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Contributions to the Fauna (Corals, Brachiopods) and Stable Isotopes of the Late Triassic Steinplatte Reef/Basin-Complex, Northern Calcareous Alps, Austria

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8 Text-Figures, 6 Plates and 2 Tables

Nördliche Kalkalpen
Steinplatte
Tirol
Salzburg
Oberrhätkalk
Kössener-Schichten
Lias
Korallen
Brachiopoden
Stabile Isotope
Mikrofazies

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Contents

Beiträge zu Fauna (Korallen, Brachiopoden) und stabilen Isotopen des Steinplatte Riff/Becken-Komplexes, Obertrias, Nördliche Kalkalpen

Zusammenfassung

Basierend auf $\delta^{18}O$-Meßdaten und deren Interpretation unter Anwendung der Gleichung von SHACKLETON & KENNETT (1975) können für die Oberrhätkalk-Capping Facies und die Kössener Kalksteine Wassertemperaturen im Bereich von 18–24°C errechnet werden, während für die überlagernden Lias-Buntkalke 14–19°C angenommen werden können. Aus unseren bisherigen Messungen stabiler Isotope können keine Hinweise auf vadose Zementation innerhalb der Oberrhätkalk-Capping Facies abgeleitet werden.

Bis jetzt wurden vom Steinplatte/Kammerköhralm-Gebiet 23 Korallenarten bekannt gemacht, wovon sieben in dieser Arbeit zum ersten Mal erwähnt werden. Sechs Arten entstammen der Oberrhätkalk-Capping Facies des Plattenkogel-"Korallengarten" ("Erik's Coral Garden"), näm-

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lich *Retiophyllia defilippi* (STOPPANI), *R. gosaviensis* RONIEWICZ, *R. multiramis* RONIEWICZ, *R. norica* (FRECH), *R. oppeli* (REUSS) und *Margarosmilia charliana* (FRECH). *Parathecosmilia sellae* (STOPPANI) und *Oedalmia norica* (FRECH) konnten bislang nur in der Korallen-Assoziation des Patch Reef A nachgewiesen werden. *Retiophyllia multiramis* RONIEWICZ wurde sowohl in der Oberrhätkalk-Capping Facies, als auch im Patch Reef A beobachtet.

Die Brachiopoden-Vergesellschaftungen der Oberrhätkalk-Capping Facies und der diversen Kössener Faziesentwicklungen scheinen eine sehr ähnliche Zusammensetzung aufzuweisen. Bislang wurde *Sinucosta emmrichi* (SUESS) in der Oberrhätkalk-Capping Facies nicht angetroffen, während *Bactrynium bicarinatum* EMMR., *Laballa suessi* (ZUGMAYER), *Triadithyris gregariaeformis* (ZUGMAYER), *Rhaetina* aff. *elliptica* DAGYS und *"Rhynchonella"* ex gr. *subrimosa* (SCHAFHÄUTL) in den Kössener Brachiopoden-Vergesellschaftungen zu fehlen scheint.

Abstract

Based on the study of $\delta^{18}O$-isotopes and using the equation of SHACKLETON & KENNETT (1975) a water temperature range of 18–24°C can be inferred for the Oberrhätkalk-Capping Facies and also for the limestones of the Kössen Formation, while for the Liassic deeper water limestones 14–19°C can be assumed. Our stable isotope data till now do not provide any indications for vadose cementation within the Oberrhätkalk-Capping Facies.

So far in all 23 scleractinian coral species are known from the Steinplatte region. Seven species are mentioned for the first time in this paper, namely six from the Oberrhätkalk-Capping Facies of Plattenkogel Coral Garden ("Erik's Coral Garden"): *Retiophyllia defilippi* (STOPPANI), *R. gosaviensis* RONIEWICZ, *R. multiramis* RONIEWICZ, *R. norica* (FRECH), *R. oppeli* (REUSS), and *Margarosmilia charliana* (FRECH), while *Parathecosmilia sellae* (STOPPANI) and *Oedalmia norica* (FRECH) are part of the Kössen-Patch Reef A assemblage. *Retiophyllia multiramis* RONIEWICZ was observed in the Oberrhätkalk-Capping Facies and also in the coral-assemblage of Patch Reef A.

The brachiopod assemblages of the Oberrhätkalk-Capping Facies and of the various Kössen facies are very similar. However, so far *Sinucosta emmrichi* (SUESS) was not observed in the Oberrhätkalk-Capping Facies assemblage, while up to date *Bactrynium bicarinatum* EMMR., *Laballa suessi* (ZUGMAYER), *Triadithyris gregariaeformis* (ZUGMAYER), *Rhaetina* aff. *elliptica* DAGYS. and *"Rhynchonella"* ex gr. *subrimosa* (SCHAFHÄUTL) were not encountered in the Kössen assemblage.

Introduction

MOJSISOVICS (1871), HAHN (1910) and in particular VORTISCH (1926) laid the foundations of facies- and palaeontological research in the Steinplatte-Kammerköhr carbonate complex.

The first stage of modern research on the Steinplatte-Kammerköhr Late Triassic carbonate-complex was initiated and supervised by A. G. FISCHER from Princeton University, N. J. and finally one of his gifted students, H. R. OHLEN, presented in 1959 his pioneer PhD-Thesis on the Steinplatte Reef Complex, which unfortunately remained unpublished. Still under FISCHER's influence H. ZANKL (at that time TU Berlin, now Marburg) continued detailed studies, including stable isotopes of various sediment types. The results were published in several papers (e.g. ZANKL, 1971; GÖKDAG, 1974). The next milestone represents the excellent study by PILLER (1981) and last but not least E. FLÜGEL and coworkers contributed essential data towards a better understanding of facies and diagenetic patterns and their spatial arrangement (e.g. FLÜGEL, 1981, 1982; FLÜGEL & KOCH, 1995; FLÜGEL & STANTON, 1989; STANTON & FLÜGEL, 1989, 1995; KUSS, 1983). Also the paper by GOLEBIOWSKI (1991) provides important new data and aspects, in particular on the Kössen-Formation. In connection with diagenetic studies, especially in respect to subaerial exposition, also the paper by MAZZULLO et al. (1990) has to be mentioned. Recently SIBLÍK (1995, 1998) started a systematic comparative study of the brachiopod assemblages of the Oberrhätkalk versus the assemblages of the Kössen-Formation.

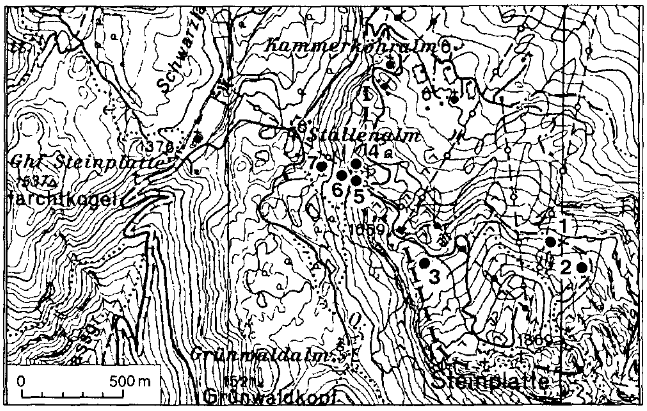
The present paper presents various independently acquired results of research on the Steinplatte-Kammerköhr region. It is important to note, that all the presented data, especially those on the scleractinians and on the stable isotopes are based on a relatively small amount of samples and therefore further sampling in the field and subsequent analytic work will be still necessary.

2. Sample List and Microfacies

According to STANTON & FLÜGEL (1989), respectively FLÜGEL & STANTON (1989), in the Upper Triassic there are three depositional units to be distinguished in the Steinplatte area. These are the Kössen facies (-Beds), underlying and laterally interfingering with the massive rocks of the mound facies (Oberrhätkalk p. p., not sampled) and the Capping Facies, the latter representing the coarsly bedded layers with abundant coral buildups of the uppermost Oberrhätkalk.

In the Steinplatte area Liassic sediments occur either as fissure fillings that penetrate deeply into the Upper Triassic host rocks or overlie the Capping beds with a hiatus. In the latter case an only about 30 cm thick, strongly condensed layer of Enzesfeld-type Limestone is followed by several meters thick rocks of the Adnet-Formation. Of special interest for further lithostratigraphic correlations might be the fact that the Enzesfeld-type Limestone exhibits 3 partitions, that may be correlated with an also 3-divided layer of the basinal Kendlbach-Limestone, cropping out at the Unkenbach (EBLI, 1997).

Our sample set for isotope analysis has been collected from the following localities (Text-Fig. 1), respectively represents the following facies types. The coral fauna has been collected mostly from sample area 2 (Plattenkogel Coral Garden) and from sample point 6 (Patch Reef A). It is not our intention to give a detailed description of the various facies-types we met in the examined rocks. For this purpose the



Text–Fig. 1.
Location of sampling areas for isotope/microfacies and coral samples.

reader is referred to the very detailed papers on the Oberrhätkalk (Upper Rhaetian Limestone) by STANTON & FLÜGEL (1989) and by EBLI (1997) for the Liassic rocks.

Therefore only those samples, for which also geochemical analysis was done are shortly described in the following paragraphs:

Sample point 1: Variegated coloured **Liassic limestones** close to the trail which runs along the northern slope of Plattenkogel, about 200m E of the spectacular Liassic slumping structures, on the way to the Plattenkogel Coral Garden. A well known sinkhole shows outcrops of bivalve-coquinas. Sample 1/2 represents brick-red Adnet-Limestone and sample 1/3 is ochre Enzesfeld-type Limestone.

Sample 1/2:

Biomicrite (packstone: MF-type 4b of EBLI, 1997) rich in ostracodes, mostly thin-shelled bivalve-debris and foraminifera (especially Lagenids and Involutinids the last beeing represented by *Involutina liassica, Trocholina umbo* and *T. turris.* Miliolids are rare. The fauna of this typical Adnet-Limestone also contains some echinodermal debris, spicula and *Globochaete alpina.*

Sample 1/3:

Densely packed foram-echinoderm biomicrite with gastropods and bivalves (packstone: MF-type 2b of EBLI, 1997). In addition to the mentioned lithology of sample 1/2 foraminifera are more abundant in this Enzesfeld-type Limestone and the fauna is more diverse and contains additional Involutinids as *Coronipora austriaca, Licispirella violae,* and *L. bicarinata.*

Sample area 2: Oberrhätkalk-Capping Facies of Plattenkogel Coral Garden ("Erik's Coral Garden", named after Erik Flügel in appreciation of his excellent and stimulating research on the Steinplatte complex). The locality shows excellent outcrops of karstified coral "reef" along the eastern slope of Plattenkogel.

Sample 2/1:

Coral biomicrite (bafflestone: MF C4 of STANTON & FLÜGEL, 1989). Several groups of densely spaced corallites of *"Thecosmilia clathrata"* are embedded in a recrystallized microsparitic matrix, containing only finest, not identifiable grains. In contrast to this, the intracorallite space is full of biota. Encrusting by microbial mats (mostly dark laminar or clotted, but also bright laminar), serpulids, foraminifera (*Alpinophragmium perforatum, Planiinvoluta carinata, Nubecularia* div. spec., *Tubiphytes obscurus* and Ataxophragmiidae gen. et spec. indet.), Porifera, Algae *(Thaumatoporella parvovesiculifera)* and the problematic *Bacinella-Lithocodium* consortium, the latter of which is thought to represent foraminifera (compare SCHMID & LEINFELDER, 1996) is a common phenomenon. The sediment also exhibits signs of early cementation (e.g. pelsparitic areas filling space between crusts).

Sample point 3: Crinoid-rich "Toe of the Slope" arenitic limestones. Outcrops along the trail from the nearby Gasthof Kammerköhr in direction to Steinplatte N'-slope, close to lift station, respectively cowshed. Transitional facies from Oberrhätkalk slope into Kössen-Formation: Light-medium grey bioarenitic limestone with abundant crinoid debris (in part encrinitic). Characteristic slight bituminous smell after hitting with the hammer, which indicates the proximity of the (generally bituminous smelling) Kössen-Formation.

