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Permocalculus (Pyrulites) theresiensteinensis n. sp., a New Calcareous Alga from the Upper Cretaceous Lower Gosau Subgroup of the Northern Calcareous Alps (Austria)

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Oberkreide
Kalkalgen
Gymnocodiaceae
Taxonomie
Biostratigraphie

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Permocalculus (Pyrulites) theresiensteinensis n. sp., eine neue Kalkalge aus der unteren Gosau-Subgruppe (Ober-Kreide) der Nördlichen Kalkalpen (Österreich)

Zusammenfassung

In der vorliegenden Arbeit wird eine neue Kalkalge als *Permocalculus (Pyrulites) theresiensteinensis* n. sp. (Gymnocodiaceae) aus dem Korallen-Riff des Theresienstein (Coniacium) am Wolfgangsee im österreichischen Salzkammergut beschrieben. *Permocalculus (Pyrulites) theresiensteinensis* n. sp. ist eine vergleichsweise großwüchsige Alge, von der nur die äußerste Kortikalzone verkalkt erhalten ist. Die neue Art wurde auch in der Gosau-Gruppe von Brandenberg (Örtlichkeit Haidach), ebenfalls in Schuttkalken mit Korallen, gefunden. Dieser Neufund erweitert das paläoalgologische Inventar der alpinen Flachwasser-Oberkreide und vertieft die mikropaläontologische Charakterisierung von Karbonatlithologien, insbesondere von rezifalen und peri-rezifalen Habitaten.

Abstract

In the present paper a new calcareous alga (Gymnocodiaceae) is described as *Permocalculus (Pyrulites) theresiensteinensis* n. sp. from the coral reef of the Theresienstein (Coniacian) at Lake Wolfgang in the Austrian Salzkammergut. *Permocalculus (Pyrulites) theresiensteinensis* n. sp. is a comparably large alga, and is preserved only by the calcified outer cortical zone. The new species was also detected in the Gosau Group of Brandenberg (location Haidach) in bioclastic limestones with corals. This new finding widens the palaeoalgological inventory of the Alpine shallow-water Upper Cretaceous, and contributes to the micropalaeontological characterization of carbonate lithologies especially of reefal and peri-reefal habitats.

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1. Introduction

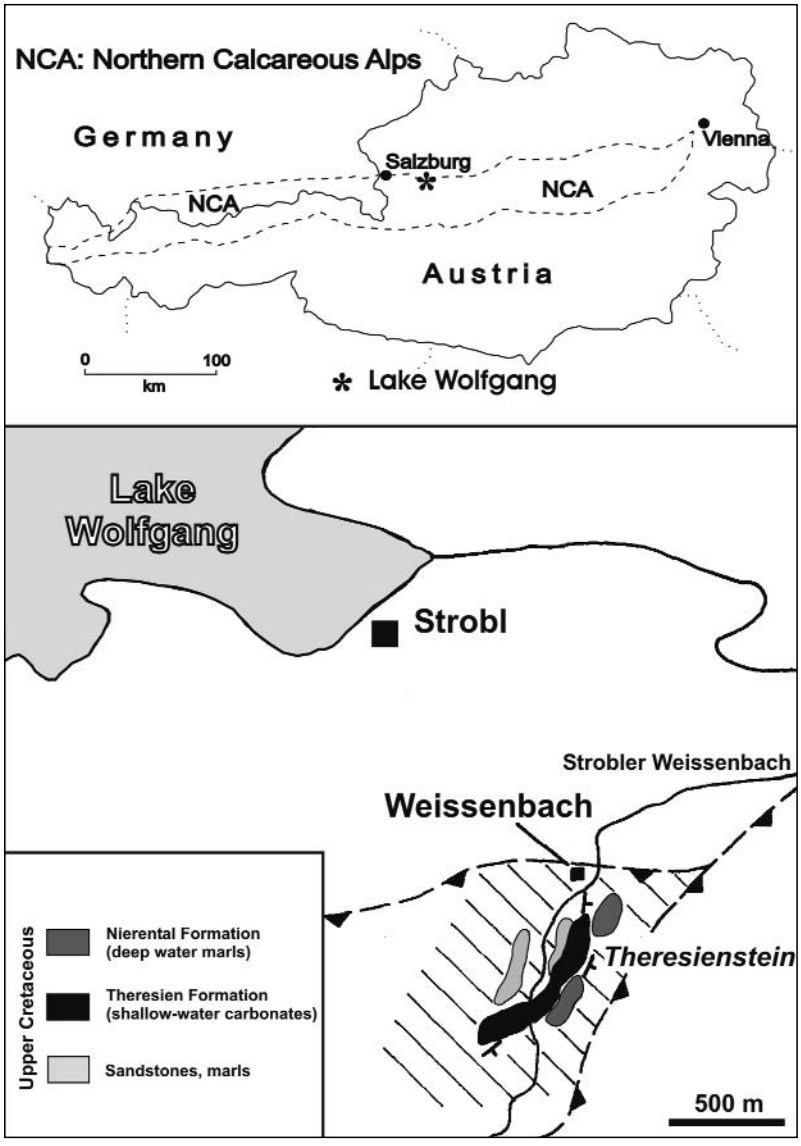
Rudist biostromes and coral-rudist reefs are well-known from the Lower Gosau Subroup (Upper Turonian to Lower Campanian) of the Northern Calcareous Alps (e.g. HÖFLING, 1985; SANDERS & PONS, 1999). By contrast, frame reefs composed practically entirely of corals are quite rare. In the area of Wolfgangsee (Salzburg, Austria), a spectacular Upper Cretaceous coral reef has been recognized only in recent years, and termed „Theresienstein Reef" (SANDERS et al., 1999). The presence of benthic foraminifera and calcareous algae in bioclastic limestones that cover this reef were already recognized by SANDERS et al. (1999). The micropalaeontological investigation of thin-sections from this interval yielded a new calcareous alga described in the present paper as *Permocalculus (Pyrulites) theresiensteinensis* n. sp.

