Geologia Croatica | 64/3 | 185–206 | 4 Figs. | 1 Tab. | 5 Pls. | Zagreb 2011

The dasycladalean algae of the Plassen Carbonate Platform (Kimmeridgian-Early Berriasian): taxonomic inventory and palaeogeographical implications within the platform-basin-system of the Northern Calcareous Alps (Austria, p.p. Germany)

Felix Schlagintweit

Lerchenauerstr. 167, D-80935 München, German; (ef.schlagintweit@t-online.de)

doi:104154/gc.2011.16

Geologia Croatica

ABSTRACT

The present paper compiles an up-to-date taxonomic inventory of dasycladalean green algae of the Kimmeridgian-Early Berriasian Plassen Carbonate Platform and their resediments in basinal sediments (e.g., Barmstein Limestone, Sillenkopf Formation) of the Northern Calcareous Alps of Austria (p.p. Germany). Today, the Plassen Carbonate Platform *sensu lato* (or Plassen Group) is divided into three independent carbonate platforms with radiolarite deep-water basins between: the Wolfgangsee Carbonate Platform to the north, the Plassen Carbonate Platform *sensu stricto* in a central position and the Lärchberg Carbonate Platform to the south. All together 42 taxa are reported from these platforms and associated resediments, each shortly commented and illustrated. Amongst these, there are taxa common in all three platforms, others exhibit restricted distributions. These peculiarities can be explained by the different lithostratigraphic and overall geodynamic evolution of the three platforms. In many cases, it allows the assignment of resediments in basinal series to a certain platform as a helpful palaeobiogeographical tool when other data are lacking.

Keywords: Dasycladales, taxonomy, palaeogeography, Northern Calcareous Alps, Austria

1. INTRODUCTION

The ocurrence of Upper Jurassic shallow-water limestones in the Northern Calcareous Alps is known since the midth of the 19th century (e.g., von HAUER, 1857; GEYER, 1884; MOJSISOVICS, 1868). In contrast to the huge Late Triassic Hauptdolomit/Dachstein carbonate platform, these Late Jurassic shallow-water carbonates should only form isolated reefs. In Early to Middle Jurassic times, the deposition was characterized by deep-water carbonates and/or cherty sediments. After tectonic movements in the early Late Jurassic, these shallow-water carbonates were described as resting transgressively above uplifted blocks of Triassic rocks (TRAUTH, 1950; PLÖCHINGER, 1964; TOLLMANN, 1965, 1981, 1985; MANDL, 1982; STEIGER & WURM, 1980). In contrast, recent results showed that this shallow-water evolution was installed in the areas of uplifting rises (e.g., Trattberg Rise, Brunnwinkl Rise, GAWLICK et al., 2007)

around the Oxfordian-Kimmeridgian boundary. Due to later erosion, these contacts are not more preserved and can only be reconstructed by analysis of mass-flow deposits in the adjacent basinal areas. All preserved shallow-water carbonate successions evolved in a shallowing upward manner above basinal deposits. From the topographic rises, representing nappe fronts (GAWLICK et al., 1999), the platforms prograded onto adjacent basin sequences delivering sediments to the deeper water areas (FRISCH & GAWLICK, 2003; GAWLICK & FRISCH, 2003). Results obtained from investigations of the last decade have shown that these today isolated occurrences belonged to at least three different shallow water areas today united as the Plassen Carbonate Platform (= Plassen Group in GAWLICK et al., 2009): the Wolfgangsee Carbonate Platform to the north, the central platform or Plassen Carbonate Platform *sensu stricto* (in part the former Plassen Limestone or Plassen Formation) and the Lärchberg Carbonate Platform to the south (Fig. 1). The exact palaeogeographic position of the different platform occurrences in the Northern Calcareous Alps can often not easily be reconstructed. Due to multiphase tectonic movements, many of these occurrences were sheared off from their basements and occur in an allochthonous position. Therefore, it is very often not easy to decide to which platform these occurrences belong especially when the normal underlying sequences are missing. For an exact reconstruction of the Jurassic palaeogeography and the tectonic motions, however, a detailed knowledge of the derivation of the shallow-water occurrences is essential. Beside some special sedimentological and microfacies features distinguishing the different platforms (GAWLICK et al. 2009, for details), also the microfaunistic and -floristic content in the different platforms can help for better palaeogeographic reconstructions.

Dasycladales are widespread constituents of the Plassen Carbonate Platform (e.g., FLÜGEL, 1964; FENNINGER & HÖTZL, 1967; STEIGER & WURM, 1980; DARGA & SCHLAGINTWEIT, 1991; DYA, 1992; SCHLAGINTWEIT & EBLI, 1999; RASSER & FENNINGER, 2002; SCHLAGINTWEIT et al., 2005) but also occur within the resediments of the Barmstein Limestone (FENNINGER, 1972; STEIGER, 1981; GAWLICK et al., 2005, 2010; SCHLAGINTWEIT & GAWLICK, 2007) or the Sillenkopf Formation (MISSONI

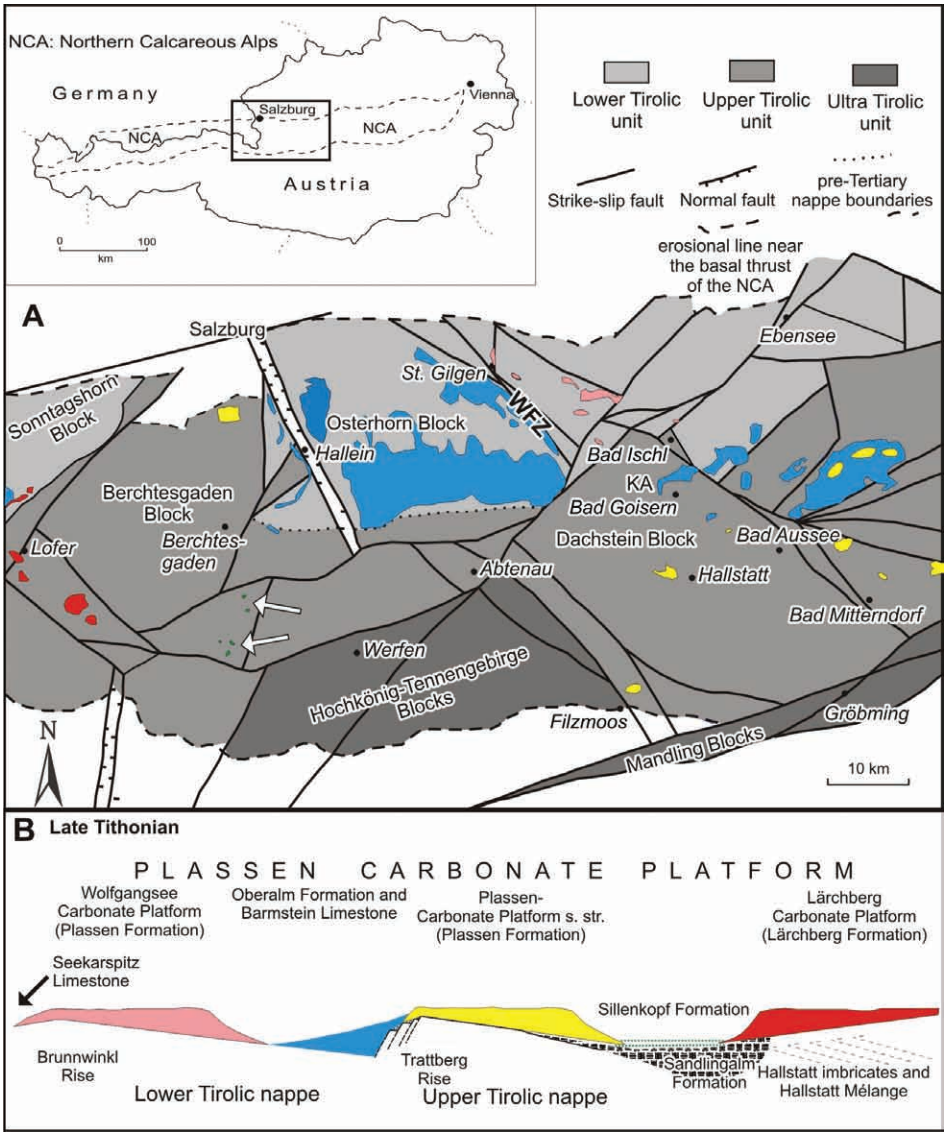


Figure 1: A) Tectonic map of the middle part of the Northern Calcareous Alps showing recent block configuration with occurrences of the Wolfgangsee Carbonate Platform (pink), Oberalm Formation + Barmstein Limestone (blue), central Plassen Carbonate Platform (yellow), Sillenkopf Formation (green) Lärchberg Carbonate Platform (red) (after FRISCH & GAWLICK, 2003, slightly modified). WFZ = Wolfgangsee Fault Zone. The two white arrows show the small outcrops of the Sillenkopf Formation. B) Platform-basin configuration during the Late Tithonian (based on GAWLICK et. al., 2009). Colours refer to A.

et al., 2001). Based on thin-section analyses of several thousand samples coming from various different localities of all three platforms and their resediments, an up-to-date inventory of the dasycladalean algae is presented and analyzed with respect to their occurrence/absence in different parts of the Late Jurassic to Earliest Cretaceous platform-basin-system of the Northern Calcareous Alps. Each taxon is illustrated and shortly commented. The distribution of the dasycladale flora is viewed and interpreted with respect to differences in the lithostratigraphic evolution of the platforms and their geodynamic framework.

2. DATA ANALYSIS

The algal inventory of the Plassen Carbonate Platform and their resediments consists of 24 genera; 3 taxonomically insufficiently known taxa are treated as gen. et sp. indet. (Tab. 1). One taxon, *Salpingoporella pygmaea* (GÜMBEL) is reported from all three platforms and the associated resediments. The number of taxa of the Plassen Carbonate Platform *s. str.* with 22 (+ 4 uncertain records) equals more or less the number known from the Lärchberg Carbonate Platform with 26. The number of known taxa of the Wolfgangsee Carbonate Platform with 9 is distinctly reduced in comparison to both the Plassen Carbonate Platform *s. str.* and the Lärchberg Carbonate Platform. Concerning the resediments of these shallow-water carbonates within basinal sediments, the inventory of taxa from the Barmstein Limestone with 27 is distinctly the highest, followed by the Sillenkopf Formation with 6 and the Rofan Breccia with 1 (3?) taxa. There are taxa that are restricted to the Wolfgangsee Carbonate Platform (1 taxon), the Barmstein Limestone (5,?7 taxa), the Plassen Carbonate Platform *s. str.* (1 taxon) and the most significantly to the Lärchberg Carbonate Platform (10 taxa). These differences and peculiarities are discussed later in the paper when each unit is dealed with separately.

The most frequent genus is *Clypeina* MICHELIN with 7 species followed by *Salpingoporella* PIA with 4 species. There are 7 species that can occur in great abundances in often more or less monospecific assemblages: *Clypeina jurassica* FAVRE, *Neoteutloporella socialis* (PRATURLON), *Campbelliella striata* (CAROZZI), *Neoteutloporella obsoleta* (CAROZZI), gen. et sp. indet. 2, occasionally also *Rajkaella bartheli* (BERNIER) and *Salpingoporella annulata* CAROZZI. From the 42 reported taxa, only 4 (~ 10 %) are reported from all the three platforms and the resediments of the Barmstein Limestone and the Sillenkopf Formation. Three taxa are reported from all three platforms and the Barmstein Limestone, but lacking in the Sillenkopf Formation.

In comparisons to other regions of the alpine-mediterranean realm, the dasycladalean flora of the Plassen Carbonate Platform of the Northern Calcareous Alps can be considered a comparable rich association (see Tab. 1 in RASSER & FENNINGER, 2002). The main reason therefore is the great variety of different platform palaeoenvironments each with characteristic associations. Furthermore, some typical environments, e.g., reefal and peri-reefal facies, occur twice (Late Kimmeridgian and Latest Tithonian-?earliest Berriasian) (Fig. 2). In this case we find common taxa such as *Salpingoporella pygmaea* in both reefal intervals and, due to differences in stratigraphic ranges, taxa that are either only occurring in the Kimmeridgian or Late Tithonian (e.g., *Neoteutloporella socialis*) reefal and peri-reefal carbonates.

2.1. Wolfgangsee Carbonate Platform

Data from the Wolfgangsee Carbonate Platform are available from Mount Falkenstein (KÜGLER et al., 2003), Mount Drei Brüder (GAWLICK et al., 2007) and Mount Bürgl (SCHLAGINTWEIT et al., 2008; GAWLICK & SCHLAGINTWEIT, 2010). All these occurrences start with resediments (breccias, mass-flows) above basinal series that can attain several tens of metres of thicknesses, followed by slope and reefal platform margin deposits. The rare debris of the dasycladale *Clypeina jurassica* FAVRE gives evidence of lagoonal influences that have so far not been detected in outcrops. The Wolfgangsee Carbonate Platform was drowned in the Late Tithonian (*intermedia* subzone), witnessed by calpionellid

Table 1: Distribution of Kimmeridgian to Early Berriasian dasycladales of the Northern Calcareous Alps within the Plassen Carbonate Platform *sensu lato*: Wolfgangsee Carbonate Platform (WCP), Plassen Carbonate Platform *sensu stricto* (PCP), Lärchberg Carbonate Platform (LCP) and the associated resediments, Seekarspitz Limestone (or Rofan Breccia) (SL), Barmstein Limestone (BL) and Sillenkopf Formation (SiF). Estimated abundances: * rare, ** common, *** abundant. 1) and 4) only locality Mount Jainzen; 2) only locality Mount Hornkogel and Mount Kehlstein; 3) only locality Mount Krahstein; 5) only locality Mount Falkenstein.

	SL	WCP	BL	PCP s. str.	SiF	LCP
Salpingoporella pygmaea	**	**	*	***	**	*
Clypeina jurassica	?	*	***	***	*	***
Griphoporella jurassica		*	**	**	*	*
Salpingoporella annulata		*1)	**	**	*	**
Clypeina loferensis		*1)	**	*		**
Clypeina cf. *parasolkani*		*1)	**	**		**
Petrascula bursiformis		*	*	**		*
Clypeina catinula						*
Cylindroporella? sp. 1						*
(= *Vederosella alimani*)						
Deloffrella quercifolipora						*
Neogyroporella gawlicki						**
Rajkaella sp.						*
Salpingoporella aff. *dinarica*						*
Terquemella sp. 1						*
Vermiporella? *tenuipora*						*
Zergabriella embergeri						*
Gen. et sp. indet. 1						*
Steinmanniporella svilajaensis				?	*	**
Chinianella scheympfluegi				**	*	*
Campbelliella striata			*2)	**		*
Clypeina aff. *solkani*			**	**		**
Cylindroporella? sp. 2			*	*		*
Otternstella lemmensis			*	*		*
Rajkaella bartheli			*	*		**
Salpingoporella sellii			*	*		*
Suppilulimaella? cf. *florifera*			*	*		*
Gyroporella? sp.				*3)		
Linoporella? sp.			*	*		
Gen. et sp. indet. sp. 2			***	**		
Neoteutloporella obsoleta			*	*		
Neoteutloporella socialis			**	*		
Pseudotrinocladus piae			*	*		
Terquemella sp. 2 aff. *concava*			*	*		
Clypeina aff. *estevezi*			*	?		
Clypeina cf. *marteli*			*	?		?
Humiella catenaeformis			*			
Gen. et sp. indet. 3			*			
Petrascula guembeli			*			
Selliporella neocomiensis			**			
Triploporella? sp.			*			
Dissocladella? n. sp.		*4)	?	?		
Suppiluliumaella delphica	?	*5)				
total number of taxa				42		
number of taxa for each unit	1 (?3)	9	27 (?28)	22 (?26)	6	26 (?27)
taxa restricted to a unit		1	5 (?7)	1		10

wackestones on the top of the series (GAWLICK & SCHLAGINTWEIT, 2010). The age of the basal resediments is unknown; the occurrence of the benthic foraminifera *Labyrinthina mirabilis* WEYNSCHENK and *Kilianina*? *rahonensis* FOURY & VINCENT, however, indicate a minimum age of Kimmeridgian. Therefore it is also unknown whether the reefal carbonates of the Wolfgangsee Carbonate Platform can stratigraphically be correlated with the first reefal interval of the Plassen Carbonate Platform *s. str.* (~ Late Kimmeridgian) or are somehow younger (?Latest Kimmeridgian-Early Tithonian). In conclusion, more data are needed for a detailed lithostratigraphic analysis of the Wolfgangsee Carbonate Platform. For illustrations of the microfacies types of the Wolfgangsee Carbonate Platform see GAWLICK et al. (2007, 2009), and GAWLICK & SCHLAGINTWEIT (2010).