Samples 2/5; 3/1; 3/2:

Biosparite with oncoids (grainstone: MF C11 of STANTON & FLÜGEL, 1989)

Besides strongly recrystallized and therefore not determinable fragments, bioclasts of echinoderms, bivalves, corals and solenoporacean algae, are encrusted by microbial films and sessile foraminifera (e.g. *Nubecularia* sp., *Tubiphytes obscurus, Planiinvoluta carinata*). The poorly sorted sediment is sparitic cemented. The samples from the toe of the slope (3/1, 3/2) are slightly more micritic and exhibit better grain-size sorting). Sample 2/5 shows very similar microfacies as the toe of slope limestones, however, it was collected at the Plattenkogel Coral Garden locality.

Text–Fig. 2.
Karstified surface of Oberrhätkalk-Capping Facies, NE of Plattenkogel.

Kössen-Formation (Sample localities 4–7)

Sample point 4: Dark grey, well bedded **limestone with chert**, but without marly intercalations, on the trail north above Patch Reef A: "Special Kössen development" with chert sensu KLEBELSBERG (1935). Probably of Rhaetian age; lowermost Liassic not excluded.

Sample 4/1:

Well sorted intraclast-rich biomicrite (packstone: MF K7 of STANTON & FLÜGEL, 1989). Well sorted, fine grained micritic intraclasts followed by biogenic detritus dominate the sediment. The bioclasts are mostly also finegrained and therefore not further identifiable. Foraminifera (mostly arenaceous forms as *Trochammina* sp.) are very rare.

Samples 4/2; 7/2:

Poorly sorted intraclast-rich biomicrite (packstone: MF K8 of STANTON & FLÜGEL, 1989). Very similar to the above mentioned sediment-type, but the content of larger bioclasts (echinoderms, bivalves) is higher, sorting is poor.

Sample point 5: Well bedded limestones of the Kössen-Formation with marly intercalations along the trail on top of Patch Reef A.

Samples 5/7; 5/8:

Bivalve-biomicrite (mudstone: MF K2 of STANTON & FLÜGEL, 1989). This sediment differs from both the above mentioned types by the lack of micritic intraclasts.

Samples 5/4; 7/6:

Bivalve-echinoderm biomicrite (wacke- to packstone: MF K4 of STANTON & FLÜGEL, 1989). Mostly thickshelled bivalve-debris, partly pyritized, is embedded in a micritic matrix. The content of echinoderms, tiny micritic intraclasts and of foraminifera (*Agathammina austroalpina, Trochammina* sp.) is highly variable.

Sample point 6: Patch Reef A

Samples 6/6; 7/3:

Coral-bivalve biomicrite (floatstone-bafflestone: MF K5 of STANTON & FLÜGEL, 1989). Besides abundant coral-debris, thick shelled bivalve-clasts are dominant. The matrix consists of finest rubble and micritic intraclasts. In sample 6/6 a partly damaged and strongly recrystallized coral-colony is only weakly encrusted by a serpulid worm and some foraminifera (Nubeculariids). Microbial coatings or other members of the encruster guild are totally absent!

Sample area 7: Kössen-Limestone scree, collected on slope below Patch Reef A in direction to Stallenalm.

Sample 7/1:

Bivalve biomicrite (floatstone: MF K9 of STANTON & FLÜGEL, 1989). Large bivalve shells are floating together with thin finegrained debris in a homogenous microsparitic matrix.

3. Stable Isotopes

3.1. Material and Methods

The isotopic measurements were carried out on un-dolomitized limestones and separated components of early and late diagenetic calcite cements. The mineralogy of the carbonate phases was determined by x-ray diffractometry and by examination of thin sections by standard optical methods, including staining with Alizarin-red. All samples were also evaluated by petrographic methods to assess their diagenetic history. Samples for isotopic measurements were obtained as a split of powder prepared from rock chips remaining after thin section preparation (whole rock samples) and/or were taken using a small dentists drill (diagenetic components). The samples were prepared for isotopic analyses by dissolution in excess 100% H_3PO_4 at 25°C (MCCREA, 1950; WACHER & HAYES, 1985). The oxygen and carbon isotopic composition of the CO_2 gas released during acid treatment were determined using a Varian MAT 250 mass spectrometer and recorded relative to Pee Dee Belemnite (PDB) standard carbonate powder (EPSTEIN et al., 1953). All bulk rock and calcite cement samples were measured twice or three times. The results are reported in the conventional delta notation as ‰ deviations from the PDB standard for oxygen and carbon. The analytical precision based on multiple analysis of internal laboratory standards was ± 0,02‰ for $\delta^{18}O$ and ± 0,01‰ $\delta^{13}C$, respectively. Overall analytical reproducibility of the isotopic data was ± 0,15 for oxygen and ± 0,1% for carbonate carbon.

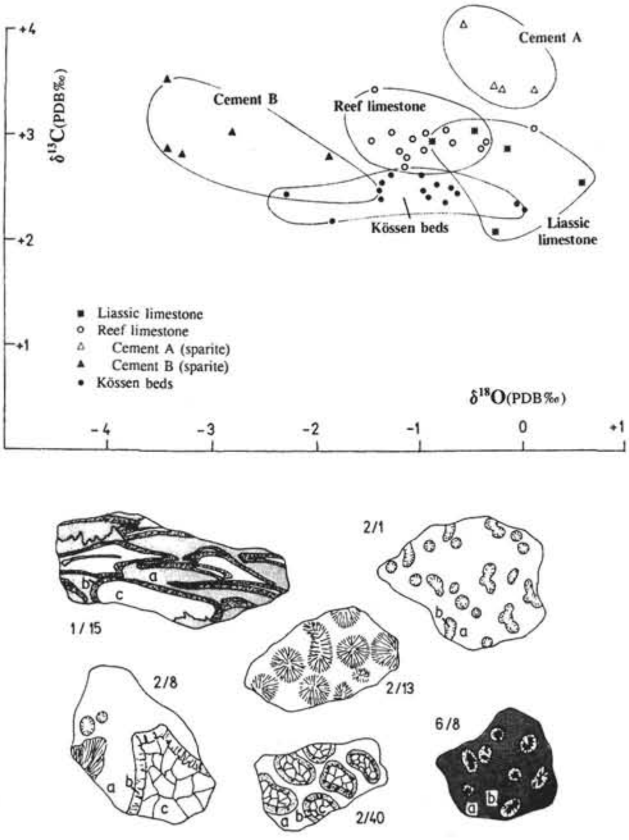
3.2. Results and Discussion

The oxygen and carbon isotope values in whole rock and calcite cements show a little scatter. The five groups (A, B, C D_1 and D_2) with 42 samples jointly that apparently are present (Text-Fig. 3) correspond to Rhaetian reef limestone (A), Kössen limestone (B), Liassic limestone (C), as well as to early (D1) and late (D2) diagenetic calcite cements. The results each of separated components and the whole rock are described below.

The oxygen and carbon isotope composition of the whole rock samples form three distinct groups (A, B and C) associated with different environments of deposition. Whereas the Rhaetian reef limestone (A) is enriched in ^{13}C ($\delta^{13}C$ = + 2,72 to + 3,48‰), $\delta^{13}C$ values of the Kössen limestone (B) containing organic matter are slightly depleted in ^{13}C ($\delta^{13}C$ = + 2,18 to +3,28‰). Similar low $\delta^{13}C$ values exhibit the deeper water Lower Jurassic limestones (C), which are also characterized

Table 1.
Oxygen and carbon isotope analyses of various carbonate rock types from the Steinplatte region. For location of samples refer to Text-Fig. 1 and chapter 2.

Sample	δ^{18}O(PDB‰)	δ^{13}C(PDB‰)	Rock type	Sample	δ^{18}O(PDB‰)	δ^{13}C(PDB‰)	Rock type
Liassic limestones							
1/2	-0,26	2,09	red biomicrite	2/39a	-1,48	2,93	biomicrite
1/3	0,59	2,54	red crinoidal lms.	2/39b	-1,26	3,01	sparite
1/9a	-0,15	2,88	red biomicrite	2/39c	-3,45	2,89	cement B
1/9b	-0,21	3,42	cement A	2/40a	-2,27	2,85	biomicrite
1/9c	-2,72	3,03	cement B	2/40b	-1,02	2,98	sparite
1/14	-0,93	2,94	yellow biomicrite	2/40c	-1,88	2,83	cement B
1/15a	-0,48	3,02	red biomicrite	**"Toe of the slope"**			
1/15b	-0,61	4,05	cement A	3/1	-2,42	2,52	biocalcarenite
1/15c	-3,36	3,56	cement B	3/2	-1,21	2,72	"
Oberrhätkalk – Capping Facies				**Kössen - Formation**			
2/1a	-1,40	3,48	micrite	4/1	-1,29	2,61	biopelmicrite
2/1b	-0,01	3,42	cement A	4/2	-1,04	2,67	"
2/4	0,09	3,10	biomicrite	5/4	-0,84	2,38	biomicrite
2/5	-1,17	2,85	biocalcarenite	5/7	-0,95	2,47	"
2/8a	-0,68	2,97	biomicrite	5/8	-0,91	2,42	sparite (corals)
2/8b	-0,30	3,47	cement A	6/6	-1,42	2,39	"
2/8c	-3,22	2,81	cement B	6/7	-1,39	2,55	"
2/10a	-1,15	2,81	biosparite	6/8a	-0,65	2,47	biomicrite
2/10b	-0,76	3,06	red biomicrite	6/8b	-2,29	2,44	sparite (corals)
			(solution cavity)	7/1	-0,68	2,46	biomicrite
2/13	-0,96	2,84	*"Thecosmilia"*	7/2	-1,85	2,18	"
2/27	-0,92	3,00	biomicrite	7/3	-0,77	2,31	"
2/38	-0,39	2,94	*"Thecosmilia"*	7/6	-0,05	2,21	"



Text–Fig. 3.
Cross-plot of $\delta^{13}C$ and $\delta^{18}O$ variations in carbonate rocks from the Steinplatte region and some typical samples analysed.

by up to 2‰ higher $\delta^{18}O$ values relative to the Rhaetian reef limestones and Kössen limestones. With the whole rock carbonate samples there is obviously a question as to whether the original isotopic values have been exchanged by meteoric water during diagenesis and deep burial. The results from the whole rock samples clearly show that no subsequent major re-equilibration has taken place. The whole rock samples give isotopic ratios where both the $\delta^{18}O$ and $\delta^{13}C$ are similar to those of marine limestone of Recent age (see Faure, 1977 and references therein).

The diagenetic calcite cement which is of two generations (early and late diagenetic calcite) is the major pore filler, and shows a relatively narrow range of oxygen (3,44‰) and carbon (1,61‰) isotope values. The early diagenetic calcite exhibits similar and/or slightly higher $\delta^{18}O$ values and slight enrichment in $\delta^{13}C$ (up to 1,03‰) relative to the host rock. The late diagenetic calcite shows a clear overall trend towards lighter values for both carbon $\delta^{13}C$ and $\delta^{18}O$ relative to the early diagnetic calcite (Text-Fig. 3, Table 1).

Many factors affect the isotopic composition of precipitated minerals. With carbonates, the most important control is the isotopic composition of the oxygen and carbon of the water from which precipitation took place. For the oxygen isotopic ratio, temperature is an equally important factor. The observed variations in $\delta^{18}O$ values between the different limestone, especially between the groups A, B and C may represent the differences in the oxygen isotopic composition of the ambient seawater and/or temperature.

Assuming an average water isotopic composition similar to the present value $\delta^{18}O$ = 0‰), the equilibrium calculations, using the equation of Shackleton & Kennett (1975):

$$T\,°C = 16{,}9–4{,}38\ (\delta c\text{-}\ \delta w) + 0{,}1\ (\delta c\text{-}\ \delta w)^2$$

(δc being the isotopic composition of CO_2 produced from the carbonate at 25°C and δw the isotopic composition of CO_2 in equilibrium with the formation water) yield a temperature range of 18 to 24°C for the shallow water Rhaetian reef limestones and Kössen limestones and of 14 to 19°C for the deeper water Lower Jurassic limestones. The relative $\delta^{18}O$ enrichment of up to 2‰ between the Rhaetian reef limestones, Kössen limestones and Liassic limestones thus would translate to change of up to 9°C of ambient seawater temperature, which seems to be real.

Most marine carbonates reflect the $\delta^{13}C$ of total dissolved inorganic carbon (TDC) of the water in which they form (Anderson & Arthur, 1983) and this is probably also the case with the investigated limestones. Their carbon isotopic composition reflects local conditions, with slightly $\delta^{13}C$ depleted carbonates (i.e Kössen and deeper water Jurassic limestone) forming in environments where the ambient seawaters were slightly influenced by recycling of carbon from organic matter. Marine carbonates formed in more open marine conditions in seawater in isotopic equilibrium with the atmosphere ($\delta^{13}C_{CO2}$ around – 7‰) at 20 °C have $\delta^{13}C$ values around + 3‰ (Faure, 1977). Similar $\delta^{13}C$ values exhibits the Rhaetian reef limestone (capping facies) which seems to be formed in isotopic equilibrium with atmospheric CO_2.

