Serpulid tubes of the genus *Carpathiella* Misík, Soták & Ziegler, 1999 from the Upper Jurassic to Paleogene of the Northern Calcareous Alps (Austria, Germany)

by

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With 9 figures, 2 tables and 4 plates

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Contents

Abstract

The genus *Carpathiella* MISÍK, SOTÁK & ZIEGLER, 1999, interpreted as serpulid worm tubes, is reported for the first time with three species from Upper Jurassic to Lower Cretaceous (Plassen Formation), Upper Cretaceous (Lower Gosau Subgroup) and Paleogene (Upper Gosau subgroup) shallow-neritic rocks of the Northern Calcareous Alps, Austria and Germany. Besides two species established by MISIK et al. (1999), *Carpathiella perforata* and *Carpathiella triangulata* a third, new representative has recently been described as *C. plassenensis* SCHLAGINTWEIT & GAWLICK, 2002 that is distinguished by characteristic cross-sections. The generic diagnosis of *Carpathiella* MISÍK, SOTÁK & ZIEGLER, 1999 has been emended by eliminating a purported trend of cross-section towards a triangular shape; a triangular cross-section of the tube is now regarded a specific criterion.
In platform margin to back-reef successions of the Plassen Formation, all *C. plassenensis*, *C. triangulata* and *C. perforata* are common, but cannot be used for biochronostratigraphy at stage level. In the Lower Gosau Subgroup, to date only *C. triangulata* MISÍK, SOTÁK & ZIEGLER was found in sandstones and carbonates from neritic environments. *Carpathiella* probably had a low sensitivity to siliciclastics and nutrients, but needed a hard substrate and water agitation to thrive. By contrast to other serpulid taxa, *Carpathiella* did not form aggregations of individuals.

Zusammenfassung

Die als serpulide Wurmröhren interpretierte Gattung *Carpathiella* MISÍK, SOTÁK & ZIEGLER, 1999 wird mit drei Arten erstmalig von oberjurassischen, unterkretazischen (Plassen-Formation), oberkretazischen (Untere Gosau Subgruppe) und paläogenen (Obere Gosau Subgruppe) Flachwassergesteinen der Nördlichen Kalkalpen (Österreich, Deutschland) beschrieben. Neben den beiden von MISÍK, SOTÁK & ZIEGLER (1999) aufgestellten Arten C*arpathiella triangulata* und *Carpathiella perforata* wurde kürzlich eine dritte Art als *C. plassenensis* SCHLAGINTWEIT & GAWLICK 2002 beschrieben, die sich durch charakteristische Röhrenquerschnitte auszeichnet. Die ursprüngliche Gattungsdiagnose wurde dahingehend emendiert, dass die Tendenz zur Ausbildung triangularer Röhrenquerschnitte nunmehr als artspezifisches Merkmal betrachtet wird.
In Faziesabfolgen des Plattformrandes und des Rückriff-Bereiches der Plassen-Formation kommen alle 3 *Carpathiella*-Arten vor, können jedoch nicht biostratigraphisch verwertet werden. In der unteren Gosau Subgruppe wurde nur *C. triangulata* MISÍK, SOTÁK & ZIEGLER in flachmarinen Sandsteinen und Karbonaten gefunden. Die Gattung *Carpathiella* wies vermutlich eine geringe Sensitivität gegenüber siliziklastischem Einfluß und Nährstoffen auf, benötigte aber für ihre Lebensweise Hartsubstrate und eine gewisse Wasserbewegung. Im Gegensatz zu anderen Serpulidentaxa bildete *Carpathiella* keine Individuenaggregationen.

1. Introduction

Serpulids thrive in calcareous tubes attached to hard substrates. Gregarious species of serpulids can build up reefal structures especially in modern mostly coastal habitats (e.g., GRUET & BODEUR 1995, HOVE & VAN DEN HURK 1993). In contrast to pelecypods, serpulid tubes are a protective dwelling-place and do not represent an integral and functional skeletal part of the worm. Since serpulids are suspension feeders, a major limiting factor is supply of particulate organic matter. In the fossil record, serpulids have been described from both, thin-sections (e.g. SENOWBARI-DARYAN 1997) and as isolated specimens (e.g. JÄGER 1991). Wheras the taxonomy of extant serpulids is based on the animals soft body, in fossils, features of the calcareous tubes (arrangement, microstructure, shape, ornamentation) are the main criteria of taxonomic distinction. SEM studies of the "ultrastructure"of serpulid tubes revealed *"a much greater diversity of microstructural types than was previously recorded*" (WEEDON 1994: p. 2). WEEDON (1994) distinguished four types of microstructures including ordered (= "Parabelschichten"), unordered and homogeneous chevron structures, and spherulitic prismatic structures assuming "*a response to differing environmental conditions or may reflect a different method or source of secretion by the worm*" (op.

cit., p. 9).
Recently, MISÍK, ZIEGLER & SOTÁK (1999) established a new genus, *Carpathiella*, with two species *C. triangulata and C. perforata* from Mesozoic limestone pebbles of the Western Carpathians. These microfossils with their characteristic tube structure build up of fibrous calcite, however, also are fairly common in Upper Jurassic to Upper Cretaceous shallow neritic lithologies of the Northern Calcareous Alps. A new taxon has been introduced recently as *Carpathiella plassenensis* n. sp. (SCHLAGINTWEIT & GAWLICK 2002).
The present paper provides a description and illustration about the occurence of *Carpathiella* in the Northern Calcareous Alps (Austria, Germany).

2. Material and localities

The present study is based exclusively on specimens in thin-sections. For a general description of the stratigraphy and sedimentology of the localties in the Northern Calcareous Alps where *Carpathiella* has been recognized, the reader is referred to the below cited papers. Besides material obtained during our own field studies, we kindly acknowledge thin-sections provided by Prof. R. LEIN, University of Vienna (Plassen Formation of Wörschach and Falkenstein), Dr. H. Lobitzer, Geological Survey of Austria (Plassen Formation of Untersberg, Ernstbrunn limestone of the Waschberg Zone, Lower Austria), S. MISSONI (Sillenkopf Formation of Berchtesgaden Alps), Dr. R. DARGA, Museum of Natural History, Siegsdorf (Lofer Member of Dietrichshorn), Dr. O. EBLI, c/o University of Munich (Lofer Member of Lärchberghörndl) and Dr. G. CSÁSZÁR, Geological Institute of Budapest (Late Jurassic to Early Cretaceous limestones from bore-holes in Hungary).

2.1. Upper Jurassic to Lower Cretaceous

Plassen Formation

- Mt. Plassen (type-locality), Salzkammergut, Austria: FENNINGER & HÖTZL (1967), SCHLAGINTWEIT, GAWLICK & LEIN (this volume). The samples with *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK 2002 have been collected in the Hohe Wasserstollen at the southeastern slope of the mountain. Facies are oncoidal back-"reef" to open lagoonal pack- to rudstones; Stratigraphy: Uppermost Kimmeridgian to Lower Tithonian. Other samples derive from near-reefal bioclastic pack- to rudstones of the summit of Mt. Plassen; Stratigraphy: Uppermost Tithonian or lowermost Berriasian.

- Krahstein and Rötelstein, Styrian Salzkammergut, Austria: STEIGER & WURM (1980), SCHLAGINTWEIT et al. in press.

- Untersberg, S-Germany: DYA (1992).

- Lärchberghörndl (type-locality of *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK), Dietrichshorn, Litzelkogel-Gerhardstein, Gföllhörndl, near Lofer, Austria: DARGA & SCHLAGINTWEIT (1991), DYA (1992). The samples of the Lärchberghörndl (Middle or Upper Tithonian) and the Dietrichshorn (Uppermost Tithonium or lowermost Berriasian) are from the Lofer Member sensu SCHLAGINTWEIT & EBLI (1999b). Facies are (oncoidal) wackestones with hydrozoans and calcareous algae. The samples of the Litzelkogel-Gerhardstein belong to sparitic open platform facies. The type-locality of *C. plassenensis* (see fig. 1) is the Konradsweg between the Loferbach and the southeastern slope of Mount Lärchberghörndl (1535 m a. s.-l.). It is located on the topographical map of Austria: 1: 50000, "Lofer" ÖK 92, and corresponds to the profile no. 7 described by DYA (1992: p. 22-24). Here, marly wackestones to floatstones with hydrozoans, gastropods, dasycladales and benthic foraminifera are exposed.

