Int J Earth Sci (Geol Rundsch) (2006) 95: 451–462
DOI 10.1007/s00531-005-0048-4

ORIGINAL PAPER

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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)

Received: 30 December 2004 / Accepted: 4 September 2005 / Published online: 1 February 2006

Abstract The Plassen carbonate platform (Kimmeridgian to Early Berriasian) developed above the Callovian to Tithonian carbonate clastic radiolaritic flysch basins of the Northern Calcareous Alps during a tectonically active period in a convergent regime. Remnants of the drowning sequence of the Plassen Formation have been discovered at Mount Plassen in the Austrian Salzkammergut. It is represented by calpionellid-radiolaria wacke- to packstones that, due to the occurrence of *Calpionellopsis oblonga* (Cadisch), are of Late Berriasian age (*oblonga* Subzone). Thus, the Plassen Formation at its type-locality shows the most complete profile presently known, documenting the carbonate platform evolution from the initial shallowing upward evolution in the Kimmeridgian until the final Berriasian drowning. The shift from neritic to pelagic sedimentation took place during Berriasian times. A siliciclastic-influenced drowning sequence sealed the highly differentiated Plassen carbonate platform. The former interpretation of a Late Jurassic carbonate platform formed under conditions of tectonic quiescence cannot be confirmed. The onset, evolution and drowning of the Plassen carbonate platform took place at an active continental margin. The tectonic evolution of the Northern Calcareous Alps during the Kimmeridgian to Berriasian time span and the reasons for the final drowning of the Plassen carbonate platform are to be seen in connection with further tectonic shortening after the closure of the Tethys Ocean.

Keywords Northern Calcareous Alps · Plassen carbonate platform · Berriasian drowning

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Introduction and Geological setting

In the Northern Calcareous Alps the Plassen carbonate platform (Late Jurassic to Early Cretaceous) represent the first carbonate platform deposits since Late Triassic (e.g., Tollmann 1976). The type locality is Mount Plassen near Hallstatt in the Austrian Salzkammergut, located on the ÖK map no. 96 Bad Ischl. From the geological point of view the Plassen area is part of the Upper Tirolic unit (Fig. 1). Due to tectonic displacement and erosion, the Plassen Formation is recorded only in the form of isolated occurrences concentrated in the middle part of the Northern Calcareous Alps and reaching to the east as far as Vienna. The original paleogeography has been strongly modified during the post-depositional Tertiary tectonic cycle (Frisch and Gawlick 2003). Despite a lot of new knowledge about its geometry and evolution (Gawlick et al. 2005—with references), the Plassen carbonate platform is still far from being completely understood. Further detailed investigations will be necessary to reconstruct the original paleogeographic situation.

After a period of systematic geological investigations from the mid-sixties to the beginning of the eighties of the last century, only little attention has been paid to the geodynamics of Late Jurassic shallow-water deposits. Until recent times, a relatively long period of non-deposition before and after sedimentation of the Plassen Formation was the generally accepted view in the literature (e.g., Schweigl and Neubauer 1997, p. 306, "two great hiatuses", text-Fig. 2). Due to new tectonic concepts (e.g., Gawlick 1996; Gawlick et al. 1999; Frisch and Gawlick 2003), the Middle to Late Jurassic period became the focus of detailed re-investigations of the most important localities of the Plassen Formation and associated sedimentary rocks (e.g., Schlagintweit and Ebli 1999: Trisselwand; Kügler et al. 2003: Falkenstein; Schlagintweit et al. 2003: Mount Plassen; Gawlick et al. 2004: Mount Krahstein; Gawlick et al. 2005: Barmsteine, type-locality of Barmstein limestones). These investigations