During diagenesis, the primary calcite dissolves and is replaced by secondary calcite that precipitates in isotopic equilibrium with pore fluids in the sediment column. In general, the equilibrium of $\delta^{18}O$ values of secondary calcite decreases with increasing burial depth because temperature increases and $\delta^{18}O$ of pore fluid typically decreases with water depth of sedimentation (Schrag et al., 1995). At temperatures typical of sedimentary enviroments, most minerals retain their isotopic signature because significant post-crystallization, isotopic exchange with water is uncommon (O'Neil, 1987). In most sedimentary systems, diagenetic carbonate minerals still retain a valuable isotopic record of the pore fluid origin, the source of carbon and the temperature at that stage of diagenesis, all of which give useful insights into the geological and hydrological history of the depositional regime (Ayalon & Longstaffe, 1995).

Early diagenetic calcite cements have similar values to depositional components such as micrite (Walls et al., 1979; Marshall & Ashton, 1980) or they have more negative $\delta^{18}O$ values (Davies & Krouse, 1975). In some cases the $\delta^{13}C$ values of cements and depositional grains are the same (Walls et al., 1979); in other instances a less pronounced but nevertheless distinct trend towards less positive $\delta^{13}C$ values occurs within sparry calcites (Dickson & Coleman, 1980).

The enrichment of early diagenetic calcite cements in ^{18}O relative to the host micritic rock may be explained by the recrystallization processes which causes $\delta^{18}O$ values of carbonate formed in warm ambient water to increase initially because primary $\delta^{18}O$ values are lower than the value in equilibrium with colder pore fluids near the sediment water interface (Schrag et al., 1995).

Assuming that the early diagenetic calcite cement was precipitated in isotopic temperature with porewater whose $\delta^{18}O$ was similar to that of the seawater ($\delta^{18}O$ = 0‰) the apparent temperature of precipitation is only up to 4 °C lower than that of the precipitation of micritic limestone. The $\delta^{18}O$ values of the early diagenetic calcite thus most probably indicate only the temperature dependency of the fractionation of the oxygen isotope between water and calcite. $\delta^{13}C$ values of this cement which are similar or/and slightly higher relative to the host rock most probably indicate that the carbon for the cement is derived from within the limestone, from solution of micrite grains.

More negative $\delta^{18}O$ values of the late diagenetic calcite cements could be interpreted in two ways, either by a change in the isotopic composition of the pore fluids, such as through influx of meteoric water or by an increase in temperature through increasing depth of burial. Because the crystallization of diagenetic calcite cements (early and late) is consistent with relatively narrow range of isotopic values ($\delta^{18}O$ = - 0,01 to - 3,45°; $\delta^{13}C$ = + 2,44 to + 4,05‰) the relative depletion in ^{18}O and ^{13}C of the late diagenetic calcite cements could be explained by an increase in temperature as well as by changes in the isotopic composition of dissolved carbonate during the dissolution/precipitation event. Because the carbon isotopic composition of late diagenetic calcite cements is also similar to that of the micritic host rocks, the possible source for the carbon is the same as for the early diagenetic calcite cements. Relatively high $\delta^{18}O$ and $\delta^{13}C$ values of diagenetic calcite cements indicate that lighter water and ^{12}C from oxidation of organic matter were not (significantly) involved in the replacement processes. The early diagenetic calcite cements were formed at shallow depth, while the late diagenetic calcite cements precipitated at greater depth most probably from the pore waters with the isotopic composition similar to the seawater ($\delta^{18}O$ = 0‰) and of temperature up to 33°C.

4. Corals

4.1. Previous Research on Steinplatte Corals

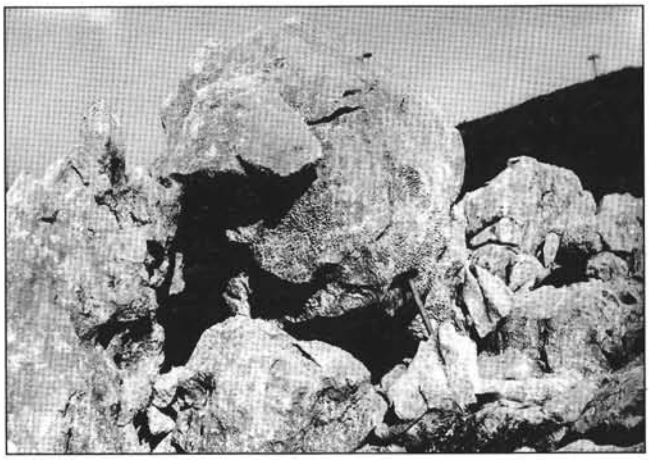
During the long lasting research activities the "Oberrhätkalk" (Upper Rhaetian Limestone) of Steinplatte is known as a "coral-reef" already since the last century (Mojsisovics, 1871). The most detailed early fossil list including findings of corals in the Kössen-Formation and in the Oberrhätkalk we owe to Hahn (1910). Also Vortisch (1926) mentiones *"Thecosmilia"* as main reef building organism of the Steinplatte Oberrhätkalk, accompanied by *Stylophyllum polyacanthum* Reuss, *Mauntlivaltia* (sic!) cf. *Fritschi* Frech and *Thamnastraea* sp.

Modern sedimentological and palaeontological research of the Steinplatte-Kammerköhr region was started by Ohlen (1959), who also distinguished several coral taxa, e. g. *"Thecosmilia" clathrata* form A and form B, the latter is dominating Ohlen's coral facies, while in the "fore-reef facies" (talus) he also refers to *Stylina, Thamnasteria rectilamellosa, Thamnasteria confusa, Thecosmilia clathrata, Montlivaltia norica, Montlivaltia marmorea* and *Margarastraea*. From the patch reefs within the Kössen-Formation Ohlen also mentioned *Procyclolites* besides *"Thecosmilia"*.

Piller (1981) reports from the lowermost Steinplatte reef-slope the solitary coral *"Montlivaltia norica" (=Distichophyllia norica)*, which is followed further upslope by massive *"Thamnasteria"* and *Astraeomorpha*, and branching *"Thecosmilia" clathrata* form B of Ohlen *(=Retiophyllia clathrata)*. The coral fauna of the reef crest is dominated also by the last mentioned taxon, however, also *Pinacophyllum* and *Styllophyllum* are common.

Kuss (1983) deals also with the coral assemblages of the Kössen-Formation and notes, that they are poorer in taxa than the assemblages of the Oberrhätkalk.

Stanton & Flügel (1989) identified 17 species of corals and illustrated them with photos in plates. They are *Retiophyllia clathrata, R. paraclathrata, Parathecosmilia sellae, "Thecosmilia"* sp., *"Montlivaltia" norica (= Distichophyllia norica), Astraeomorpha crassisepta, Thamnasteriamorpha* sp., *Stylophyllum polyacanthum, Cyathocoenia schafhäutli (=Chondrocoenia schafhäutli), Actinastraea juvavica (=Crassistella juvavica), Paradistichophyllum* sp. *(=Retiophyllia norica), Pinacophyllum* sp. and *Pamiroseris rectilamellosa.*



Text–Fig. 4.
Retiophyllia buildup, Oberrhätkalk-Capping Facies, "Fischer's Coral Garden".

Roniewicz (in Lobitzer, 1994) named 7 species of corals, one is represented with photo. They are: *Retiophyllia gracilis, Retiophyllia* cf. *fenestrata, Retiophyllia* cf. *gephyrophora, Retiophyllia* sp. 1, *Retiophyllia* sp. 2, *Distichophyllia* ex gr. *norica, Pamiroseris rectilamellosa, Astraeomorpha confusa, Astraeomorpha crassisepta* and *Distichoflabellum zapfei.*

The names of taxa in brackets were revised according to Roniewicz (1989).

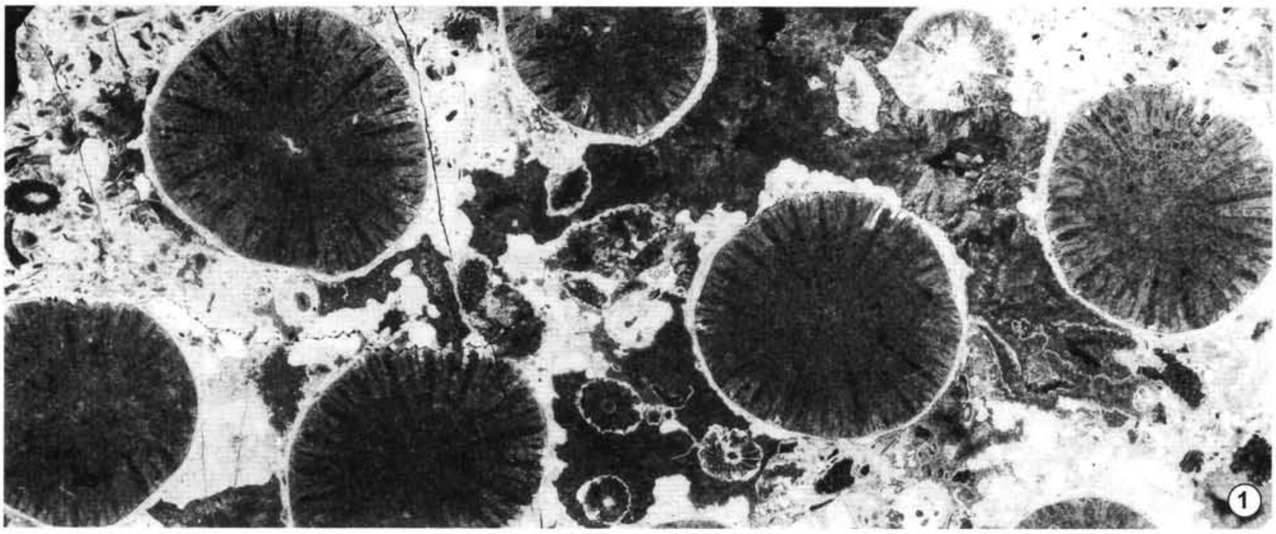
4.2. Short Representation of Corals from Capping Facies and Kössen Patch Reef A

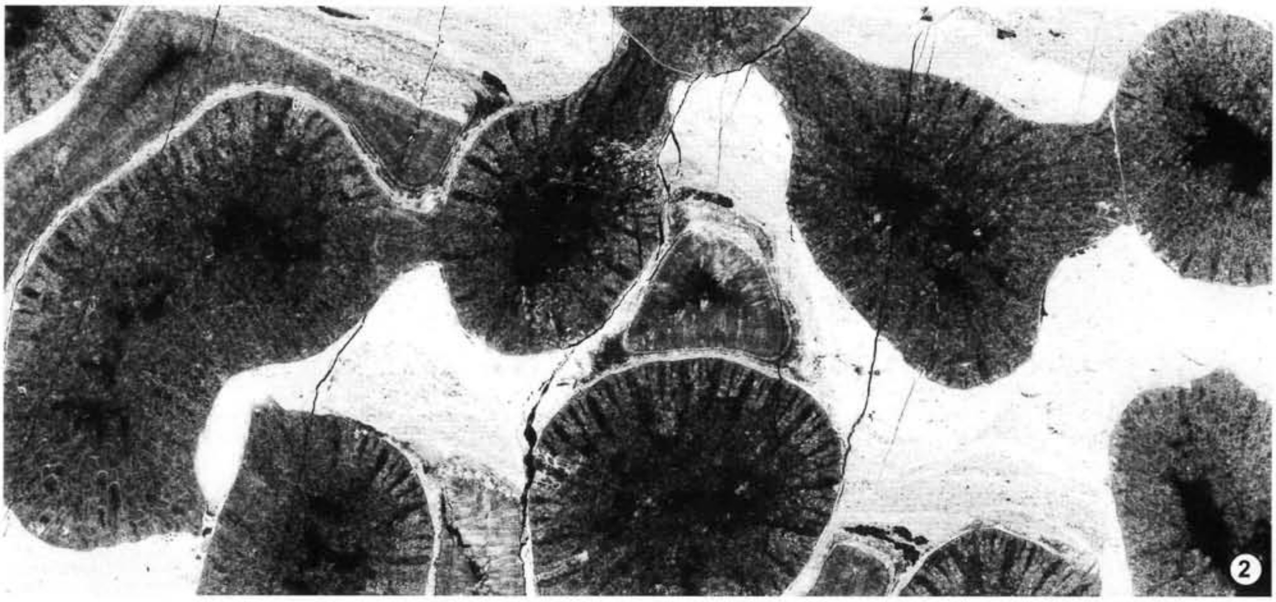
Only a relatively small amount of coral-bearing samples has been studied so far by our working group. Therefore the presented data can only provide some additions to the already known fauna lists (e.g. Stanton & Flügel, 1989). For the examination of corals from the Steinplatte 40 thin sections have been analysed: 2/1,-2,-11,-15,-16,-17,-18,-19,-20,-21,-22,-23,-24,-25,-26,-27,-29,-30,-31,-32,-33-34, -35,-37,-38,-39,-41,-42,-43,-A2,-A,-B,-2C,-2E,-2F,-2G, and 6/2,-4,-6,-7. From these samples 14 coral species were identified (d = diameter of corallites, s = number of septa).