- Trisselkogel near Altaussee, Salzkammergut, Austria: SCHLAGINTWEIT & EBLI (1999b)

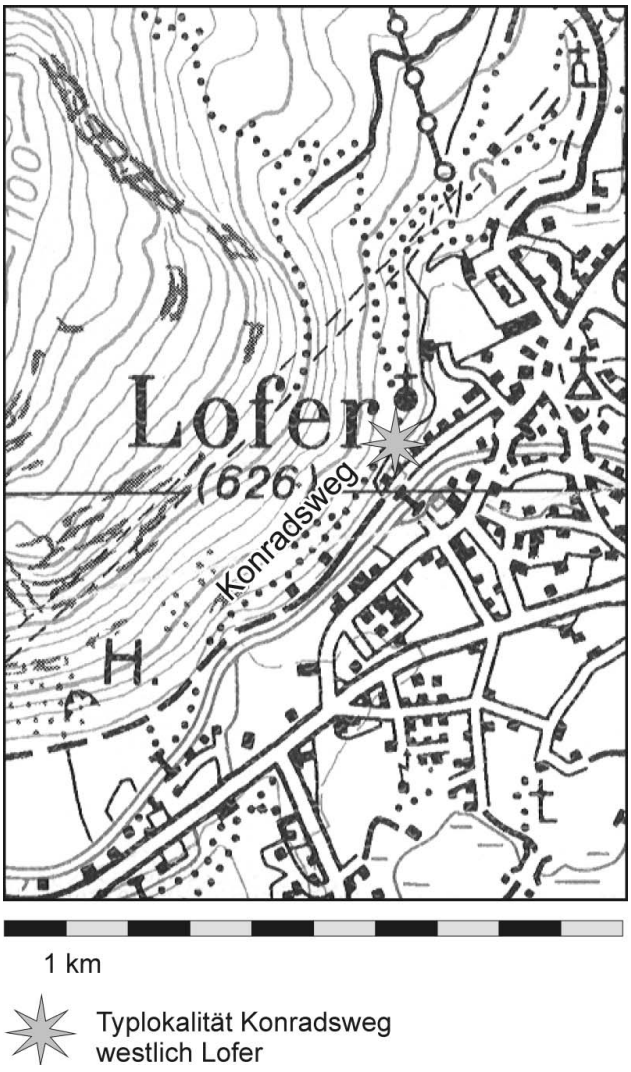

Fig. 1: Topographic sketch map of the type-locality of *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK, 2002.

Barmstein Limestones

- Barmsteine near Hallein, Austria (type-locality): STEIGER (1981).

Tressenstein Limestone

- Tressenstein near Altaussee, Salzkammergut, Austria: HÖTZL (1966), SCHLAGINTWEIT & EBLI (1999a).

Sillenkopf Formation

- Sillenköpfe, Abwärtsgraben, Berchtesgaden, Germany: MISSONI et al. (2001).

Hornsteinbreccia

- Sonnwendjoch-Rofan Mountains of Tyrol/Austria: (WEYNSCHENK 1951, WÄCHTER 1987).

In his paper on benthic foraminifera, WEYNSCHENK (1951) showed on plate 112, fig. 8 an encrusting foraminifer (not *Labyrinthina mirabilis* as indicated) attached to *Carpathiella plassenensis* from the Upper Jurassic "Hornsteinbreccie" of the Rofan Mountains/Tyrol (see Fig. 8).

2.2. Upper Cretaceous part of Gosau Group

- Brandenberg, Tyrol, Austria: Samples with *Carpathiella* are from Upper Turonian shallow-marine arenites (cf. SUMMESBERGER & KENNEDY 1996) composed mainly of serpentine grains. The arenites locally are rich in fossils from shallow-marine environments, including rudists and corals (e.g. HERM et al. 1979, SANDERS 1998). Specimens of *Carpathiella* were also found in Coniacian shallow-water limestones.

- Theresienstein near Strobl, federal state of Salzburg, Austria: At Theresienstein, a spectacular coral buildup of Late Turonian to Early Coniacian age is exposed (SANDERS et al. 1999, PONS & SANDERS 1999). There, serpulid tubes are attached to corals, and were also identified in bioclastic limestones immediately above the buildup.

2.3. Tertiary part of Gosau Group

Flyschoid Gosau of Mooshuben, Mürztal Alps: Olistostromes containing boulders of Paleocene Kambühel Limestones (LEIN 1982, TRAGELEHN 1996). Here, *Carpathiella* is associated by corals, coralline red algae, benthic foraminifera and bryozoa. Other material comes from the southern part of Gosau locus classicus (unpubl. data, material leg. Dr. H. Lobitzer, Geological Survey, Vienna).

3. Systematic Palaeontology

The new genus *Carpathiella* established by MISÍK, SOTÁK & ZIEGLER (1999) was referred to serpulids (Polychaeta). Because of tube morphology and the attached way of life, we follow this interpretation.

Class Polychaeta GRUBE, 1850
Order Sedentaria LAMARCK, 1818
Family Serpulidae RAFINESQUE, 1815

Genus ***Carpathiella*** MISÍK, SOTÁK & ZIEGLER, 1999

Carpathiella perforata MISÍK, SOTÁK & ZIEGLER, 1999
(Fig. 4, Pl. 4, fig. 1-3)

* 1999 ***Carpathiella perforata*** n. sp. – MISÍK, SOTÁK & ZIEGLER: 309, Pl. 3, fig. 1-3, Barremian to Paleocene of Western Carpathians.

Remarks: Triangular shaped tubes with rounded corners containing void structures. In the Upper Jurassic samples investigated, *C. perforata* is distinctly less frequent than *C. plassenensis* followed by *C. triangulata*; in the Lower Gosau Subgroup (Turonian-Campanian), *C. perforata* has so far not been identified. One specimen has been detected in

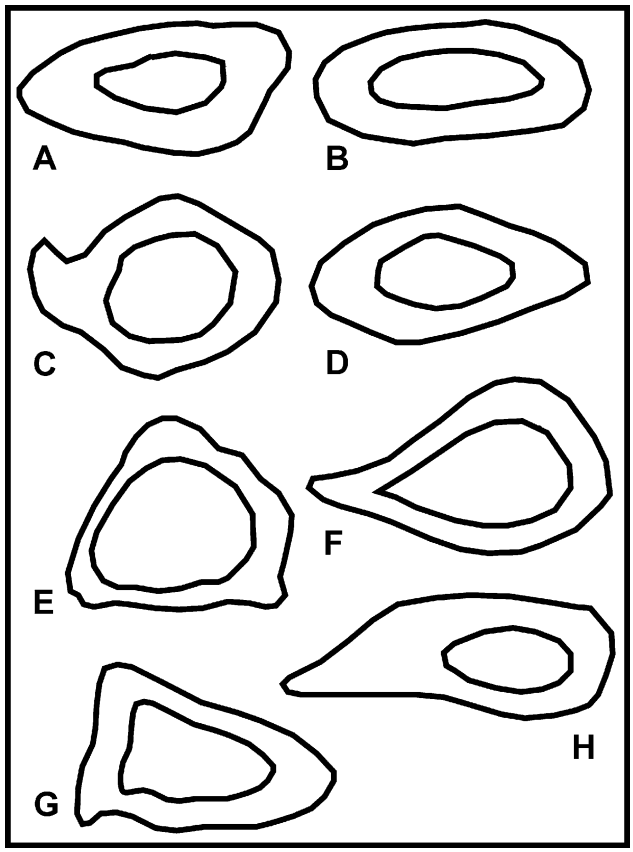

Fig. 2: Cross-sections (drawings) of *Carpathiella triangulata* MISÍK, SOTÁK & ZIEGLER, 1999 (without scale). A-D: Upper Jurassic to Lower Cretaceous Plassen Formation, E-G: Upper Cretaceous Lower Gosau Subgroup.

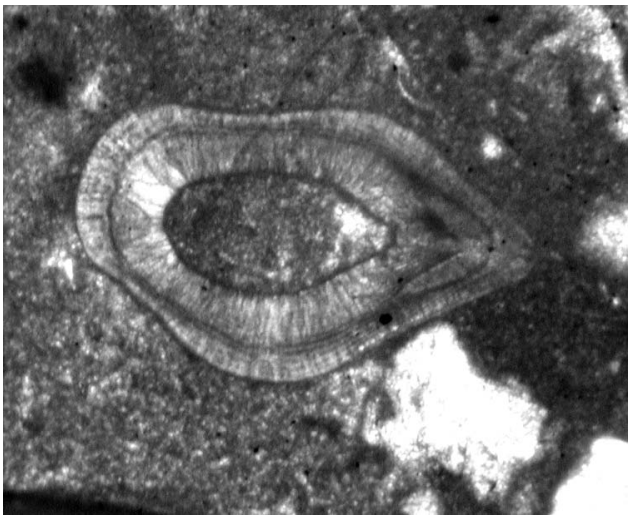

Fig. 3: *Carpathiella triangulata* MISÍK, SOTÁK & ZIEGLER, 1999 (1,05 mm). Resedimented Kambühel Limestone (Paleocene) from the Upper Gosau Subgroup.

allochthonous Kambühel limestone pf Paleocene age (Fig. 4).

Carpathiella triangulata MISÍK, SOTÁK & ZIEGLER, 1999
(Fig. 2-3, Pl. 4, fig. 4-12)

1972 "section dans un appendice du crustacé" – MONLEAU & PHILIP: Pl. 3, fig. 2, Turonian of S-France.
1976 "sezione di piccola Rudista (*Eoradiolites* ? sp.)" – LUPERTO SINNI: Pl. 59, fig. 1, Senonian of S-Italy.
1993 Crustaceen-Rest – DARGA: Pl. 2, fig. 2, Lower Priabonian of the Northern Calcareous Alps.
? 1994 *Solenopora helvetojurassica* PETERHANS - BODROGI et al.: Pl. 5, fig. 2, Tithonian of Hungary
1998 ACCORDI, CARBONE & PIGNATTI: Pl. 8, c, not indicated (middle below), Late Rupelian-Early Aquitanian of Greece.
* 1999 *Carpathiella triangulata* n.sp. – MISÍK, SOTÁK & ZIEGLER: 309, pl. 2, fig. 3-9, Lower Cretaceous of Western Carpathians.