Within the three platforms, the Wolfgangsee Carbonate Platform shows the lowest number of taxa with 9 species, some of these (*Clypeina loferensis, Clypeina parasolkani, Salpingoporella annulata*) are only reported from Mount Jainzen. *Suppiluliumaella delphica* (CARRAS) seems to be restricted to the Wolfgangsee Carbonate Platform. *Dissocladella*? n. sp. was detected at Mount Jainzen in peri-reefal limestones, *Suppiluliumaella delphica* (CARRAS) within similar facies only from Mount Falkenstein (see also FENNINGER & HOLZER, 1972, pl. 17, fig. 6, figured as *Macroporella gigantea* CAROZZI). Both taxa have so far not been reported for sure from any other locality within the Northern Calcareous Alps. As time equivalent facies is reported from many other localities of the Plassen Carbonate Platform, it is assumed that this has no special reason and future findings of both taxa can be expected. The reduced number of taxa of the Wolfgangsee Carbonate Platform as a whole can be explained by the stratigraphic restriction (Kimmeridgian-Early Tithonian) with respect for example to the Plassen Carbonate Platform *s. str.* on the one hand as the Wolfgangsee Carbonate Platform was drowned in the Late Tithonian (GAWLICK & SCHLAGINTWEIT, 2010). On the other hand, only at a small part of Mount Jainzen, interpreted as being a part of the former Wolfgangsee Carbonate Platform (see GAWLICK et al., 2007), carbonates refered to the closed lagoonal facies have been detected (unpubl. data). Therefore, most taxa characteristic for the lagoonal facies are missing in the Wolfgangsee Carbonate Platform.

2.2. Seekarspitz Limestone (or Rofan Breccia)

Following the current model of GAWLICK et al. (2010), the informal Seekarspitz Limestone (or Rofan Breccia), represents resediments of the Wolfgangsee Carbonate Platform that were shed towards the north (Fig. 1B). The name refers to Mount Rofanspitze in the Sonnwend Mountains of Tyrol. It is worth to mention, that the two widespread Late Jurassic foraminifers *Protopeneroplis striata* and *Labyrinthina mirabilis* were described from this locality (WEYNSCHENK 1950, 1951). In general, little is known about the micropaleontology of the Seekarspitz Limestone. Amongst the dasycladalean algae, only *Salpingoporella pygmaea* (GÜMBEL) is rather common. A possible fragment of *Suppiluliumaella delphica* (CARRAS) was observed in the Obersee Breccia in the Ybbsitz area of Lower Austria, which, according to GAWLICK et al. (2009), could represent an equivalent to the Rofan Breccia. Although more samples are needed to be studied, the number of dasycladalean algae will presumably not increase significantly as the thin-sections studied show a rather uniform micropaleontological content. Also, the algal content of the Wolfgangsee Carbonate Platform as the assumed source area is rather low.

2.3. Plassen Carbonate Platform *s. str.*

One of the best studied occurrences and most complete successions of the Plassen Carbonate Platform is the name giving type-locality Mount Plassen near Hallstatt (SCHLAGINTWEIT et al. 2003, 2005). It represents the most complete sequence from the initial shallowing-upwards to the final drowning phase. As it is the reference section for the Plassen Carbonate Platform *s. str.* its facies evolution with respect to dasycladalean algal occurrences is shortly presented (Fig. 2). In the initial phase of the Plassen Carbonate Platform, coral patch-reefs following slope deposits were installed at the platform margin(s), that, together with the associated peri-reefal deposits contain a dasycladale assemblage of *Salpingoporella pygmaea* (GÜMBEL), *Petrascula bursiformis* (ETTALON), *Griphoporella jurassica* (ENDO) and *Gyroporella*? sp. The patch-reef facies can be ascribed to the Late Kimmeridgian (GAWLICK et al., 2004, e.g. locality Krahstein). At the type-locality Mount Plassen, the platform-margin facies is partly replaced by *Labyrinthina* shoals devoid of dasycladales and followed by transgressive-regressive cycles of tidal flat and lagoonal deposits. The latter are typically dominated by an association of rivulariacean-type porostromate algae and an assemblage of dasycladales amongst *Salpingoporella annulata* CAROZZI, *Clypeina jurassica* FAVRE, *Clypeina* cf. *parasolkani* FARINACCI & RADOIČIĆ or *Campbelliella striata* (CAROZZI). Approximately around the Early-Late Tithonian boundary, these mainly sea-level controlled transgressive-regressive (T-R) cycles are followed by inner platform facies with typical lagoonal wackestones. Especially in the transitional beds (between the T-R-cycles and the inner lagoon) the dasycladale *Campbelliella striata* (CAROZZI) occurs in great abundances forming a monospecific assemblage (Fig. 2). In the Upper Tithonian lagoonal wackestones dasycladales are widespread with typical taxa including *Clypeina* cf. *parasolkani* FARINACCI & RADOIČIĆ, *Otternstella lemmensis* (BERNIER), *Clypeina loferensis* SCHLAGINTWEIT, DIENI & RADOIČIĆ, *Clypeina jurassica* FAVRE, gen. et sp. indet. 2 and *Rajkaella bartheli* (BERNIER). The latter three can occur in more or less monospecific assemblages, e.g., *Clypeina*- or *Rajkaella*-wackestones. The lagoonal carbonates are followed by back-reef, reefal platform margin and finally slope deposits. The total stratigraphic interval of the Plassen Carbonate Platform *s. str.* is Kimmeridgian to Early Berriasian at the type-locality Mount Plassen when the central platform became drowned during the Berriasian and was finally covered by Late Berriasian (*oblonga* calpionellid subzone) calpionellid limestones (GAWLICK & SCHLAGINTWEIT, 2006). From the Late Tithonian onwards, a new

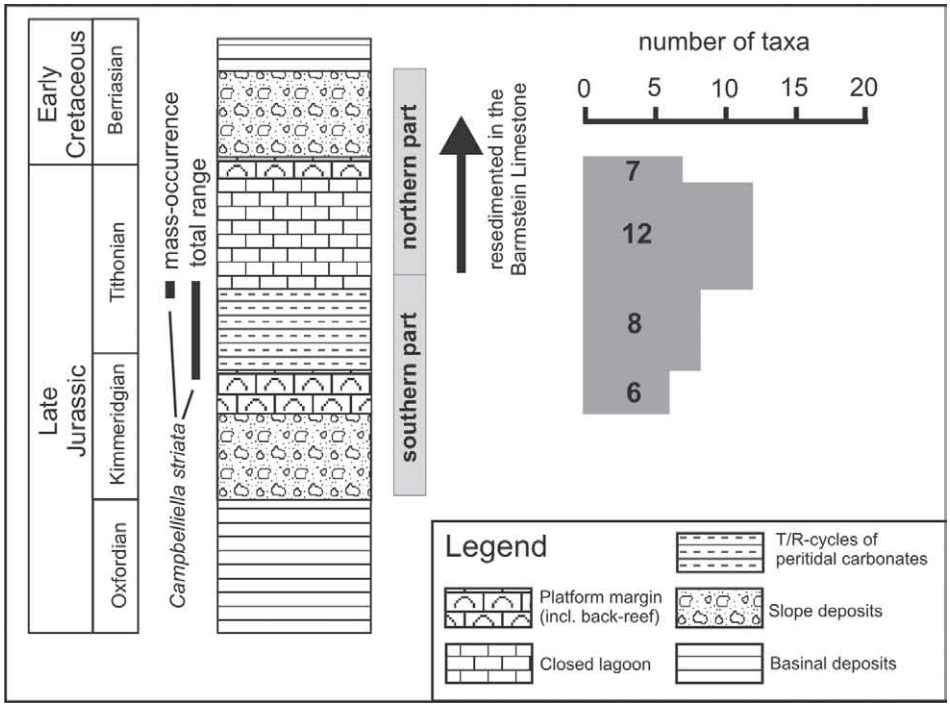


Figure 2: Distribution of dasycladalean algae within the Plassen Carbonate Platform *s. str.* The lithostratigraphic column refers to the most complete section of the type-locality Mount Plassen (SCHLAGINTWEIT et al., 2003, for details). Data used additionally are mainly from Mount Krahstein (see GAWLICK et al., 2004) and other localities. Note that the number of taxa for each unit of the schematized column can not be accumulated to the total number of taxa as some, e.g. *Salpingoporella pygmaea* (GÜMBEL), occur in more than one facies unit.

northward-directed palaeoslope was established. This part of the Plassen Carbonate Platform typically forms the source area for the Barmstein Limestone. It is important to stress, that almost all the different isolated occurrences of the Plassen Carbonate Platform s. str. comprise only a part of the Kimmeridgian-Early Berriasian lithostratigraphic section. Therefore, also the dasycladalean algae content may differ from one locality to the other. For illustrations of the microfacies types of the Plassen Carbonate Platform *s. str.* see STEIGER & WURM (1980), SCHLAGINTWEIT et al. (2003, 2005) and GAWLICK et al. (2009).

The dasycladalean algal inventory of the Plassen Carbonate Platform *s. str.* comprises definite 22 (possibly 26) taxa, a number similar compared to the Barmstein Limestone and the Lärchberg Carbonate Platform. For the systematics see SCHLAGINTWEIT et al. (2005). As already remarked previously, the about three times higher number with respect to the Wolfgangsee Carbonate Platform is easily explained by a complete Kimmeridgian-Early Berriasian succession including many species restricted either to internal or external platform environments. Although the overall facies variability in the Plassen Carbonate Platform *s. str.* is higher then in the Lärchberg Carbonate Platform, the total number of taxa is comparable as in the latter this trend is counterbalanced by a high number of taxa restricted to this platform.

2.4. Barmstein Limestone

The Barmstein Limestone is interpreted as representing mass -flows and turbiditic layers in basinal sediments (Oberalm Formation) of the Tauglboden Basin, with components mainly deriving from the adjacent Plassen Carbonate Platform and minor clasts from the underlying substratum (STEIGER, 1981; GAWLICK et al., 2005). The Barmstein Limestone witnesses the collapse of the Trattberg Rise around the Jurassic/Cretaceous boundary (GAWLICK & SCHLAGINTWEIT, 2009; MISSONI & GAWLICK, 2011). Many of the dasycladalean algae of the Barmstein Limestone occur within lithoclasts belonging to different facies zones of the Plassen Carbonate Platform *s. str.* (reefal, back-reefal, lagoonal environments). Based on microfacies aspects (e.g., bored clasts of slope facies; infiltration of fine-siltic matrix between clasts, etc.), an emersion of the northernmost part of the Trattberg Rise (being the source area of the Barmstein Limestone in the type-area) was assumed (SCHLAGINTWEIT et al., 2006; SCHLAGINTWEIT, 2008). With an assumed shallowing-upward, clasts of different facies zones (with its different algal contents) could become mixed together. The clasts were already lithified during resedimentation and therefore slightly older as the Latest Tithonian; clasts of Kimmeridgian age of the Plassen Carbonate Platform *s. str.* are extremely rare. One single finding of a specimen of *Labyrinthina mirabilis* WEYNSCHENK, however, evidences that occasionally also older strata (e.g., Kimmeridgian) were eroded or became uplifted before resedimentation. The reefal bioclasts of the Barmstein Limestone are assumed to belong to the second reefal belt that formed in Late Tithonian times at the northern rim of the Trattberg rise (GAWLICK & SCHLAGINTWEIT, 2009) (Fig. 2.). Within the associated calciturbidites isolated bioclasts of, Dasycladales such as *Clypeina jurassica* FAVRE or *Selliporella neocomiensis* (RADOIČIĆ) occur often exhibiting micritic coatings, indicating more or less synsedimentary transportation.

Referring to the general lithostratigraphic succession of the Plassen Carbonate Platfrom *s. str.* at the type-locality Mount Plassen, the erosion/reworking of the Barmstein Lime-

stone normally did not reach the *Campbelliella* limestones. These mark the major change from the Lower Tithonian transgressive-regressive cycles of the southern part of the Plassen Carbonate Platform to the Upper Tithonian closed lagoonal facies, followed by a northward facing second reefal belt (see SCHLAGINTWEIT et al., 2003; SCHLAGINTWEIT & GAWLICK (2007); GAWLICK & SCHLAGINTWEIT (2009) (Fig. 2)). The absence of *Campbelliella striata* (CAROZZI) in the Barmstein Limestone was already observed by STEIGER (1981, p. 277) and interpreted in terms of a source area where the species could not evolve. As discussed by SCHLAGINTWEIT & GAWLICK (2007, fig. 5), this observation can be better explained by the microfacies evolution and succession of the Late Tithonian closed lagoonal facies at Mount Plassen, where this species is absent. Two exceptions are the occurrences of *Campbeliella striata* (CAROZZI) at Mount Hornkogel (GAWLICK & SCHLAGINTWEIT, 2009) or Mount Kehlstein (MISSONI & GAWLICK, 2011; own observation). Referring to the classical definition, these sediments at Mount Hornkogel cannot be included in the Barmstein Limestone. Here, *C. striata* (CAROZZI) occurs as resedimented bioclasts, not within lithoclasts. A possible explanation could be that we are dealing with stratigraphically two different levels of "Barmstein Limestone": an older one (following the Agatha Formation) where *Campbelliella striata* (CAROZZI) may occur and a younger level where it is obviously absent. The older level might be placed into the interval Late Early Tithonian to the Early/Late Tithonian boundary, the younger in the Late Tithonian (*Crassicollaria* calpionellid subzone) to Early Berriasian. For example, the first resediments of Barmstein Limestone at Mount Tressenstein occur about 175 m below the first occurrences of both *Calpionella alpina-Crassicollaria intermedia* (GAWLICK & SCHLAGINTWEIT, 2009, fig. 5). In contrast to this "Barmstein Limestone" assumed to have been deposited in a more southern position on the Trattberg Rise (GAWLICK & SCHLAGINTWEIT, 2009), the northern occurrences Ewige Wand, Zwerchwand, Jochwand can be placed within the Late Tithonian *Crassicollaria* subzone. In all these occurrences, *Campbelliella striata* (CAROZZI) does occur neither as individual bioclast nor as component of reworked lithoclasts. Except *Gyroporella*? sp. and *Chinianella scheympflugi* HOFMANN, that both seem to be restricted to the Late Kimmeridgian southward-facing platform margin, all species known from the Plassen Carbonate Platform *s. str.* also occur in the Barmstein Limestone. Gen. et sp. indet 2, reported only from the Late Tithonian closed lagoonal facies of the Plassen Carbonate Platform *s. str.* as typical algal debris facies within wackestones (SCHLAGINTWEIT & GAWLICK, 2007, for details) is rather common in the Barmstein Limestone and occurs also at the type-locality of the Plassen Carbonate Platform *s. str.*, Mount Plassen. This constellation explains its absence in the resediments of the Sillenkopf Formation to the south and the northern Wolfgangsee Carbonate Platform; so far gen. et sp. indet. 2 has not been identified from the Lärchberg Carbonate Platform. Three taxa, *Neoteutloporella socialis* (PRATURLON), *Neoteutloporella obsoleta* CAROZZI and *Terquemella* sp. aff. *T. concava* BERNIER are restricted to the Late Tithonian reefal interval of the Plassen Carbonate Platform *s. str.* from where these became reworked within the Barmstein Limestone (SCHLAGINTWEIT, 2010, for details). Five (possibly seven) taxa have so far only been observed in the Barmstein Limestone assuming that these have both a biostratigraphic limitation (lacking in strata older than the Late Tithonian) and palaeogeographic limitation with an assumed occurrence at the northward-facing reefal margin of the Plassen Carbonate Platform *s. str.* that became eroded and resedimented. An example is *Selliporella neocomiensis* (RADOIČIĆ), having its first appearance in the Late Tithonian (see also GRANIER & BUCUR, 2010) and being typical for external platform environments (BUCUR & SĂSĂRAN, 2005). From the available data it can be assumed that the former platform margin parallel belt where *S. neocomiensis* (RADOIČIĆ) was dwelling in an assumed back-reef position (= the north-western edge of the Trattberg Rise; see MISSONI & GAWLICK, 2011, fig. 25A), has been eroded and resedimented as Barmstein Limestone within the Tauglboden Basin.