2. Geological Setting and Stratigraphiy

The Upper Cretaceous shallow-water limestones exposed at Theresienstein in Strobler Weissenbach valley previously had been mapped and labelled as „rudist limestones" (e.g. PLÖCHINGER, 1973; WAGREICH, 1998: Fig. 2). In fact, however, the major part of the limestone succession at Theresienstein consists of the thickest and best-developed Upper Cretaceous coral reef of the Eastern Alps. The sedimentary succession at and near Theresienstein (Text-Fig. 2), defined as Theresienstein Formation, is described in SANDERS et al. (1999).

Rudists are common in the basal part of the exposed succession (interval A in Text-Fig. 2B), followed up-section by limestones composed mainly of large corals (interval B) in platestone to domestone textures. Interval B is laterally exposed over a few hundreds of meters, without a significant decrease in abundance of corals. Sixteen taxa of corals (prevalently encrusting and laminar morphs), including one new species, were described from this locality by BARON-SZABO (2001). The interval rich in corals, in turn, is overlain by the topmost exposed interval C, a package a few meters thick of bioclastic grainstones/packstones to floatstones (Text-Fig. 2C). The bioclastic limestones are very poorly sorted, and locally contain toppled and coarsely fragmented rudists and rudist clusters. Interval C probably accumulated in an open, shallow subtidal environment below fairweather wave base, but within storm wave base (SANDERS et al., 1999). Based on the rudists, a Coniacian age was inferred by SANDERS et al. (1999) for the Theresienstein Reef.

Sr-isotope data from rudist shells (taken from interval B) yielded ages of 88.65 MY (without standard deviation) (STEUBER, 2001), indicating the Turonian-Coniacian boundary zone in the geological time scale of GRADSTEIN et al. (2004).



Text-Fig. 1.
Position of Lake Wolfgang in Austria (above) and location of the Gosau deposits in the Theresienstein area (below) (from SANDERS et al. 1999).

3. Systematics

Family Gymnocodiaceae (?)

Remarks: Originally, the genus *Permocalculus* ELLIOTT, 1955 was assigned to the red algae (ELLIOTT, 1955, 1956). The suprageneric systematic position of *Permocalculus* ELLIOTT, red algae (Gymnocodiaceae) versus green algae (e.g. Halimedaceae) has been discussed by several authors (MU & RIDING, 1983; ROUX & DELOFFRE, 1990; MU, 1991; BUCUR, 1994; RADOIČIĆ, 2004). There seems to be consensus amongst palaeoalgologists to consider the genus *Permocalculus* as a calcareous green alga rather than a red alga. In a recent paper, the Triassic species *Permocalculus aegaeicus* (? *Permocalculus pelagonicus* or ? *Pseudopenicillus aegaeicus* of DRAGASTAN et al., 2000) was treated as a halimedacean taxon, but without further explanations (SENOWBARI-DARYAN & ZAMPARELLI, 2005: Tab. 1).

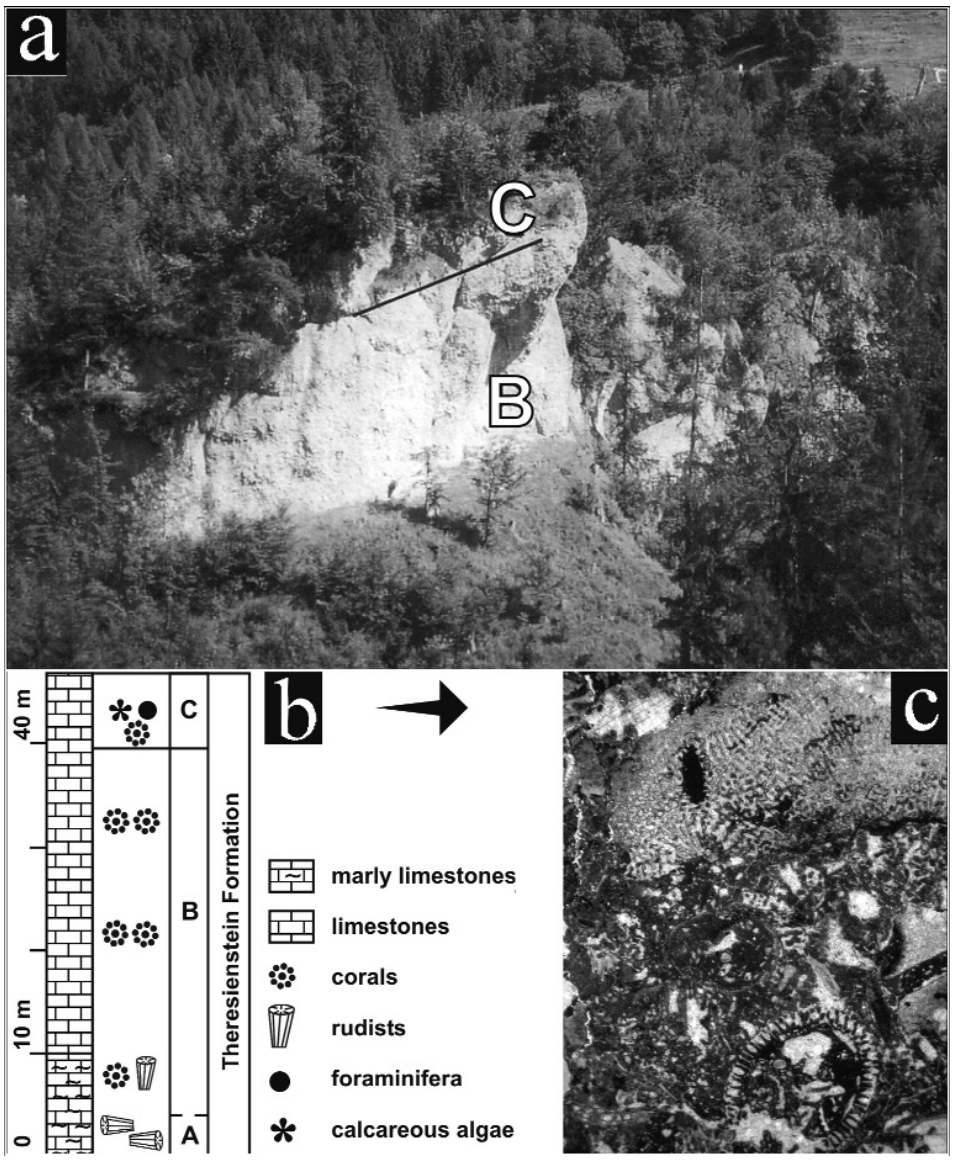
Genus: ***Permocalculus* ELLIOTT, 1955**