Remarks: Triangle shaped tubes (diameter: 0,44-1,5 mm, MISÍK et al. 1999: 0,45-1,12 mm) with two rounded corners and a more acute corner. In the latter, a thin dark line can be observed transjecting the complete wall (Pl. 4, fig. 4, 7, 9). In some specimens we observed the calcareous wall exhibiting alternating dark und light-bright layering (? seasonal growth differences). The outer as well as the inner tube shape are highly variable (see fig. 2). Thus, the inner tube diameter can equal the wall thickness and in other cases is much larger than the latter. The shape of the tube lumen more or less follows the outer shape varying from rounded (e.g. Pl. 4, fig. 8) to irregular triangular (e.g. Pl. 4, fig. 7). As different types may occur within the same sample, a correlation of tube morphology and facies (paleoecological factors) is not evidenced.

Carpathiella plassenensis SCHLAGINTWEIT & GAWLICK, 2002
(Fig. 5, Pl. 1, fig. 1-2, 4-6, 8, Pl. 2, fig. 1-12, Pl. 3, fig. 1-8)

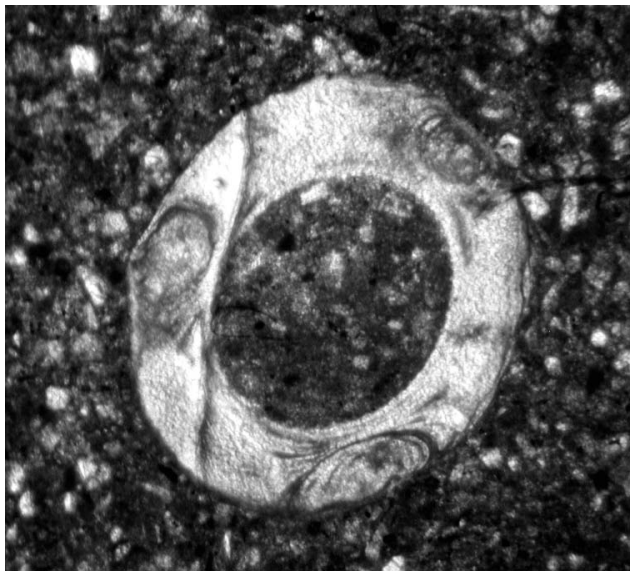

Fig. 4: *Carpathiella triangulata* MISÍK, SOTÁK & ZIEGLER, 1999 (0,96 mm). Resedimented Kambühel Limestone (Paleocene) from the Upper Gosau Subgroup.

Locality	Thin-section	D	H	Locality	Thin-section	D	H
Die	8	2,48 mm	1,4 mm	**Lä**	Eis 1	2,3 mm	1,5 mm
	1985/IX 31	2,65 mm	0,85 mm		Eis 8	2,45 mm	1,1 mm
	1985/IX 164	3,1 mm	1,8 mm	**Wörsch**	A 602	2,52 mm	1,84 mm
Fa	A 2570	1,0 mm	0,5 mm		A 602	1,6 mm	1,12 mm
Si	Ber 31/1/1	1,32 mm	0,68 mm	**Krah**	A 438	0,8 mm	0,5 mm
Unt	MD 11-3B-4	1,92 mm	0,88 mm		HR 18	2,3 mm	1,2 mm
TK	TK 24	2,7 mm	0,9 mm		HR 80b	1,36 mm	0,64 mm
	TK 33	1,44 mm	0,96 mm				

Tab. 1: Dimensions of *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK. D = „double tube" outer diameter, H = height of „double tube" (see Fig. 6). Plassen Formation: Die = Dietrichshorn near Lofer/Austria, Fa = Falkenstein/Schwarzau, Lä = Lärchberghörndl, Krah = Krahstein/Styrian Salzkammergut, Austria, TK = Trisselkogel, Unt = Untersberg, Germany, Wörsch = Wörschach; Si = Sillenkopf Formation, Berchtesgaden Alps (type-locality).

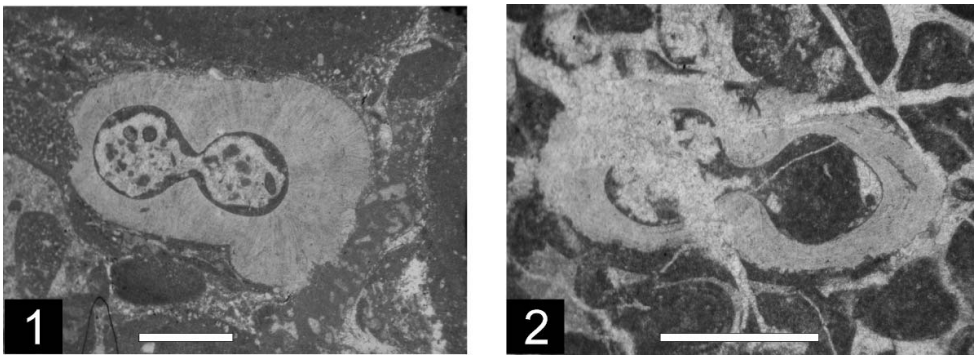

Fig. 5: Holotype (1) and paratype (2) of *Carpathiella plassenensis* n. sp., cross-section. Thin-section BSP 2002-I-21 and -22, scale = 1 mm. Locality: Konradsweg near Lofer, Salzburg Calcareous Alps.

* 2002 ***Carpathiella plassenensis*** n. sp. – SCHLAGINTWEIT & GAWLICK: Fig. 1-2, supplement Volume 53 Geologica Carpathica

Description: Relatively thick-walled, U-shaped calcareous tube (unilocular), appearing as two oval to oval elongated separate tubes in cross-sections. The light yellowish to brownish calcification made up of radially arranged calcite fibres is massive in most cases, reaching thicknesses of up to 0,8 mm. The wall thickness attains its greatest thickness in the central part where both „tubes“ touch (Pl. 2, fig. 11). There maybe also specimens with reduced wall thickness (Pl. 2, fig. 2) but a direct relationship between wall-thickness and environment, e.g. thicker walls in habitats of higher water energy conditions, is not observable. In cross sections, the “tubes” equal in diameter. Both sides of the parallel „double-tube“ are fairly smooth lacking any ornamentation. In the distal parts (towards the opening), both „tubes“ are clearly individualized separated by a calcareous wall from each others. Towards the curved part, they become succesively more connected to each others laterally. In this manner, the central massive calcification becomes reduced. In longitudinal sections the tube diameter remains more or less constant without any outer surface ornamentation. The maximum observed tube length is about 8 mm. Toward the tube opening, the wall thickness increases forming a trumpet-like peristome (“Ringwulst” e.g. Pl. 2, fig. 12, pl. 3, fig. 6, 8). In some cases this coincides with the reduction of the inner tube diameter (e.g. plate 3, Fig. 8).

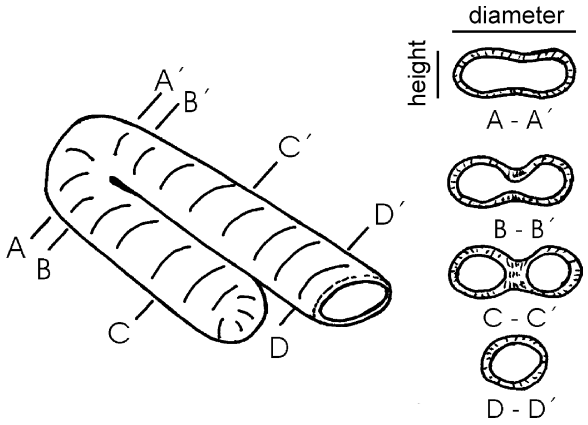

Fig. 6: Reconstruction of *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK, 2002 and cross-section appearances in thin sections (A-A´- D-D´)

Dimensions: Dimensions are given in table 1. Compared with *Carpathiella perforata* (up to 1,92 mm acc. to MISÍK et al., 1999) and *Carpathiella triangulata* (up to 1,12 mm), *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK, 2002 is distinctly larger (Tab. 2). If we only consider „one“ tube size, however, *C. plassenensis* is comparable to both, *C. triangulata* and *C. perforata*.

Remarks: Based on all available sections, the morphology has been reconstructed assuming one U-shaped tube with parallel arrangement (Fig. 6). Whether both tubes were opened or closed is uncertain since no operculi have been detected. In this context, our reconstruction provided in figure 6 is hypothetical. In cross sections it is clearly distinguishable from both, *C. triangulata* and *C. perforata* by its typical shape of two separate tubes (Fig. 7).