Subordo: Distichophyllina Cuif, 1977
Family: Distichophylliidae Cuif, 1977
Genus: *Retiophyllia* Cuif, 1967

***-Retiophyllia clathrata* (Emmrich, 1853)** [Pl. 1, Fig. 1]
Phaceloid colony, corallites round, d = 7-9 mm, s = ca 70
Material: Thin sections: 2/18,-20,-31,-38.

****Retiophyllia defilippi* (Stoppani, 1865)** [Pl. 1, Fig. 2]
Phaceloid colony, corallites irregular, d = 7-9 x 9-15 mm, s = 54-96
Material: Thin sections: 2/11,-30.
***Retiophyllia fenestrata* (Reuss, 1854)** [Pl. 1, Fig. 3]
Phaceloid colony, corallites round to oval, d = 6-8(9) mm, s = 40-50
Material: Thin sections: 2/19,-21,-41.





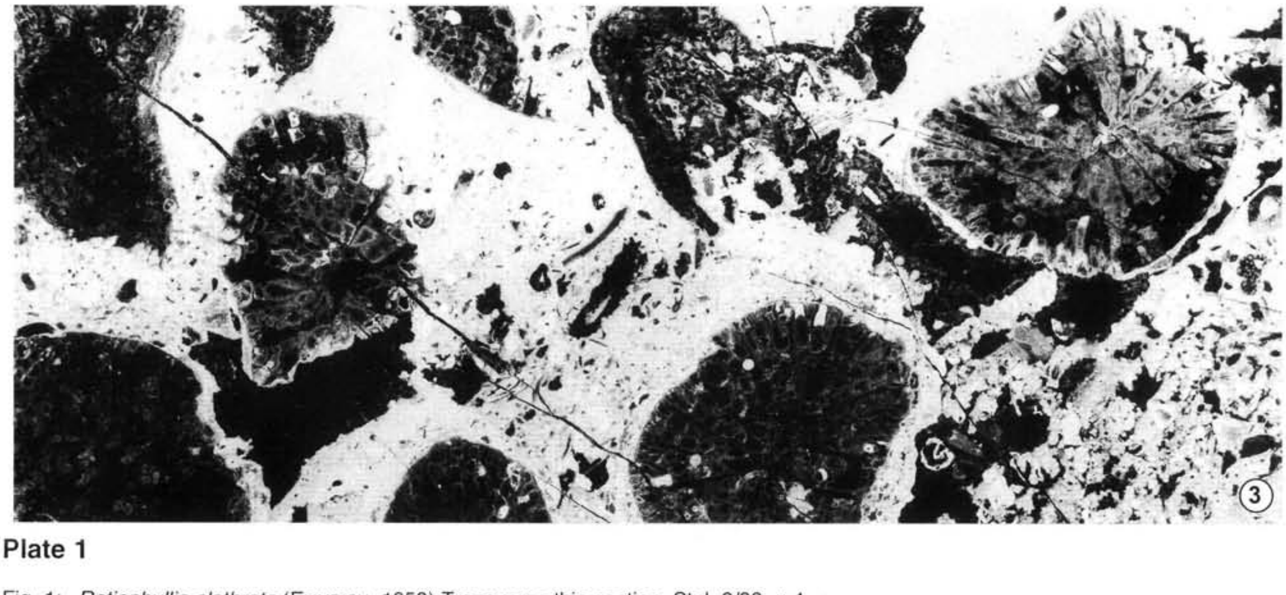
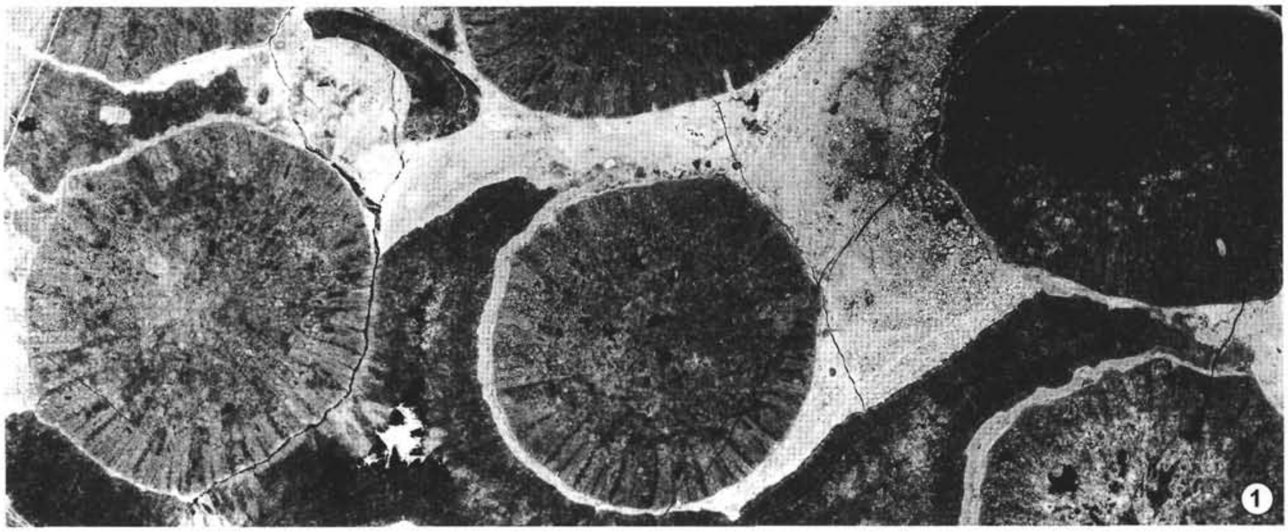
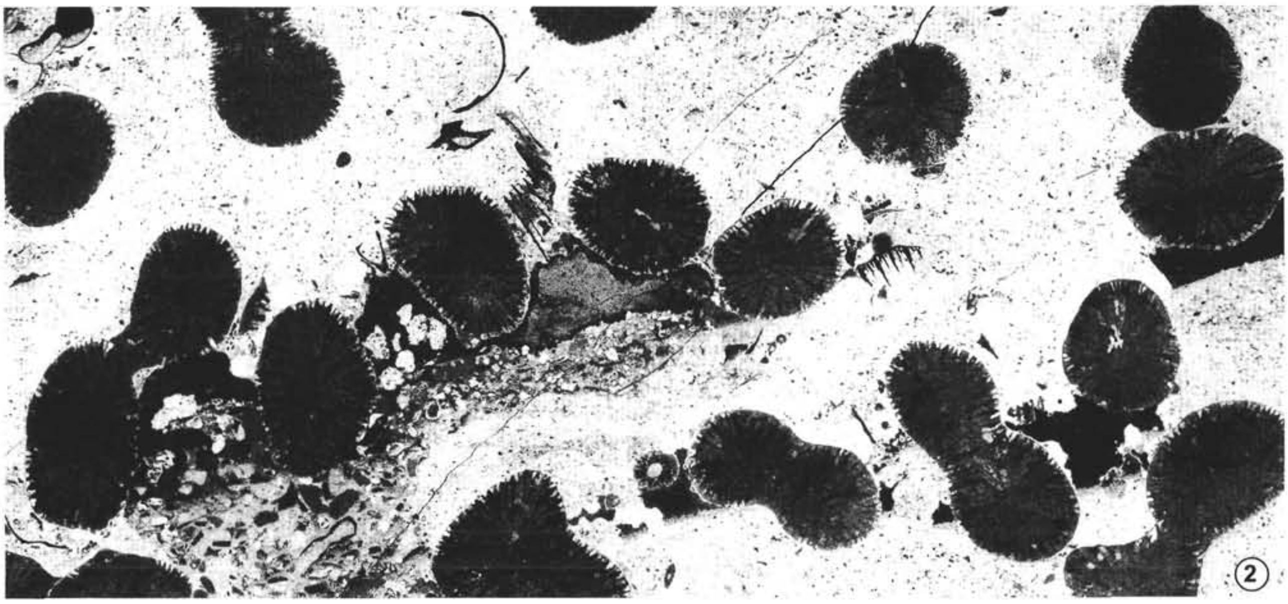


Plate 1

Fig. 1: *Retiophyllia clathrata* (Emmrich, 1853) Transverse thin section, Stpl. 2/38, x 4.
Fig. 2: *Retiophyllia defilippi* (Stoppani, 1865) Transverse thin section, Stpl. 2/11, x 4.
Fig. 3: *Retiophyllia fenestrata* (Reuss, 1854) Transverse thin section, Stpl. 2/41, x 4.





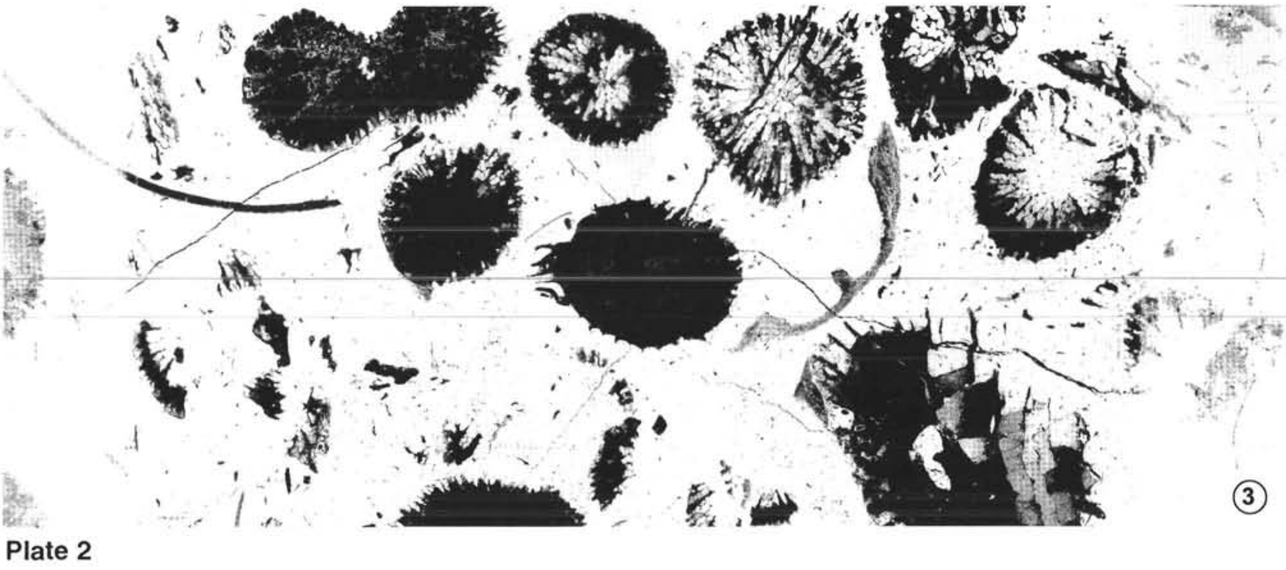


Plate 2

Fig. 1: *Retiophyllia gosaviensis* (Roniewicz, 1989) Transverse thin section, Stpl. 2/23, x 4.
Fig. 2: *Retiophyllia gracilis* (Roniewicz, 1989) Transverse thin section, Stpl. 2/15, x 4.
Fig. 3: *Retiophyllia multiramis* Roniewicz, 1989) Transverse thin section, Stpl. 6/2, x 4.