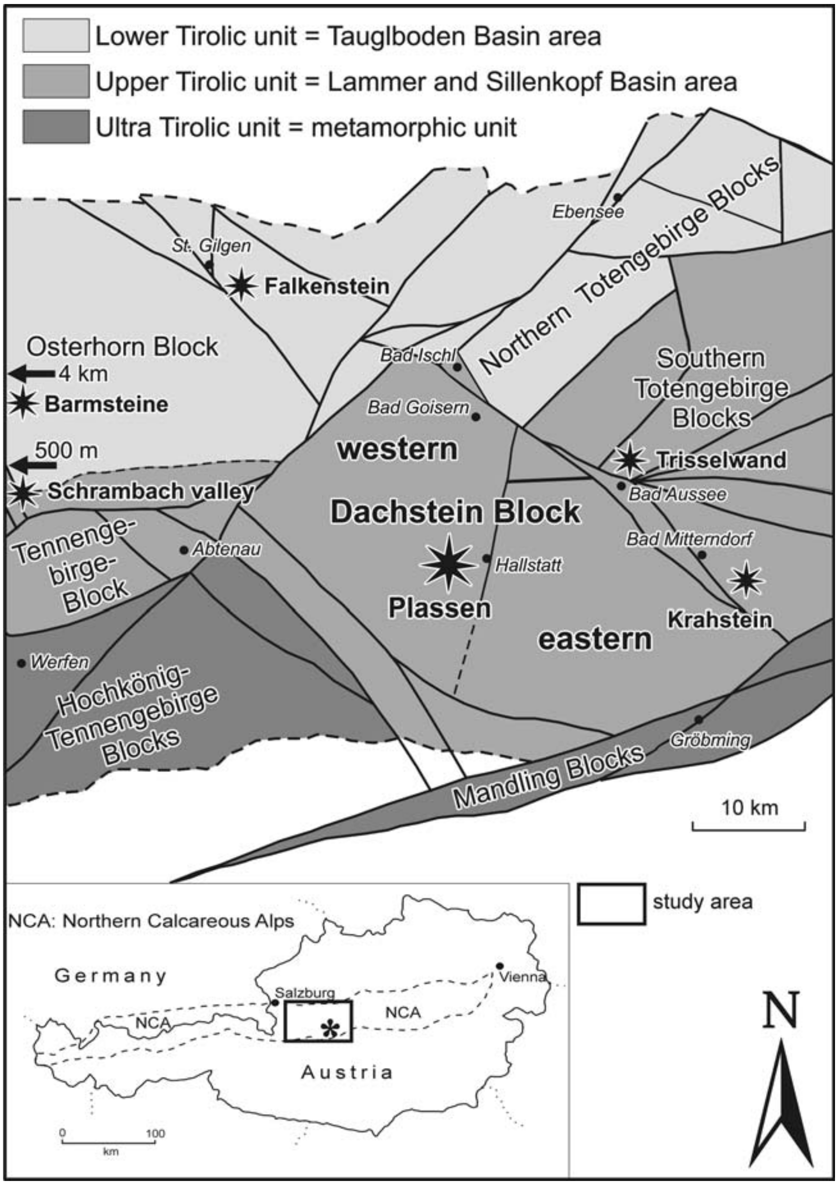


Fig. 1 Tectonic map of the middle sector of the Northern Calcareous Alps (Frisch and Gawlick 2003, for explanation), showing the recent block configuration, radiolaritic basins, locality of Mount Plassen and localities mentionened in the text in the central Salzkammergut area

showed that at different localities the Plassen Formation may show specific depositional environments and stratigraphic ranges. For example, Tithonian or younger shallow water rocks are missing at the Krahstein (southern Salzkammergut) or Falkenstein (Lake Wolfgangsee). According to previous assumptions, the Plassen deposits represent Bahama-type platforms with steep slopes. This generalized model is to be modified to also include ramp settings with abundant microbial crusts and diverse micro-encrusters in the initial phase of platform evolution and progradation (Schlagintweit and Gawlick 2003). The Plassen carbonate platform can be ascribed as an isolated intraoceanic platform typus surrounded by deep water carbonate clastic radiolaritic flysch basins (e.g., Tauglboden Basin to the north: Schlager and Schlager 1973; Gawlick and Frisch 2003; Sillenkopf Basin to the south: Missoni et al. 2001).

From the results of the studies it can be shown that the Plassen carbonate platform was formed on an active continental margin with the onset of shallow water carbonate production on the uplifting fronts of advancing nappes (e.g., Trattberg Rise—Gawlick et al. 1999; Gawlick et al. 2005 with references). From the uplifting fronts of advancing nappes the deposition of shallow-water carbonates started in the Kimmeridgian (e.g., Lammer Basin, Tauglboden Basin, Sillenkopf Basin—Gawlick and Frisch 2003 with references) or in the Tithonian (Tauglboden Basin—Gawlick et al. 2005) and was followed by rapid platform progradation to the adjacent basins. The Plassen Formation at the type-locality was formed on top of the Lammer Basin (Fig. 2) following the Callovian to Oxfordian carbonate clastic radiolaritic flysch sequences of the so-called Hallstatt Mélange.