Subgenus: ***Permocalculus (Pyrulites)* MU, 1981**

***Permocalculus (Pyrulites) theresiensteinensis* n.sp.**

Pl. 1, Figs. 1–3, 5–7, 8 (pars)

?1992 *Griphoporella* ? sp. – SCHLAGINTWEIT: p. 5, Pl. 1, Figs. 6–7, Gosau Group of Krumbachalm.



Text.-Fig. 2.
a) View of the northern outcrop of the Theresienstein coral reef (interval B) and the overlying bioclastic limestones containing *Permocalculus (Pyrulites) theresiensteinensis* n. sp. (interval C).
b) Type section of the Theresienstein Formation (adopted from SANDERS et al. [1999]).
c) Thin-section photograph from the bioclastic interval C. Sample BSPG2006/51.

Derivatio nominis: The name refers to the type locality, the Theresienstein Reef in the Strobler Weissenbach Valley.

Holotype: Slightly oblique longitudinal section with broken stalk, shown in Pl. 1, Fig. 3. The thin-section containing the holotype (BSPG 2006/50) and two other thin section (BSPG 2006/51 and /52) are deposited at the "Bayerische Staatssammlung für Paläontologie und historische Geologie", Munich. BSPG 2006/50 and /51 are from the Theresienstein, BSPG 2006/52 is from the Gosau of Brandenberg (Tyrol, Austria).

Locus typicus: Theresienstein, Lake Wolfgang, Austrian Salzkammergut, interval C of SANDERS et al. (1999) (see Fig. 1-2). Geographic position of type section: 13°29´47´´E/ 47°42´25´´N.

Stratum typicum: Bioclastic limestones with corals, benthic foraminifera (encrusting, rarely free taxa), the dasycladale *Neomeris (Drimella)* cf. *jerinae* RADOIČIĆ, red algae *Sporolithon* sp. and *Polystrata alba* (PFENDER) and the microproblematicum *Pienina oblonga* BORZA & MISIK. *Neomeris (Drimella)* cf. *jerinae* RADOIČIĆ, so far not reported from the Alpine Upper Cretaceous is only preserved with the calcified distal parts of the laterals (only R2; see Pl. 1, Figs. 8–10).

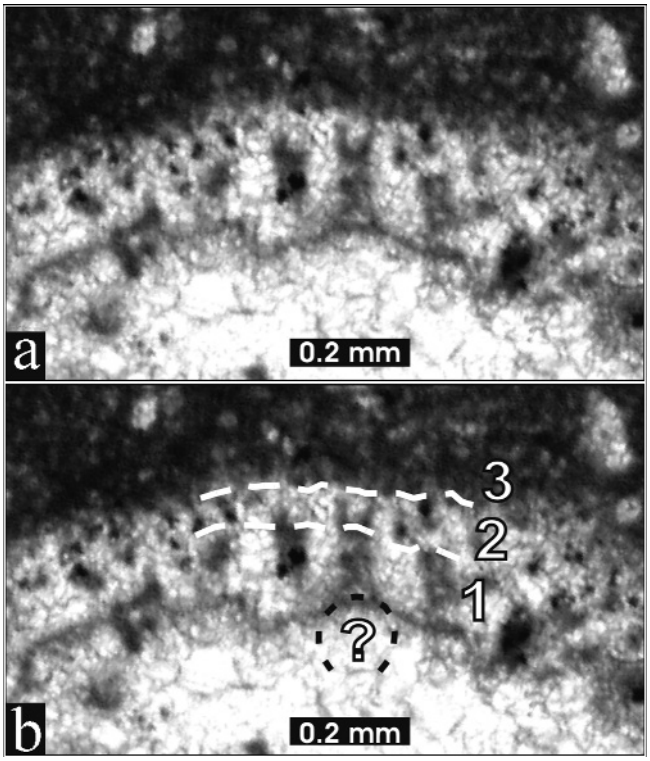
Material: About 10 specimens in several thin sections.