***Retiophyllia gosaviensis* Roniewicz, 1989** [Pl. 2, Fig. 1]
Phaceloid colony, corallites round, d = 10-12 mm, s = ca 100.
Material: Thin section 2/23.

-*Retiophyllia gracilis* Roniewicz, 1989 [Pl. 2, Fig. 2]
Phaceloid colony, small round to slightly oval corallites, less dissepiments as in *R. paraclathrata.* d = 3-4 mm, s = 40-50
Material: Thin sections 2/15,-19.

***Retiophyllia multiramis* Roniewicz, 1989** [Pl. 2, Fig. 3]
Phaceloid colony, round corallites, very granulated septa, d = 4-5 mm, s = 60.
Material: Thin sections 2/A,-B,-21, 6/2.

***Retiophyllia norica* (Frech, 1890)** [Pl. 3, Fig. 1]
Phaceloid colony, round to oval corallites, abundant endotheca, d = 7-10 x 7-14 mm, s = 48-80
Material: Thin sections 2/16,-21,-22,-32,-B.

***Retiophyllia oppeli* (Reuss, 1865)** [Pl. 3, Fig. 2]
Phaceloid colony, corallites round to slightly oval, d = 2.5-3(4) mm, s = 12-24
Material: Thin sections 2/1,-17,-25.

-*Retiophyllia paraclathrata* Roniewicz, 1974 [Pl. 3, Fig. 3]
Phaceloid colony, corallites round, d = 3-4 mm, s = 56
Material: Thin sections 2/33,-34.

Genus: *Parathecosmilia* Roniewicz, 1974

-*Parathecosmilia sellae* (Stoppani, 1862) [Pl. 4, Figs. 1, 2]
Phaceloid colony, round to slightly oval corallites, axial and peripheral septal structure, d = 4-8 mm, s = 28-48
Material: Thin sections 6/3,-6,-7

Genus: *Oedalmia* Cuif, 1976

***Oedalmia norica* (Frech, 1890)** [Pl. 4, Fig. 3]
Massive colony, thamnasteriid corallites, d in series = 5-6 mm, out = 7-10 mm, s = 34.
Material: Thin section 6/4.

Family: Margarophylliidae Cuif, 1977
Genus: *Margarosmilia* Volz, 1896

***Margarosmilia charliana* (Frech, 1890)** [Pl. 4, Fig. 4]
Phaceloid colony, round to irregular corallites, d = 8-10(12) mm, s = 48-96.
Material: Thin sections 2/26,-29,-35,-39,-B,-42.

Subordo: ?Archaeofungiina Beauvais, 1981
Family: Astraeomorphidae Frech, 1890
Genus: *Astraeomorpha* Reuss, 1854

-*Astraeomorpha confusa* Winkler, 1861 [Pl. 3, Fig. 4]
Massive bulbous colony, thamnasteriid corallites, d = ca 1.2-2 mm, s = 12,
Material: Thin section 2/21.

-*Astraeomorpha crassisepta* Reuss, 1854 [Pl. 3, Fig. 5]
d = 1.5-2(2.5) mm, s = 12,
Material: Thin sections 2/31,-36.
The compilation of all coral species represented or mentioned from Steinplatte so far shows, that seven (*) species have been found now for the first time in this locality, seven (-) species found in our material were represented or mentioned also by Piller (1981), Stanton & Flügel (1989) and Lobitzer (1994). Ten (+) coral taxa mentioned by Stanton & Flügel (1989) and Lobitzer (1994) have not been found in our material.

So altogether 23 coral species are known from Steinplatte (see Table 1), however, the Photo-Plates of the paper by Ohlen (1959) were not at our disposition and therefore could not be included into our considerations.

Besides corals also the following other "reef" organisms have been found in thin sections (thin section numbers in brackets):

Porifera:
- *Welteria rhaetica* Senowbari-Daryan, 1990 (2/2) [Pl. 5, Fig. 1]
- *Paradeningeria alpina* Senowbari-Daryan & Schäfer, 1979 (2/27) [Pl. 5, Fig. 2]
- *Cheilosporites tirolensis* Wähner, 1903 (2/22) [Pl. 5, Fig. 3]
- not determined: (2/1,-?15,-19,-29,-37,-?Ba)

Stromatoporoidea:
- *Disjectopora* sp. (2/27) [Pl. 5, Fig. 4]
- *Spongiomorpha* sp. (2/18) [Pl. 5, Fig. 5]

Foraminifera:
- *Diplotremina* sp. (2/16,-31,-36,-?38,-39,-41,-18,-21,-22,-33.
- *Involutina* sp. (2/16,-41,-Ba)
- ?*Alpinophragmium perforatum* Flügel, (?2/1, ?6/2)
- ?*Spirillina* sp. (6/7)
- ***Tolypammina* sp. (2/26,-29)**
- not determined ((2/15)

Dasycladacean algae:
- *Diplopora adnetensis* Flügel, 1975 (2/18,-20,-31,-43, -36, -38,-41,-A, A/F,A/G)
- *Heteroporella zankli* Ott, 1967 (2/18,-31)
- *Gryphoporella* sp. (2/16,-30,-Ba, 2/25)
- ?*Poikiloporella* sp. (2/36)

Red algae:
- Solenoporaceans (2/36,-37)
- Cyanophyceans: (2/1,-11,-36,-37, 2/E)

Microproblematica:
- *Microtubus communis* Flügel, 1964 (2/15,-26,-29, 6/4,-7)
- *Bacinella irregularis* Radoičić 1959 (2/36, 2/E)
- *Bacanella floriformis* Pantić, 1971 (2/29)

Gastropods: (2/1,-15,-16,-19,-20,-29,-30,-32,-37, 6/2,-4,-6)
Crinoids: (2/1,-15,-16,-19,-30,-37,-39,-41,-Ba)
?Annelids: (2/32)

4.3. Stratigraphical Comparison of Steinplatte Coral Assemblages with other Localities

The age of all determined coral species from Steinplatte can be compared with many other localities in Europe and outside.

All species without exception are already known from several localities in Austria (and Bavaria):

Frech (1890) mentioned the following localities with findings of Norian-Rhaetian corals: Oedalm, Fischerwiese, Hallstätter Salzberg, Hammerkogel, Zlambachgraben, Gotzenalp bei Königssee, Voralpe bei Altenmarkt, Kothalp, Berchtesgaden, Hochfelln, Hierlatz, Hallstatt and Donnerkogel.

Detailed studies of corals from Zlambach-Formation in the Northern Calcareous Alps were performed by Roniewicz (1989). There 64 species were described, of which 16 are common with the Steinplatte ones. She mentioned the following localities: Fischerwiese, Gosaukamm vicinity (Schnec-kengraben, Kesselwand-Rohrmoos), Sommeraukogel, Hall-stätter Salzberg and Zlambach-Graben, and put all into the Rhaetian stage.

In a more recent paper Roniewicz (1996) describes 12 new species of solitary corals from the Norian Dachstein-Limestone from various Austrian localities, namely from the Gosaukamm, Loser near Alt Aussee, Hochschwab and from the Rhaetian Dachstein-Limestone of Hochkönig and from the Zlambach-Formation of Kesselwand-Rohrmoos in the Dachstein region.

Gruber and Feichtenstein reefs were precisely analysed by Senowbari-Daryan (1980). In Gruber reef there are three coral species of total 23 and in Feichtenstein five of total 20 identical with Steinplatte species. They are ascribed to the Rhaetian age.

In Adnet and Rötelwand coral reefs were studied by Schäfer (1979) and put into the Rhaetian stage. In Adnet homotypic reef communities are predominated where three of total 13 coral species are identical with Steinplatte. In Rötelwand four of total 25 are identical with Steinplatte species. Schäfer accented the similarity of Adnet fossil association to that of Steinplatte. The beautiful paper by Bernecker et al. (1999) deals with the coral communities of the spectacular outcrops in Tropf-Quarry, Adnet. The authors distinguish three »reef growth stages« and among many other important notes state, that the massive coral *Pamiroseris* grew under higher energy conditions at the rim of the knob, whereas branching *Retiophyllia* colonies preferred less agitated water in the center of the knobs.

The »Wilde Kirche« reef complex in Tyrol was studied in detail by Riedel (1988). *Retiophyllia* type is predominant and at least one species is surely identical with the Steinplatte coral association. The reef complex is considered as of the Rhaetian stage.

The Hohe Wand reef, SW of Vienna, is considered to be of Norian to Rhaetian age (Sadati, 1981). Three coral species of 8 are identical with the Steinplatte association.

Reef buildups in southwestern Gesäuse in Styria were studied by Dullo (1980), where phaceloid types of corals prevail, and one species is identical with Steinplatte. They were put into the Norian.

A coral association of 12 species is mentioned in Dachstein Reef Limestone of Gosaukamm by Wurm (1982). He considered the assemblage as of Norian age. Two species are identical with Steinplatte forms.

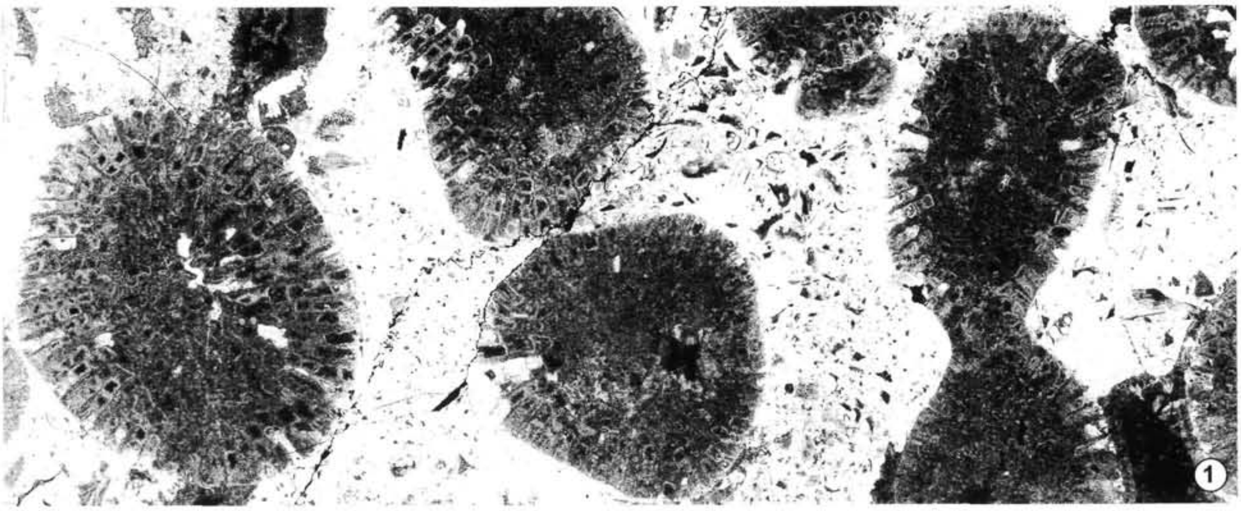
A very lucid review of all Upper Triassic reefs until that time was given by Flügel (1981, 1982).

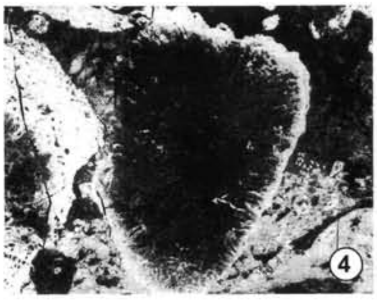
The coral species of Steinplatte can be compared also with several localities in countries outside of Austria. Five species in Tatra Mountains (Rhaetian; Roniewicz, 1974), two in Bakony and Buda Mountains in Hungary (Upper Triassic; Kolosvary, 1966), three in Lombardy in north Italy (Rhaetian; Stoppani, 1862-65), four in Sicily (Norian; Senowbari-Daryan et al., 1982), seven in northwest Slovenia (Norian-Rhaetian; Turnšek, 1997), three in Oman (Norian-Rhaetian; Bernecker, 1996), four in Pamir (Norian-Rhaetian; Melnikova, 1975), three in Timor (Upper Triassic; Vinassa De Regny, 1915), four in western North America (Norian-Rhaetian) (Stanley, 1979), one in Mexico (Norian-Rhaetian; Stanley et al., 1994), and one in Peru (Norian-Rhaetian; Stanley, 1994).

Table 2:
List of all so far known Steinplatte coral species with their geographical and stratigraphical world correlation (in alphabetic order).