The calcitic wall is composed of one layer but sometimes exhibits thin dark layers perhaps reflecting varying seasonal changes in geochemistry of the sea-water. As has been mentioned, the diameter of the “tubes” is equal in cross-section. This observation contrasts the appearance of coiled serpulids with closed initial part, where cross sections are smaller in the juvenile stage (or part) and larger in the adult part (e.g. RADWANSKA, 1996: *Proliserpula ampullacea*, pl. 2, fig. 7b). In contrast hereto, the U-shaped tube of *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK, 2002 could posses a double opening. In this context, our reconstruction (Fig. 6) is rather tentative. We exclusively observed straight elongated tubes. Obviously, *C. plassenensis* was not able to build up tubes that could follow curved substrates, needing flat clasts for fixation. It might be possible that this observation could show a dependance between tube size (lenght) and the availability of convenient substrates.
The generic diagnosis for *Carpathiella* has been given by MISÍK et al., 1999 as follows: *“Tubes relatively thick (mostly 0,13-0,18 mm). The tube is formed by one layer; the calcite*

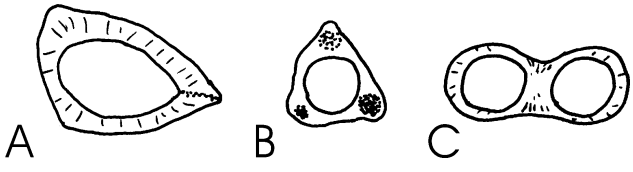

Fig. 7: Cross-sections *of Carpathiella triangulata* MISIK et al., 1999 (A), *Carpathiella perforata* MISIK et al., 1999 (B), *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK (C)

Fig. 8: Cross-section of *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK, 2002 figured by WEYNSCHENK (1951: Pl. 112, fig. 8) from the Upper Jurassic "Hornsteinbreccie" of the Rofan Mountains/Tyrol.

fibres are oriented radially in the cross-section. The cross-section tends to a triangular shape". The latter feature, however, should in our opinion not be overestimated and results from the both so far known species that do fit this shape. Since the characteristic wall structure clearly demonstrates the belonging of the new Alpine taxon to the genus *Carpathiella,* the generic definition is herewith emended as follows: *"Tubes relativ thick (mostly 0,13-0,18 mm). The tube is formed by one layer; the calcite fibres are oriented radially in cross-section. The cross-section maybe variable"*. Note also, that cross-sections of other serpulids may be similar to *C. plassenensis*, but are distinct by their wall structure (e.g. RADWANSKA 1996: Pl. 2, fig. 7b *Proliserpula ampullacea*).

Stratigraphy: *C. triangulata* has been reported from Upper Jurassic to Paleogene strata, *C. perforata* from Barremian to Paleogene rocks (MISIK et al., 1999). In the Northern Calcareous Alps, all three representatives of the genus *Carpathiella* have been found in Kimmeridgian to Berriasian strata. The type-species *C. perforata* was so far only known from Barremian to Paleocene strata of the Western Carpathians. Due to the Alpine finding its stratigraphic range can be enlarged to the (Kimmeridgian ?) Tithonian. According to MISÍK et al. (1999), *C. triangulata* is known from Kimmeridgian to Lower Aptian of the Western Carpathians. Due to the findings in the Upper Eocene (Priabonian) of the Eisenrichterstein near Hallthurm/Germany and the references cited (see synonymy), its stratigraphic range must be enlarged distinctly up to the Oligocene (? Lower Miocene).

Besides the above mentioned localities within the Northern Calcareous Alps, we also identified *Carpathiella* (*C. plassenensis*) in the Ernstbrunn Limestone (upper Tithonian or Lower Berriasian) of the Waschberg Zone, Austria (e.g. MOOSHAMMER & SCHLAGINTWEIT 1999).

The presence of *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK, 2002 in the Kimmeridgian to Berriasian Plassen Formation may not represent its total stratigraphic range. *Carpathiella* was recently identified also in Oxfordian strata near Hannover, northwestern Germany (HELM, SCHÜLKE & SCHLAGINTWEIT, unpubl. data).

The genus has also been reported by MISIK et al. (1999) from Paleocene reefal limestones of the Carpathians, and therefore may also be expected in similar Paleocene limestones (Kambühelkalk Fomation) near the present southern limit of the Northern Calcareous Alps (e.g. PLÖCHINGER, 1967, TOLLMANN 1976, TRAGELEHN 1996). Besides these (par-)autochthonous occurrences, clasts of facies equivalent shallow-water limestones are present also as components in Upper Cretaceous to Paleogene lithoclastic turbidites (e.g. LEIN, 1982) where *C. triangulata* and *C. perforata* has recently been observed (material H. Lobitzer, Vienna) (Fig. 3, 4).

Summarizing, the so far known stratigraphic ranges can be indicated as follows:

- *Carpathiella plassenensis*: Kimmeridgian – (Lower) Berriasian
- *Carpathiella triangulata*: Oxfordian – Oligocene (?

Species / Locality	*Carpathiella triangulata* MISIK et al.	*Carpathiella perforata* MISIK et al.	*Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK
1. Dietrichshorn (LM)			X
2. Falkenstein/Wörschach	X		X
3. Gföllhörndl			X
4. Hochkranz			X
5. Krahstein	X	X	X
6. Lärchberghörndl (LM)			X
7. Litzlkogel	X		X
8. Plassen	X	X	X
9. Rötelstein	X	X	
10. Trisselwand	X		X
11. Untersberg			X
12. Barmstein Limestone	X		X
13. Tressenstein Limestone	X		
14. Sillenkopf Formation	X		X
15. Rofan/Tyrol			X

Tab. 2: Occurrences of *Carpathiella* species in the Alpine Plassen Formation (1.-11.), Barmstein limestones (type-locality), Tressenstein limestone (type-locality), Sillenkopf Formation (type-locality and other occurrences) and the so-called "Hornsteinbreccia" of the Rofan Mountains/Tyrol. LM = Lofer Member.

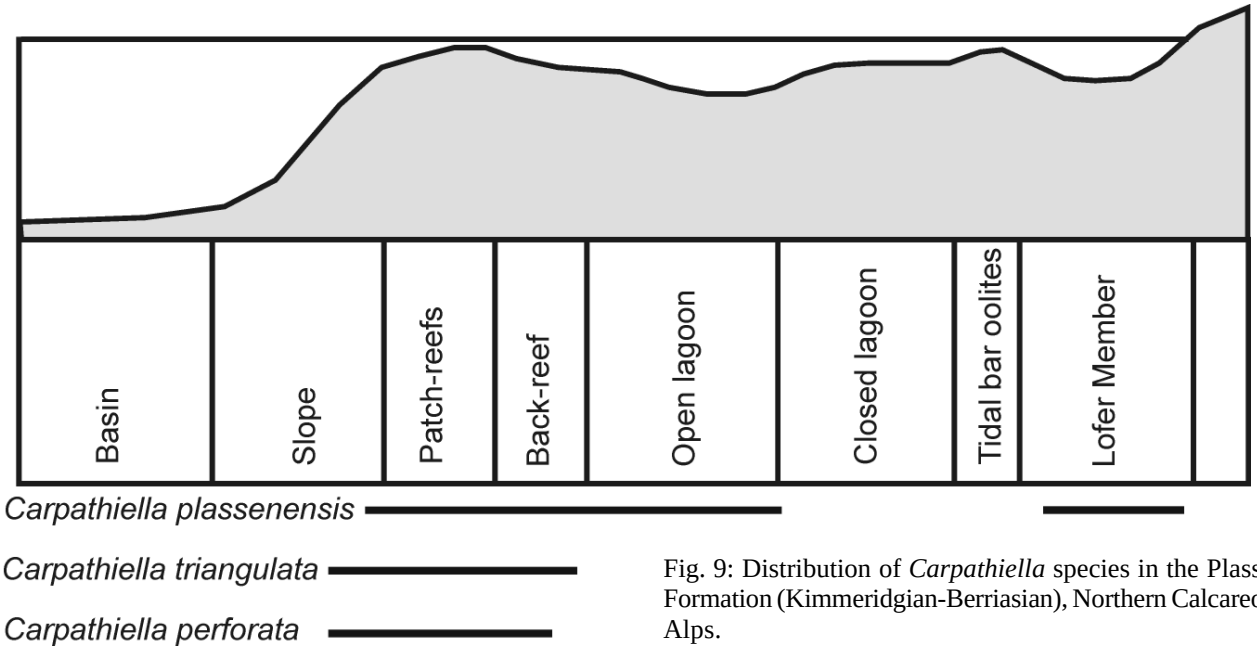

Fig. 9: Distribution of *Carpathiella* species in the Plassen Formation (Kimmeridgian-Berriasian), Northern Calcareous Alps.

Lowermost Miocene)

- *Carpathiella perforata*: Kimmeridgian - Paleocene

Carpathiella thus is of low biochronostratigraphic resolution.

4. Facies and paleoecology of *Carpathiella*, Northern Calcareous Alps

In the Northern Calcareous Alps, specimens of *Carpathiell*a MISÍK, ZIEGLER & SOTÁK ,1999 were known to the present authors for years, but were commonly regarded as calcareous tubes of unknown systematic position ("incertae sedis").