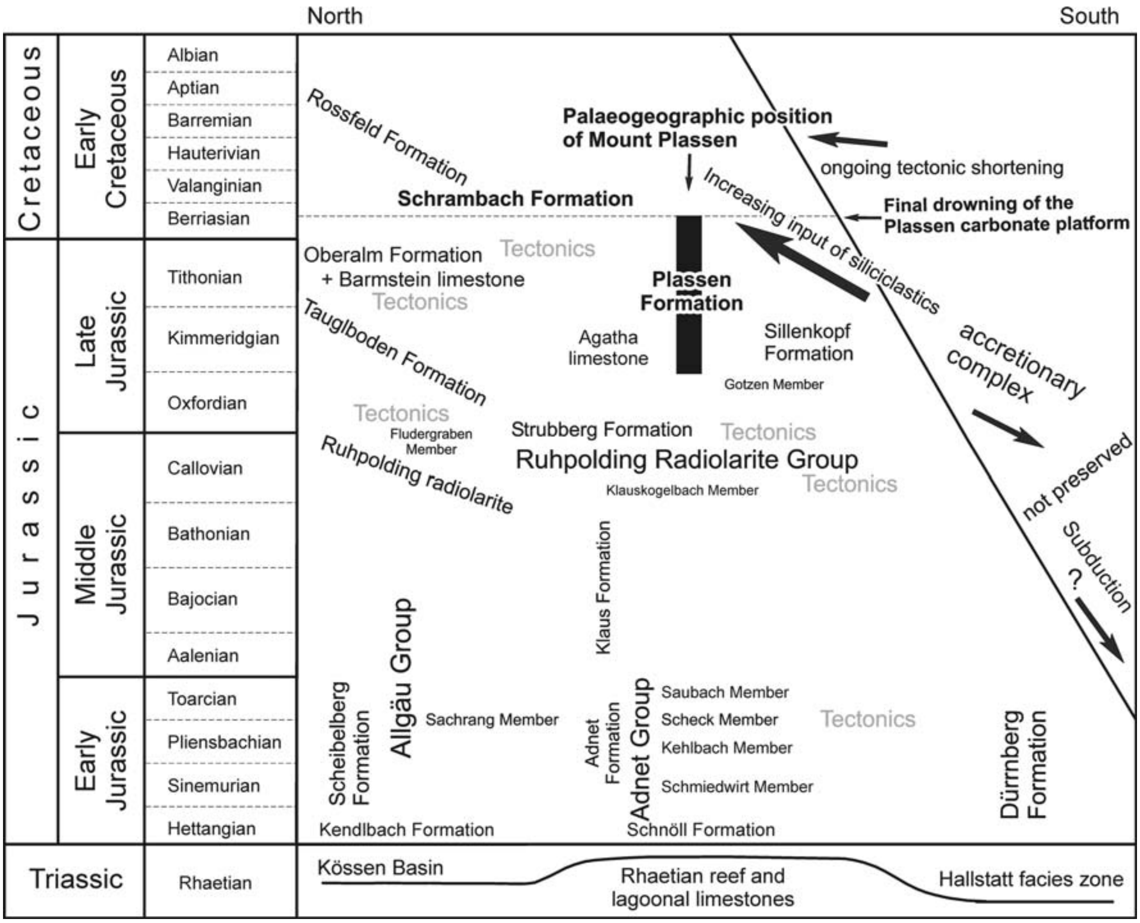


Fig. 2 Stratigraphic table of the Jurassic to Early Cretaceous in the central Northern Calcareous Alps (after Gawlick and Frisch 2003 and Gawlick et al. 2005)

Generally, the analysis of the Late Jurassic to Early Cretaceous platform and basin sequences is limited due to poor chronostratigraphic correlation. Thus, the total stratigraphic interval of the Plassen Formation from its beginning to its end was still poorly known. At Mount Plassen, neither the underlying Jurassic sediments nor the overlying younger sediments above the Plassen Formation have been known so far (e.g., Mandl 1999).