	Steinplatte	World distribution		
Coral species		Stratigraphy No LU	R	Geography
in our material:				
Astraeomorpha confusa	T,L	U	R	A,PA,IR,AM.PE
Astraeomorpha crassisepta	T,L,SF	U	R	A,T,LO,SI,AM,PA,TI
Margarosmilia charliana	T	U	R	A,SL,PE,OM
Oedalmia norica	T		? R	A,?SI
Parathecosmilia sellae	T,SF	U	R	A,T,LO,SL
Retiophyllia clathrata	TP,SF	LU	R	A,T,SI,SL,H,AM,PA,IR
Retiophyllia defilippi	T	LU	R	A,LO,SL,H
Retiophyllia fenestrata	T,L	LU	R	A
Retiophyllia gosaviensis	T	U	R	A,SL
Retiophyllia gracilis	T,L	U	R	A
Retiophyllia multiramis	T		R	A
Retiophyllia norica	T,SF	LU	R	A,SL,AM,ME,OM,IR,TI
Retiophyllia oppeli	T	U	R	A,AM,PA,TI
Retiophyllia paraclathrata	T,SF	LU	R	A,T,SL,SI
known before:				
Chondrocoenia schafhäutli	SF	LU	R	A,LO,T,PA
Crassistella juvavica	SF	LU	R	A,PA
Distichophyllia norica	L,SF	U	R	A,T,SL,OM,PA,AM
Distichoflabellum zapfei	L		R	A
Pamiroseris rectilamellosa	L,SF	U	R	A,T,PA
Pinacophyllum sp.	SF	-	-	-
Retiophyllia gephyrophora	L		R	A
Stylophyllum polyacanthum	SF		R	A
Thamnasteriamorpha sp.	SF	-	-	-

T = this paper, P = Piller (1981) , L = Lobitzer (1994), SF = Stanton & Flügel (1989). Stratigraphical range: No = Norian (L = Lower, U = Upper), R = Rhaetian. Geographical distribution: A = Austria (Northern Calcareous Alps); AM = Northern America; H = Hungary; IR = Iran; LO = Lombardy (Italy); ME = Mexico; OM = Oman; PA = Pamir; PE = Peru; SI = Sicily (Italy); SL = Slovenia; T = Tatra (Slovakia); TI = Timor.





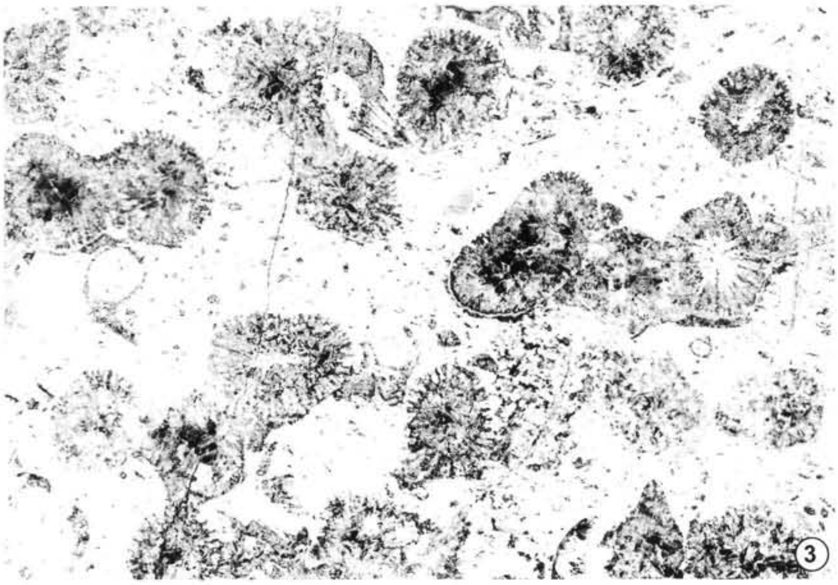
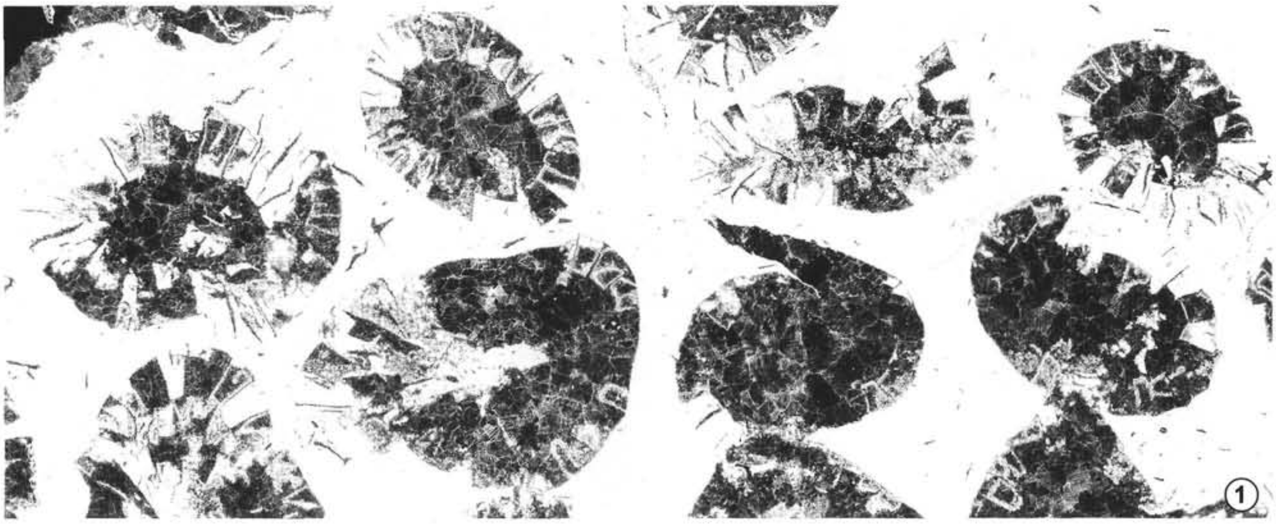


Plate 3

Fig. 1: *Retiophyllia norica* (Frech, 1890) Transverse thin section, Stpl. 2/16, x 4.
Fig. 2: *Retiophyllia oppeli* (Reuss, 1865) Transverse thin section, Stpl. 2/1, x 4.
Fig. 3: *Retiophyllia paraclathrata* Roniewicz, 1974 Transverse thin section, Stpl. 2/34, x 4.
Fig. 4: *Astraeomorpha confusa* Winkler, 1861 Transverse thin section, Stpl. 2/21, x 4.
Fig. 5: *Astraeomorpha crassisepta* Reuss, 1854 Transverse thin section, Stpl. 2/36, x 4.



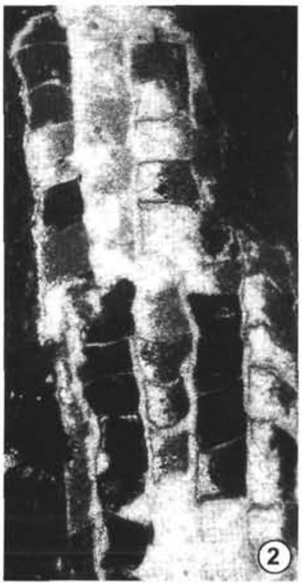
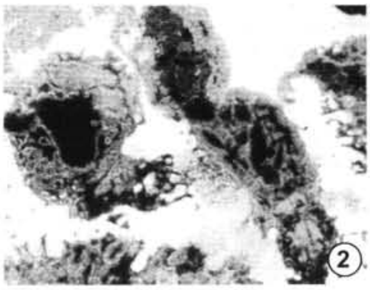
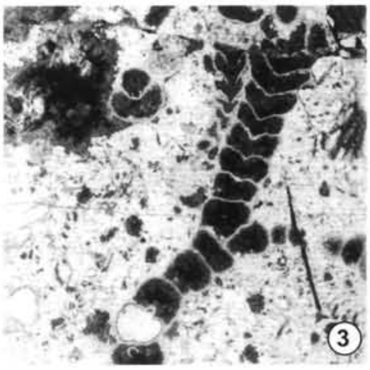
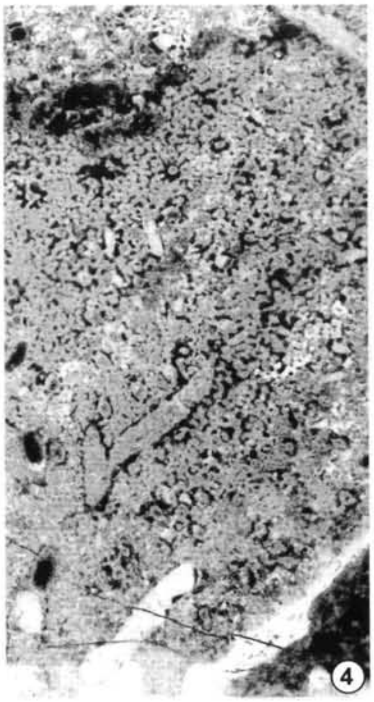


Plate 4

Fig. 1: *Parathecosmilia sellae* (STOPPANI, 1862) Transverse thin section, Stpl. 6/7, x 4.
Fig. 2: *Parathecosmilia sellae* (STOPPANI, 1862) Longitudinal thin section, Stpl. 6/3, x 11.
Fig. 3: *Oedalmia norica* (FRECH, 1890) Transverse thin section, Stpl. 6/4, x 4.
Fig. 4: *Margarosmilia charliana* (FRECH, 1890) Transverse thin section, Stpl. 2/35, x 4.







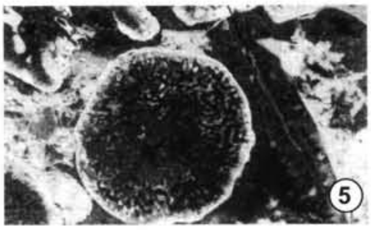


Plate 5

Fig. 1: *Welteria rhaetica* Senowbari-Daryan, 1990 Longitudinal thin section, Stpl. 2/2, x 4.
Fig. 2: *Paradeningeria alpina* Senowbari-Daryan & Schäfer, 1979 Transverse thin section, Stpl 2/27, x 4.
Fig. 3: *Cheilosporites tirolensis* Wähner, 1903 Longitudinal thin section, Stpl. 2/22, x 4.
Fig. 4: *Disjectopora* sp. Longitudinal thin section, Stpl. 2/27, x 4.
Fig. 5: *Spongiomorpha* sp. Transverse thin section, Stpl. 2/18, x 4.

Detailed stratigraphical comparison of Steinplatte corals with other localities shows that they as a whole can be put into the Norian-Rhaetian stage. More precise division of age is not possible at present, because Norian and Rhaetian stages are used in different meanings and cannot be compared in detail (see Table 2).

4.4. Palaeoecology

In Steinplatte the corals *Astraeomorpha, Chondrocoenia, Crassistella, Distichoflabellum, Oedalmia, Pamiroseris* and *Thamnasteriamorpha* are represented by massive colonies, but their dimensions are small. They have so far mostly been found at the periphery of reef areas or in sheltered parts of platforms. *Distichophyllia* is a solitary coral and mainly lives in somehow deeper environments. Main corals in Steinplatte are branching phaceloid forms belonging to the genera *Retiophyllia, Margarosmilia, Pinacophyllum* and *Parathecosmilia*. This kind of corals together with red alge, Cyanophyceae and some microproblematica *(Microtubus communis, Bacinella irregularis)* mainly grow at the high energy margins and build patch reefs or biostromes in different parts of platforms (see FLÜGEL, 1981), respectively on the slope towards the Kössen intraplatform-basin ("coral gardens" of Oberrhätkalk-Capping Facies).

It is interesting that in many specimens between the corallites dasyclad algae (*Diplopora adnetensis, Heteroporella zankli* and others) were found, which are considered to grow in lagoons. Exactly the same fossil association was discovered in Sicily by SENOWBARI-DARYAN et al., 1982), who considered it to belong to the "coral-algal biolithite" occuring predominantly in lagoonal areas. Among reef guilds FAGERSTROM (1988) ranged dasycladaceans to "reef dwellers".

In our material the species *Parathecosmilia sellae* and *Oedalmia norica* were found only in the locality 6, i.e. in Patch Reef A. All the other species were collected in the Capping Facies east of Plattenkogel. The only species *Retiophyllia multiramis* we found as well in Patch Reef A as in the assemblages of the Capping Facies.

