.-naturw. Kl., 169, 127 p., 31 Text-Figs., 34 Pl., München.

HRADECKÁ L., LOBITZER, H., OTTNER, F., SACHSENHOFER, R. F., SIEGL-FARKAS, Á., ŠVÁBENICKÁ, L. & ZORN, I. (1999): Biostratigraphy and Palaeoenvironment of the marly marine transgression of Weißenbachalm, Lower Gosau Subgroup (Late Turonian – Early Santonian Grabenbach Formation, Northern Calcareous Alps, Styria). – Abh. Geol. B.-A., 56/2, 475–517, 4 Text-Figs., 7 Tabs, 11 Pls., Wien.

KOLLMANN, H. A., LUPU, D. & VELITZELOS, E. (1985): Rudisten aus der oberen Kreide von Agios Christophoros, östlich Ptolemais (Mazedonien, Griechenland). – Ann. Naturhist. Mus. Wien, 87A, 121–134, Wien.

KOLLMANN, H. A. & SUMMESBERGER, H. (1982): Stop 30. Weissenbach Alm. Rudist-Coral-Brachiopod Facies. – In: Working Group on the Coniacian-Maastrichtian Stages – Fourth Meeting. Excursions to Coniacian-Maastrichtian in the Austrian Alps. – p. 75, Wien (Naturhistor. Mus.).

KUHN, O. (1925): Die Echinodermen der Gosauformation. – Ann. Naturhist. Mus. Wien, 39, 177–189, Pl. 11, Wien.

KÜHN, O. (1965): Rudistenhorizonte in den Alpen. – Anzeiger math.-naturw. Klasse österr. Akad. Wiss., Jg. 1965, 11, 245–256, Wien.

LAMBERT, J. (1907): Etude sur quelques échinides des couches à hippurites de Gosau. – Bull. Soc. belge Géol., 21, 83–95, Pl. 1, Bruxelles.

LUPU, D. (1976): Contributions sur l'étude des rudistes sénoniens des Monts Apuseni. – Mémoires de'l Institut de Géologie et de Géophysique, 24, 83–152, 45 Pls, Bucarest.

MENNESSIER, G. (1957): Remarques sur les espèces européens de Rudistes appartenant au genre *Plagioptychus* MATHERON (1842). – Bull. Soc. géol. France (sér. 6), 7, 833–852, Paris.

MIŠIK, M. (1998): *Pienina oblonga* – skeletal parts of endoparasites of Keratosa sponges? – Geol. Carpathica, 49, 401–407, Bratislava.

PETERS, C. (1852): Beitrag zur Kenntniss der Lagerungsverhältnisse der oberen Kreideschichten an einigen Localitäten der östlichen Alpen. – Abk. k. k. geol. R.-A., 1, 1, 1–20, 1 Pl., Wien.

PHILIP, J. (1998): Biostratigraphie et paléobiologie des rudistes: évolution des concepts et progrès récents. – Bull. Soc. géol. France, 169(5), 689–708, Paris.

POIGNANT, A. F. (1982): Les algues Turoniennes. – Mém. Mus. d'Hist. Nat., N. S., XLIX, 197–202, Paris.

POLŠAK, A. (1959): Rudisti i neki drugi fosili okolice Vrpolja i Perkoviza u Dalmaciji. – Geološki Vjesnik, 12, 53–76, 7 Pls, Zagreb.

POLŠAK, A.(1967): Kredna makrofaune juzne Istre. – Palaeontologica Jugoslavica, 8, 5–219, 85 Pls., Zagreb.

REUSS, A. E. (1853): Ueber zwei neue Rudistenspecies aus den alpinen Kreideschichten der Gosau. – Sitzungsber. k. k. Akad. Wiss., math.-naturw. Kl., 11(2), 923–927, Pl. 1, Wien.

REUSS, A. E. (1854): Beiträge zur Charakteristik der Kreideschichten in den Ostalpen, besonders im Gosauthale und am Wolfgangsee. – Denkschr. k. Akad. Wiss., mathem.-naturwiss. Kl., 7, 1–156, Wien.

SANDERS, D. (1998): Upper Cretaceous "Rudist Formations". – Geol. Paläont. Mitt. Innsbruck, 23, 37–59, Innsbruck.

SANDERS, D. & BARON-SZABO, R. Ch. (1997): Coral-Rudist Bioconstructions in the Upper Cretaceous Haidach Section (Gosau Group; Northern Calcareous Alps, Austria). – Facies 36, 69–90, Pls. 21–23, Erlangen.

SANDERS, D. & PONS, J. P. (1999): Rudist formations in mixed siliciclastic – carbonate depositional environments, Upper Cretaceous, Austria: stratigraphy, sedimentology, and models of development. – Palaeogeography, Palaeoclimatology, Palaeoecology, 148, 249–284, Amsterdam.

SCHLAGINTWEIT, F. (1992): Further record of calcareous algae (dasycladaceae, udoteaceae, solenoporaceae) from the Upper Cretaceous of the Northern Calcareous Alps (Gosau Formation, Branderfleck Formation). – Rev. Paléobiol., 11/1, 1–12, Genf.

SCHLAGINTWEIT, F. & EBLI, O. (1995): Remarks on *Neomeris circularis* BADVE & NAYAK, 1983 (Calcareous Alga, Dasycladacea). – Jb. Geol. B.-A., 138, 4, 715–724, Wien.

SEDGWICK, A. & MURCHISON, R. I. (1831): A Sketch of the Structure of the Eastern Alps; with Sections through the Newer Formations on the Northern Flanks of the Chain, and through the Tertiary Deposits of Styria, & c. & c. – Transactions Geol. Soc., II. Ser., III, 2, 301–420, London.

STUR, D. (1871): Geologie der Steiermark. – XXXI + 654 p., Graz.

TOLLMANN, A. (1960a): Die Hallstätterzone des östlichen Salzkammergutes und ihr Rahmen. – Jb. Geol. B.-A., 103, 37–131, Wien.

TOLLMANN, A. (1960b): Die Foraminiferenfauna des Oberconiac aus der Gosau des Ausseer Weißenbachtales in Steiermark. – Jb. Geol. B.-A., 103, 133–203, Wien.

TOLLMANN, A. (1985): Geologie von Österreich. Band II. Außerzentralalpiner Anteil. – XV + 710 p., Wien (Deuticke).

VICENS, E. (1992): Intraspecific variability in Hippuritidae in the Southern Pyrenees, Spain: taxonomic implications. – Geologica Romana, 28, 119–161, Roma.

WAGREICH, M. (1998): Lithostratigraphie, Fazies und Sequenzstratigraphie der Gosau Gruppe von Bad Ischl und Strobl am Wolfgangsee (Oberturon-Maastricht), Nördliche Kalkalpen, Österreich. – Jb. Geol. B.-A., 141, 209–234, Wien.

ZAPFE, H. (1937): Paläobiologische Untersuchungen an Hippuritenvorkommen der nordalpinen Gosauschichten. – Verh. Zool.-Bot. Ges. Wien, 86/87, 73–124, Wien.

ZITTEL, K. A. (1865–1866): Die Bivalven der Gosaugebilde in den Nordöstlichen Alpen. – Denkschriften k. Akad. Wiss. Wien, math.-nat. Kl., 24, 105–179, Pls. 1–10; 25, 77–198, Pls. 11–27, Wien.