2.5. Lärchberg Carbonate Platform

The facies evolution of the Lärchberg Carbonate Platform is still not known in all details. As outstanding characteristic, contrasting the Plassen Carbonate Platform *s. str*. and the Wolfgangsee Carbonate Platform, an overall terrigenous input can be stated. It should be noted that the carbonates of the Plassen Carbonate Platform *s. str*. are highly pure limestones with a $CaC0_3$ content larger then 99 % (MOSHAMMER & LOBITZER, 2000). Due to new unpublished results, the classical scheme of FERNECK (1962) with a basal transgressive series (Lofer Beds or Lofer Unit, see also SANDERS et al., 2007, fig. 2) passing into a limestone complex, the Lärchberg Limestone, is completely the other way round. The clastic series represents a Late Tithonian to?earliest Berriasian final coarsening-upward series, with *Anchispirocyclina lusitanica* (EGGER) as one main characteristic microfossil. The Kimmeridgian parts are well documented with *Labyrinthina mirabilis* WEYNSCHENK and *Kilianina*? *rahonensis* FOURY & VINCENT, for example from Mounts Litzelkogel-Gerhardstein (e.g., DYA, 1992; own observations). The more or less absence of high-energy reefal platform margin deposits, e.g. well documented for the Plassen Carbonate Platform *s. str.* (e.g., GAWLICK et al., 2004; AUER et al., 2009), points to a different platform geometry, with a less inclined slope. For example, thrombolithic boundstones with abundant tubes of *Terebella lappiloides* MÜNSTER associated with *Crescentiella morronensis* (CRESCENTI) are a characteristic feature of the Kimmeridgian slope deposits of the Lärchberg Carbonate Platform, unreported from both the Plassen Carbonate Platform *s. str*. and the Wolfgangsee Carbonate Platform (see Fig. 49/1 in GAWLICK et al. 2009). This peculiar facies is directly comparable to the *Terebella*-"*Tubiphytes*" association *sensu* SCHMID (1996) refered to quiet water depositional settings well below the storm wave base and may in cases be indicative for oxygene depletion. Such an assumption would fit to the interpretation of the Sillenkopf Basin as a starved basin by MISSONI & GAWLICK (2011). In analogy to the northern Tethyan occurrences of

this peculiar facies, a comparable gentle northward-facing slope of the Lärchberg Carbonate Platform can be postulated. Equivalent to the Plassen Carbonate Platform *s. str.*, also the isolated occurrences of the Lärchberg Carbonate Platform may show differences in the lithostratigraphic column and thus, also does their dasycladalean algal content. For illustrations of the microfacies types of the Lärchberg Carbonate Platform see DARGA & SCHLAGINTWEIT (1991), DYA (1992) and SANDERS et al. (2007).

With 11 species (when including also *S. svilajaenis*) only recorded from the Lärchberg Carbonate Platform and resedimented in the Sillenkopf Formation, it is the most individualized character of all three platforms. Most of these taxa are reported from marly wackestones of an assumed internal infralittoral environment, *Zergabriella embergeri* (BOURGUEOULLEC & DELOFFRE) from the same palaeoenvironment additionally shows influences of fresh-water (e.g., JAFFREZO & RENARD, 1979). *Cylindroporella*? sp. 1 known only from the Lärchberg Carbonate Platform occurs in well-agitated back-reef/open lagoonal facies. The overall terrigeneous input, and partly assumed brackish influence of the Lärchberg Carbonate Platform, lacking in the Wolfgangsee Carbonate Platform and Plassen Carbonate Platform, are considered the main influencing factors for this discrete microflora.

2.6. Sillenkopf Formation

The Sillenkopf Formation comprises basinal sediments occurring between the Plassen Carbonate Platform *s. str*. to the north and the Lärchberg Carbonate Platform to the south. Type-locality is Mts. Sillenköpfe in the Berchtesgaden Alps (MISSONI et al., 2001). The siliciclastic detritus of the older orogen in the resediments (breccias, calciturbidites) evidences that the basin mainly received material from the south as transport from the north can be excluded in Late Jurassic times (see for example newest reconstruction for this time interval of MISSONI &

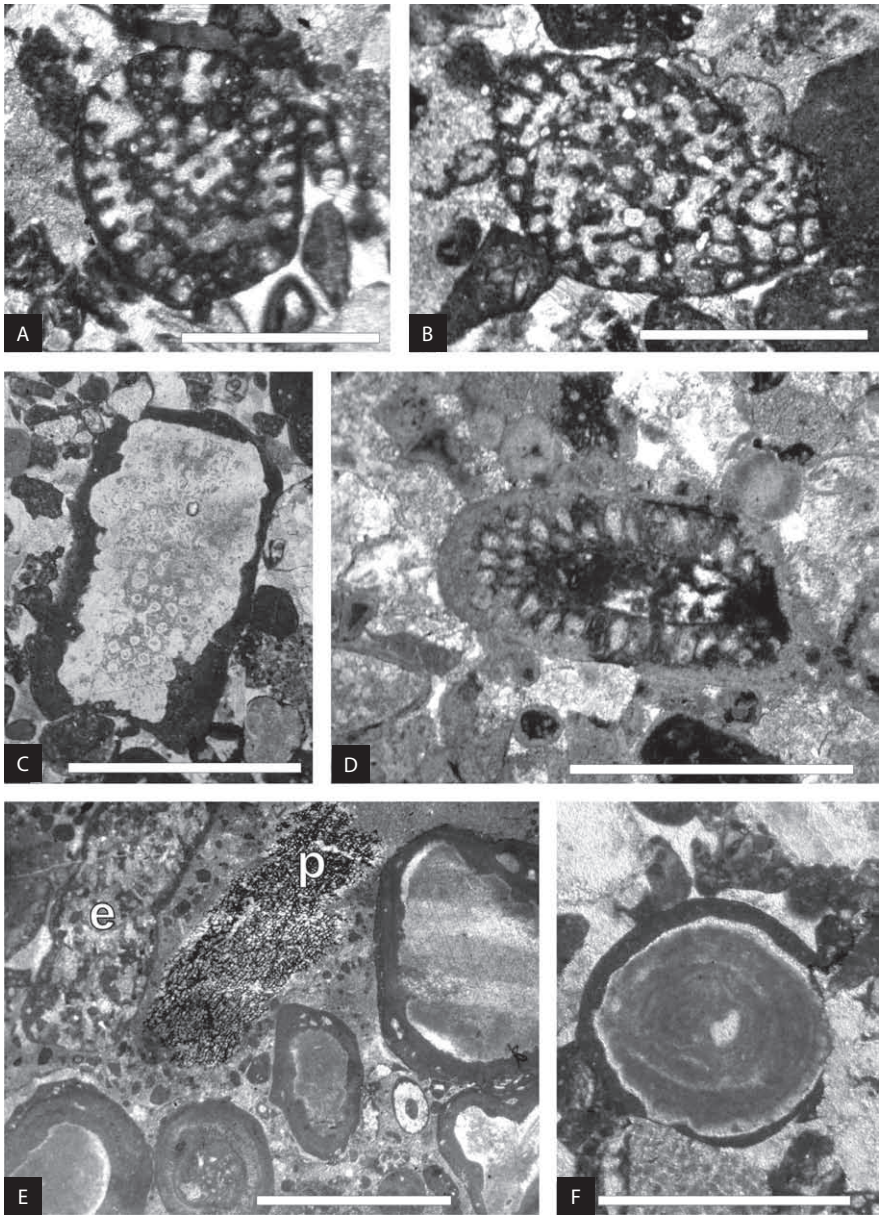


Figure 3: Aspects of microfacies and microfossils (benthic foraminifers, dasycladales) from the Sillenkopf Formation of Mount Sillenköpfe (A–D, E) and the Lärchberg Carbonate Platform (E). A–B: *Labyrinthina mirabilis* WEYNSCHENK exhibiting agglutination of siliciclastic grains. Sample Ber 31-1b-4 and Ber 31-1b-1. C: Tangential section of *Salpingoporella pygmaea* (GÜMBEL) showing silification. Sample Ber 31-5b-7. D: Oblique section of *Chinianella scheympflugi* HOFMANN showing silification. Sample Ber 51-5. E: Microfacies of the Lärchberg Formation with silicified oncoids, plant remains (p) and extraclasts (e). Mount Dietrichshorn, sample Die-170f. F: Silicified oncoid from the Sillenkopf Formation. Sample Ber 31-4B. Scale bars = 1 mm, except E = 2 mm.

GAWLICK, 2011, fig. 24D–E). Silicified oncoids reworked in these breccias are a further characteristic feature and are only known from the Lärchberg Carbonate Platform (own observations, Fig. 3E–F). The occurrence of *Labyrinthina mirabilis* WEYNSCHENK and occasionally *Kilianina*? *rahonensis* FOURY & VINCENT in the coarser breccias layers, indicates that the resediments are mainly of Kimmeridgian age. Dasycladalean thalli and test of larger foraminifers on occasion show silification (Fig. 3C–D). As a further characteristic of the resediments, siliciclastic grains may become incorporated especially in the tests of *Labyrinthina mirabilis* WEYNSCHENK (Fig. 3A–B), never observed in specimens from the central Plassen Carbonate Platform or the Wolfgangsee Carbonate Platform.

Dasycladalean algae occur as individual bioclasts in the breccias comprising a handful of taxa known from the whole Plassen Carbonate Platform system (Tab. 1). The occurrence of the alga *Steinmanniporella svilajaensis* (SOKAČ & VELIĆ) especially in proximal deposits of the Sillenkopf Formation, that is typical for the Kimmeridgian external facies of the Lärchberg Carbonate Platform (e.g., Mounts Litzelkogel-Gerhardstein), can also be considered an indication for the southern source area of the Lärchberg Carbonate Platform (see Tab. 1). The distinctly reduced algal content compared to the Barmstein Limestone is due to mostly synsedimentary resedimentation as individual bioclasts (often with taxa typical for external habitats) and the lack of mixed assemblages from clasts of different facies zones. In some aspects such as the co-occurrence of dasycladales with the foraminifers *Protopeneroplis striata* WEYNSCHENK and *Labyrinthina mirabilis* WEYNSCHENK and the presence of ooids, the resediments of the Sillenkopf Formation are similar to those of the Seekarspitz Limestone. The siliciclastic influx evidenced in the Sillenkopf Formation (MISSONI et al., 2001) is lacking in the latter as well as in the Barmstein Limestone.

3. TAXONOMIC INVENTORY

The occurring taxa (Tab. 1) are illustrated and listed in alphabetical order including short comments on occurrences and distribution in the Northern Calcareous, information on semiquantitative abundances (rare/common/abundant); in some cases taxonomic remarks are provided in addition.

Campbelliella striata (CAROZZI)

(Pl. 1, Fig. A)

Well recorded from the Late Kimmeridgian to Early Late Tithonian of the Plassen Carbonate Platform *s. str.* and rare from the Lärchberg Carbonate Platform. Individual specimens may occur in the Upper Kimmeridgian reefal facies; at Mount Plassen the species occurs in monospecific assemblages and great abundances (FENNINGER & HOLZER, 1972; SCHLAGINTWEIT et al., 2003). Occurrences: Barmstein Limestone (rare), Plassen Carbonate Platform *s. str.* (common to abundant), Lärchberg Carbonate Platform (rare).

Chinianella scheympflugi HOFMANN

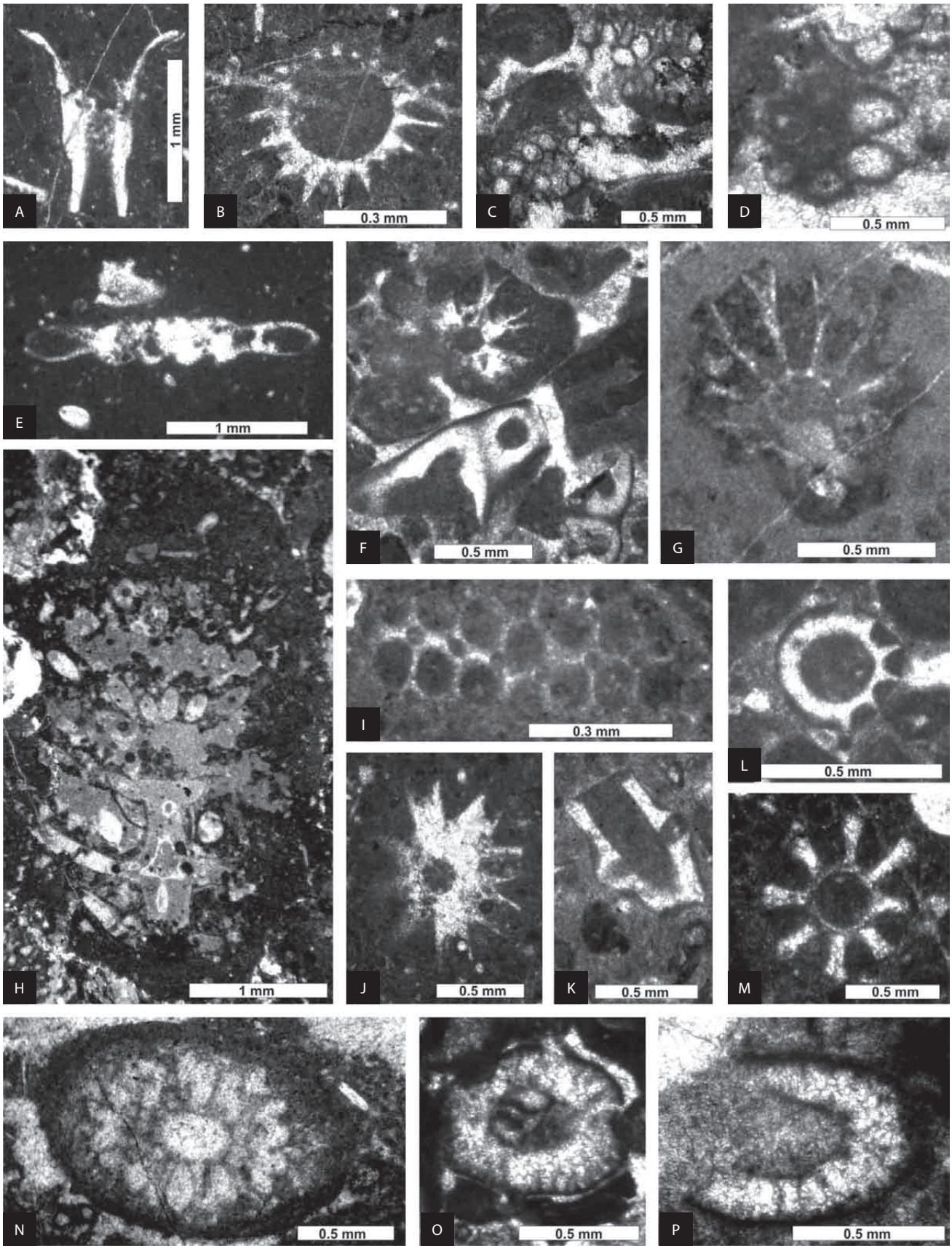
(Pl. 1, Fig. N, Text-Figure 3D)

This alga occurs in well-agitated back-reef to open lagoonal facies. It was described from the middle to Late Tithonian Ernstbrunn Limestone of Lower Austria by HOFMANN (1994) and has so far been recorded from Poland, Greece and Crimea/Ukraine (SCHLAGINTWEIT, 2011). In the Northern Calcareous Alps it is, besides from Tithonian strata, also recorded from the Kimmeridgian of the Plassen Carbonate Platform *s. str.*, e.g. Mount Rettenstein, or the Sillenkopf Formation. Occurrences: Plassen Carbonate Platform *s. str.* (common), Sillenkopf Formation (rare), Lärchberg Carbonate Platform (rare).