5. Brachiopods (SIBLÍK)

The limestone/marl sequence of the Kössen-Formation deposited in the intraplatform Kössen basin in the Steinplatte-Kammerköhr area contains a relatively abundant brachiopod fauna. Finds of brachiopods were mentioned in the older literature already several times.

A rich collection was made by HAHN (1910, p.348) who mentioned from the lower part of the Kössen Limestone on the western side of Steinplatte: *Spiriferina jungbrunnensis* var. *uncinata, Rhynchonella fissicostata* var. *inflata, longirostris* and *applanata, Rhynchonella subrimosa* var. *complanata, Terebratula gregaria, Terebratula grossulus, Terebratula pyriformis* and *Waldheimia norica*, and from the upper part of the Kössen Limestone of the Kammerkeralp: *Spiriferina jungbrunnensis* var. *austriaca, Spirigera oxycolpos, Rhynchonella fissicostata, Rhynchonella subrimosa* var. *globosa, Terebratula pyriformis* and *Waldheimia norica*. VORTISCH' s finds (1926, p. 5) came from W of Steinplatte: *Spiriferina uncinata, Terebratula pyriformis* and *Rhynchonella fissicostata*. KUSS (1983, p. 91) found *Oxycolpella oxycolpos, Rhaetina pyriformis, Rhaetina gregaria* and *Fissirhynchia fissicostata*. KRISTAN-TOLLMANN (1987, Pl. 3, Figs. 8 and 13) figured 2 specimens of *Oxycolpella oxycolpos* from S of Kammerköhr. It is interesting that these authors did not mention a characteristic element of Rhaetian brachiopod fauna – *Austrirhynchia cornigera*. On the other hand, they recorded *Rhynchonella subrimosa* which is missing in my collection.

The present contribution summarizes my finds in the Kössen-Formation NW of Steinplatte (1869 m) made during several last years. Quite recent paper (SIBLÍK, 1998) dealt with the brachiopod fauna coming from the Oberrhätriffkalk of the same area and there were published necessary comments on respective species. In contrast with that paper my collection from the Kössen Formation contains *Sinucosta emmrichi* (SUESS) and lacks *Bactrynium bicarinatum* EMMRICH, *Laballa suessi* (ZUGMAYER), *Triadithyris gregariaeformis* (ZUGMAYER). *Rhaetina* aff. *elliptica* DAGYS. and *"Rhynchonella"* ex gr. *subrimosa* (SCHAFHÄUTL). The bulk of both assemblages is practically the same, however.

5.1. Brachiopod Localities

It is important to note, that the location of the mentioned brachiopod localities (Text-Fig. 5: sample points BR1-BR6) is not identical with the sample points for corals, respectively stable isotope samples (Text-Fig. 1: sample points 1-7)!

Locality BR1 - Köhrgatterl - Dreiländereck (locality 2 in KRISTAN-TOLLMANN et al., 1991): *Fissirhynchia fissicostata, Zugmayerella koessenensis, Zugmayerella uncinata, Sinucosta emmrichi, Oxycolpella oxycolpos, Rhaetina pyriformis, Zeilleria austriaca, Zeilleria* cf. *elliptica, Zeilleria norica.*

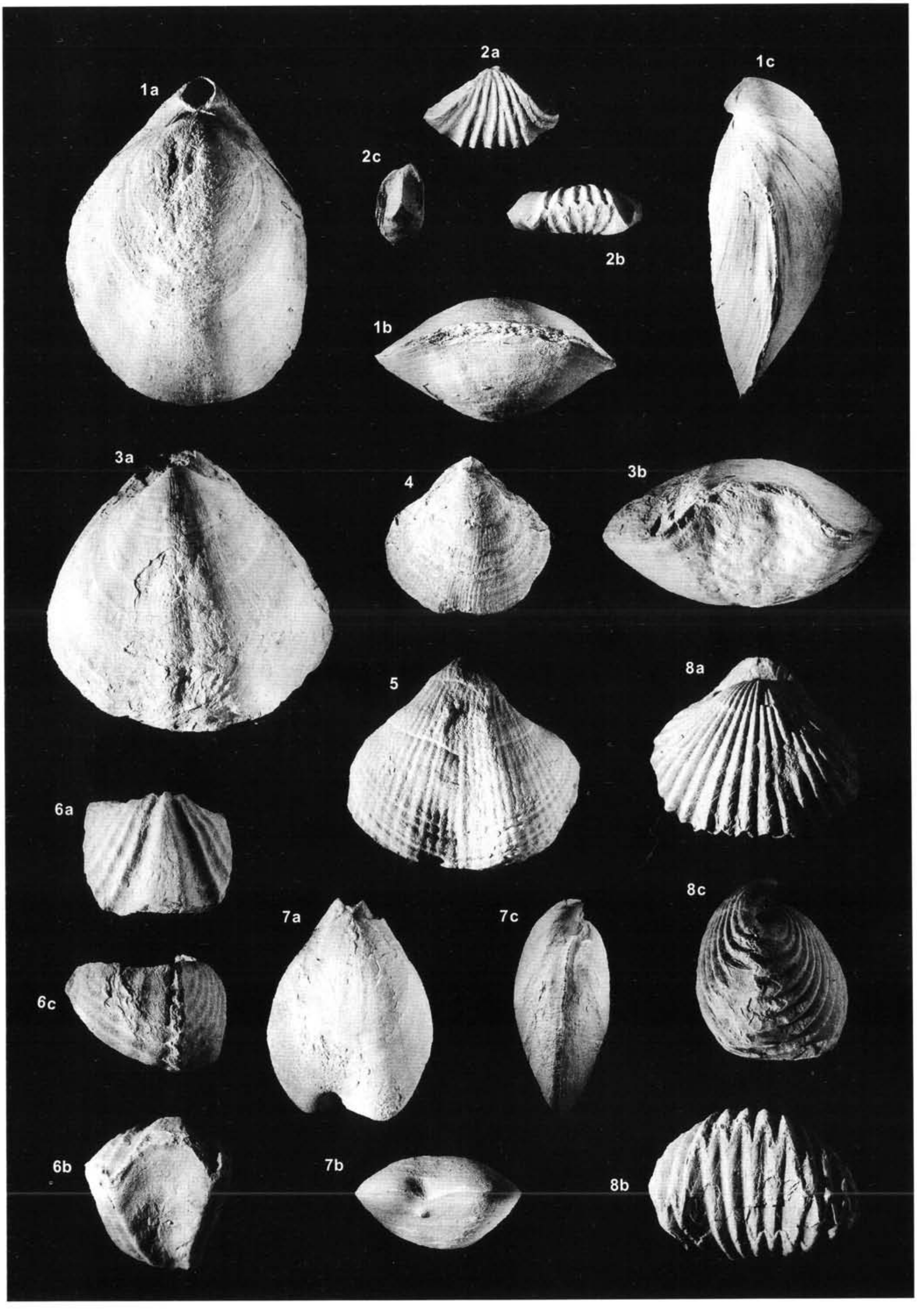
Locality BR2 - about 150 m S of Köhrgatterl. Kössen Formation exposed on the northern (left) and southern (right) side of the "new" patch-reef (locality 2.3 in SIBLÍK, 1998): left side - *Oxycolpella oxycolpos*, right side - *Fissirhynchia fissicostata, Austrirhynchia cornigera, Zugmayerella uncinata, Rhaetina pyriformis, Zeilleria austriaca, Zeilleria elliptica, Zeilleria norica.*

Locality BR3 - small occurrence above the road, 70 m SW of Köhrgatterl (*"Zugmayerella"* locality): *Thecospira haidingeri, Fissirhynchia fissicostata, Zugmayerella uncinata,*

Plate 6

Fig. 1: *Rhaetina pyriformis* (SUESS). Locality BR1. GBA no. 1999/1/1. x 1.5.
Fig. 2: *Austrirhynchia cornigera* (SCHAFHÄUTL). Locality BR2. GBA no. 1999/1/2. x 2.
Fig. 3: *Oxycolpella oxycolpos* (SUESS). Locality BR1. GBA no. 1999/1/3. x 1.
Fig. 4: *Oxycolpella oxycolpos* (SUESS). Locality BR1. Juvenile specimen figured in LOBITZER et al., 1994 on Plate 1, Fig.3. x 1.5.
Fig. 5: *Sinucosta emmrichi* (SUESS). Locality BR1. GBA no. 1999/1/4. x 1.5.
Fig. 6: *Zugmayerella koessenensis* (ZUGMAYER). Locality BR3. GBA no. 1999/1/5. x 2.
Fig. 7: *Zeilleria norica* (SUESS). Slightly damaged specimen. Locality BR4, near lower turnstile. GBA no. 1999/1/6. x 1.5.
Fig. 8: *Fissirhynchia fissicostata* (SUESS). Locality BR1. GBA no. 1999/1/7. x 2.

All brachiopod specimens were coated with ammonium chloride before photographing. They are deposited in the Museum of the Geologische Bundesanstalt in Vienna (GBA). Photographs by Mr. J. BROŽEK (Prague).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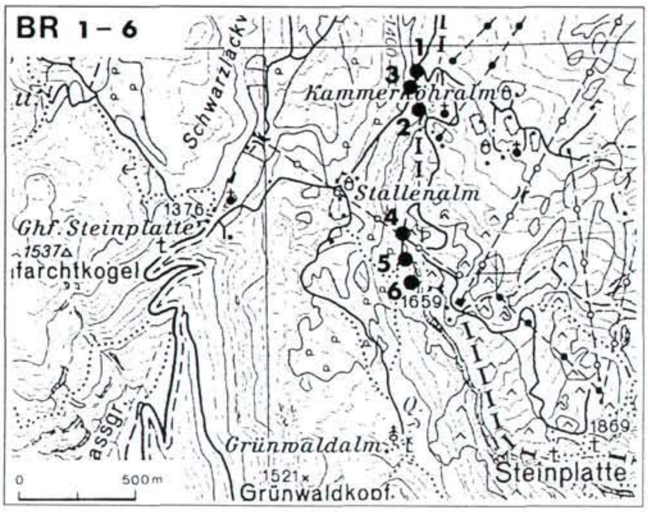


Text–Fig. 5.
Situation map of the Steinplatte brachiopod sampling localities BR1 – BR6.

Zugmayerella koessenensis, Oxycolpella oxycolpos, Rhaetina pyriformis, Zeilleria austriaca, Zeilleria elliptica, Zeilleria norica.

Locality BR4 - section in the Kössen Beds SE of the Stallenalm on the path from Grünwaldalm to the Kammerköhr Gasthaus (= locality 5 in Kristan-Tollmann et al., 1991, p.159) (= locality 2 in Stanton & Flügel, 1989, p.10): *Fissirhynchia fissicostata, Oxycolpella oxycolpos, Rhaetina gregaria, Rhaetina pyriformis, Zeilleria elliptica, Zeilleria norica.*

Locality BR5 - bottom of the Kössen Beds cliff between Ohlen's patch-reefs A and B, near to the locality 4 in Stanton & Flügel (1989): *Fissirhynchia fissicostata, Austrirhynchia cornigera, Rhaetina pyriformis, Zeilleria norica.*

Locality BR6 - Kössen Beds above Ohlen's patch-reef B (above the locality 7 in Stanton & Flügel, 1989): *Fissirhynchia fissicostata, Oxycolpella oxycolpos, Rhaetina pyriformis.*

One specimen of *Fissirhynchia fissicostata* was found about 200 m NE of the Stallenalm, near the road from the Stallenalm to the Köhrgatterl.

Text–Fig. 6.
Brachiopod locality BR4, lower part of the section near the turnstile. Marly intercalation in the middle of the photo yielded *Fissirhynchia fissicostata* and *Zeilleria elliptica.*

5.2. Systematic Descriptions

Order: Strophomenida Öpik, 1934
Superfamily: Thecospiracea Bittner, 1890
Family: Thecospiridae Bittner, 1890
Genus: *Thecospira* Zugmayer, 1880

Thecospira haidingeri (Suess, 1854)

1998 *Thecospira haidingeri* (Suess) - Siblík, p. 76 (cum syn.).

Material: One complete specimen measuring c.15.0 x 16.5 mm, and 2 pedicle valves.
Remark: Poor preservation of the specimens precluded the detailed study.
Occurrence: Steinplatte, locality BR3.