At all re-investigated occurrences of the Plassen Formation, cherty limestones and radiolarites of late Middle to Late Jurassic age were found underneath the platform succession (e.g., Plassen: Wegerer et al. 2003; Falkenstein, Lake Wofgangsee: Kügler et al. 2003; Mount Krahstein: Gawlick et al. 2004).

Dating of the underlying cherty sediments with the comprehensive radiolarian zonation for the complete Jurassic system of the Northern Calcareous Alps with their 13 radiolarian zones (Suzuki and Gawlick 2003) indicate a continuous sedimentation of a shallowing-upward trend—there are no hints on a major gap in the depositional record. The overlying pelagic carbonates evolve into shallowing-upward sequences.

However, some uncertainties remain concerning the top of the Plassen Formation. According to recent studies it is generally accepted that sedimentation of the Plassen Formation outlasts the Jurassic/Cretaceous boundary, reaching into the Berriasian based on benthic foraminifera and dasycladales (Darga and Schlagintweit 1991; Dya 1992; Schlagintweit and Ebli 1999; Schlagintweit et al. 2003). The change from pelagic carbonatic (Oberalm Formation) to siliciclastic-influenced pelagic sedimentation (Schrambach Formation) in Late Berriasian in the northern parts of the Northern Calcareous Alps indicates also a change in the tectonic setting. As yet, only very little is known about the evolution of the Jurassic to Cretaceous shallow-water carbonates in the southern parts of the Northern Calcareous Alps (uplift with erosion or drowning).

After dating and facies description of the shallow water carbonates in the framework of the re-investigation of the Plassen type location (Schlagintweit et al. 2003 with references), sediments covering the Plassen Formation have been sampled during another field campaign and are in focus of the present study (Fig. 3). Here the first direct dating of overlying pelagic sedimentary rocks on top of the Late Jurassic to Early Cretaceous shallow-water Plassen carbonate platform in the western Tethys region are presented, indicating