PLATE I

Dasycladales from the Late Jurassic-Earliest Cretaceous of the Northern Calcareous Alps: Plassen Carbonate Platform *s. str.* (A, F–G, L, N), Wolfgangsee Carbonate Platform (O–P), Lärchberg Carbonate Platform (C–D, H–I, K), Barmstein Limestone (B, E, M)

A *Campbelliella striata* (CAROZZI), Mount Trisselwand, sample MT 144.
B, E *Clypeina* aff. *estevezii* GRANIER, Mount Zwerchwand, sample B 86 (b) and Mount Trisselwand, sample T 166-3 (e).
C–D *Cylindroporella*? sp. 1, Mount Lärchberghörndl, sample KS 71.
F *Clypeina loferensis* SCHLAGINTWEIT, DIENI & RADOIČIĆ (above) and *Clypeina jurassica* FAVRE (below), Mount Plassen, sample A 3168.
G *Clypeina loferensis* SCHLAGINTWEIT, DIENI & RADOIČIĆ, Mount Plassen, sample A 3168.
H *Clypeina catinula* CAROZZI, Mount Lärchberghörndl, sample Lof 1.
I *Cylindroporella*? sp. 2, Mount Dietrichshorn, sample Die 170.
J *Clypeina* cf. *marteli* EMBERGER, locality Postalm, sample H-14.
K–L *Clypeina parasolkani* FARINACI & RADOIČIĆ, Mount Dietrichshorn, sample GS 135F and Mount Plassen, sample A 3167–1.
M *Clypeina* aff. *solkani* CONRAD & RADOIČIĆ, Mount Ewige Wand, sample E 36.
N *Chinianella scheympflugi* HOFMANN, Mount Plassen, sample PL 70d.
O–P *Dissocladella*? n. sp., Mount Jainzen, samples D 576 and D 575.


A
1 mm
B
0.3 mm
C
0.5 mm
D
0.5 mm
E
1 mm
F
0.5 mm
G
0.5 mm
H
1 mm
I
0.3 mm
L
0.5 mm
J
0.5 mm
K
0.5 mm
M
0.5 mm
N
0.5 mm
O
0.5 mm
P
0.5 mm

Clypeina catinula CAROZZI

(Pl. 1, Fig. H)

Only known from the Late Tithonian (?Earliest Berriasian) of the Lärchberg Carbonate Platform (SCHLAGINTWEIT & EBLI, 2000, for details). Occurrences: Lärchberg Carbonate Platform (common).

Clypeina aff. *estevezii* GRANIER

(Pl. 1, Figs. B, E)

Originally described from the Berriasian of southern Spain (GRANIER, 1988), it has also been recorded from the earliest Berriasian of Sardinia (DIENI & RADOIČIĆ, 2000). In the Northern Calcareous Alps it occurs in Late Tithonian strata. Occurrences: Barmstein Limestone (rare), Plassen Carbonate Platform *s. str.* (rare). Mention must be made, that from the Tithonian-Berriasian Torinosu Limestone of Japan ENDO (1961) described a new taxon as "*Calcisphera*" *jurassica* that seems to belong to a shallow tangential section of a *Clypeina* species with numerous and distally unfused laterals such as for instance *C. estevezii* or others.

Clypeina jurassica FAVRE

(Pl. 1, Fig. F pars)

A widespread taxon that occurs in great abundances in closed/open lagoonal wacke-/packstones. Depending on the platform morphology, individual verticil fragments are also found in external platform facies. The common occurrence in calciturbidites of the Barmstein Limestone can be explained by the retrograde erosion of the platform margins affecting also lagoonal environments. Concerning the systematic, *C. jurassica* FAVRE *vs*. *Clypeina sulcata* (ALTH) see comments in SCHLAGINTWEIT et al. (2009). Occurrences: Wolfgangsee Carbonate Platform (rare), Barmstein Limestone (common), Plassen Carbonate Platform *s. str.* (abundant), Sillenkopf Formation (rare), Lärchberg Carbonate Platform (abundant).

Clypeina loferensis SCHLAGINTWEIT, DIENI & RADOIČIĆ

(Pl. 1, Fig. F pars, G)

Illustrated from the Lärchberg Carbonate Platform as *Actinoporella podolica* (ALTH) by DYA (1992). Occurrences: Barmstein Limestone (common), Plassen Carbonate Platform *s. str.* (common), Lärchberg Carbonate Platform (abundant).

Clypeina cf. *marteli* EMBERGER

(Pl. 1, Fig. J)

Very rare sections with stellate outline, elongated laterals only fused at the proximal parts and comparable small main axis can be referred with some restrictions to *Clypeina marteli* EMBERGER (e.g., BASSOULLET et al., 1978, pl. 38, fig. 1; DIENI & RADOIČIĆ, 2000, pl. 5, figs. 6–7). Occurrences: Barmstein Limestone (rare, e.g., GAWLICK et al., 2005, fig. 13/5), possible occurrences: Plassen Carbonate Platform *s. str.*, Lärchberg Carbonate Platform.

Clypeina cf. *parasolkani* FARINACCI & RADOIČIĆ

(Fig. 1, Figs. K–L)

This species was originally described from the Berriasian of Turkey (FARINACCI & RADOIČIĆ, 1991). A longitudinal section cutting 15 succesive verticils has been illustrated by STEIGER & WURM (1980, pl. 26, fig. 2) as *Salpingoporella annulata* CAROZZI from the Late Kimmeridgian of the Plassen Carbonate Platform *s. str.* of Mount Krahstein. Occurrences: Barmstein Limestone (common), Plassen Carbonate Platform *s. str.* (common), Lärchberg Carbonate Platform (common).

Clypeina aff. *solkani* CONRAD & RADOIČIĆ

(Pl. 1, Fig. M)

This *Clypeina* with massive calcification can be compared with *Clypeina solkani* CONRAD & RADOIČIĆ. It typically occurs in the Upper Tithonian wackestones of the closed lagoonal facies. According to GRANIER & DELOFFRE (1993) this species should have an assumed total stratigraphic range of Oxfordian-Albian, SOKAČ (1996, p. 26) indicates a Hauterivian to Barremian age doubting both older and younger occurrences. Occurrences: Limesone (common), Plassen Carbonate Platform *s. str.* (common), Lärchberg Carbonate Platform (common).

Cylindroporella? sp. 1

(Pl. 1, Figs. C–D)

This alga has been detected only at Mount Lärchberghörndl in well washed-out packstones of a back-reef to open lagoonal facies; age: Late Kimmeridgian or Tithonian. Such a microcrystalline calcification is known from other cylindriporelliform dasycladales: *Cylindroporella taurica* CONRAD & VAROL, 1990 (Albian of Turkey) and *Vederosella*? *alimani* DRAGASTAN, 1999 (Late Hauterivian of Romania). Similar forms were illustrated also by BUCUR et al. (2000) from the Valanginian-Hauterivian of Turkey. Occurrences: Lärchberg Carbonate Platform (rare).

Cylindroporella? sp. 2

(Pl. 1, Fig. I)

A very rare alga occurring in wackestone facies and reported from the Barmstein Limestone, the Plassen Carbonate Platform *s. str.* and the Lärchberg Carbonate Platform. The tangential section shown in Plate 1, Figure I can be compared with *Cylindroporella faronensis* MASSE, BUCUR, VIRGONE & DELMASSO, 1999 from the Berriasian-Valanginian of SE France. Occurrences: Barmstein Limestone (rare), Plassen Carbonate Platform *s. str.* (rare), Lärchberg Carbonate Platform (rare).

Dissocladella? n. sp.

(Pl. 1, Figs. O–P)

This tiny dasycladale with supposedly two orders of laterals is so far only reported from the Wolfgangsee Carbonate Platform of Mount Jainzen where it typically occurs in peri-ree-

fal limestones. The strong recrystallization and so far poor available material does not allow for a detailed taxonomic description at the moment. Occurrences: Wolfgangsee Carbonate Platform (rare).

Deloffrella quercifoliipora GRANIER & MICHAUD

(Pl. 2, Fig. A)

This species has so far only been reported from the Lärchberg Carbonate Platform of Mount Dietrichshorn associated besides others, with *Zergabriella embergeri* (BOUROULLEC & DELOFFRE). Occurrences: Lärchberg Carbonate Platform (rare).

Gen. et sp. indet 1

(Pl. 2, Fig. B)

Very rare dasycladalean alga showing thallus annulation and numerous laterals. Shape of laterals, orders and connection to the main axis unknown. The illustrated specimens comes from Mount Dietrichshorn; age: Tithonian? Occurrences: Lärchberg Carbonate Platform (rare).

Gen et sp. indet 2

(Pl. 2, Figs. C–D)

This alga typically forms monospecific debris facies (wackestones) (see SCHLAGINTWEIT & GAWLICK, 2007, for details). It is recorded from Upper Tithonian wackestones of the Plassen Carbonate Platform *s. str.* and equivalent clasts resedimented in the mass-flows of the Barmstein Limestone. Details of this alga showing a comparable wide main axis and segmentation recalling the genus *Neomizzia* LEVY, are unknown. Occurrences: Barmstein Limestone (abundant), Plassen Carbonate Platform *s. str.* (common).

Gen et sp. indet 3

(Pl. 2, Fig. G)

Very rare and large Dasycladale with massive calcification and numerous primaries. The proximal narrow primaries with a peduncle then gently widening and clusters of secondaries point to the genus *Triploporella* STEINMANN. Occurrences: Late Tithonian Barmstein Limestone of Mount Sandling.

Griphoporella jurassica (ENDO)

(Pl. 2, Fig. E)

Rather widespread form in reefal platform margin deposits occurring often as debris. For the taxonomy see BUCUR & SCHLAGINTWEIT (2009). Occurrences: Wolfgangsee Carbonate Platform (rare), Barmstein Limestone (common), Plassen Carbonate Platform *s. str.* (common) and Lärchberg Carbonate Platform (rare).

Gyroporella? sp.

(Pl. 2, Figs. H, J)

So far, this taxon has only been reported from Upper Kimmeridgian platform margin deposits of Mount Krahstein, belonging to the Plassen Carbonate Platform *s. str.* (SCHLAGINTWEIT & EBLI, 1999, for details). Occurrences: Plassen Carbonate Platform *s. str.* (rare).

Humiella catenaeformis (RADOIČIĆ)

(Pl. 2, Fig. I)

This alga was so far unknown from the Northern Calcareous Alps, it is very rarely reported only from the Late Tithonian Barmstein Limestone. Note that in the Dinarids, HUSINEC & SOKAČ (2006) established a *Clypeina parasolkani-Humiella catenaeformis* interval zone (Berriasian-earliest Valanginian). The stratigraphic relevance was already discussed by SOKAČ (1987) previously. The shown specimen comes from the Barmstein Limestone of Mount Zwerchwand intercalated in calpionellid wackestones with *Crassicollaria intermedia* (GAWLICK et al., 2010, for details). Therefore, the first appearance of *Humiella catenaeformis* (RADOIČIĆ) has to be changed from Berriasian to Late Tithonian. Occurrences: Barmstein Limestone (rare).

Linoporella? sp.

(Pl. 3, Figs. A–B)

This rare alga is known only from the (Lower) Tithonian of the Plassen Carbonate Platform *s. str.* where it occurs in well washed-out packstones of a back-reef to open lagoonal facies. Occurrences: Barmstein Limestone (rare), Plassen Carbonate Platform *s. str.* (rare).

Neoteutloporella socialis (PRATURLON)

(Pl. 3, Fig. C)

Neoteutloporella obsoleta CAROZZI

(Pl. 3, Fig. D)

Restricted to the Upper Tithonian reefal interval of the Plassen Carbonate Platform *s. str.* where it became resedimented northwards within the Barmstein Limestone (see SCHLAGINTWEIT, 2010, for details). Lacking at the Mt. Barmsteine type-locality, *N. socialis* (PRATURLON) was described by FENNINGER (1972) from the so-called "Barmsteinkalk-Bank B2" of the Osterhorn Mountains. Thus, it has a restricted palaeogeographic occurrence within the Northern Calcareous Alps and also a stratigraphic importance as it lacks in strata older than the Late Tithonian. *N. socialis* (PRATURLON) and *N. obsoleta* CAROZZI are lacking in the Lärchberg Carbonate Platform as this second reefal interval seems to be absent there. Occurrences: Barmstein Limestone (common), Plassen Carbonate Platform *s. str.* (rare).

Neogyroporella? gawlicki SCHLAGINTWEIT

(Pl. 3, Figs. E–F)

Restricted to the Lärchberg Carbonate Platform (SCHLAGINTWEIT, 2005). According to BARATTOLO et al. (2008), the genus *Neogyroporella* YABE & TOYAMA could represent a synonym of *Holosporella* PIA and consequently *N.*?

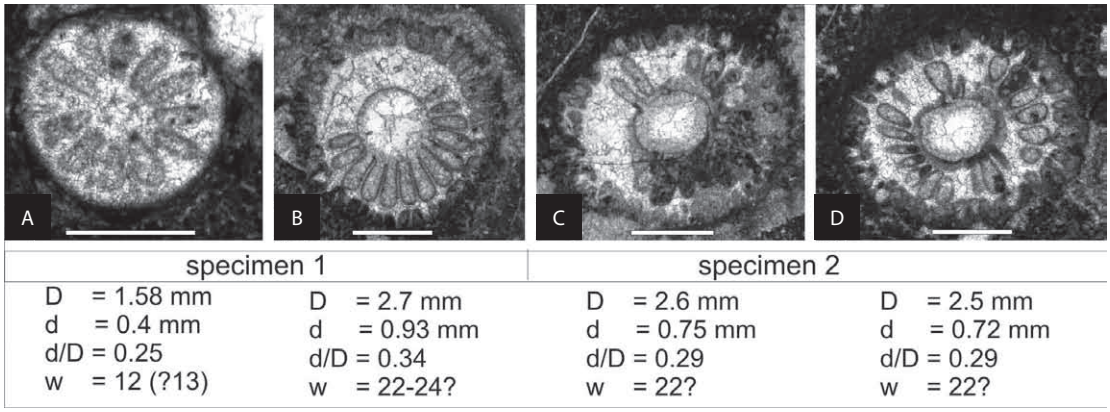


Figure 4A–D: Sections through different levels of the thallus stipe of *Petrascula bursiformis* (ETTALON), Mount Jainzen, Wolfgangsee Carbonate Platform. All specimens are from different thin-sections of the same sample. Compare the different morphological aspect of the primaries (A versus D). In A (assumed lower portion of the stipe), only two orders of laterals are discernible. D = outer diameter, d = inner diameter, w = number of primaries.

gawlicki SCHLAGINTWEIT a representative of this genus. It should be mentioned, that this alga has so far been recorded only from the Northern Calcareous Alps and within an Upper Jurassic pebble from the Losenstein Formation (SCHLAGINTWEIT, 1991, pl. 1, fig. 7). Occurrences: Lärchberg Carbonate Platform (common).