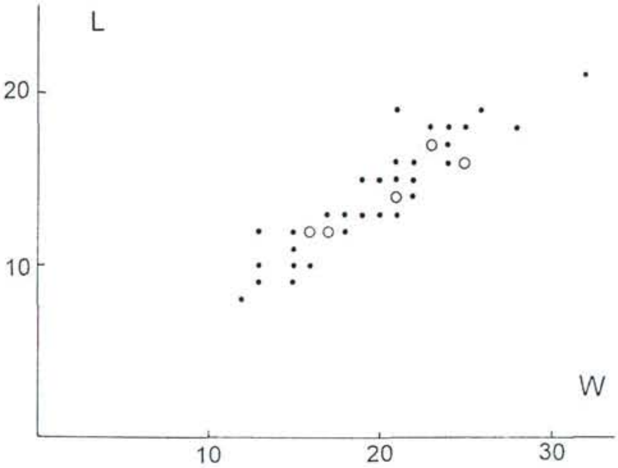
Order: Rhynchonellida Kuhn, 1949
Superfamily: Rhynchonellacea Gray, 1848
Family: Praecyclothyrididae Makridin, 1964
Genus: *Fissirhynchia* Pearson, 1977

Fissirhynchia fissicostata (Suess, 1854)

(Pl. 6, Fig. 8)

1996 *Fissirhynchia fissicostata* (Suess) variant allongé - Patrulius, p. 5, Pl. 1, Fig. 4.
1998 *Fissirhynchia fissicostata* (Suess) - Siblík, p. 77, Pl. 1, Figs. 1, 4, Text-Fig. 4 (cum syn.).

Material: 29 complete specimens and 2 pedicle and 2 brachial valves. The longest specimen has dimensions 26.0 x 18.0 x 13.1 mm, the figured specimen measures 17.8 x 19.8 x 13.0 mm.
Remarks: The detailed description of the species was given by Pearson (1977). His figured specimen from Steinplatte (Pl. 6, Fig. 3) is flat, with very low uniplication. Its exact location is unclear, however (Kössen Beds or Oberrhätkalk?).
Occurrence: Steinplatte - loc. BR1 (10 specimens), loc. BR2 (12 specimens), loc. BR3 (3 sp.), loc. BR4 (4 sp.), loc. BR5



Text–Fig. 7.
Length/width scattergram for 41 brachial valves of *Zugmayerella uncinata.* Brachiopod locality BR3 (circle = 2 specimens).

(2 sp.) and loc. BR6 (1 sp.). One further specimen was found about 200 m from the Stallenalm near the road to the Köhrgatterl.

Genus: *Austrirhynchia* Ager, 1959

Austrirhynchia cornigera (Schafhäutl, 1851)
(Pl. 6, Fig. 2)

1998 *Austrirhynchia cornigera* (Schafhäutl) - Siblík, p. 78, Pl. 1, Fig. 8 (cum syn.).

Material: 10 partly damaged specimens, up to 9.5 mm long, 14.0 mm wide and 6.5 mm thick. Dimensions of the figured specimen: 7.8 x 12.7 x 5.0 mm.

Occurrence: Steinplatte - loc. BR2 (9 specimens), loc. BR5 (1 sp.).

Order: **Spiriferinida Ivanova, 1972**
Suborder: **Cyrtinidina Carter & Johnson, 1994**
Superfamily: **Spondylospiroidea Hoover, 1991**
Family: **Spondylospiridae Hoover, 1991**
Genus: ***Zugmayerella* Dagys, 1963**

Zugmayerella koessenensis (Zugmayer, 1880)
(Pl. 6, Fig. 6)

1998 *Zugmayerella koessenensis* (Zugmayer) - Siblík, p. 81, Pl. 2, Fig. 2 (cum syn.).

Material: 4 complete specimens and 6 pedicle valves. The largest pedicle valve has dimensions 21.0 x 27.2 mm. The figured specimen measures c.17.0 (length of brachial valve 11.5 mm) x 13.8 x c.12.0 mm.

Occurrence: Steinplatte - locality BR1 (2 specimens), loc. BR3 (8 sp.).

Zugmayerella uncinata (Schafhäutl, 1851)
(Text-Figs. 7-8)

1994 *Zugmayerella uncinata* (Schafh.) - Siblík in Lobitzer et al., Pl. 1, Fig. 2.
1998 *Zugmayerella uncinata* (Schafhäutl) - Siblík, p. 81, Pl. 2, Figs. 4, 6 (cum syn.).

Material: 21 specimens with both valves and 64 pedicle and 59 brachial isolated valves. The best preserved specimens measure 28.0 (length of brachial valve 18.8 mm) x 25.8 x 19.0 mm and 26.2 x 23.0 x 16.2 mm.

Remarks: The most specimens show smooth area and correspond thus to *Spirifer Münsteri* var. *austriaca* Suess, 1854 which is here regarded a junior synonym of *"uncinata"*, following Pearson (1977).

Occurrence: Steinplatte - locality BR1 (1 specimen), loc. BR2 (2 sp.) and loc. BR3 (141 sp.).

Suborder: **Spiriferinidina Ivanova, 1972**
Superfamily: **Spiriferinoidea Davidson, 1884**
Family: **Sinucostidae Xu & Liu, 1983**
Genus: ***Sinucosta* Dagys, 1963**

Sinucosta emmrichi (Suess, 1854)
(Pl. 6, Fig. 5)

1978 *Sinucosta emmrichi* (Suess) - Iordan, Pl. 2, Fig. 5.
1979 *Sinucosta emmrichi* (Suess) - Kristan-Tollmann, Tollmann & Hamedani, p. 141, Pl. 5, Figs. 3-4.
?1979 *Sinucosta emmrichi* (Suess) - Ching, Sun & Ye, p. 175, Pl. 48, Figs. 28-29, 34.
1988 *Sinucosta emmrichi* (Suess) - Siblík, p. 68 (cum syn.).

Material: 6 partly fragmentary specimens with 2 valves and 6 isolated pedicle valves. The figured specimen measures 27.5 x 29.0 x c.16.5 mm.

Remarks: My specimens have up to 30-32 ribs on valve, and they are very well comparable to the specimens with denser ornamentation described and figured by Pearson (1977).

Occurrence: Steinplatte - locality BR1.

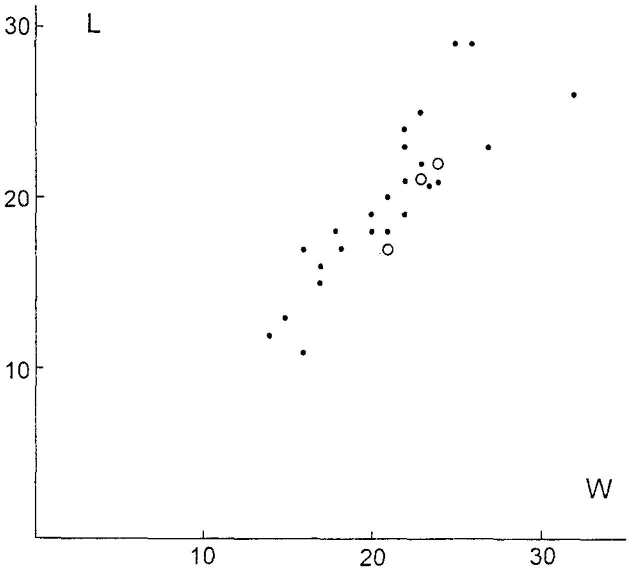
Order: **Athyridida Boucot, Johnson & Staton, 1964**
Suborder: **Athyrididina Boucot, Johnson & Staton, 1964**
Superfamily: **Athyridacea Davidson, 1881**
Family: **Spirigerellidae Grunt, 1965**
Genus: ***Oxycolpella* Dagys, 1962**

Oxycolpella oxycolpos (Suess, 1854)
(Pl. 6, Figs. 3-4)

1998 *Oxycolpella oxycolpos* (Suess) - Siblík, p. 82, Pl. 2, Fig.1 (cum syn.).

Material: 18 partially damaged specimens with both valves and 2 pedicle valves. The largest measurable specimens have the dimensions: 54.0 x 58.2 x 36.5 mm, 49.5 x 53.5 x 34.1 mm and 48.0 x 56.0 x 31.4 mm. The specimen on Pl. 6, Fig. 3 measures c.53.0 x 53.8 x 29.5 mm.

Occurrence: Steinplatte - locality BR1 (15 specimens), locality BR2 - northern part (2 sp.), locality BR3 (1 sp.), loc. BR4 (1 sp.), loc. BR6 (1 sp.).



Text-Fig. 8.
Length/width scattergram for 30 pedicle valves of *Zugmayerella uncinata*. Brachiopod locality BR3 (circle = 2 specimens).

Order: Terebratulida Waagen, 1883
Superfamily: Dielasmatacea Schuchert, 1913
Family: Dielasmatidae Schuchert, 1913
Genus: *Rhaetina* Waagen,1882

Rhaetina gregaria (Suess, 1854)

1998 *Rhaetina gregaria* (Suess) - Siblík, p. 83, Pl. 3, Fig. 4 (cum syn.).

Material: One deformed specimen approx. 25.0 mm long.
Remark: The species seems to be a rare find at Steinplatte, the similar situation was stated in the case of the "Oberrhätkalk" (Siblík, 1998).
Occurrence: Steinplatte - locality BR4.

Rhaetina pyriformis (Suess, 1854)
(Pl. 6 , Fig. 1)

1998 *Rhaetina pyriformis* (Suess) - Siblík, p. 83, Pl. 3, Figs. 2-3, Text-Figs. 13-15 (cum syn.).

Material: 32 more or less fragmentary specimens with both valves and 2 isolated pedicle valves, up to 51.0 mm long, 37.5 mm wide and 31.0 mm thick. Dimensions of the figured specimen: 41.0 x 30.6 x 16.7 mm.
Remarks: The specimens from Steinplatte show the same variability as the specimens figured by Pearson (1977). The sulciplication of the anterior commissure has not been ascertained in our material.
Occurrence: Steinplatte - locality BR1 (15 specimens), loc. BR2 (14 sp.), loc. BR3 (1 sp.), loc. BR4 (1 sp.), loc. BR5 (1 sp.) and loc. BR6 (2 sp.).

Superfamily: Zeilleriacea Allan, 1940
Family: Zeilleriidae Allan, 1940
Genus: *Zeilleria* Bayle, 1878

Zeilleria austriaca (Zugmayer, 1880)

1998 *Zeilleria austriaca* (Zugmayer) - Siblík, p. 84, Pl. 3, Fig. 6, Text-Fig. 16 (cum syn.).

Material: 13 mostly fragmentary specimens with both valves. The best preserved specimens have dimensions: 27.5 x 20.5 x 11.0 mm, 25.6 x 18.1 x 10.9 mm and 19.2 x 15.4 x 8.4 mm.
Occurrence: Steinplatte - locality BR1 (3 specimens), loc. BR2 (5 sp.) and loc. BR3 (5 sp.).

Zeilleria elliptica (Zugmayer, 1880)

? 1996 *Zeilleria elliptica* (Zugmayer) - Patrulius, p. 7, Pl. 1, Fig. 16.
1998 *Zeilleria elliptica* (Zugmayer) - Siblík, p. 85 (cum syn.).

Material: 5 specimens with both valves, and moreover 1 specimen determined as *Zeilleria* cf. *elliptica*. The only one complete specimen measures 18.9 x 15.0 x 9.4 mm.
Remark: The specimen figured by Patrulius (1996) differs from average specimens of the species in its different outline and the maximum-width situated forward.
Occurrence: Steinplatte - locality BR1 (1 specimen cf. *elliptica*), loc. BR2 (2 sp.), loc. BR3 (2 sp.) and loc. BR4 (1 sp.).

Zeilleria norica (Suess, 1859)
(Pl. 6, Fig. 7)

1994 *Zeilleria norica* (Suess) - Siblík in Lobitzer et al., Pl. 1, Figs. 1, 4.
1996 *Zeilleria norica* (Suess) - Patrulius, p. 7, Pl. 1, Fig. 14.
1998 *Zeilleria norica* (Suess) - Siblík, p. 86, Pl. 2, Figs. 3, 5, Text-Figs. 17-20 (cum syn.).

Material: 30 specimens with both valves and 1 pedicle valve. The largest well-measurable specimen has dimensions 37.0 x 29.2 x 19.5 mm. The figured specimen measures 28.0 x 21.2 x 12.6 mm.
Occurrence: Steinplatte - locality BR1 (15 specimens), loc. BR2 (13 sp.), loc. BR3 (1 sp.), loc. BR4 (1 sp.) and loc. BR5 (1 sp.).

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