Diagnosis: Large representative of *Permocalculus (Pyrulites)* MU, 1981 with reduced calcified cortical zone, crossed by small bifurcating pores (up to third order). Reproductive structures not observed; rounded outlines of dissolution could suggest the existence of such bodies.

Description: Thallus pyriform with only thin outer part calcified and preserved. Most sections in our material are round transverse sections, the pyriform shape is evidenced in the holotype specimen figured in Pl. 1, Fig. 3 showing the transition to the supposedly cylindroconic stalk part. Broken parts of the stalk can be found either in the surrounding sediment (Pl. 1, Fig. 6, left side) or as infilling of the medullary hollow of the bulbous part ("head") (Pl. 1, Fig. 2, 6). In all cases, the central medullar zone is represented by a large hollow that can occupy up to 90 % of the total diameter (Pl. 1, Figs. 1, 3). The medullary hollow shows either geopetal infillings (basal micrite followed by sparry calcite, Pl. 1, Fig. 1, 3) or is completely made up of sparry calcite. In these cases, the outer cortical zone can hardly be delimited only recognizable at the outer surface by tiny last order filaments (Pl. 1, Fig. 5). Pores piercing the thin walls are of small diameter, whereas most often exact measurements are impossible due to the bad state of preservation (recrystallization). There can be three orders of cortical filaments that divide dichotomously by successively becoming thinner.
Towards the medullary hollow, somewhat larger cavities with terminal rounded outline can be observed. These may represent parts of reproductive organs or more likely dissolution cavities (Text-Fig. 3).

Dimensions:
Outer diameter of upper part („head"): 1.72–3.8 mm
Diameter central hollow of upper part: 1.45–3.12 mm
Outer diameter of lower part ("stalk"): 0.65–0.95 mm
Inner diameter of lower part: 0.35–0.78 mm.
Diameter cortical filaments: 0.01–0.08 mm
Diameter subcortical filaments: up to 0.05 mm

Remarks: The subgenus has been erected by MU (1981) from the Upper Permian of China with the type-species *Permocalculus (Pyrulites) sinicus*, a large representative (with diameters of more than 5 mm for the upper part) with



Text-Fig. 3.
Permocalculus (Pyrulites) theresiensteinensis n. sp., detail of the cortical/subcortical zone (a) and structural interpretation (b).
White dashed lines indicate boundaries between different orders of cortical filaments (1, 2, 3) and rounded outlines of dissolution cavivities (? or conceptacle-like structure = black dashed line with question mark).

respect to the two Cretaceous forms. *Permocalculus (Pyrulites) decenei* BUCUR, 1993 from the Lower Cretaceous (Upper Barremian) of Romania has diameters of 0.98 to 1.16 mm. *Permocalculus (Pyrulites) theresiensteinensis* n. sp. is the third species and the stratigraphically youngest representative of the subgenus (see BUCUR, 1999: Tab. 15). With diameters of 1.45 to 3.12 mm it ranges between the larger Permian and the smaller Lower Cretaceous representatives.

From the Lower Gosau Subgroup of Pletzachalm (Tyrol, Austria), the species *Permocalculus gosaviensis* was established by SCHLAGINTWEIT (1991) with assumed pyriform thallus (diameter of segments: 0.35–0.6 mm). This species is present in shallow subtidal wackestones rich in benthic foraminifera, and was found in Strobler Weissenbach valley and at Pletzachalm. Whereas the exact shape of this alga is uncertain, it is of distinctly smaller size.

Representatives of *Permocalculus nikolapantici* RADOIČIĆ, 2004 from the Upper Turonian of NW Serbia, were discovered from identical facies of Late Turonian-Early Coniacian age in the Lower Gosau Subgroup of Haidach (Tyrol, Austria). *Permocalculus nikolapantici* RADOIČIĆ belongs to the form-group of the so-called "waxing-waning" type showing alternating constrictions and swellings (see Pl. 1, Fig. 4). Oblique sections of swollen part or terminal segment parts may pretend pyriform thallus shapes, especially when longitudinal sections are not available. Thus, it cannot be excluded that *Permocalculus gosaviensis* SCHLAGINTWEIT 1991, established without longitudinal sections, in fact represents oblique sections of *Permocalculus nikolapantici* RADOIČIĆ, 2004. Both "species" were described from similar facies and from successions of similar age. In addition, the diameters of the segments of *Permocalculus nikolapantici* fall within the range of the segment diameters of *Permocalculus gosaviensis*.

