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

1. INTRODUCTION

The occurrence of Upper Jurassic shallow-water limestones in the Northern Calcareous Alps is known since the mid 19th century (e.g., von HAUER, 1857; GEYER, 1884; MOJISISOVICS, 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; PLOCHINGER, 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 basement 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 Passen 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 reseeds of the Barmstein Limestone (FENNINGER, 1972; STEIGER, 1981; GAWLICK et al., 2005, 2010; SCHLAGINTWEIT & GAWLICK, 2007) or the Sillenkopf Formation (MISSONI...
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 dasycladalean 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 (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 dealt 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* (FA VRE), *Neoteutloporella socialis* (CAV.) and *Salpingoporella annulata* (BERNIER) and the rare debris of the dasycladale algae is presented and analyzed with respect to differences in stratigraphic ranges, taxa that are either only occurring in the Kimmendigian or Late Tithonian (e.g., *Neoteutloporella socialis*), reefal and perireefal 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 basinl 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* FA VRE 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
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* WEYNSENCHENK and *Kilfinania? 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 (Late 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 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 FENINGER & HOLZER, 1972, pl. 17, fig. 6, figured as *Macroproporella 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 referred 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 Sonnwand Mountains of Tyrol. It is worth to mention, that the two widespread Late Jurassic foraminifers *Protoperonoplis striata* and *Labyrinthina mirabilis* were described from this locality (WEYNSENCHENK 1950, 1951). In general, little is known about the micropaleontological 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 Ybbitsz 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 Krahnstein). At the type-locality Mount Plassen, the platform-margin facies is partly replaced by *Labyrinthina shools* devoid of dasycladales and followed by transgressive-regressive cycles of tidal flat and lagoonal deposits. The latter are typically dominated by an association of rivilirariacean-type porostromate algae and an assemblage of dasycladales amongst *Salpingoporella annulata* CAROZZI, *Clypeina jurassica* FAVRE, *Clypeina cf. parasolkani* FARINACCI & RADOIČIĆ or *Campbelliella striata* (CAROZZI). Both taxa have so far not been reported 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...
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 than 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 neoconiensis (RADOIČIĆ) occur often exhibiting micritic coatings, indicating more or less synsedimentary transportation.

Referring to the general lithostratigraphic succession of the Plassen Carbonate Platform 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 reeval 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 Campbelliella 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 reworked bioclasts, not within bioclasts. 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, Zwerpewand, 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 reworkd bioclasts. Excerpt Gyroporella? sp. and Chinianella scheypflogi 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, Neoeutuporella socialis (PRATURING), Neoeutuporella obsoleta CAROZZI and Terque- mella 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 reeval 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 & SĂSĂRĂN, 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 CaCo3 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 elastic series represents a Late Tithonian to?earliest Berriasian final coarsening-upward series, with Anachispyocy- clina lusitania (EGGER) as one main characteristic microfossil. The Kimmeridgian parts are well documented with Labyrinthina mirabilis WEYNESCHENK and Kilianina? rathonensis FOURY & VINCENT, for example from Mounts Litzelkogel-Gerhardstein (e.g., DYAR, 1992; own observations). The more or less absence of high-energy reeval 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 kappiloides 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) referred 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 starred 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 (BOURBOULLEC & DELOFFRE) from the same palaeoenvironment additionally shows influences of fresh-water (e.g., JAFFREZ & RENARD, 1979). Cylindroporella? sp. 1 known only from the Lärchberg Carbonate Platform occurs in well-agitated back-reef/open lagoonal facies. The overall terrigenous 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. Sillenköpfte 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 &
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)

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

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).
Felix Schlagintweit: The dasycladalean algae of the Plassen Carbonate Platform (Kimmeridgian-Early Berriasian)...
**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. estevezi 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 (abundant). 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. estevezi* 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 (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 (abundant), 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 mar- teli* 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 (rare), Lärchberg Carbonate Platform.

**Clypeina cf. parasolkani FARINACCI & RADOIČIĆ**

(Pl. 1, Figs. K–L)

This species was originally described from the Berriasian of Turkey (FARINACCI & RADOIČIĆ, 1991). A longitudinal section cutting 15 successive 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 cylindroporelliform dasycladales: *Cylindroporella taurcha* CONRAD & VAROL, 1990 (Albian of Turkey) and *Federosella? 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 & DEL-MASSO, 1999 from the Berriasian-Valanginian of SE France. Occurrences: Barmstein Limestone (rare), Plassen Carbonate Platform *s. str.* (rare), Lärchberg Carbonate Platform (rare).