Otternstella lemmensis (BERNIER)

(Pl. 3, Fig. G)

Typical alga of the closed lagoonal facies, occurring in Upper Tithonian wackestones with *Clypeina* species, *Rajkaella bartheli* (BERNIER) and *Salpingoporella annulata* CARROZZI. Occurrences: Barmstein Limestone (rare), Plassen Carbonate Platform *s. str.* (rare), Lärchberg Carbonate Platform (rare).

Petrascula bursiformis (ETTALON)

(Pl. 3, Fig. H, Text-Figure 4)

Common species, especially in the Upper Kimmeridgian platform reefal interval (e.g. Mount Jainzen, Mount Krahstein, Mount Rettenstein). For the occurrences in the Barmstein Limestone it is unclear whether these derive from the Upper Kimmeridgian or Late Tithonian reefal intervals.

The occurrence of three orders of laterals in the stalk part of the thallus is well recorded (BERNIER, 1979, 1984; BUCUR & SĂSĂRAN, in press). Thin-sections prepared successively from the same piece of sample have shown that the thinner proximal part of the stalk is characterized by a reduced number of presumably only two orders of laterals (Fig. 4a). It must be noted that in the fundamental work of BASSOULLET et al. (1978) the specimens of "*Petrascula bursiformis*" shown in plate 24, figs. 1–5, 7–8 have been provided by BERNIER. In his revisional work on the genus *Petrascula* one year later, BERNIER (1979) assigned the specimen shown in Pl. 24, fig. 2 in BASSOULLET et al. (1978) as holotype for the new species *Petrascula guembeli*; also the specimen illustrated in pl. 24, fig. 1 belongs to this species. Occurrences: Wolfgangsee Carbonate Platform (rare), Barmstein Limestone (rare), Plassen Carbonate Platform *s. str.* (common), Sillenkopf Formation (?).

Petrascula guembeli BERNIER

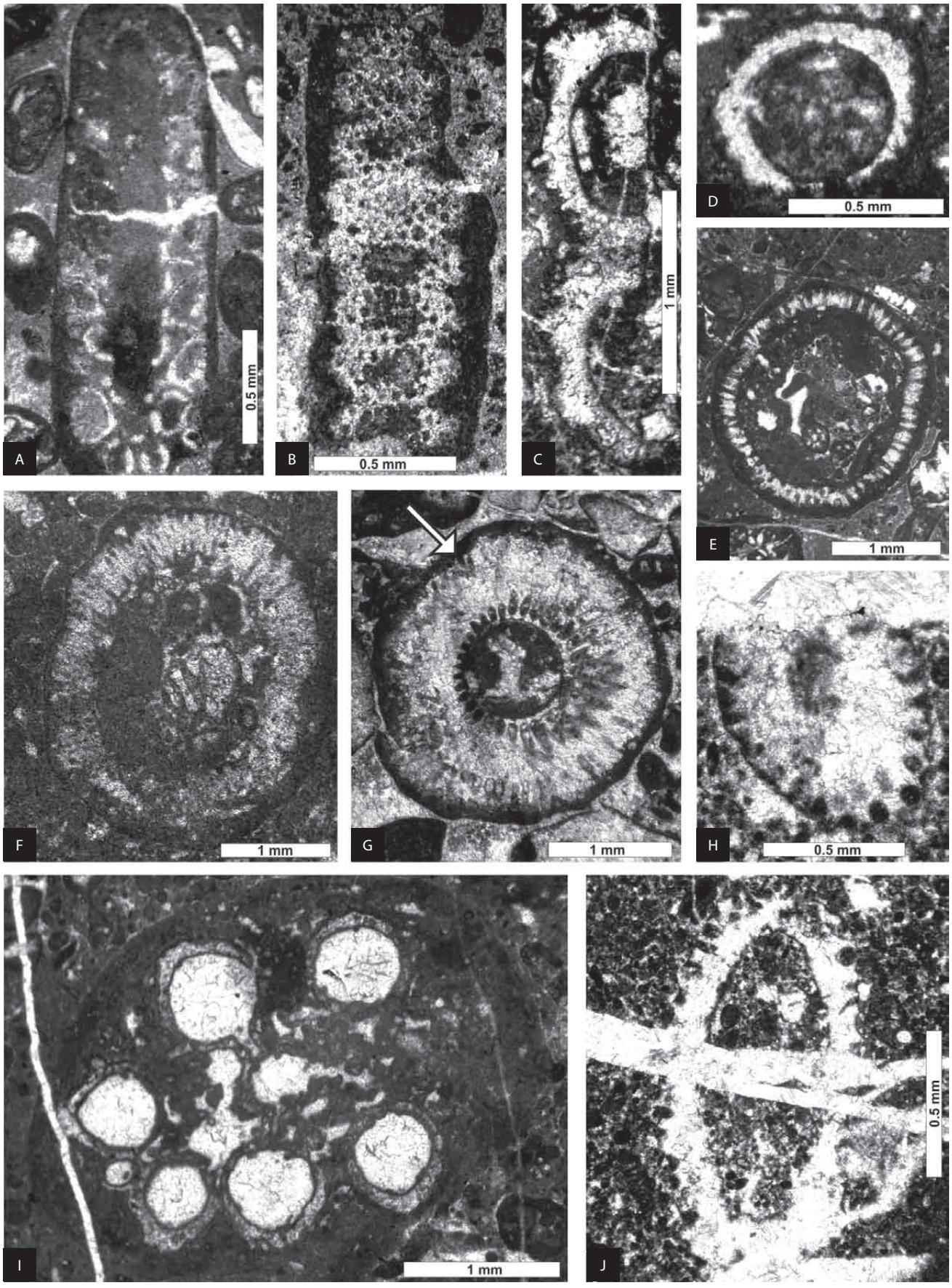
(Pl. 3, Figs. I–J, Pl. 4, Fig. J)

Rare specimens only recorded from the Barmstein Limestone (Mount Barmsteine, Mount Sandling, Mount Trisselwand). This species was described by BERNIER (1979) from the Late Kimmeridgian of Switzerland. The well-cal-

PLATE 2

Dasycladales from the Late Jurassic-Earliest Cretaceous of the Northern Calcareous Alps: Plassen Carbonate Platform *s. str.* (C, H, J), Lärchberg Carbonate Platform (A–B), Barmstein Limestone (D–G, I).

A *Deloffrella quercifoliipora* GRANIER & MICHAUD, Mount Dietrichshorn, sample Die 170.
B Gen. et sp. indet. 1, Mount Dietrichshorn, sample GAG 21b.
C Gen. et sp. indet. 2, Mount Trisselwand, sample MT 614.
D Gen. et sp. indet. 2, Mount Barmsteine, sample Ber 30-2b-3.
E *Griphoporella jurassica* (ENDO), Mount Zwerchwand, sample B 87.
F *Pseudotrinocladus piae* (DRAGASTAN), Mount Zwerchwand, sample B 45.
G Gen. et sp. indet. 3. Note a bush of three secondaries (arrow). Mount Sandling, sample D 765.
H, J *Gyroporella*? sp., Mount Krahstein, samples Krah 122–5, 122–9.
I *Humiella catenaeformis* (RADOIČIĆ), Mount Zwerchwand, sample B 82.


A
0.5 mm
B
0.5 mm
C
1 mm
D
0.5 mm
E
1 mm
F
1 mm
G
1 mm
H
0.5 mm
I
1 mm
J
0.5 mm

cified stalk (Pl. 4, Fig. J, figured as *Thyrsoporella alpina* DRAGASTAN & RICHTER in GAWLICK et al., 2005) shows the three order of laterals, whereas in the head mostly only the last order laterals are preserved (Pl. 3, Fig. I). In rare cases, parts of the first and second order laterals may be preserved also in the head portion (Pl. 3, Fig. J). The stratigraphy of *P. guembeli* BERNIER is generally indicated as Kimmeridgian (BUCUR, 1999, Tab. 9). Concerning the specimens in the Barmstein Limestone, it is unclear whether these belong to the Upper Kimmeridgian or Upper Tithonian reefal interval. Occurrences: Barmstein Limestone (rare).

Pseudotrinocladus piae (DRAGASTAN)

(Pl. 2, Fig. F)

Very rare and large alga with numerous pores (laterals?) so far recorded from the Late Tithonian Barmstein Limestone and the Plassen Carbonate Platform *s. str.*. This alga was originally described from Late Tithonian of Romania (DRAGASTAN, 1971, 1989). RADOIČIĆ (2005) considered *P. piae* (DRAGASTAN) a synonym of *Griphoporella*? *perforatissima* CAROZZI and preferred a udoteacean rather then a dasycladalean nature, a view that cannot be commented on the basis of the available sections. The irregular denticulated transition of the calcified part towards the central hollow could be an indication for such an interpretation; in this case the central part would correspond to a decalcified or not calcified medullary zone. Occurrences: Barmstein Limestone (rare), Plassen Carbonate Platform *s. str.* (rare).

Rajkaella bartheli (BERNIER)

(Pl. 4, Fig. A)

Typical alga of the closed lagoonal facies. In the Lärchberg Carbonate Platform, wackestones with abundant debris of this alga occur associated with the larger benthic foraminifer *Anchispirocyclina lusitanica* (EGGER). Occurrences: Barmstein Limestone (rare), Plassen Carbonate Platform *s. str.* (rare), Lärchberg Carbonate Platform (common).

Rajkaella sp.

(Pl. 4, Fig. B)

Occurrence: Lärchberg Carbonate Platform (rare).

Salpingoporella annulata CAROZZI

(Pl. 4, Fig. F)

One of the most widespread species in the Plassen Carbonate Platform *sensu lato* occurring in closed and open lagoonal limestones. Occurrences: Wolfgangsee Carbonate Platform (rare), Barmstein Limestone (common), Plassen Carbonate Platform *s. str.* (common), Sillenkopf Formation (rare), Lärchberg Carbonate Platform (common).

Salpingoporella aff. *dinarica* RADOIČIĆ

(Pl. 4, Fig. C)

Occurrences: Only known from the Late Tithonian?-Early Berriasian? of the Lärchberg Carbonate Platform (Mount Dietrichshorn) (rare).

Salpingoporella pygmaea (GÜMBEL)

(Pl. 4, Fig. E, Text-Figure 3C)

One of the most widespread species in the Plassen Carbonate Platform *sensu lato*. This alga is restricted to agitated peri-reefal platform margin deposits; therefore *S. pygmaea* is comparable rare in the Lärchberg Carbonate Platform. According to CARRAS et al. (2006), *Salpingoporella johnsoni* (DRAGASTAN) and *Salpingoporella enayi* BERNIER, recorded from the Plassen Carbonate Platform *s. str.* (SCHLAGINTWEIT & EBLI, 1999; SCHLAGINTWEIT et al. 2005) are synonyms of *S. pygmaea.* Occurrences: Wolfgangsee Carbonate Platform (common), Barmstein Limestone (rare), Plassen Carbonate Platform *s. str.* (common), Sillenkopf Formation (common), Lärchberg Carbonate Platform (rare).

Salpingoporella sellii (CRESCENTI)

(Pl. 4, Fig. D)

Due to the unusual microgranular pattern of calcification, the attribution of this alga to the genus *Salpingoporella* is ambiguous (e.g., CARRAS et al., 2006, p. 460). Consequently, when calcification pattern are considered of generic importance, also *Salpingoporella dinarica* RADOIČIĆ must be treated in an adequate manner. Occurrences: Barmstein Limestone (rare), Plassen Carbonate Platform *s. str.* (rare), Lärchberg Carbonate Platform (rare).

PLATE 3

Dasycladales from the Late Jurassic-Earliest Cretaceous of the Northern Calcareous Alps: Plassen Carbonate Platform *s. str.* (A–C, D, H), Lärchberg Carbonate Platform (E–F), Barmstein Limestone (G, I–J).

A–B *Linoporella?* sp., Mount Plassen, samples PL 80 and PL 73a.

C *Neoteutloporella socialis* (PRATURLON), Mount Trisselwand, sample MT 356.

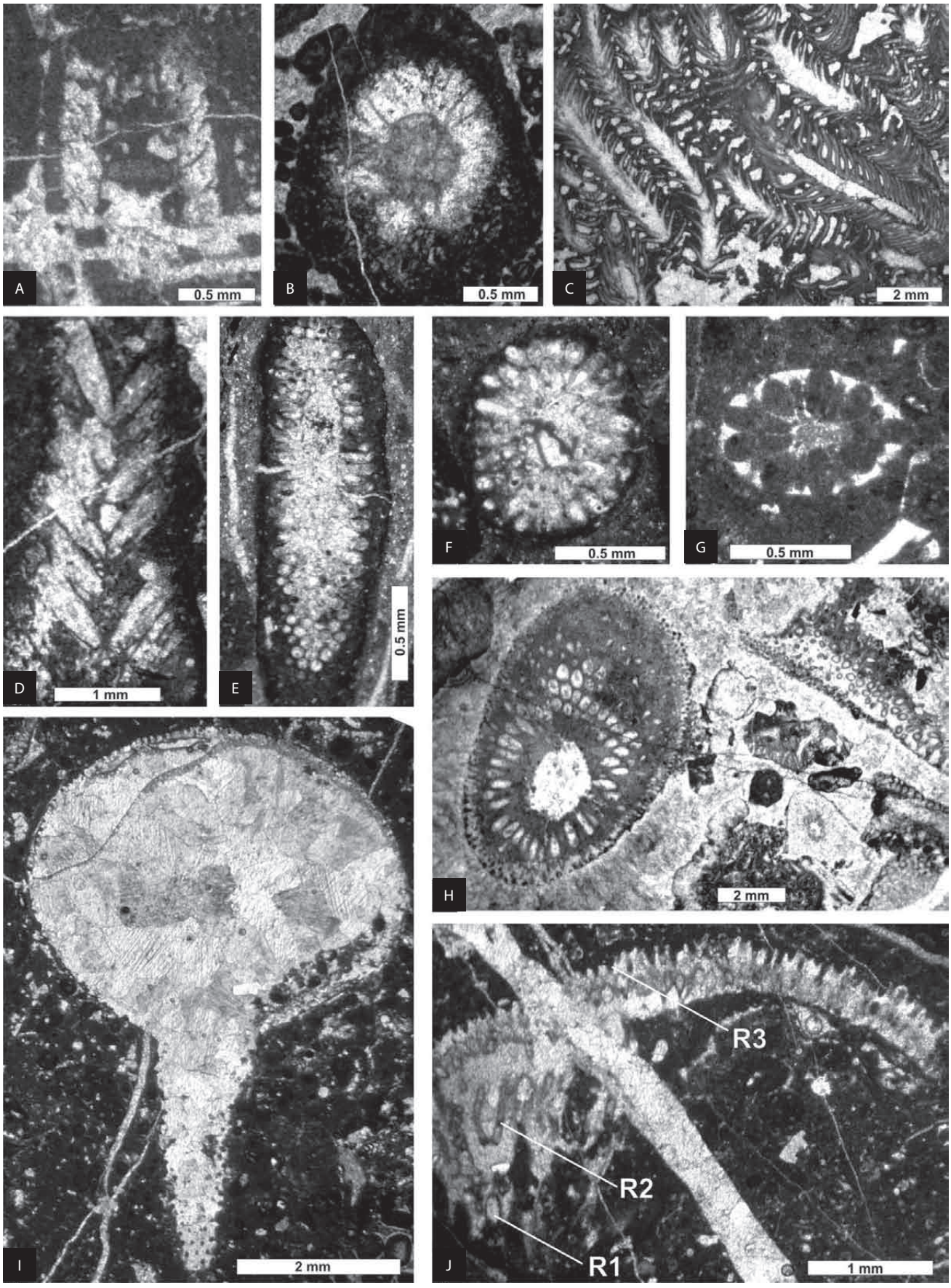
D *Neoteutloporella* cf. *obsoleta* (CAROZZI), locality Knallalm, sample MR 111.