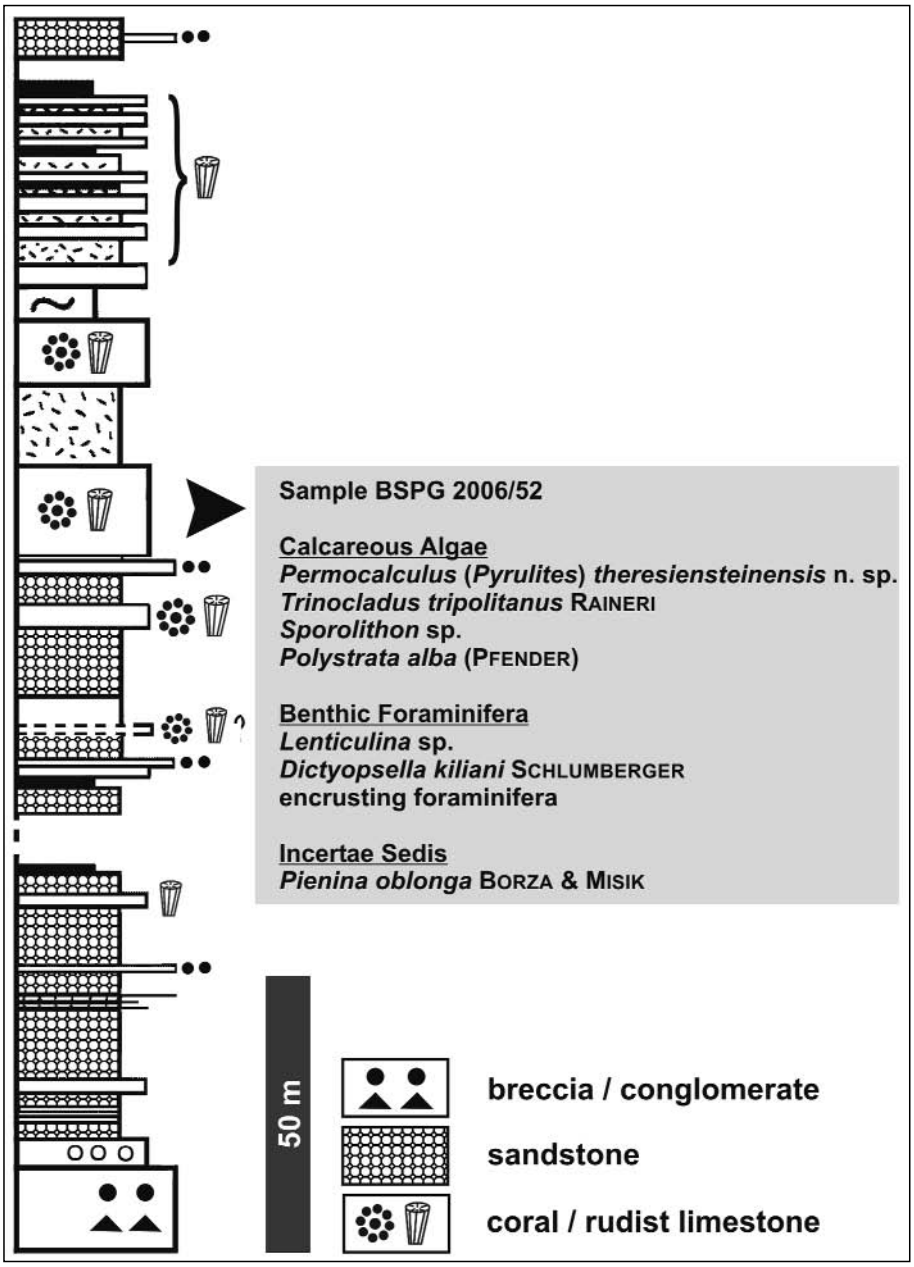
Finally, the *Permocalculus* described herein shows some degree of homeomorphism to the dasycladalean alga *Trinocladus divnae* RADOIČIĆ, 2006, described recently from the Upper Cenomanian Mirdita Zone of Serbia. *T. divnae* often shows a peculiar style of fossilization wherein only the secondaries and the tertiaries, and in some cases the latter only, are preserved due to carbonate dissolution or recrystallization. In such cases, representatives of *Permocalculus* and *Trinocladus* can hardly be distinguished, as noted by RADOIČIĆ (2006). Apart from coming from stratigraphically younger strata, the Alpine representatives of *Permocalculus* described herein are distinctly larger (diameters of *T. divnae*: 0.71–1.64 mm, maximum 1.947 mm) and do not show a cylindrical shape of the thallus.

Occurrences and Facies: The holotype is from interval C of the Theresienstein section, i. e. from a veneer of bioclastic limestones that capped the underlying coral reef. It is assumed that *Permocalculus (Pyrulites) theresiensteinensis* n. sp. lived in areas with open circulation and with moderate to intermittently high water energy, within and close to areas colonized by corals, where it was associated with the dasycladalean alga *Neomeris (Drimella)* cf. *jerinae* RADOIČIĆ. The presence of both these algae seems to be "limited to peri-reefal areas, in particular flats and niches among patch-reefs, mainly composed of rudists, corals, sphinctozoans and algae" (RADOIČIĆ & RUBERTI, 1992: p. 187).

Besides the Theresienstein, *Permocalculus (Pyrulites) theresiensteinensis* n. sp. was found in ?Upper Turonian to Coniacian shallow-water limestones of Brandenberg (Tyrol, Austria), more precisely in the area of Krumbachalm-Nachbergalm and at Haidach. The alga was prevalently found in poorly-sorted bioclastic packstones to floatstones (sample 15.11.94/1, see Pl. 1, Figs. 6–7), and in grainstones to rudstones with admixed siliciclastic sand (sample 21.11.94/3, see Pl. 1, Fig. 2) in the area of Krumbachalm. The limestones of Krumbachalm probably were deposited in an open, shallow subtidal (open „lagoonal") carbonate environment that was subject to episodic, low siliciclastic input and intermittent high-energy events (SANDERS, 1998). From Krumbachalm, *Permocalculus (Pyrulites) theresiensteinensis* n. sp. was mentioned by SCHLAGINTWEIT (1992) by one transverse section as *Griphoporella* ? sp. The limestones in which the new taxon was found are characterized by a diversified spectrum of shallow-water bioclasts.