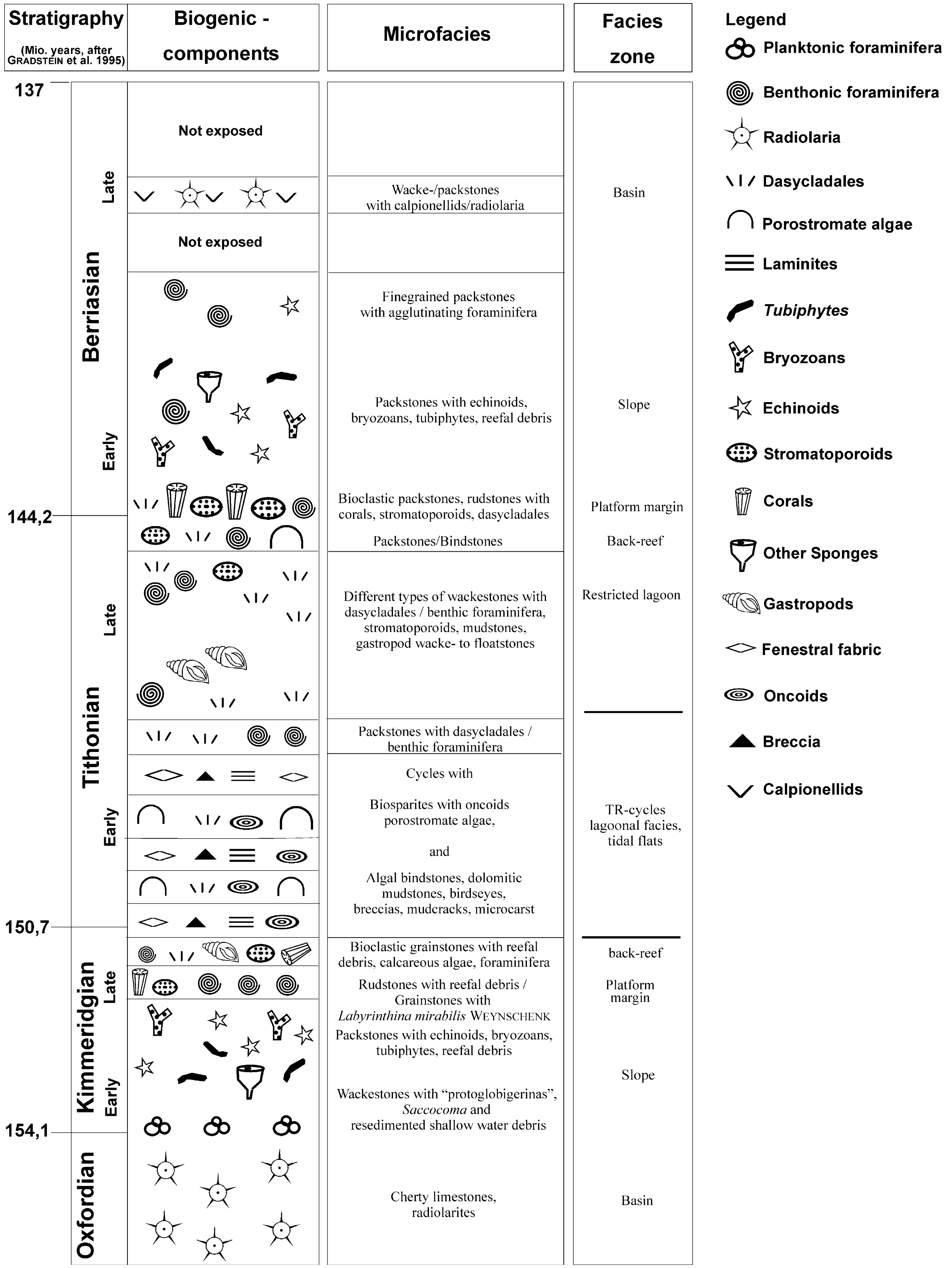


Fig. 3 Sedimentary sequence of the Mount Plassen area (Oxfordian to Berriasian), based on the results of Wegerer et al. (2003), Schlagintweit et al. (2003) and new results

drowning instead of uplift, which is an important parameter for the reconstruction of the Cretaceous tectonic cycle after the Late Jurassic collisional event.

Stratigraphy and facies of the Plassen Formation

At Mount Plassen, the Plassen Formation evolves in a course of continuous sedimentation of a shallowing upward trend manifested in a succession of cherty sediments (Early Callovian to Late Oxfordian/Lower Kimmeridgian: Suzuki et al. 2001; Wegerer et al. 2003) followed by pelagic limestones. These pelagic limestones on top of the Late Oxfordian radiolarites and below the carbonates of the Plassen Formation may contain "protoglobigerinas" or *Saccocoma* (Fig. 3; Schlagintweit et al. 2003). With rare exceptions, trochospiral protoglobigerinids cannot be determined in thin sections (Wernli and Görög 2000). First appearing in the Early Toarcian (Wernli 1995) they are known to persist until the Late Jurassic (e.g., Gorbatchik and Kuznetsowa 1983). In previous studies the occurrence of *Globuligerina oxfordiana* (Grigelis) inferred an Oxfordian age. This species has also been reported from the Early Kimmeridgian (Farinacci et al. 2000) besides uncertainties in determination. According to Diersche (1980) the "*Saccocoma*-Coeno-Zone" reaches from the Kimmeridgian up to the base of the Late Tithonian.