4.1. Upper Jurassic to Lower Cretaceous

In the Northern Calcareous Alps, the Lower and Middle Jurassic strata are represented by deeper water deposits. Starting in the Callovian, the overall paleogeographic situation changed. Due to the beginning closure of the Tethys, the southernmost parts of the former northern passive continental margin of the Austroalpine microplate became successively involved in shortening (GAWLICK et al., 1999).

Due to out-of-sequence thrusting, the Trattberg Rise was formed. On top of this rise the onset of shallow water carbonates started. From there the shallow water carbonate platform/ramp prograded towards the south and was sedimented over the Hallstatt Mélange (SCHLAGINTWEIT, GAWLICK & LEIN this volume).

Recent investigations showed that these platforms began with a shallowing upward sequence from the basin facies to slope deposits and finally external and internal platform deposits followed by a final drowning successions, again with slope deposits (SCHLAGINTWEIT, GAWLICK & LEIN this volume). All representatives of *Carpathiella* are ubiquitous microfossils in the Plassen Formation (Kimmeridgian-Berriasian, 11 localities, Tab. 2).

Microfacies analysis indicates a facies dependence of different species. Whereas *Carpathiella plassenensis* and *C. triangulata* may both be present in reefal debris facies (pl. 1, fig. 2), at Mount Plassen, *C. plassenensis* alone is typical in packstones to oncoidal packstones of back-reef settings. Two sections of *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK can be detected in the photomicrographs of RASSER & FENNINGER (2002: Fig. B left above and fig. D middle below), from the lower part of a small profile that has been studied at the eastern part of the Plassen. The microfacies photos and description corresponds to the "facies 4.4 open lagoon" of SCHLAGINTWEIT, GAWLICK & LEIN (this volume). *Carpathiella plassenensis* is also widespread within the basal portion of the Lofer Member (e.g. Pl. 1, fig. 6), whereas the other two species are absent. The Lofer Member accumulated in a shallow subtidal environment of overall low water energy (e.g. DARGA & SCHLAGINTWEIT 1991, DYA 1992). In the Lofer Member, the tubes are either completely filled by lime mudstone, or contain geopetals thereof; moreover, many tubes are encrusted by microbialites of probable cyanobacterial origin (e.g. Pl. 2, fig. 10). In platform margin successions, the worm tubes are either filled by sparite, or also contain geopetal sediments. No correlation between wall thickness and water energy was identified. For instance, in the wackestones of the Lofer Member, specimens with very thick-walled (e.g. Pl. 2, fig. 11) and with thinner-walled tubes (e.g. Pl. 2, fig. 5), respectively, are present.

Whereas the mentioned paleoenvironments (outer / inner platform) are quiet different with respect to water energy and accompanying biota, both settings provided abundant hard substrata for settlement of *Carpathiella*. No curved tubes of *Carpathiella plassenensis* were observed. Thus, availability of flat bioclasts might have controlled the

presence of the serpulid, while the size of flat bioclasts may have limited tube length. The absence of both *C. triangulata* and *C. perforata* in the Lofer Member may indicate that these are facies-dependent taxa that prefered well-agitated waters. *Carpathiella* maybe present in the reefal facies of the Plassen Formation, but is most typical for the reef debris facies.
In facies of reef-debris and back-reef, *Carpathiella* is present together with dasycladales such as *Salpingoporella* gr. *pygmaea* (GÜMBEL 1891) and benthic foraminifera (lituolids, *Mohlerina*, *Trocholina*, *Protopeneroplis*). In upper slope deposits, they are accompanied by echinoids, bryozoa, brachiopods and *Tubiphytes*. In almost all cases, *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK, 2002 is present as an isolated component. In the Lofer Member of Dietrichshorn near Lofer, we detected a single specimen fixed to a „hydrozoan" skeleton (Pl. 3, fig. 3). Here and at the nearby Lärchberghörndl (see text-fig. 1), it occurs in fossiliferous marly, partly oncoidal limestones (wacke- to packstones) containing stromatoporids, benthic foraminifera in abundances and also dasycladales. The latter are represented by *Clypeina catinula* CAROZZI 1956, *Clypeina sulcata* (ALTH 1882), *Clypeina isabellae* MASSE et al. 1999, *Rajkaella bartheli* (BERNIER 1971) and *Salpingoporella annulata* CAROZZI 1953. Benthic foraminifera include miliolids, *Anchispirocyclina lusitanica* (EGGER 1902), *Bramkampella arabica* REDMOND 1964 *„Mayncina" gediki* TASLI 1993, *Redmondoides lugeoni* (SEPTFONTAINE 1977), *Trocholina* sp. and others not further determined taxa. The facies of the Lofer Member refers to a typical internal infralittoral environment (e.g. SCHLAGINTWEIT & EBLI 2000).
Due to the occurrences within outer platform settings, representatives of *Carpathiella* can be transported downslope usually as single components (not within clasts) explaining the findings in the resediments of the Tressenstein Limestone, Barmstein Limestone, Sillenkopf Formation and the „Hornsteinbreccie". Here they are associated with microfossils from their original environment but also with taxa that are lacking there ("thanatocoenosis"). Summarizing, Carpathiellas are typical shallow water inhabitants and all findings in the platform associated resediments are interpreted as allochthonous.

4.2. Upper Cretaceous part of Gosau Group

With respect to their presence in shallow neritic deposits, the Upper Cretaceous occurrences of *Carpathiella* are similar to the Upper Jurassic. The Upper Cretaceous succession (Gosau Group p.p.) of the Northern Calcareous Alps is characterized by a wide spectrum of shallow-marine facies that accumulated in differentiated, mixed siliciclastic-carbonate environments (e.g. SANDERS & PONS 1999).

Upper Turonian occurrence: In Brandenberg, Tyrol, samples with *Carpathiella triangulata* MISÍK et al. were found in Upper Turonian sandstones (*Deverianum* zone, e.g. SUMMESBERGER & KENNEDY 1996). In the sandstones, oblique cross-laminasets, mixed bioclastic-siliciclastic tempestite beds riddled by *Ophiomorpha nodosa*, and intervals of shoreface conglomerates all indicate deposition in a shoreface environment (SANDERS et al. 1997). The arenites locally are rich in fossils from shallow-marine environments, mainly rudists (*Vaccinites* ssp., radiolitids, *Plagioptychus*), colonial corals and solitary corals, non-rudist bivalves and ammonites (e.g. HERM et al. 1979, SANDERS 1998). The serpulid tubes are attached to rudists shells and to corals. In a few cases, serpulid tubes intercalated into coral colonies are present.

?Upper Turonian to Lower Coniacian occurrence: Also in Brandenberg, within intervals of shallow-marine limestones rich in corals, rudists and skeletal sponges (SANDERS 1998), *Carpathiella* is present on corals and rudists. These limestones have been age-dated by rudists and, locally, bracket-dated by inoceramids and nannofossils into the ?Upper Turonian to Lower Coniacian (see TRÖGER & SUMMESBERGER 1994, SUMMESBERGER & KENNEDY 1996, SANDERS et al. 1997, PONS & SANDERS 1999).

Upper Turonian to Lower Coniacian occurrence: At Theresienstein near Strobl, federal state of Salzburg, the largest Cretaceous coral buildup of the Eastern Alps is exposed (SANDERS et al. 1999). The buildup is of Early Coniacian age (PONS & SANDERS 1999). The buildup is covered by an interval a few meters thick of poorly sorted shallow-water bioclastic grainstones/packstones to floatstones that contain toppled and coarsely fragmented rudists and rudist clusters. These limestones probably accumulated in an open shallow subtidal environment below fair-weather wave base, but within storm wave base (SANDERS et al. 1999). Within the bioclastic limestones, specimens of *Carpathiella triangulata* MISÍK, SOTÁK & ZIEGLER are present together with the dasycladale *Neomeris* (*Drimella*) cf. *jerinae* RADOICIC 1984 (det. R. RADOICIC, Beograde), the gymnocodiacea *Permocalculus* (*Pyrulites*) n. sp. and the microfossil incertae sedis *Pienina oblonga* BORZA & MISÍK 1976.
From the three species described so far, to date only *C. triangulata* MISÍK, SOTÁK & ZIEGLER was found in the Upper Cretaceous of the Northern Calcareous Alps.

4.3. Tertiary part of Gosau Group

In the Paleocene Kambühel Limestone Carpathiellas are frequent microfossils in reefal and peri-reefal limestones. In accordance to the Upper Jurassic and Upper Cretaceous occurences, the species *C. triangulata* is more frequent than *C. perforata*. In the Alpine Paleocene Carpathiellas are associated with a diverse association of coralline red algae, solenoporaceans, bryozoa, coral, benthic foraminifera (e.g., *Miscellanea, Planorbulina, Miniacina*), dasycladales such as *Sarosiella feremollis* SEGONZAC 1972, the parataxon *Russoella radoicicae* BARATTOLO 1984 and the Microproblematicum *Pienina oblonga* BORZA & MISÍK 1976.