In the Haidach section (Text-Fig. 4), *Permocalculus (Pyrulites) theresiensteinensis* n. sp. was found in a sheet of bioclastic grain- to rudstones that form the substrate of an interval of coral-rudist limestones, and that probably were deposited during transgression (see SANDERS & BARON-SZABO, 1997; SANDERS, 1998). The bioclastic fraction of these limestones is highly diversified with corals, rudists, calcareous algae, gastropods, bryozoans, echinoderms and benthic foraminifera.

Stratigraphy: The dasycladalean *Neomeris (Drimella)* cf. *jerinae* RADOIČIĆ, co-occurring with *Permocalculus (Pyrulites) theresiensteinensis* n. sp., was described by RADOIČIĆ (1984) from coral-rudist reefs of Serbia that, according to rudists, "most probably" are of Santonian age. Since then, no further data have been obtained from the type-locality of *Neomeris (Drimella)* cf. *jerinae* RADOIČIĆ (pers. comm. R. RADOIČIĆ). The potential Santonian age of this alga is indicated in several compilations on biochronostratigraphy (GRANIER & DELOFFRE, 1993; BUCUR, 1999). Based on our results, provided that the type-locality of *N. (Drimella)* cf. *jerinae* is Santonian in age, the partial taxon range of this alga must be enlarged down to least the lowest Coniacian. Summarizing the stratigraphic data obtained from Theresienstein and Brandenberg, a Late



Text-Fig. 4.
The occurrence of *Permocalculus (Pyrulites) theresiensteinensis* n. sp. at the Haidach-Kreuthalm section, Lower Gosau subgroup of Brandenberg area, Tyrol.
The schematic profile shows a transgressive succession with basal breccias, conglomerates, arenites/sandstones and coral-rudistid limestones in the middle/upper part (further details in SANDERS & BARON-SZABO, 1997; SANDERS, 1998).

Turonian to Coniacian age is indicated for the limestones containing *Permocalculus (Pyrulites) theresiensteinensis* n. sp. Whether this interval represents the total taxon range, however, is unknown.

4. Conclusions

Calcareous green algae (Dasycladales, Gymnocodiacea, Halimedaceae) are known from the Lower Gosau Subgroup (Upper Turonian to Lower Campanian) from different shallow-marine environments. The findings of *both Permocalculus (Pyrulites) theresiensteinensis* n. sp. and *Neomeris (Drimella)* cf. *jerinae* RADOIČIĆ enlarges the Late Cretaceous palaeoalgological inventory of the Northern Calcareous Alps (see overview in SCHLAGINTWEIT, 2004). Whereas most taxa of calcareous green algae are reported from limestones to marly limestones of shallow subtidal („lagoonal“) environments of overall moderate to low water energy, both *P. (Pyrulites) theresiensteinensis* n. sp. and *N. (Drimella)* cf. *jerinae* appear to characterize peri-reefal to reefal facies. The stratigraphic range of the subgenus *Pyrulites* MU, previously known only from the Permian and the Lower Cretaceous, is extended into the Upper Cretaceous.