E–F *Neogyroporella*? *gawlicki* SCHLAGINTWEIT, Mount Litzelkogel, sample A 190 and Mount Dietrichorn, sample Die 170–2.

G *Otternstella lemmensis* (BERNIER), Mount Sandling, D 775.

H *Petrascula bursiformis* (ETTALON), Mount Rettenstein, sample Rö 364.

I–J *Petrascula guembeli* BERNIER, Mount Sandling, sample D 190 and Mount Trisselwand, sample MT 855 (*R1 to R3 = primary, secondary, tertiary laterals*).


A
0.5 mm
B
0.5 mm
C
2 mm
D
1 mm
E
0.5 mm
F
0.5 mm
G
0.5 mm
H
2 mm
I
2 mm
R3
R2
R1
J
1 mm

Selliporella neocomiensis (RADOIČIĆ)

(Pl. 4, Figs. G–H)

Large Dasycladale with stratigraphic importance in the Northern Calcareous Alps as it is not reported from strata older then the Late Tithonian (BUCUR & SĂSĂRAN, 2003). Previously it has been reported from Mount Sandling by FENNINGER & HOLZER (1972, pl. 18/2); in the Barmstein Limestones the star-shaped sections of the secondary laterals are common in some clasts (SCHLAGINTWEIT & GAWLICK, 2007, for details). Occurrences: Barmstein Limestone (common).

Steinmanniporella svilajaensis (SOKAČ & VELIĆ)

(Pl. 5, Figs. D–E)

This alga is most typical for the Kimmeridgian external facies of the Lärchberg Carbonate Platform, often associated with corals. Resedimented it occurs also in the proximal Sillenkopf Formation (compare Fig. 49/2 in GAWLICK et al., 2009). The species *Anthracoporella torinosensis* described by ENDO from the Tithonian-Berriasian reefal facies of the Torinosu Limestone of Japan might also belong to the genus *Steinmanniporella* BUCUR, GRANIER & SCHLAGINTWEIT, but a species different from *S. svilajaensis*. Occurrences: Lärchberg Carbonate Platform (common), Sillenkopf Formation (rare to common).

Suppiluliumaella cf. *delphica* (CARRAS)

(Pl. 4, Figs. I)

Rather large Dasycladale originally described as *Clypeina*? *delphica* from Kimmeridgian reefal platform margin deposits of Greece (CARRAS, 1989) trasferrred to the genus *Suppiluliumaella* ELLIOTT by SENOWBARI-DARYAN et al. (1994) based on material from the Late Tithonian of Sicily/Italy. Occurrences: Wolfgangsee Carbonate Platform (rare).

Suppiluliumaella? cf. *florifera* (BERNIER)

(Pl. 5, Figs. A–B)

Reported as *Suppiluliumaella tuberifera* (SOKAČ & NIKLER) by DYA (1992) from the Lärchberg Carbonate Platform occurring in poorly washed-out carbonates with scattered ooids marking a depositional realm at the transition from poorly to well agitated habitats. FENNINGER (1978) reported the species from the Plassen Carbonate Platform *s.str.* of Mount Trisselwand. Occurrences: Lärchberg Carbonate Platform (rare), Plassen Carbonate Platform (rare), Barmstein Limestone (rare).

Terquemella sp. 1

(Pl. 5, Fig. F)

Small representative of *Terquemella* with low number of cysts, so far only reported from the Lärchberg Carbonate Platform.

Terquemella sp. 2 aff. *concava* BERNIER

(Pl. 5, Fig. G)

Taxon typically for the Upper Tithonian platform margin deposits (details see in SCHLAGINTWEIT et al., 2005).

Triploporella? sp.

(Pl. 5, Fig. I)

Rare large alga, known only as debris from the Barmstein Limestone.

Vermiporella? tenuipora CONRAD

(Pl. 5, Figs. J–K)

An alga *incertae sedis*, described originally from the Lower Cretaceous (Urgonian) of Switzerland (CONRAD, 1970); it has been reported later also from Upper Cretaceous strata (RADOIČIĆ, 1972; SCHLAGINTWEIT, 1992). Its stratigraphic range can now be extended into the Tithonian. Occurrence: only from the Lärchberg Carbonate Platform (Mts. Dietrichhorn and Lärchberghörndl-Lofer Kalvarienberg).

Zergabriella embergeri (BOUROULLEC & DELOFFRE)

(Pl. 5, Figs. H)

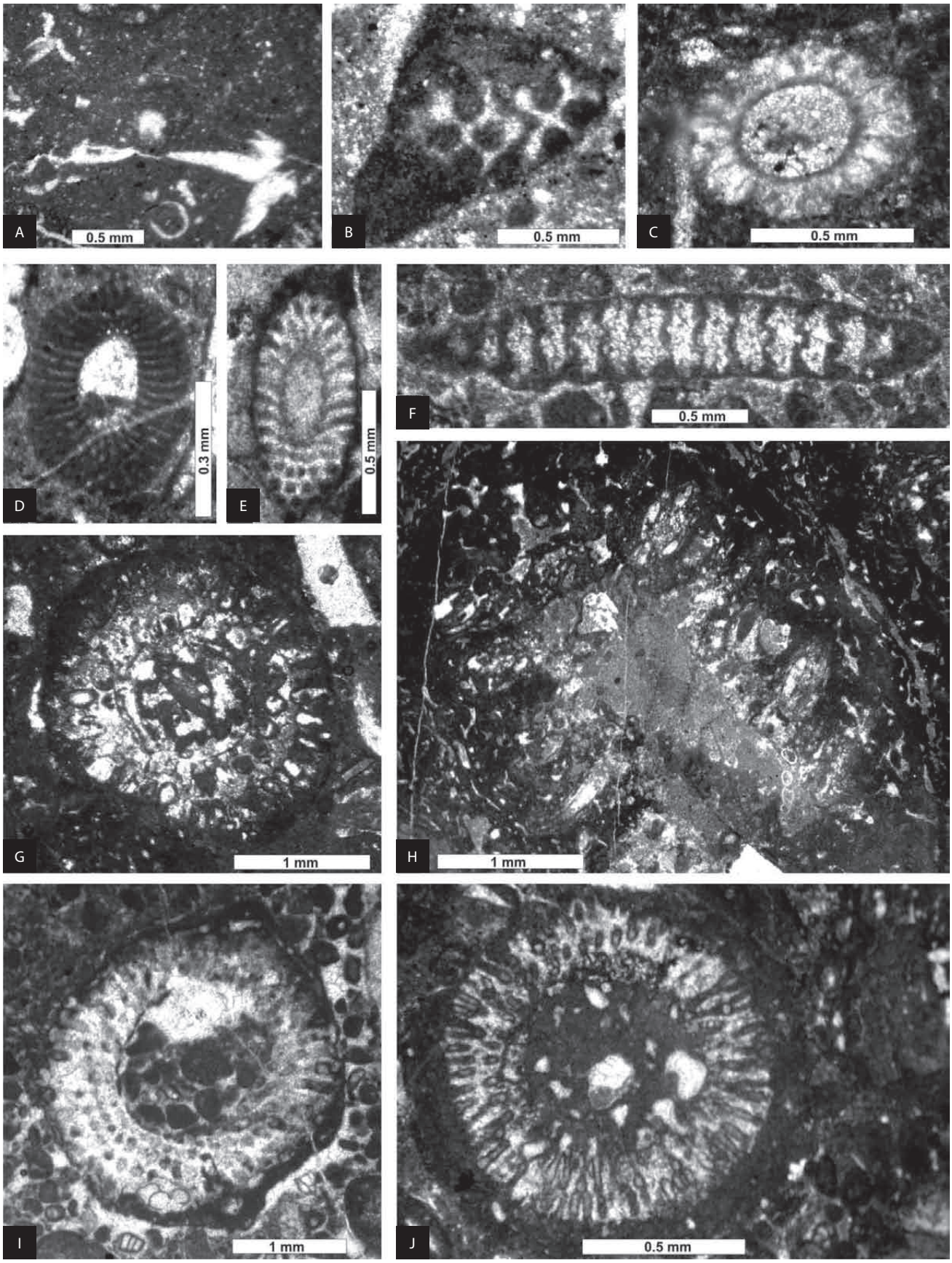
So far only reported from the Lärchberg Carbonate Platform (Mount Dietrichshorn: DARGA & SCHLAGINTWEIT,

---

PLATE 4

Dasycladales from the Late Jurassic-Earliest Cretaceous of the Northern Calcareous Alps: Wolfgangsee Carbonate Platform (I), Lärchberg Carbonate Platform (A–D, F), Barmstein Limestone (E, G–H, J).

A *Rajkaella bartheli* (BERNIER), Mount Dietrichshorn, sample GAG 29a.
B *Rajkaella* sp., Mount Lärchberghörndl, sample LOF 1.
C *Salpingoporella* aff. *dinarica* RADOIČIĆ, Mount Dietrichshorn, sample Die-170.
D *Salpingoporella sellii* (CRESCENTI), Mount Dietrichshorn, sample Die 156.
E *Salpingoporella pygmaea* (GÜMBEL), Mount Trisselwand, sample MT 54.
F *Salpingoporella annulata* CAROZZI, Mount Dietrichshorn, sample Die 156.
G–H *Selliporella neocomiensis* (RADOIČIĆ), Mount Sandling and Mount Trisselwand, samples D 200 and MT 367.
I *Suppiluliumaella* cf. *delphica* (CARRAS), Mount Falkenstein, samples UK 61 and UK 13a.
J *Petrascula guembeli* BERNIER, Mount Barmstein, sample B 16.


A
0.5 mm
B
0.5 mm
C
0.5 mm
D
0.3 mm
E
0.5 mm
F
0.5 mm
G
1 mm
H
1 mm
I
1 mm
J
0.5 mm

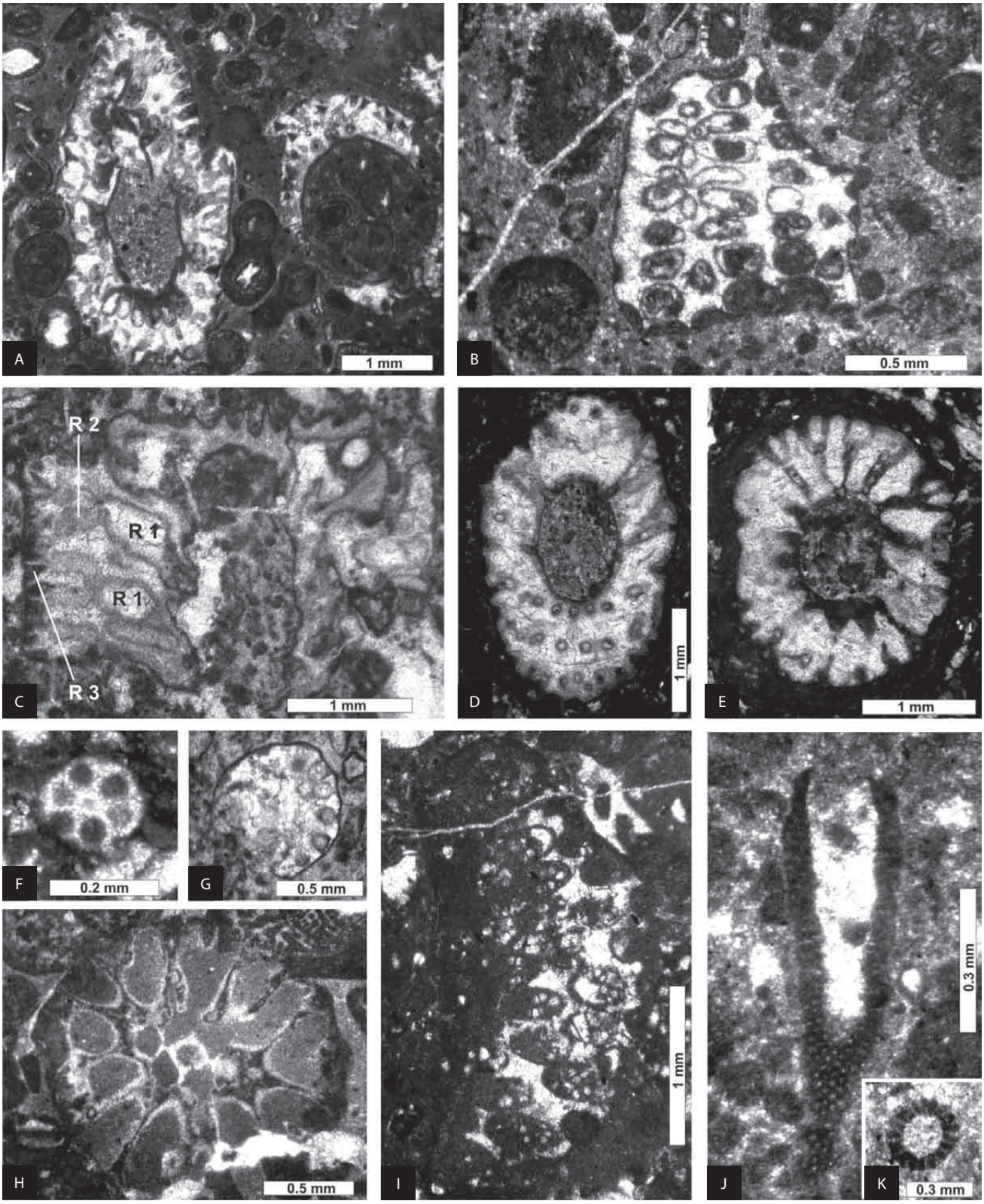


PLATE 5: Dasycladales from the Late Jurassic-Earliest Cretaceous of the Northern Calcareous Alps: Plassen Carbonate Platform *s. str.* (C, G), Lärchberg Carbonate Platform (A–B, D–F, H, J–K), Barmstein Limestone (I). **A–B** *Suppiluliumella*? cf. *florifera* (BERNIER) in ooidal wacke-/packstone, Mount Lärchberghörndl, sample 7/4 of Dya (1991). **C** Unknown Dasycladale (*Suppiluliumaella*? sp.) with three orders of laterals (R1–3 = primary, secondary, tertiary ramifications/laterals), Mount Trisselwand, sample MT 293. **D–E** *Steinmanniporella svilajaensis* (SOKAČ & VELIĆ), Mount Gerhardstein, sample DM 75. **F** *Terquemella* sp. 1, Mount Litzelkogel, sample A 182. **G** *Terquemella* sp. 2 aff. *concava* BERNIER, Mount Plassen, sample PL 58a. **H** *Zergabriella embergeri* (BOUROULLEC & DELOFFRE), Mount Dietrichshorn, sample Die 170. **I** *Triploporella*? sp., Mount Ewige Wand, sample E 384. **J–K** *Vermiporella*? *tenuipora* CONRAD, longitudinal-tangential and transverse section, sample Die IX-170, Mount Dietrichshorn and sample LOF 6, Mount Lofer Kalvarienberg.