5. Conclusions

In the Plassen Formation of the Northern Calcareous Alps, all species of *Carpathiella* MISIK, SOTAK & ZIEGLER, 1999 including *C. plassenensis*, *C. triangulata* and *C. perforata*

are common. The latter two species are recorded for the first time for the Northern Calcareous Alps. The species of *Carpathiella* are present in different stratigraphic intervals ranging from Kimmeridgian to Berriasian, thus cannot be used for biochronostratigraphy at the stage or biozone level. In the Plassen Formation, *Carpathiella* is most common in platform margin successions deposited at moderate to high water energy. By contrast, *C. plassenensis* SCHLAGINTWEIT & GAWLICK was found also in back-reef successions and the internal platform (Lofer Member). The presence of *Carpathiella* mainly in platform margin settings fits its occurrence in allodapic limestones and breccias within basinal successions (Tressenstein Limestone, Barmstein Limestone, Sillenkopf Formation, „Hornsteinbreccie").

In the Upper Turonian to Coniacian part of the Lower Gosau Subgroup, to date only *C. triangulata* MISIK, SOTAK & ZIEGLER was identified in sandstones and carbonates from open, shallow subtidal environments of overall moderate to episodically high water energy. Similar to recent serpulids, *Carpathiella* probably had a low sensitivity to input of siliciclastics and nutrients. As a tube-dwelling suspension feeder, however, the form needed hard substrate and fairly constant water agitation to thrive. By contrast to other serpulid taxa, *Carpathiella* did not form aggregations of individuals.

With respect to systematic micropaleontology, the generic diagnosis of the genus *Carpathiella* MISIK, SOTAK & ZIEGLER, 1999 has been emended by eliminating the discussed trend of cross-sections towards a triangular shape. This feature is now regarded a specific criterion.

6. Acknowkedgements

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Plate 1

***Carpathiella* microfacies from the Plassen Formation (Kimmeridgian to Berriasian) (Figs. 1-2, 4, 6-8), the Ernstbrunn Limestone (Fig. 5) and the Lower Gosau Subgroup (Turonian to Coniacian) of the Northern Calcareous Alps (Fig. 3)**

1: Cross section of *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK within open lagoonal packstone. Locality Konradsweg, Lärchberghörndl near Lofer. Thin-section BSP 2002-I-22, scale = 1 mm.

2: Reefal debris limestone (bioclastic packstone) with cross section of *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK (right) and *Carpathiella triangulata* MISIK, SOTAK & ZIEGLER (left). Locality: Wörschach. Thin-section A 602-2, scale = 1 mm.

3: Floatstone with small patches of boundstone composed of corals and with *Carpathiella triangulata* MISIK, SOTAK & ZIEGLER (centre). Locality Theresienstein. Thin-section T 4, scale = 1 mm.

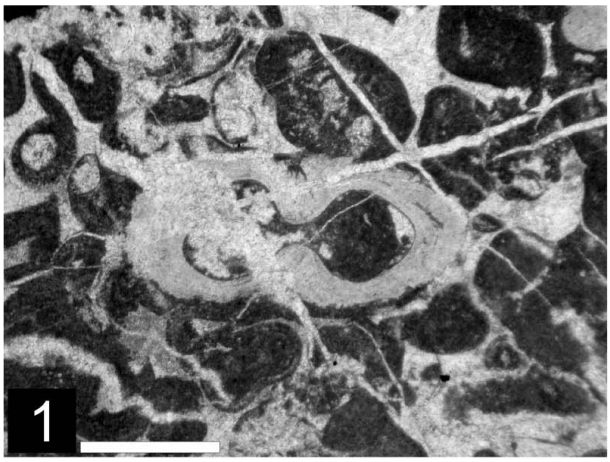
4: Bioclastic packstone to rudstone with several specimens of *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK. Locality Untersberg. Thin-section 93-25-C, scale = 1 mm.

5: Bioclastic packstone with rivulariacean algae and oblique section of *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK. Locality: Ernstbrunn. Thin-section MD 11-3B-4, scale 1 mm.

6: Stromatoporid wackestone with dasycladales, benthic foraminifera and longitudinal section of *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK. Locality: Dietrichshorn near Lofer. Thin-section Die 1985-IX-166, scale = 1 mm.

7: Platform margin/upper slope facies with *Carpathiella triangulata* MISIK, SOTAK & ZIEGLER, bryozoa and the foraminifera *Mohlerina basiliensis* (MOHLER 1936). Locality: Trisselwand. Thin-section TP 21a, scale = 0,5 mm.

8: Wackestone with dasycladale *Clypeina sulcata* (ALTH) and slightly oblique cross section of *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK. Locality: Dietrichshorn. Thin-section Die-9, scale = mm.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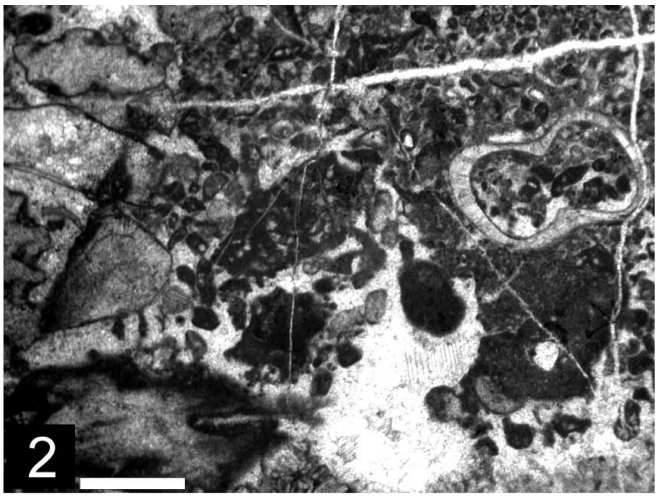
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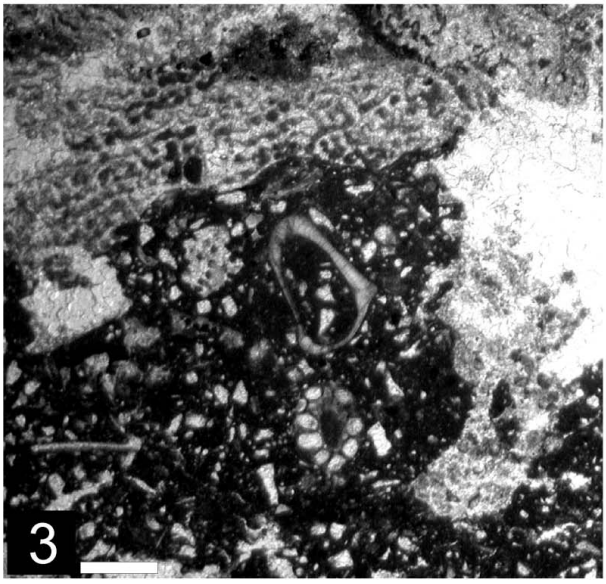
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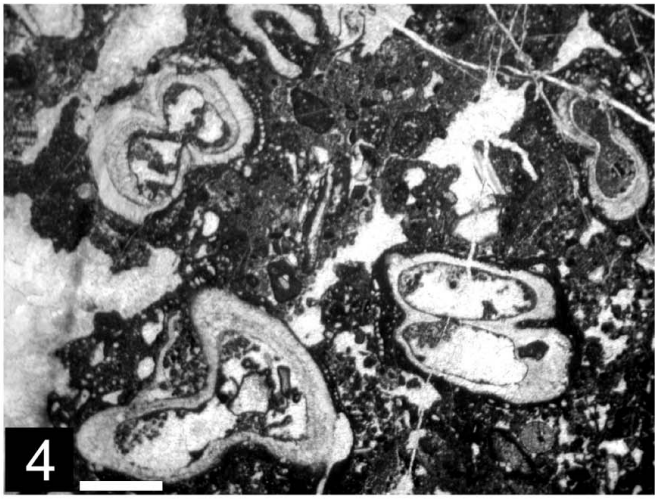
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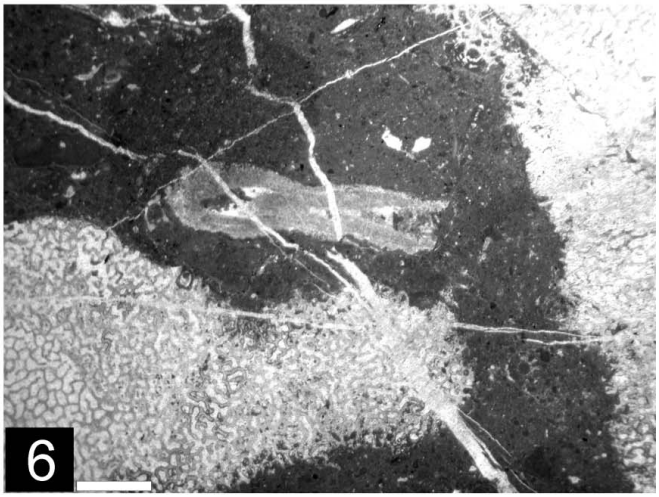
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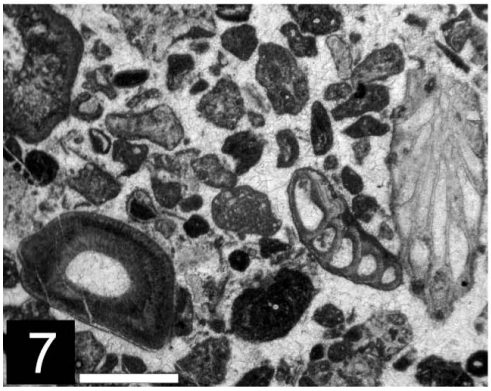
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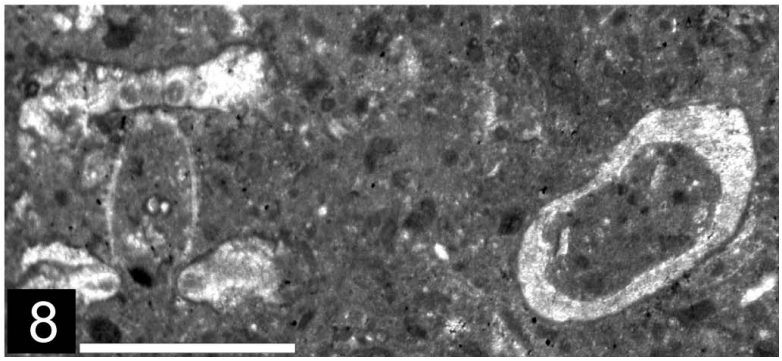
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Plate 2

***Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK from the Plassen Formation (Kimmeridgian to Berriasian) of the Northern Calcareous Alps**

1: Cross section, slightly oblique. Locality: Lärchberghörndl. Thin-section LOF, scale = 0,5 mm.