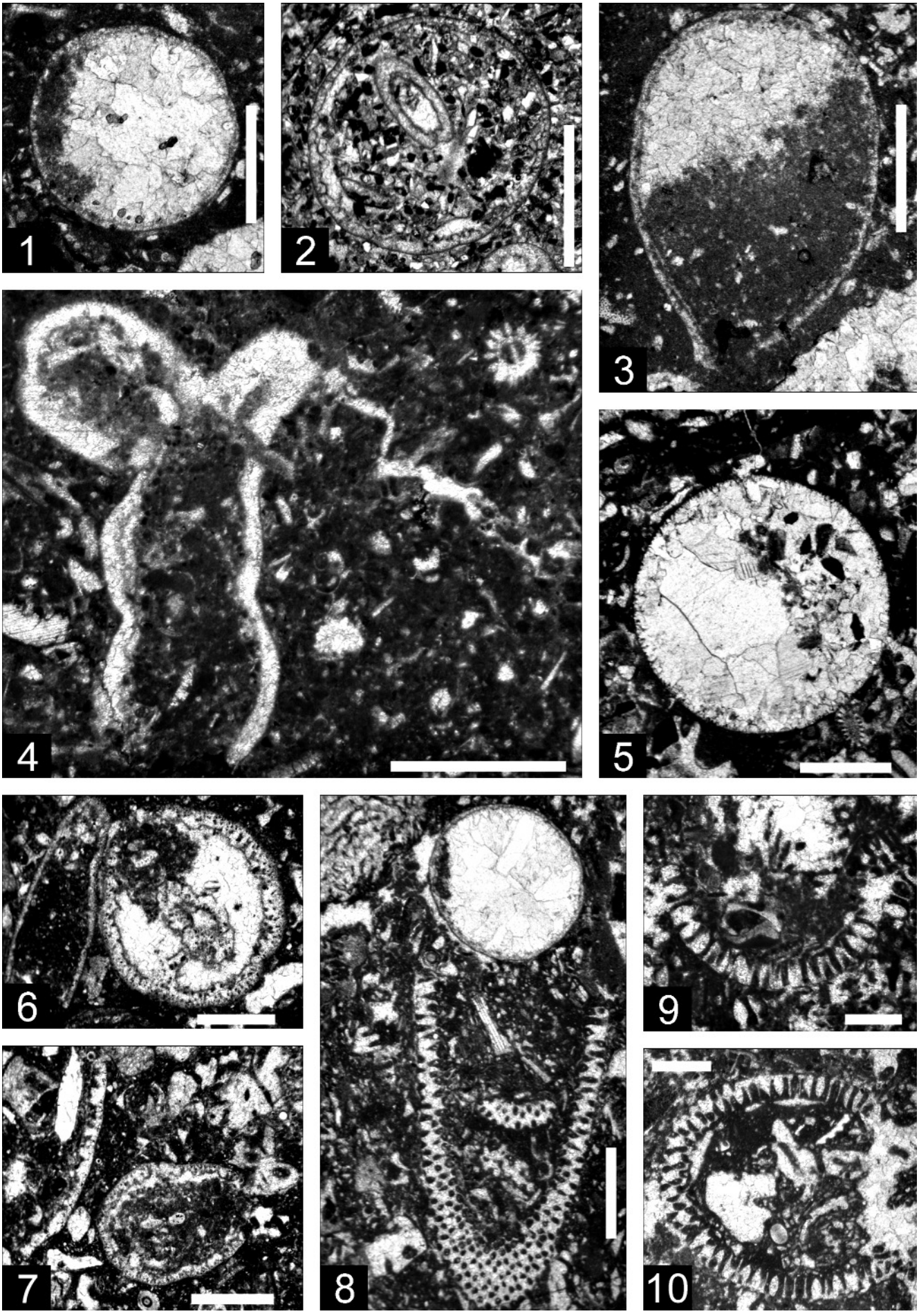
Plate 1

Figs. 1–3, 5-7, 8 (pars): *Permocalculus (Pyrulites) theresiensteinensis* n. sp.
Fig. 1: Transverse section.
Theresienstein, sample BSPG 2006/50.
Fig. 2: Transverse section of the "head" with broken "stalk" inside the medullary hollow.
Krumbachalm, sample 21.11.94/3.
Fig. 3: Holotype; oblique section showing pyriform thallus with bulbous "head" and partly visible the cylindro-conical "stalk".
Theresienstein, sample BSPG 2006/50.
Fig. 5: Transverse section of a completely recrystallized specimen, only last order pores are recognizable.
Atzl Reef, Brandenberg, sample BSPG 2006/52.
Fig. 6: Transverse section of the "head" (right) and broken "stalk" (left).
Krumbachalm, sample 15.11.94/1.
Fig. 7: Debris within bioclastic packstone. Note microproblematicum *Pienina oblonga* BORZA & MISIK.
Krumbachalm, sample 15.11.94/1.
Fig. 8: Bioclastic packstone with coral debris, transverse section of *Permocalculus (Pyrulites) theresiensteinensis* n. sp. and oblique section of the Dasycladale *Neomeris (Drimella)* cf. *jerinae* RADOIČIĆ.
Theresienstein, sample BSPG 2006/51.

Fig. 4: "Waxing-waning" type bifurcating thallus of *Permocalculus nikolapantici* RADOIČIĆ.
Note transverse section of the Dasycladale *Milanovicella hammudai* (RADOIČIĆ) (right above).
Haidach 1 profile, sample 16.7.95/9. Late Turonian – ? Early Coniacian.

Figs. 9–10: Different sections of the Dasycladale *Neomeris (Drimella)* cf. *jerinae* RADOIČIĆ.
Theresienstein, sample BSPG 2006/51.

Scale bar for all figures = 1 mm.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References

BARON-SZABO, R.C. (2001): Corals of the Theresienstein reef (Upper Turonian-Coniacian, Salzburg, Austria). – Bull. Biol. Soc. Washington, **10,** 257–268, Washington.

BUCUR, I.I. (1993): Some new or poorly known calcareous algae (Dasycladales, Gymnocodiaceae) in the Lower Cretaceous deposits from the Reşiţa-Moldova Nouă Zone (Southern Carpathians, Romania). – Revista Esp. Micropaleont., **35**/1, 93–126, Madrid.

BUCUR , I.I. (1994): Lower Cretaceous Halimedaceae and Gymnocodiaceae from Southern Carpathians and Apuseni Mountains (Romania) and the systematic position of the Gymnocodiaceae. – Beitr. Paläontol., **19**, 13–37, Wien.

BUCUR , I.I. (1999): Stratigraphic significance of some skeletal algae (Dasycladales, Caulerpales) of the Phanerozoic. – In: FARINACCI, A. & LORD, A. R. (Eds.): Depositional Episodes and Bioevents, Palaeopelagos Spec. Pub. **2**, 53–104, Rom.

DRAGASTAN, O., KUBE, B. & RICHTER, D.K. (2000): New Late Triassic calcareous algae from Hydra, Greece. – In: BUCUR, I.I. & FILIPESCU, S. (Eds.), Acta Palaeontol. Romaniae, **2** (1999), 139–156, Cluj-Napoca.

ELLIOTT, G.F. (1955): The Permian alga *Gymnocodium*. – Micropaleont., **1**/1, 83–90, London.

ELLIOTT , G.F. (1956): *Galaxaura* (calcareous algae) and similar fossil genera. – Journ. Washington Acad. Sci., **46**/11, 341–343, Washington D.C.

GRADSTEIN, F., OGG, J., SMITH, A. (2004) (Eds.): A geologic Time Scale. – 589 pp., Cambridge University Press.

GRANIER, B. & DELOFFRE, R. (1993): Inventaire critique des algues dasycladales fossiles IIº Partie – les algues dasycladales du Jurassique et du Crétacé. – Rev. Paléobiol., **12**/1, 19–65, Genf.