The wacke- to packstones with "protoglobigerinas" and with resedimented shallow water bioclasts were followed by slope deposits with "*Tubiphytes*", echinoids, and bryozoans? and in the upper part with resedimented *Labyrinthina mirabilis*. The platform margin facies is represented by high-energy *Labyrinthina* shoals of Late Kimmeridgian age, containing also clasts of corals and stromatoporoids indicating the existence of reefal areas. It is assumed that these mark the change from an initial ramp to a rimmed platform margin (Fig. 3; Schlagintweit et al. 2003). The complete absence of ooidal shoals is conspicuous. The backward shoal/"reef" facies consists of bioclastic grainstones with benthic foraminifera, dasycladales and rivulariacean algae passing into oncoidal open lagoonal facies and *Bacinella* bindstones. These are followed by transgressive–regressive(TR)-cycles (Fig. 3) with repeated series of tidal flats and open/restricted lagoonal facies documenting the interplay of tectonic subsidence and oscillating sea-level. Emersions are evidenced by desiccation breccias and cracks filled with clasts from overlying beds. The platform margin facies obviously formed an effective barrier isolating a lagoonal environment and enabling the formation of early diagenetic dolomite preferentially in mudstones and oncoidal wackestones. It is assumed that these cycles started in the latest Kimmeridgian persisting approximately until the Lower/Late Tithonian boundary based on the benthic foraminifera *L. mirabilis* Weynschenk, *Kurnubia palastiniensis* Henson and "*Kilianina*" *rahonensis* Foury and Vincent in its lower part (e.g., Bassoullet 1997). The transition from these TR-cycles to the following restricted lagoonal facies is marked by an erosional surface (?sequence boundary) with overlying packstones composed exclusively of fragments of the dasycladale *Campbelliella striata* (Carozzi) ("*Campbelliella* limestones"). This observation of "*Campbelliella* limestones" was previously made by Fenninger and Holzer (1972, p. 71). Probably the abundance of *Campbelliella* represents an isochronous interval that could be traced in other localities. The restricted lagoonal facies consists of dasycladale and foraminifera wackestones typically with pseudocyclamminids, gastropod wacke- to floatstones, mudstones and stromatoporoid wackestones and lasts approximately the whole Late Tithonian. Following packstones and *Bacinella* bindstones, the Jurassic/Cretaceous boundary is marked by the occurrence of coral-stromatoporoid limestones containing few foraminifera *Protopeneroplis ultragranulata* (Gorbatchik). Skeletal rudstones pass into proximal slope deposits with bryozoans, brachiopods, echinoids, *Tubiphytes* and also reef debris becoming increasingly finer grained. These fine grained packstones with small benthic foraminifera of a presumed lower slope position are the youngest sediments within the continuous carbonate sequence. The transition to the radiolarian-calpionellid marly limestones described in detail later is not exposed, but there is no evidence for subaerial exposure prior to the drowning of the platform. In fact, a gradual deepening- and fining-upward tendency can be observed. The microfacies of the latest Jurassic-to Berriasian-drowned platform depositional system is illustrated in Fig. 4.

The sedimentary cover of the Plassen Formation

The sedimentary cover of the Plassen Formation is made of bedded marly wacke- to packstones. Most of these basinal sediments have been eroded to this day. There is only one small fault-bounded occurrence, which has exceptionally been preserved near the summit of Mount Plassen at a present-day altitude of approximately 1,755 m above sea level (see Fig. 5, samples Pl 92–93).

The dominant microfossils are calpionellids and radiolaria. Furthermore there are some small textulariids, *Spirillina* sp., calcisphaerulids and debris of echinoids. Among the calpionellids, *Calpionellopsis oblonga* (Cadisch) is the dominant species, and rare *Tintinopsella* gr. *carpathica* (Murgeanu and Filipescu) can be observed in addition (Fig. 6). The calpionellid limestones can be assigned to the Late Berriasian (*oblonga* Subzone, e.g., Grün and Blau 1997). *C. oblonga* (Cadisch) has already been reported from the Late Berriasian of the northern part of the Northern Calcareous Alps, for

– Boorová et al. 1999: Pl. 7, Fig. 9, Gutrathsberg quarry south of Salzburg, Schrambach Formation