2: Cross section. Locality: Falkenstein, SE slope. Thin-section A 2570, scale = 0,5 mm.

3: Cross section slightly oblique. Locality: Dietrichshorn. Thin-section Die-8, scale = 1 mm.

4: Cross section, slightly oblique. Locality: Krahstein, SE slope. Thin-section A 438, scale = 0,5 mm.

5: Longitudinal section. Locality: Dietrichshorn. Thin-section Die 1985-IX-166, scale = 0,5 mm.

6: Cross section. Locality: Plassen, Hohe Wasserstollen. Thin section HW 142-b, scale = 0,5 mm.

7: Cross section, slightly oblique. Locality: Dietrichshorn. Thin section Die 1985-IX-31, scale = 0,5 mm.

8: Longitudinal oblique section. Locality Dietrichshorn. Thin section Die-1985-IX-166, scale = 0,5 mm.

9: Cross section, slightly oblique. Locality: Hochkranz. Thin section HK-18, scale = 1 mm.

10: Cross section, slightly oblique with oncoidal enveloping. Locality: Lärchberghörndl. Thin section Eis-1, scale = 1 mm.

11: Cross section, slightly oblique, holotype. Locality: Lärchberghördl. Thin-section BSP 2002-I-21, scale = 1 mm.

12: Tangential oblique section. Locality: Litzelkogel. Thin section LK 15, scale = 1 mm.

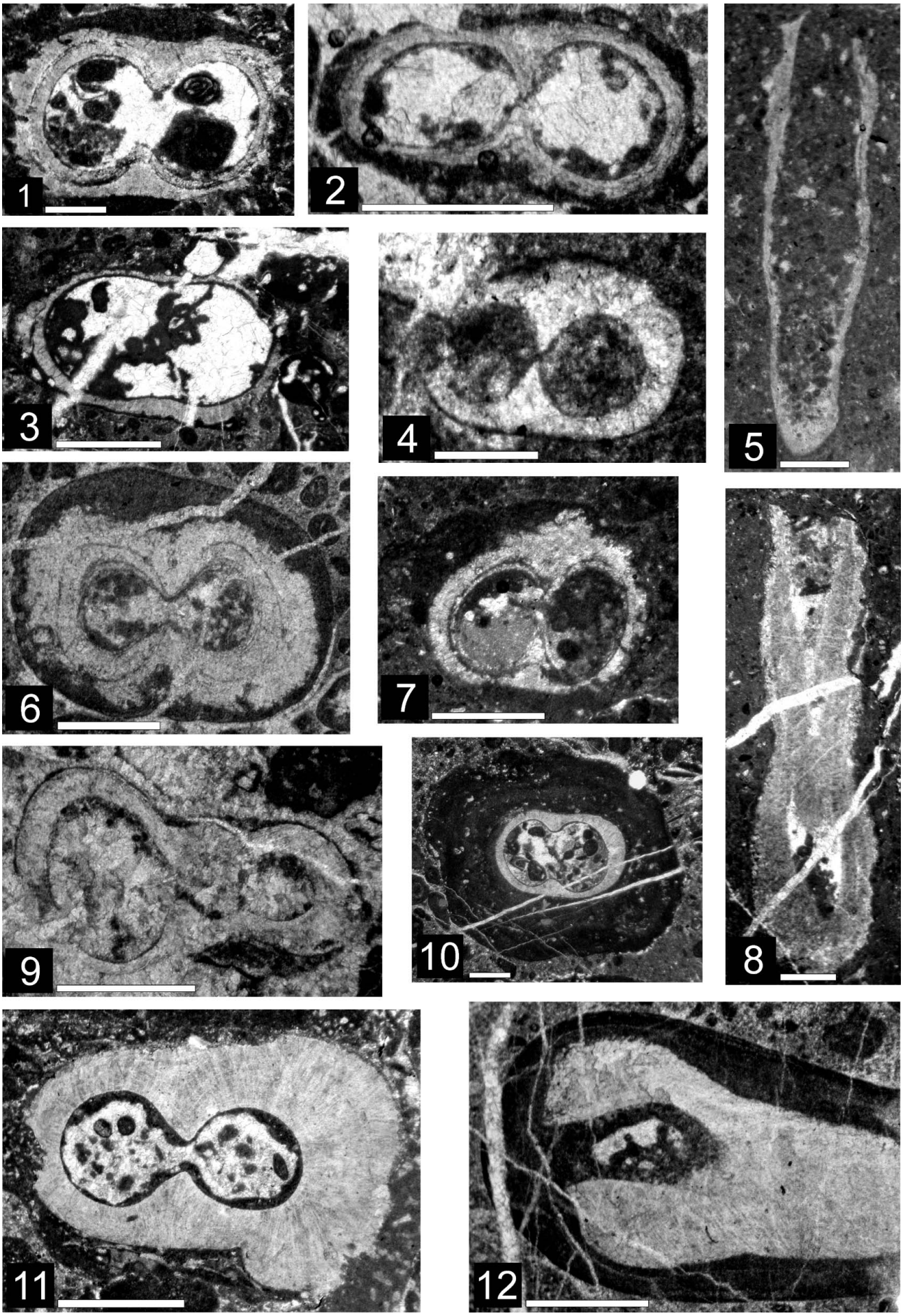
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Plate 3

***Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK from the Plassen Formation (Kimmeridgian to Berriasian) of the Northern Calcareous Alps**

1: Oblique section. Locality: Plassen, Hohe Wasserstollen. Thin section HW 187, scale = 1 mm.

2: Tangential section with encrusting foraminifera. Locality: Dietrichshorn. Thin section Die-1985-IX-170, scale = 2 mm.

3: Specimen fixed to a „hydrozoa". Locality: Dietrichshorn. Thin section Die 1985-IX-166, scale = 0,5 mm.

4: Detail of figure 2 showing radial fibrous calcitic wall structure and alternating of thick bright and thin dark layers. Locality: Dietrichshorn. Thin section Die-1985-IX-170, scale = 1 mm.

5: Oblique section exhibiting massive calcification. Locality: Lärchberghörndl (Konradsweg). Thin section KOW-6, scale = 1 mm.

6: Fragmentary longitudinal section showing the the bulged distal tube ending. Locality: Lärchberghörndl. Thin section LOF, scale = 1 mm.

7: Back-„reef" facies with gastropods, shell debris, benthic foraminifera and longitudinal section cutting both tubes (left side). Locality: Trisselkogel near Altaussee. Thin section TK 24, scale = 1 mm.

8: Longitudinal oblique section. Locality: Plassen, Hohe Wasserstollen. Thin section HW 281, scale = 1 mm.