HÖFLING, R. (1985) : Faziesverteilung und Fossilvergesellschaftungen im karbonatischen Flachwasser-Milieu der alpinen Oberkreide (Gosau-Formation). – Münchner geowiss. Abh., **3**, 1–240, München.

MU, X. (1981): Upper Permian algae from Western Guizhou. – Acta Palaeont. Sinica, **20**/1, 34–48, Peking (in Chinese with English abstract).

MU, X. (1991): Fossil Udoteaceae and Gymnocodiaceae. – In: RIDING, R. (Ed.): Calcareous Algae and Stromatolites, 146–166, Berlin (Springer).

MU, X. & RIDING, R. (1983): Silicified gymnocodiacean algae from the Permian of Nanjing, China. – Palaeontol., **26**/2, 261–276, London.

PLÖCHINGER, B. (1973): Erläuterungen zur geologischen Karte des Wolfgangseegebietes 1 : 25.000. – 91 p., Wien (Geol. B.-A.).

RADOIČIĆ, R. (1984): New species and new subgenus of *Neomeris* (Dasycladaceae, green algae) from the Upper Cretaceous of Metohija. – Bull. Acad. Serbe Sci. arts Cl. Sci. nat. math. Sci. nat., **25**, 17–32, Beograd.

RADOIČIĆ, R. (2004): *Permocalculus nikolapantici* n. sp. (Udoteaceae ?) from the Upper Turonian of the NW Serbia. – Bull. T. CXXVIII Acad. Serbe sci. arts, Cl. sci. mathém. Nat., Sci. nat., **42**, 237–257, Beograd.

RADOIČIĆ, R. (2006): *Trinocladus divnae* and *Montiella filipovici* – a new species (Dasycladales, green algae) from the Upper Cretaceous of the Mountain Patrik (Mirdita Zone). – Ann. Géol. Pénins. Balkanique, 67, 65–87, Belgrade.

RADOIČIĆ, R. & RUBERTI, D. (1992): The occurrence of *Neomeris (Drimella) drimi* RADOIČIĆ (Dasycladales) in the Late Turonian of the Matese Mountains. – Paleopelagos, **1992**/2, 183–191, Roma.

ROUX, A. & DELOFFRE, R. (1990): Révision des Gymnocodiaceae (Algues rouges, Permien-Crétacé). Taxonomie, Biostratigraphie, Paléobiogéographie. 1re partie: Généralités sur la famille. – Rev. Micropaléont., **33**/2, 123–137, Paris.

SANDERS, D. (1998): Tectonically controlled Late Cretaceous terrestrial to neritic deposition, Gosau Group, Northern Calcareous Alps (Tyrol, Austria). – Facies, **39**, 139–178, Erlangen.

SANDERS , D. & BARON-SZABO, R. (1997): Coral-rudist bioconstructions in the Upper Cretaceous Haidach section (Northern Calcareous Alps, Austria). – Facies, **36**, 69–90, Erlangen.

SANDERS , D., BARON-SZABO,, R. & PONS, J. M. (1999): Short description of the largest Upper Cretaceous coral reef of the Eastern Alps (Theresienstein Formation nom. nov.), and a newly recognized coral-rudist buildup (Billroth Formation nom. nov.), Salzburg, Austria. – Geol. Paläont. Mitt. Innsbruck, **24**, 1–16, Innsbruck.

SANDERS, D. & PONS, J. M. (1999): Rudist formations in mixed siliciclastic-carbonate depositional environments, Upper Cretaceous, Austria: Stratigraphy, sedimentology, and models of development. – Palaeogeogr., Palaeoclimatol., Palaeoecol., **148**/4, 249–284, Amsterdam.

SCHLAGINTWEIT, F. (1991): On the occurrence of the genus *Permocalculus* ELLIOTT, 1955 (Calcareous algae, Gymnocodiaceae) in the Upper Cretaceous of the Northern Calcareous Alps (Branderfleck Formation, Gosau Formation) with the description of *Permocalculus gosaviense* n. sp. – Rev. Paléobiol., **10**/1, 37–46, Genève.

SCHLAGINTWEIT , F. (1992): Further record of calcareous algae (Dasycladaceae, Udoteacea, Solenoporaceae) from the Upper Cretaceous of the Northern Calcareous Alps (Gosau Formation, Branderfleck Formation). – Rev. Paléobiol., **11**/1, 1–12. Genève.

SCHLAGINTWEIT , F. (2004): Calcareous green algae from the Santonian Hochmoos Formation of Gosau (Northern Calcareous Alps, Austria, Lower Gosau Subgroup). – Zitteliana, **A44**, 97–103, München.

SENOWBARI-DARYAN, B. & ZAMPARELLI, V. (2005): Triassic Halimedaceans: New genera and species from the Alps, Sicily and Southern Apennines. – Rev. Esp. Micropaleontol., **37**/1, 141–169, Madrid.

STEUBER, T. (2001): Strontium isotope stratigraphy of Turonian-Campanian Gosau-type rudist formations in the Northern Calcareous Alps (Austria and Germany). – Cret. Res., **22**, 429–441, London.

WAGREICH, M. (1998): Lithostratigraphie, Fazies und Sequenzstratigraphie der Gosau-Gruppe von Bad Ischl und Strobl am Wolfgangsee (Oberturon-Maastricht, Nördliche Kalkalpen, Österreich). – Jb. Geol. B.-A., **141**/2, 209-234, Wien.

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