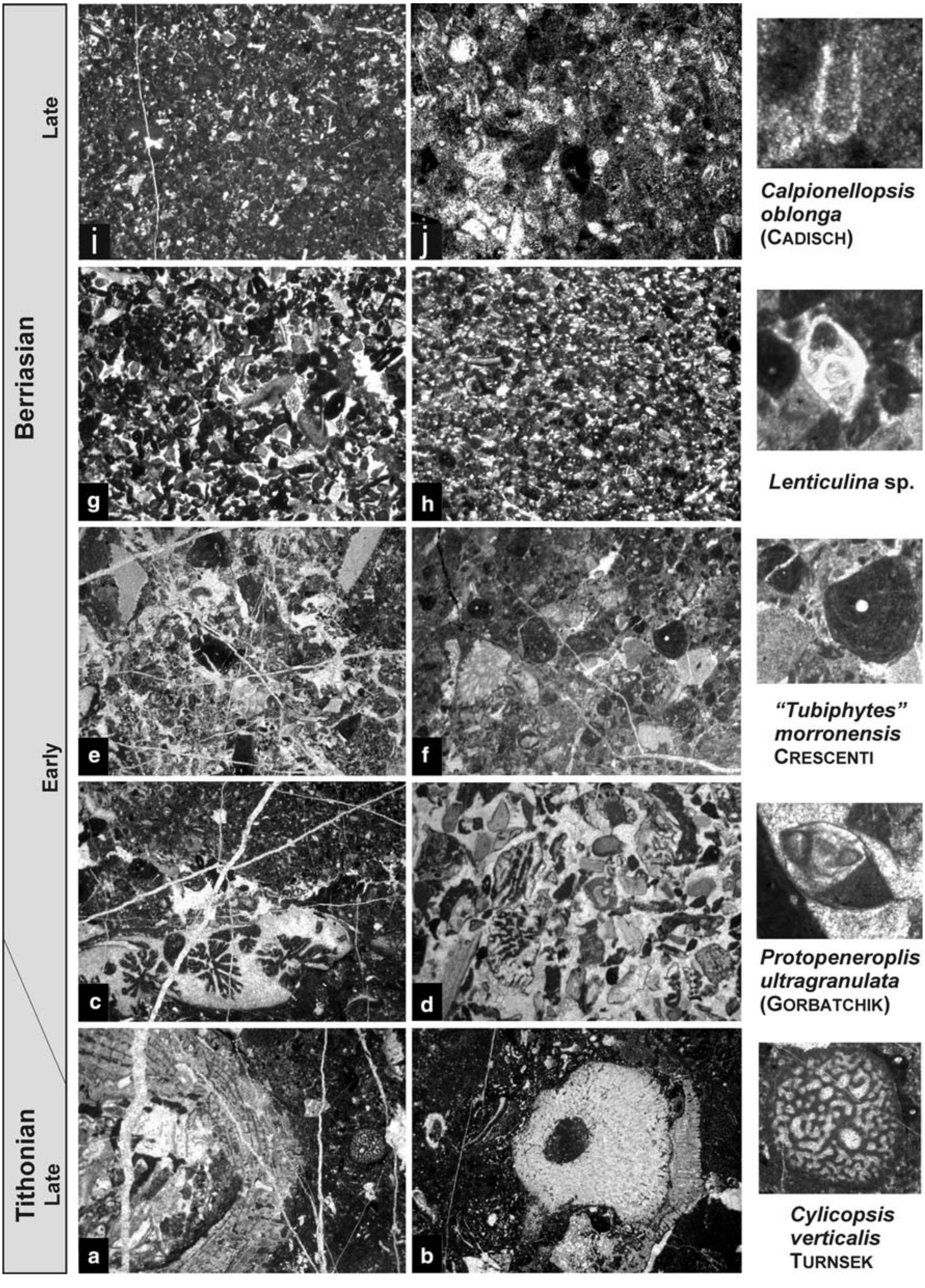


Fig. 4 Late Jurassic–Early Cretaceous drowning succession of the Plassen Formation at Mount Plassen. **a, b** Stromatoporoid limestones with *Ellipsactinia, Milleporidium* and *Cylicopsis*, **c** coral debris facies, **d**: bioclastic grain- to packstone with echinoids, bryozoa, **e**–**f**: Packstones with echinoids, *Tubiphytes*, **g**–**i**: Packstones with successive decrease in grain size, **j**: Calpionellid wacke- to packstone