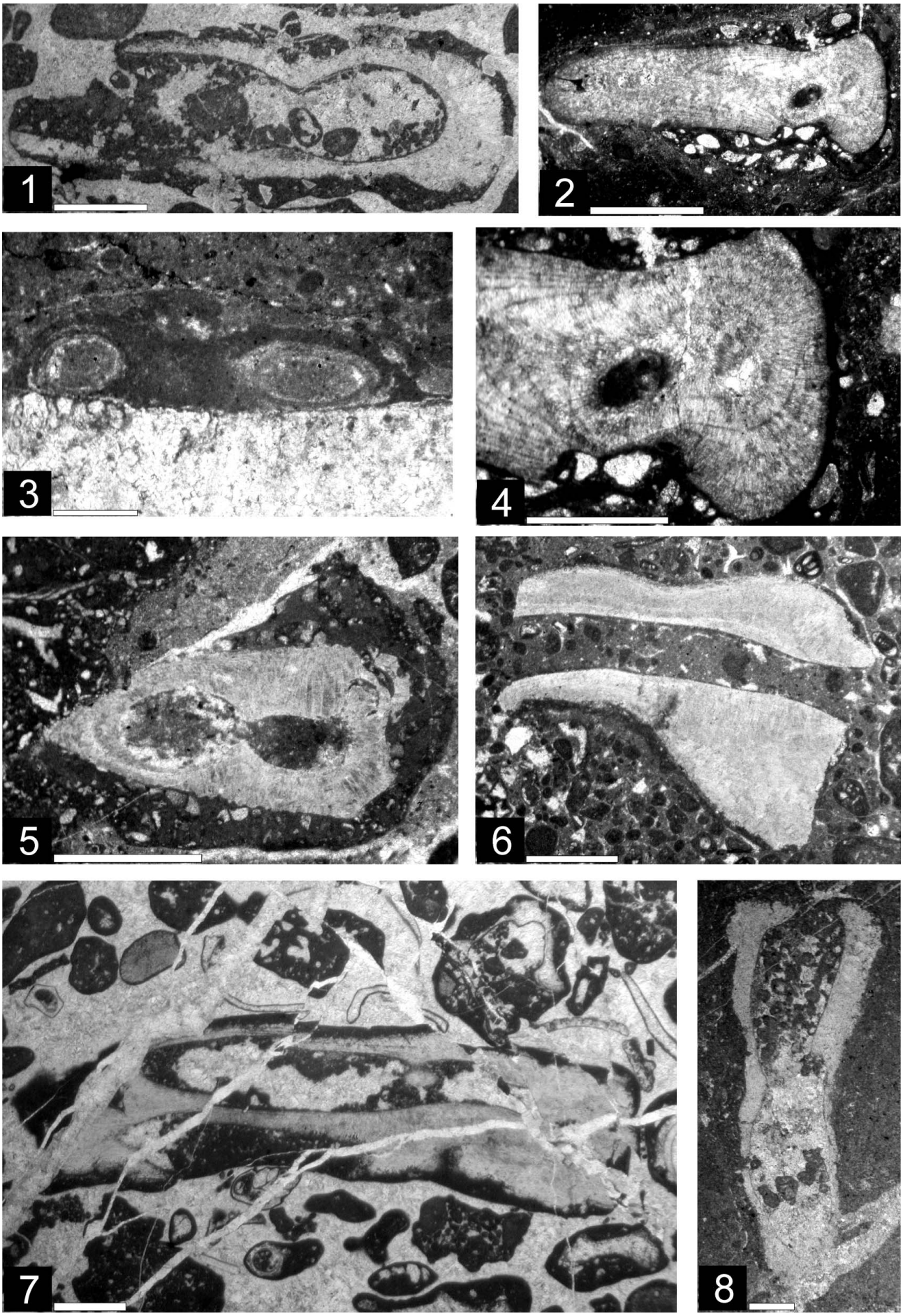
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Plate 4

***Carpathiella*s from the Plassen Formation (Kimmeridgian-Berriasian, Figs. 1-3, 5-6, 10, 13), the Barmstein Limestones (Fig. 8), Gosau Formation (Turonian-Coniacian, Figs. 4, 7, 9, 11) of the Northern Calcareous Alps and the Tithonian/ Berriasian of Hungary (Fig. 12)**

1: *Carpathiella perforata* MISIK, SOTAK & ZIEGLER, cross section. Locality: Lärchberghörndl (Eismannsteig). Thin section Eis-8, scale = 0,5 mm.

2: *Carpathiella perforata* MISIK, SOTAK & ZIEGLER, cross section. Locality: Plassen. Thin section Pl-58a, scale = 0,5 mm.

3: *Carpathiella perforata* MISIK, SOTAK & ZIEGLER, cross section. Locality: Rötelstein. Thin section dd-23a, scale = 0,5 mm.

4: *Carpathiella triangulata* MISIK, SOTAK & ZIEGLER, note the thin dark line transjecting the wall at the acute corner. Locality: Brandenberg. Thin section 17995-22, scale = 0,5 mm.

5: *Carpathiella triangulata* MISIK, SOTAK & ZIEGLER. Locality: Krahstein. Thin section Krah-111, scale = 1 mm.

6: Slope packstone with cross section of *Carpathiella plassenensis* SCHLAGINTWEIT & GAWLICK 2002. Locality: Litzelkogel near Lofer. Thin section Ber 100-21, scale = 0,5 mm.

7: *Carpathiella triangulata* MISIK, SOTAK & ZIEGLER. Locality: Theresienstein. Thin section T 4, scale = 0,5 mm.

8: *Carpathiella triangulata* MISIK, SOTAK & ZIEGLER. Locality: Barmsteine near Hallein. Thin section Ber 30-2-3, scale = 0,5 mm.

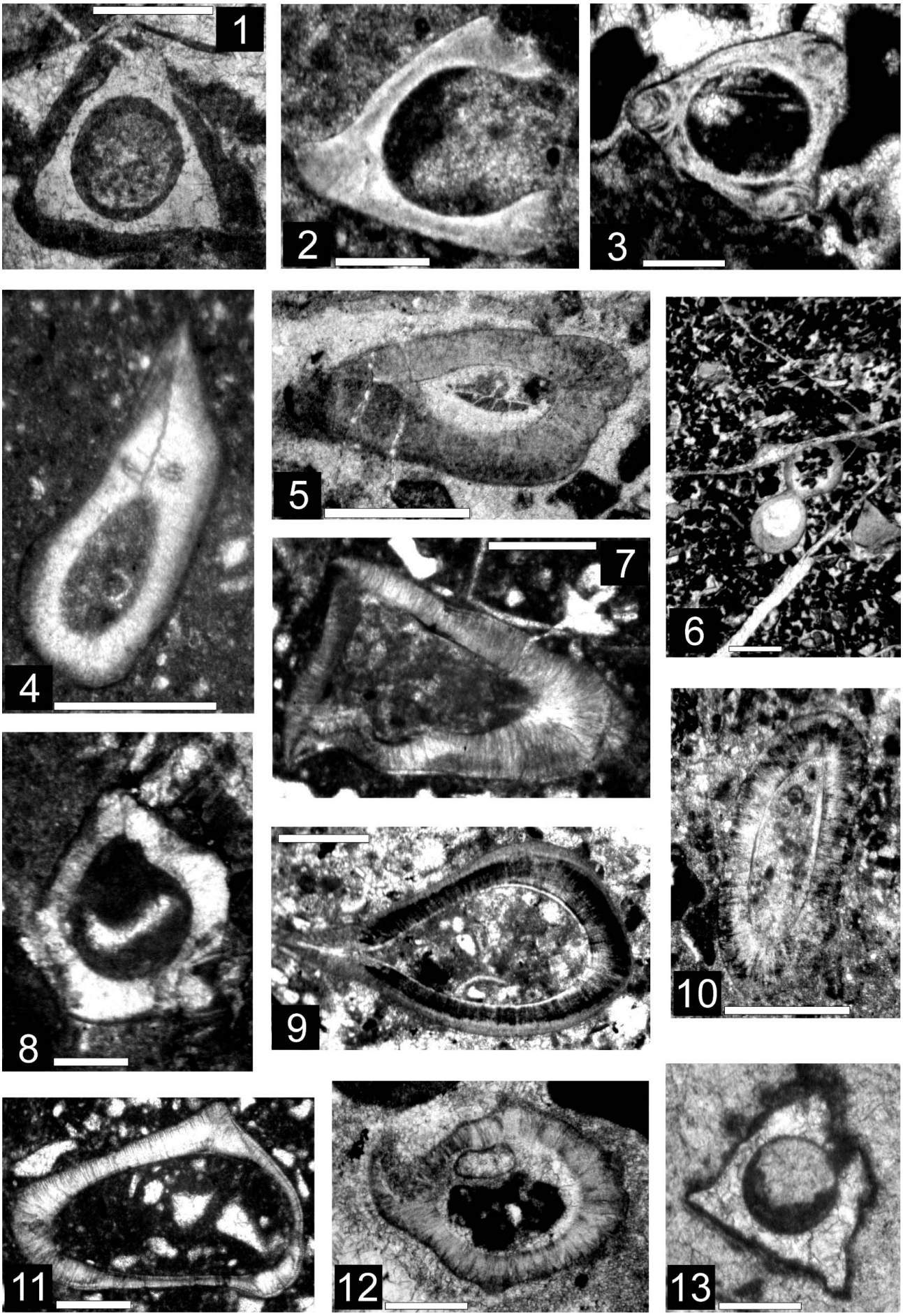
9: *Carpathiella triangulata* MISIK, SOTAK & ZIEGLER. Locality: Brandenberg. Thin section 16795-19, scale = 0,5 mm.

10: *Carpathiella triangulata* MISIK, SOTAK & ZIEGLER. Locality: Lärchberghörndl. Thin section 6-2-2, scale = 0,5 mm.

11: *Carpathiella triangulata* MISIK, SOTAK & ZIEGLER. Locality: Theresienstein. Thin section T 4, scale = 0,5 mm.

12: *Carpathiella triangulata* MISIK, SOTAK & ZIEGLER. Locality: Labatlan/Hungary. Thin section Labat-190, scale = 0,5 mm.

13: *Carpathiella* ? sp. Locality: Plassen. Thin section PL 27 with recrystallized wall. scale = 0,5 mm.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