1991; Mount Hochkranz: DYA, 1992) where it occurs in the final shallowing upwards-phase with fine terrigeneous influence. For general distribution of this alga see recent synonymy provided by GRANIER (2010). *Z. embergeri* (BOUROULLEC & DELOFFRE) is often reported to co-occur with characean algae and can be considered an indicator for brackish water influences (e.g., PEYBERNÈS, 1979; CONRAD, 1977; WYSSLING, 1986; GRANIER, 1988).

Refering to the review of RASSER & FENNINGER (2002), four more taxa, not incorporated into the present work, are listed. These were either incorrectly determined or no proofable evidences for their real occurrence are available or were reported from strata that from a palaeogeographic point of view are totally different from the Plassen Carbonate Platform and therefore must be excluded:

Salpingoporella grudii RADOIČIĆ: In our opinion, the figurations of DYA (1992) from the Lärchberg Carbonate Platform rather belong to thallus fragments of *Salpingoporella annulata* CAROZZI, one of the most widespread taxa in the Plassen Carbonate Platform *sensu lato* (see Tab. 1), exhibiting a pronounced distal widening of the laterals. In our own material we find wackestones with abundant specimens of *S. annulata* CAROZZI where it can be seen, that depending on the distal branch opening/compression, different sections are prevailing some of which could assume to belong to *Salpingoporella grudii* RADOIČIĆ. However, so far no sections of *Salpingoporella grudii* RADOIČIĆ with the typical horizontally compressed branches have been figured in the Alpine literature. All other citations of *Salpingoporella grudii* RADOIČIĆ from the Northern Calcareous Alps have not been provided with illustrations (FENNINGER & HOLZER, 1972), thus, generally puting some doubt on it, since we have never observed the mentioned taxon in the material investigated from various Alpine localities.

Actinoporella podolica (ALTH): The figurations of *Actinoporella podolica* (ALTH) given by DYA (1992) in fact belong to *Clypeina loferensis* a taxon described recently by SCHLAGINTWEIT et al. (2010). The rare other reports of *Actinoporella podolica* (ALTH) have not been provided with illustrations. For example, the species has been mentioned by FENNINGER (1967) from the type-locality of the Plassen Formation; in the framework of detailed recent investigations carried out, this species has not been observed (SCHLAGINTWEIT et al., 2003, 2005). Again, *Clypeina loferensis* SCHLAGINTWEIT, DIENI & RADOIČIĆ occurs in the closed lagoonal facies at Mount Plassen (Pl. 1, Fig. G).

Acicularia elongata CAROZZI: It has been reported by DYA (1992) from the Plassen Carbonate Platform of Mount Untersberg and the Lofer area. However, no illustrations have been provided so that a final evaluation is not possible. According to our own material, the species in question has never been observed in the Plassen Carbonate Platform. Elongated acicullariacean-type sections can be misinterpreted as tangential sections of individual articles of *Neoteutloporella socialis* (PRATURLON) (SCHLAGINTWEIT, 2010).

Pseudocymopolia pluricellata BAKALOVA: The species *Pseudocymopolia pluricellata* BAKALOVA has been mentioned by SCHLAGINTWEIT (1991) from Upper Jurassic pebbles resedimented in the Albian-Cenomanian Losenstein Formation of the "Kalkalpine Randzone". As the source area of these shallow water limestones, an "exotic ridge" situated north of the Northern Calcareous Alps is assumed (e.g., GAUPP, 1983). Thus, it has to be eliminiated from the flora list provided by RASSER & FENNINGER (2002) referring to the Plassen Carbonate Platform. Instead, the dasycladales occurring in pebbles of the Outer Carpathian Pieniny Klippen Zone (e.g., MISIK & SYKORA, 1981; SOTAK & MISIK, 1993) should be compared directly with those from the Losenstein Formation (GAUPP, 1983; SCHLAGINTWEIT, 1991).

Apart from the four mentioned taxa, *Salpingoporella enayi* BERNIER and *Salpingoporella johnsoni* DRAGASTAN, both listed by RASSER & FENNINGER (2002), too, are considered synonyms of *Salpingoporella pygmaea* (GÜMBEL) (CARRAS et al., 2006).

4. CONCLUSIONS

The Alpine Plassen Carbonate Platform represents a system of several isolated platforms separated by basins. These platforms differ in parts in their geometries, sedimentological evolution, subsidence history and faunal and floral content. As a consequence of this, the distribution of dasycladalean algae within the Plassen Carbonate Platform is not homogeneous but shows several peculiarities. The most discrete inventory is reported from the Lärchberg Carbonate Platform with its overall terrigeneous input. Also the Barmstein Limestone shows independent composition relating to parts of the Plassen Carbonate Platform that have been eroded.

The Dasycladalean flora known so far consists of 42 (40 when excluding problematic forms *Vermiporella*? *tenuipora* and *Pseudotrinocladus piae*). From these, three taxa are treated as gen. et sp. indet.; some of which could represent new species to be described on the basis of more material. The main reason for the comparable rich association of dasycladales is, that there is a multiple change of facies with a great variety of different platform paleoenvironments each with typical algal associations. Furthermore, some typical environments, e.g. reefal and peri-reefal facies, occur twice (Late Kimmeridgian and Latest Tithonian-?earliest Berriasian). In this case, there are taxa that occur in both reefal intervals, others being restricted either to one or the other.

The flora consists mostly of ubiquistic species and some species that can be considered typical for Southern Tethyan communites such as *Salpingoporella sellii* (CRESCENTI), *Humiella catenaeformis* (RADOIČIĆ) or *Steinmanniporella svilajaensis* (SOKAČ & VELIĆ). The species *Neogyroporella*? *gawlicki* SCHLAGINTWEIT is so far only reported from the Northern Calcareous Alps, and could therefore represent an endemic taxon.

The present study demonstrates that the assessment and analysis of the micropaleontological inventories, exemplified with dasycladalean algae, can be a helpful palaeogeographical tool to differentiate different Late Jurassic carbonate platforms and their resediments in the Northern Calcareous Alps as part of the northwestern Tethyan realm.

ACKNOWLEDGEMENT

Without the numerous thin-sections provided by Hans-Jürgen GAWLICK, Sigrid MISSONI and Matthias AUER (Leoben), this work wouldn´t have been possible. Many thanks to both reviewers Ioan BUCUR (Cluj-Napoca) and Filippo BARATTOLO (Naples) for their helpful comments. Thanks also to Julie ROBSON for the English review of the paper.

REFERENCES

AUER, M., SUZUKI, S., SCHLAGINTWEIT, F. & GAWLICK, H.J. (2009): Spatial and temporal development of siliceous basin and shallow-water carbonate sedimentation in Oxfordian Northern Calcareous Alps.– Facies, 55, 63–87. doi: 10.1007/s10347-008-0155-3

BARATTOLO, F., COZZI, A. & ROMANO, R. (2008): New dasycladalean algae from the Middle Norian (Upper Triassic) of northern Italy (Mt. Pramaggiore, Carnic Prealps).– Facies, 54, 549–580. doi: 10.1007/s10347-008-0146-4

BASSOULLET, J.P., BERNIER, P., CONRAD, M.A., DELOFFRE, R. & JAFFREZO, M. (1978): Les algues Dasycladales du Jurasique et du Crétacé.– Géobios, Mém. Spec., 3, 1–333.

BERNIER, P. (1979): Le genre *Petrascula* GÜMBEL 1873, algue dasycladacée : émendation, révision des espèces du genre, création de nouvelles espèces.– Géobios, 12/6, 839–861.

BERNIER, P. (1984): Les formations carbonatées du Kimmeridgien et du Portlandien dans le Jura méridional. Stratigraphie, micropaléontologie, sédimentologie.– Doc. Lab. Geol., 92, 1–803.

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.

BUCUR, I.I., KOCH, R., KIRMACI, Z.M. & TASLI, K. (2000): Les algues Dasycladales du Crétacé inférieur (Calcaire de Berdiga) de Kircaova (région de Kale-Gümüshane, NE Turquie).– Rev. Paléobiol., 19/2, 435–463.

BUCUR, I.I. & SĂSĂRAN, E. (2003): *Selliporella neocomiensis* RADOIĆIČ, 1975 (non 1963), nov. comb., a Lower Cretaceous dasyclad alga from the Tethyan realm.– Acta Micropal. Sinica, 20, 57–66.

BUCUR, I.I. & SĂSĂRAN, E. (2005): Relationship between algae and environment: an Early Cretaceous case study, Trascău Mountains, Romania.– Facies, 51, 274–286. doi: 10.1007/s10347-005-001-9

BUCUR, I.I. & SĂSĂRAN, E. (in press): Large dasycladalean algae from Upper Jurassic limestone deposits of the Apuseni Mountains (Romania) – habitat and depositional environment.– Geodiversitas.

BUCUR, I.I. & SCHLAGINTWEIT, F. (2009): Taxonomic revision of *Pseudoepimastopora* ENDO 1960 and its Upper Jurassic to Lower Cretaceous representatives.– Abstract Book IFAA 6th Reg. Symp. 1–5 July 2009 Milan, 20–21.

CARRAS, N. (1989): *Clypeina*? *delphica* (Alghe calcare, Dasicladali) nel Malm dell´area del Parnaso (Grecia).– Boll. Soc. Paleont., 28/1, 63–70.

CARRAS, N., CONRAD, M.A. & RADOIČIĆ, R. (2006): *Salpingoporella*, a common genus of Mesozoic Dasycladales (calcareous green algae).– Rev. Paléobiol., 25/2, 457–517.

CONRAD, M.A. (1970): *Vermiporella*? *tenuipora* n. sp., une algue incertae sedis des calcaires urgoniens de la région genevoise.– C. R. Séances Soc. Phys. Hist. Nat., 5, 37–42.

CONRAD, M.A. (1977): The Lower Cretaceous algae in the area surrounding Geneva (Switzerland): Biostratigraphy and depositional environments.– In: FLÜGEL, E. (ed.): Fossil Algae. New York, Springer, 295–300.

CONRAD, M.A. & VAROL, B. (1990): *Cylindroporella taurica*, n. sp., urge to review different patterns of calcification in the Mesozoic Dasycladales (green algae).– Arch. Sci. Genève, 43, 193–214.

DARGA, R. & SCHLAGINTWEIT, F. (1991): Mikrofazies, Paläontologie und Stratigraphie der Lerchkogelkalke (Tithon-Berrias) des Dietrichshorns (Salzburger Land, Nördliche Kalkalpen).– Jb. Geol. B.–A., 134, 205–226.

DIENI, I. & RADOIĆIČ, R. (2000): *Clypeina dragastani* sp. nov., *Salpingoporella granieri* sp. nov. and other Dasycladalean algae from the Berriasian of Eastern Sardinia.– Acta Palaeont. Romaniae, 2 (1999), 105–123.

DRAGASTAN, O. (1971): New algae in the Upper Jurassic and Lower Cretaceous in the Bicaz Valley, East Carpathians (Romania).– Rev. Espan. Micropal., 3, 155–192.

DRAGASTAN, O. (1989): Calcareous algae (new and revised), microproblematicae and foraminiferida of Jurassic – Lower Cretaceous deposits from the Carpathian area.– Rev. Espan. Micropal., 21, 5–65.

DRAGASTAN, O. (1999): Early Cretaceous algae of Aliman (South Dobrogea): a revision and description of two new species from East Carpathians.– Acta Palaeont. Romaniae, 2, 125–137.

DYA, M. (1992): Mikropaläontologische und fazielle Untersuchungen im Oberjura zwischen Salzburg und Lofer.– Unpubl. PhD Thesis, Techn. Univ. Berlin, 138 p.

ENDO, R. (1961): Calcareous algae from the Jurassic Torinosu Limestone of Japan.– Sci. Rep. Saitama Univ. Ser. B comm, 53–75.

FARINACCI, A. & RADOIĆIČ, R. (1991): Late Jurassic-Early Cretaceous Dasycladales (Green algae) from the Western Pontides, Turkey.– Geol. Rom., 27, 135–165.

FENNINGER, A. (1967): Riffentwicklung im oberostalpinen Malm.– Geol. Rdsch., 56, 171–185.

FENNINGER, A. (1972): Die Fauna und Flora der Barmsteinkalk-Bank B2 im Raume des Trattberges (Osterhorngruppe, Salzburg).– Ber. Haus Nat Salzburg, 3, 10–23.

FENNINGER, A. (1978): Neue Faunen- und Florenelemente aus den Plassenkalken der Trisselwand (Totes Gebirge, Steiermark).– Mitt. Natwiss. Ver. Steiermark, 108, 115–119.

FENNINGER, A. & HÖTZL, H. (1967): Die Mikrofauna und –flora des Plassen- und Tressensteinkalkes der Typlokalität (Nördliche Kalkalpen).– N. Jb. Geol. Paläont. Abh., 128, 1–37.

FENNINGER, A. & HOLZER, H.L. (1972): Fazies und Paläogeographie des oberostalpinen Malms.– Mitt. Geol. Ges., 63 (1970), 52–141.

FERNECK, F.E. (1962): Stratigraphie und Fazies im Gebiet der mittleren Saalach und des Reiteralm-Gebirges: ein Beitrag zur Deckenfrage in den Berchtesgadener Alpen.– Unpubl. PhD Thesis, Techn. Univ. München, 107 p.

FLÜGEL, E. (1964): Ein neues Vorkommen von Plassenkalk (Ober-Jura) im Steirischen Salzkammergut, Österreich.– N. Jb. Geol. Paläont. Abh., 120, 213–232.

FRISCH, W. & GAWLICK, H.J. (2003): The nappe structure of the central Northern Calcareous Alps and its disintegration during Miocene tectonic extrusion – a contribution to understanding the orogenic evolution of the Eastern Alps.– Int. J. Earth Sci., 92, 712–727. doi: 10.1007/s00531-003-0357-4

GAUPP, R.H. (1983): Die paläogeographische Bedeutung der Konglomerate in den Losensteiner Schichten (Alb, Nördliche Kalkalpen).– Zitteliana, 10, 155–171.

GAWLICK, H.J. & FRISCH, W. (2003): The Middle to Late Jurassic carbonate clastic radiolaritic flysch sediments in the Northern Calcareous Alps: sedimentology, basin evolution and tectonics – an overview.– N. Jb. Geol. Paläont. Abh., 230, 163–213.

GAWLICK, H.J. & SCHLAGINTWEIT, F. (2006): Berriasian drowning of the Plassen carbonate platform at the type-locality and its bearing on the early Eoalpine orogenic dynamics in the Northern Calcareous Alps (Austria).– Int. Journ. Earth Sci., 95, 451–462. doi: 10.1007/s00531-005-0048-4

GAWLICK, H.J. & SCHLAGINTWEIT, F. (2009): Revision des Tressensteinkalkes: Neuinterpretation der späten Ober-Jura bis? Unter-Kreide-Entwicklung des Plattform-Becken-Überganges der Plassen-Karbonatplattform (Österreich, Nördliche Kalkalpen).– J. Alpine Geol., 51, 1–30.

GAWLICK, H.J. & SCHLAGINTWEIT, F. (2010): The drowning sequence of Mount Bürgl in the Salzkammergut area (Northern Calcareous Alps, Austria): Evidence for a diachronous Late Jurassic to Early Cretaceous drowning of the Plassen Carbonate Platform.– Austrian J. Earth Sci., 103, 58–75.

GAWLICK, H.J., FRISCH, W., VECSEI, A., STEIGER, T. & BÖHM, F. (1999) : The change from rifting to thrusting in the Northern Calcareous Alps as recorded in Jurassic sediments.– Geol. Rdsch., 87, 644–657.

GAWLICK, H.J., MISSONI, S., SCHLAGINTWEIT, F., SUZUKI, H. & FRISCH, W. (2009): Jurassic Tectonostratigraphy of the Austroalpine Domain.– Journal of Alpine Geology, 50, 1–152.