**Dissocladelia? 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-
The dasycladalean algae of the Plassen Carbonate Platform (Kimmeridgian-Early Berrissian)...

The dasycladalean algae of the Plassen Carbonate Platform (Kimmeridgian-Early Berrissian)...

**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 specimen 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 *Neomizziella* 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 reeal 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 Zwerchwald 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 “Barmsteinalk-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.?
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 Losensteint 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, Rajkea bartelli (BERNIER) and Salpingoporella annulata CAR- OZZI. Occurrences: Barmstein Limestone (rare), Plassen Carbonate Platform s. str. (rare), Lärchberg Carbonate Platform (common).

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 Krah- stein, Mount Rettenstein). For the occurrences in the Barm- stein 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: Wolfgongsee 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 Lime- stone (Mount Barmsteine, Mount Sandling, Mount Trissel- wand). This species was described by BERNIER (1979) from the Late Kimmeridgian of Switzerland. The well-cal-
Felix Schlagintweit: The dasycladalean algae of the Plassen Carbonate Platform (Kimmeridgian-Early Berriasian)...
Geologia Croatica 64/3

Pseudotrinoiclades piae (DRAGASTAN)

(Pl. 2, Fig. F)

Very rare and large alga with numerous pores (laterals?) so far recorded from the Late Tithonian Barmstein Limestone s. str. This alga was originally described from Late Tithonian of Romania (DRAGASTAN, 1971, 1989). RADOIĆIĆ (2005) considered P. piae (DRAGASTAN) a synonym of Grifoporella? porofrattissima CAROZZI and preferred a udoteacean rather than 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 RADOIĆIĆ

(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 (CRESSENTI)

(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 RADOIĆIĆ 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).

C Neoteutloporella socialis (PRATURLON), Mount Trisselwand, sample MT 356.
D Neoteutloporella cf. obsoleta (CAROZZI), locality Knallalm, sample MR 111.
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).
Felix Schlagnweit: The dasycladalean algae of the Plassen Carbonate Platform (Kimmeridgian-Early Berriasian)
Selliporella neocomiensis (RADOIĆIĆ)

(Pl. 4, Figs. G–H)

Large Dasycladale with stratigraphic importance in the Northern Calcareous Alps as it is not reported from strata older than 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) transferred 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 (RADOIĆIĆ, 1972; SCHLAGINTWEIT, 1992). Its stratigraphic range can now be extended into the Tithonian. Occurrence: only from the Lärchberg Carbonate Platform (Mts. Dietrichshorn 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, 2007, for details).
The Dasycladalean flora known so far consists of 42 (40 when excluding problematic forms *Vermiporella teniopora* 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 dasycladaleans is, that there is a multiple change of facies with typical algal associations. Furthermore, some typical environments, e.g. reeval and peri-reefal facies, occur twice (Late Kimmeridgian and Latest Tithonian–earliest Berriasian). In this case, there are taxa that occur in both reeval intervals, others being restricted either to one or the other.

The flora consists mostly of ubiquitous species and some species that can be considered typical for Southern Tethyan communities 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 Alpes that have been eroded.

Apart from the four mentioned taxa, *Salpingoporella johnsoni* BERNIER and *Salpingoporella johnsoni DRAGA-STAN, 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 terrigenous 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 teniopora* 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 dasycladaleans 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. reeval and peri-reefal facies, occur twice (Late Kimmeridgian and Latest Tithonian–earliest Berriasian). In this case, there are taxa that occur in both reeval intervals, others being restricted either to one or the other.

The flora consists mostly of ubiquitous species and some species that can be considered typical for Southern Tethyan communities 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 Alpes, 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 Alpes as part of the northwestern Tethyan realm.
ACKNOWLEDGEMENT

Without the numerous thin-sections provided by Hans-Jürgen Gawlick, Sigrid Missioni and Matthias Aué (Leoben), this work wouldn’t have been possible. Many thanks to both reviewers Ioan Bucur (Cluj-Napoca) and Filippo Baratello (Naples) for their helpful comments. Thanks also to Julie Robson for the English review of the paper.

REFERENCES