GAWLICK, H.J., MISSONI, S., SCHLAGINTWEIT, F. & HISASHI, S. (2010): Tiefwasser Beckengenese und Initiierung einer Karbonatplattform im Jura des Salzkammergutes (Nördliche Kalkalpen, Österreich).– J. Alpine Geol., 52, 63–136.

GAWLICK, H.J., SCHLAGINTWEIT, F., EBLI, O. & SUZUKI, H. (2004): Die Plassen-Formation des Krahstein (Steirisches Salzkammergut, Österreich) und ihre Unterlagerung: neue Daten zur Fazies, Biostratigraphie und Sedimentologie.– Zbl. Geol. Paläont. Teil 1 2003 3/4, 295–334.

GAWLICK, H.J., SCHLAGINTWEIT, F. & MISSONI, S. (2005): Die Barmsteinkalke der Typlokalität nordwestlich Hallein (hohes Tithonium bis tieferes Berriasium; Salzburger Kalkalpen) – Sedimentologie, Mikrofazies, Stratigraphie und Mikropaläontologie: neue Aspekte zur Interpretation der Entwicklungsgeschichte der Ober-Jura-Karbonatplattform und der tektonischen Interpretation der Hallstätter Zone von Hallein – Bad Dürrnberg.– N. Jb. Geol. Paläont. Mh., 236, 351–421.

GAWLICK, H.J., SCHLAGINTWEIT, F. & MISSONI, S. (2007): Das Ober-Jura Seichtwasser-Karbonat-Vorkommen der Drei Brüder am Wolfgangsee (Salzkammergut, Österreich): das westlichste Vorkommen der Wolfgangsee-Karbonatplattform südlich der Brunnwinkl-Schwelle am Nordrand des Tauglboden-Beckens.– J. Alpine Geol. (Mitt. Ges. Geol. Bergbaustud. Österr.), 48, 83–100.

GEYER, G. (1884): Über jurassische Ablagerungen auf dem Hochplateau des Toten Gebirges in der Steiermark.– Jb. Geol. R.A., 34, 335–366.

GRANIER, B. (1988) : Algues chlorophyceae du Jurassique terminal et du Crétacé inférieur en Alicante.– Mediterranea Ser. Estud. Geol., 5 (1986), 5–96.

GRANIER, B. (2010): *Bucurella*, a new genus of the tribe Thyrsoporelleae (fossil dasycladalean algae).– Carnets de Géologie / Notebooks on Geology CG2010_A03.

GRANIER, B. & BUCUR, I.I. (2010): Stratigraphic ranges of some Tithonian-Berriasian benthic foraminifers and Dasycladales. Re-evaluation of their use in identifying this stage boundary in carbonate platform settings.– In: GROSHENY, D., GRANIER, B. & SANDERS, N. (eds.): Platform to basin correlations in Cretaceous times. Abstracts. Boletín del Instituto de Fisiografía y Geología, 79–80.

GRANIER, B. & DELOFFRE, R. (1993): Inventaire critique des algues Dasycladales fossils – II° Partie – Les algues Dasycladales du Jurassique et du Crétacé.– Rev. Paléobiol., 12, 19–65.

HAUER, F., von (1857): Ein geologischer Schnitt der Alpen von Passau bis Duino.– Sitzber. Math.-naturwiss. Cl. K. Akad. Wiss., 25/1, 253–348.

HOFMANN, T. (1994): *Chinianella* (?) *scheympflugi*, a new Dasyclad alga (green algae) from the Tithonian Ernstbrunn Limestone in Lower Austria.– Beitr. Geol., 19, 143–147.

HUSINEC, A. & SOKAČ, B. (2006): Early Cretaceous benthic associations (foraminifera and calcareous algae) of a shallow tropical-water platform environment (Mljet Island, southern Croatia).– Cret. Res., 27, 418–441. doi: 10.1016/j.cretres.2005.07.008

JAFFREZO, M. & RENARD, M. (1979): Elements en traces de calcaires à Dasycladales et Charophytes.– Bull. Cent. Rech. Explor.-Prod. Elf-Aquitaine Mém., 3, 639–649.

KÜGLER, U., SCHLAGINTWEIT, F., SUZUKI, H. & GAWLICK, H.J. (2003): Stratigraphie und Fazies des höheren Mittel- bis Ober-Jura im Bereich des Falkensteinzuges am Wolfgangsee, Salzkammergut (Österreich) mit besonderer Berücksichtigung der Plassen-Formation (Kimmeridgium).– In: WEIDINGER, J.T., LOBITZER, H. & SPITZBART, I. (eds.): Beiträge zur Geologie des Salzkammergutes. Gmundner Geo-Stud., 2, 97–106.

MANDL, G. (1982): Jurassische Gleittektonik im Bereich der Hallstätter Zone zwischen Bad Ischl und Bad Aussee (Salzkammergut, Österreich).– Mitt. Ges. Geol.-Bergbaustud. Österr., 28, 55–76.

MASSE, J.-P., BUCUR, I.I., VIRGONE, A. & DALMASSO, H. (1999): Nouvelles espèces de Dasycladales du Crétacé inférieur de Provence (S.E. France).– Rev. Micropaléont., 42/3, 231–243.

MISIK, M. & SYKORA, M. (1981): Der pieninische exotische Rücken, rekonstruiert aus Geröllen karbonatischer Gesteine kretazischer Konglomerate der Klippenzone und der Manín-Einheit.– Západne Karpaty sér. Geol., 7, 7–111.

MISSONI, S. & GAWLICK, H.J. (2011): Jurassic mountain building and Mesozoic-Cenozoic geodynamic evolution of the Northern Calcareous Alps as proven in the Berchtesgaden Alps (Germany).– Facies, 57, 137–186. doi: 10.1007/s10347-010-0025-1

MISSONI, S., SCHLAGINTWEIT, F., SUZUKI, H. & GAWLICK, H.J. (2001): Die oberjurassische Karbonatplattformentwicklung im Bereich der Berchtesgadener Kalkalpen (Deutschland) – eine Rekonstruktion auf der Basis von Untersuchungen polymikter Brekzienkörper in pelagischen Kieselsedimenten (Sillenkopf-Formation).– Zbl. Geol. Paläont. 2000 Heft 1/2, 117–143.

MOJSISOVICS, E. (1868): Über den Malm des Salzkammergutes.– Verh. Geol. R.A., 1868, 124–128.

MOSHAMMER, B. & LOBITZER, H. (2000): Weißmetrik und Geochemie ausgewählter österreichischer Kalkstein- und Marmor-Vorkommen.– Mitt. Österr. Geol. Ges., 91, 63–77.

PEYBERNÈS, B. (1979) : Les algues du Jurassique et du Crétacé inférieur des Pyrénées Franco-Espagnoles. Interêt biostratigraphiqe et paléoécologique.– Bull. Centres Rech. Explor.-Prod. Elf-Aquitaine, 3, 733–741.

PLÖCHINGER, B. (1964): Zum Nachweis jurassisch-kretazischer Eingleitungen von Hallstätter Gesteinsmassen beiderseits des Salzach-Quertales (Salzburg).– Geol. Rdsch., 73/1, 293–306.

RADOIĆIČ, R. (1972): Contributions to the stratigraphy of the Upper Cretaceous in Western Serbia. Micropaleontological aspects of the Upper Cretaceous sedimentary series of Skrapez.–Ann. géol. Pénins. balkan., 37, 89–99.

RADOIĆIČ, R. (2005): New Dasycladales and microbiota from the lowermost Valanginian of the Mirdita Zone.– Ann. géol. Pénins. balk., 66 (2004–2005), 27–53.

RASSER, M. & FENNINGER, A. (2002): Jurassic / Cretaceous dasycladalean algal stratigraphy in the Northern Calcareous Alps: A critical review and a palaeobiogeographic approach using similarity indices.– In: BUCUR, I.I. & FILIPESCU, S. (eds.): Research advances in calcareous algae and microbial carbonates. Proc 4th Int IFAA Reg Meet Cluj-Napoca, 167–190, Cluj University Press.

SANDERS, D., LUKESCH, M., RASSER, M. & SKELTON, P. (2007): Shell beds of diceratids ahead of a low-energy gravelly beach (Tithonian, Northern Calcareous Alps, Austria): Palaeoecology and Taphonomy.– Austrian J. Earth Sci., 100, 186–199.

SCHLAGINTWEIT, F. (1991): Neritische Oberjura- und Unterkreide-Kalkgerölle aus den Losensteiner Schichten (Alb-Cenoman) der Typlokalität Stiedelsbachgraben (Oberösterreich; Nördliche Kalkalpen).– Mitt. Ges. Geol. Bergbaustud. Österr., 37, 83–95.

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

SCHLAGINTWEIT, F. (2005): *Neogyroporella*? *gawlicki* n. sp., a new Dasycladale from the Upper Jurassic-Lower Cretaceous "Lärchberg Formation" of the Northern Calcareous Alps.– Geol. Croat., 58, 1–15.

SCHLAGINTWEIT, F. (2008): Bioerosional structures and pseudoborings from Late Jurassic and Late Cretaceous-Paleocene shallow-water carbonates (Northern Calcareous Alps, Austria; SE France) with special reference to cryptobiotic foraminifera.– Facies, 54, 377–402. doi: 10.1007/s10347-008-0137-5.

SCHLAGINTWEIT, F. (2010): A false acicullariacean alga and its origin: an example from the Upper Jurassic of the Northern Calcareous Alps, Austria.– Facies, 57, 267–273. doi: 10.1007/s10347-010-0242-0

SCHLAGINTWEIT, F. (2011): Morphological precisions on *Chinianella*? *scheympflugi* HOFMANN, 1994, a widespread Late Jurassic dasycladalean algae of the western Tethyan domain.– Studias Universitatis Babes-Bolyai, Geologia, 56, 3–9. doi: 10.5038/1937-8602.56.1.1

SCHLAGINTWEIT, F., DIENI, I. & RADOIĆIČ, R. (2009): Two look-alike dasycladalean algae: *Clypeina isabellae* MASSE, BUCUR, VIRGONE & DELMASSO, 1999 from the Berriasian of Sardinia (Italy) and *Clypeina loferensis* n. sp. from the Upper Jurassic of the Northern Calcareous Alps (Austria).– Ann. Géol. Penins. Balk., 70, 43–59.

SCHLAGINTWEIT, F., DRAGASTAN, O. & GAWLICK, H.-J. (2008): *Halimeda misiki* n. sp., a new calcareous alga from the Late Jurassic of the Northern Calcareous Alps (Austria).– N. Jb. Geol. Paläont., 248/2, 171–182. doi: 10.1127/0077-7749/2008/0248-0171

SCHLAGINTWEIT, F. & EBLI, O. (1999): New results on stratigraphy, facies and sedimentology of Late Jurassic to Early Cretaceous platform carbonates of the Austrian Salzkammergut (Plassen Formation, Tressenstein Limestone).– Abh. Geol. B.-A., Wien, 56/2, 379–418.

SCHLAGINTWEIT, F. & EBLI, O. (2000): Short note on *Clypeina catinula* CAROZZI, 1956 (dasycladale).– Rev. Paléobiol., 19, 465–473.

SCHLAGINTWEIT, F. & GAWLICK, H.J. (2007): Analysis of Late Jurassic to Early Cretaceous algal debris-facies of the Plassen carbonate platform in the Northern Calcareous Alps (Germany, Austria) and in the Kurbnesh area of the Mirdita zone (Albania) – a tool to reconstruct tectonics and paleogeography of eroded platforms.– Facies, 53, 209–227. doi: 10.1007/s10347-006-0100-2

SCHLAGINTWEIT, F., GAWLICK, H.J. & MISSONI, S. (2006): Nachweis einer Emersion der Trattberg-Schwelle im Ober-Jura-Klastenspektrum der Barmsteinkalke und paläogeographische Bedeutung (Nördliche Kalkalpen, Österreich).– In: TESSADRI-WACKERLE, M. (ed.): PANGEO Austria, Innsbruck University Press 2006, 306–307.

SCHLAGINTWEIT, F., GAWLICK, H.J. & LEIN, R. (2003): Die Plassen-Formation der Typlokalität (Salzkammergut, Österreich) – neue Daten zur Fazies, Sedimentologie und Stratigraphie.– Mitt. Ges. Geol. Bergbaustud. Österr., 46, 1–34.

SCHLAGINTWEIT, F., GAWLICK, H.J. & LEIN, R. (2005): Mikropaläontologie und Biostratigraphie der Plassen-Karbonatplattform der Typlokalität (Ober-Jura bis Unter-Kreide, Salzkammergut, Österreich).– J. Alpine Geol. (Mitt. Ges. Geol. Bergbaustud. Österr.), 47, 11–102.

SCHMID, D.U. (1996): Marine Mikrobolithe und Mikroinkrustierer aus dem Oberjura.– Profil, 9, 101–251.

SENOWBARI-DARYAN, B., BUCUR, I.I. & ABATE, B. (1994): Upper Jurassic calcareous algae from the Madonie Mountains, Sicily.– Beitr. Paläont., 19, 227–259.

SOKAČ, B. (1987): On some controversial Dasyclad genera and species and their stratigraphic position in the Lower Cretaceous deposits of the Dinarides.– Geol. vjesnik, 40, 9–38.

SOKAČ, B. (1996): Taxonomic review of some Barremian and Aptian calcareous algae (Dasycladales) from the Dinaric and Adriatic Karst regions of Croatia.– Geol. Croat., 49, 1–79.

SOTAK, J. & MISIK, M. (1993): Jurassic and Lower Cretaceous dasycladalean algae from the Western Carpathians.– In: BARATTOLO, F. et al. (eds.): Studies on Fossil Benthic Algae. Boll. Soc. Paleont. Ital. Spec. 1, 383–404.

STEIGER, T. (1981): Kalkturbidite im Oberjura der Nördlichen Kalkalpen (Barmstein Kalke, Salzburg, Österreich).– Facies, 4, 215–348. doi: 10.1007/BF02536589

STEIGER, T. & WURM, D. (1980): Faziesmuster oberjurassischer Plattform-Karbonate (Plassenkalke, Nördliche Kalkalpen, Steirisches Salzkammergut, Österreich).– Facies, 2, 241–284. doi: 10.1007/BF02536468

TOLLMANN, A. (1965): Faziesanalyse der alpidischen Serien der Ostalpen.– Z. dtsch. Geol. Ges., 116 (1964), 359–389.

TOLLMANN, A. (1981): Oberjurassische Gleittektonik als Hauptformungsprozeß der Hallstätter Region und neue Daten zur Gesamttektonik der Nördlichen Kalkalpen in den Ostalpen.– Mitt. Österr. Geol. Ges., 74/75, 167–195.

TOLLMANN, A. (1985): Geologie von Österreich. Wien, Franz Deuticke, Volume 2, 710 p.

TRAUTH, F. (1950): Die fazielle Ausbildung und Gliederung des Oberjura in den nördlichen Ostalpen.– Verh. Geol. B.A., 1948, 145–218.

WEYNSCHENK, R. (1950): Die Jura-Mikrofauna und –flora des Sonnwendgebirges (Tirol).– Schlern-Schriften, Universität Innsbruck, 83, 1–32.

WEYNSCHENK, R. (1951): Two new foraminifera from the Dogger and Upper Triassic of the Sonnwend Mountains of Tyrol, Austria.– Journ. Paleontol., 25, 793–795.

WYSSLING, G. (1986): Der frühkretazische helvetische Schelf in Vorarlberg und im Allgäu – Stratigraphie, Sedimentologie und Paläogeographie.– Jb. Geol. BA, 129, 161–265.

Manuscript received April 04, 2011
Revised manuscript accepted July 15, 2011
Available online October 26, 2011