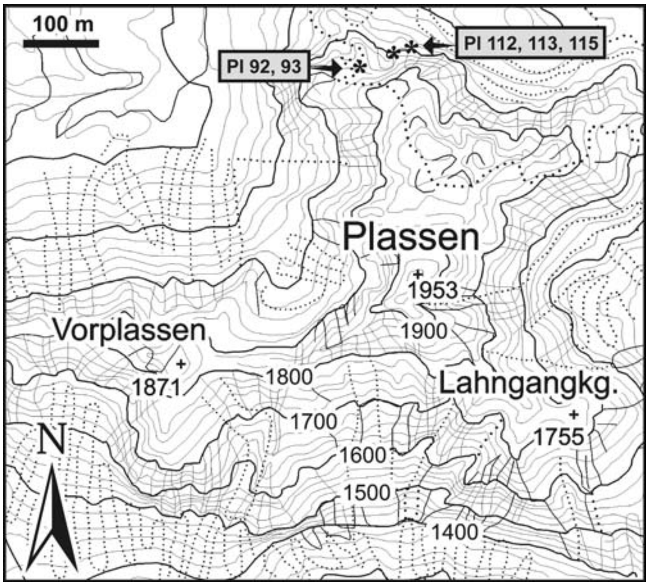


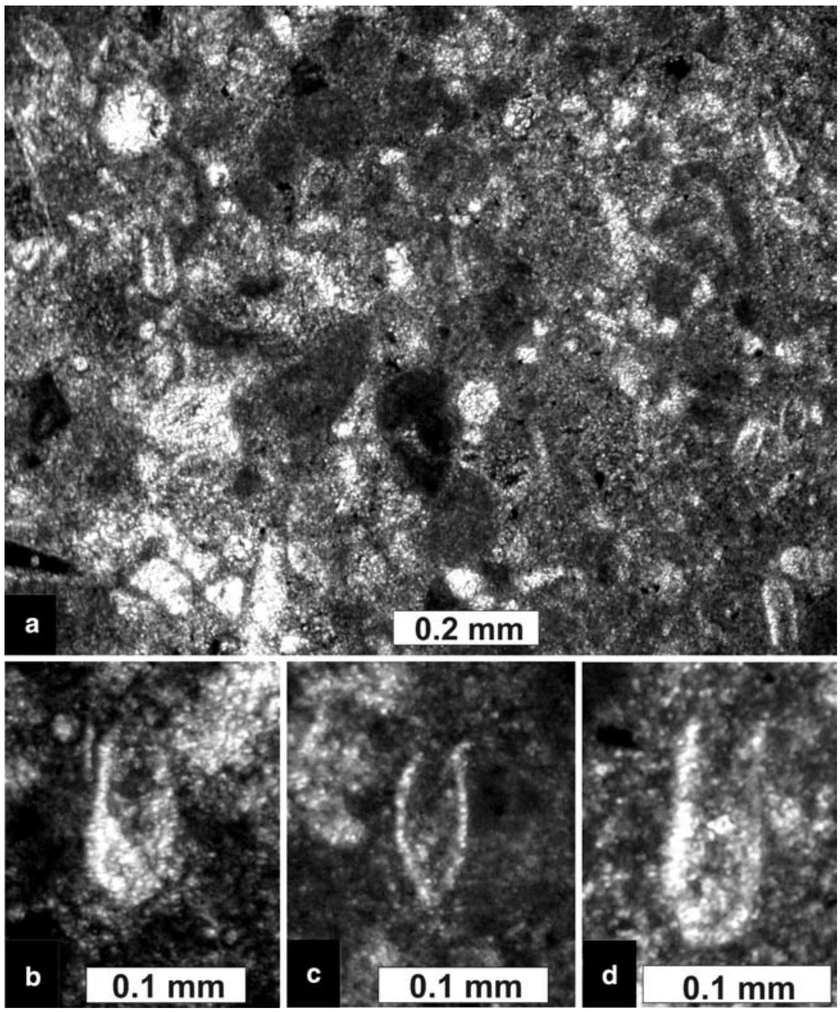
Fig. 5 Topographic sketch map of Mount Plassen and sample locations of the Late Berriasian calpionellid limestones

– Vasícek et al. 1999: Pl. 5, Fig. 9 (p.p.), 12, Schrambach Formation of the Lunz Nappe near Hollenstein a.d. Ybbs.

The sequence of shallow-water rocks overlain by basinal deposits records a typical drowning unconformity sensu Schlager (1989).

The youngest sediments at Mount Plassen are reddish-brown sandstones, partly occurring as fissure fillings within the Plassen Formation or lying with erosional contact upon the latter. Radiolarians within these sandstones are poorly preserved and, therefore, not of stratigraphic use. Apart from dark mineral grains, quartz and "fritted" clasts of radiolarites occur. According to the occurrence and characteristics of these rocks they can only be assigned to the Early (Rossfeld Formation) or Late Cretaceous (Gosau Group) succession. The transgressive Lower Gosau Subgroup, however, consists of shallow-water lithologies while the sandstones of the Plassen area contain radiolarians and are supposedly of deeper water origin. Thus, a Lower Cretaceous age (Valanginian, Hauterivian) for these sandstones is favored.

Fig. 6 **a** Calpionellid radiolarian packstone with Calpionellopsis oblonga (Cadisch); **b**, **c** *Calpionellopsis oblonga* (Cadisch). **d** *Tintinopsella* gr. *carpathica* Murgeanu. All figures from sample Pl 92 (see Fig. 5)



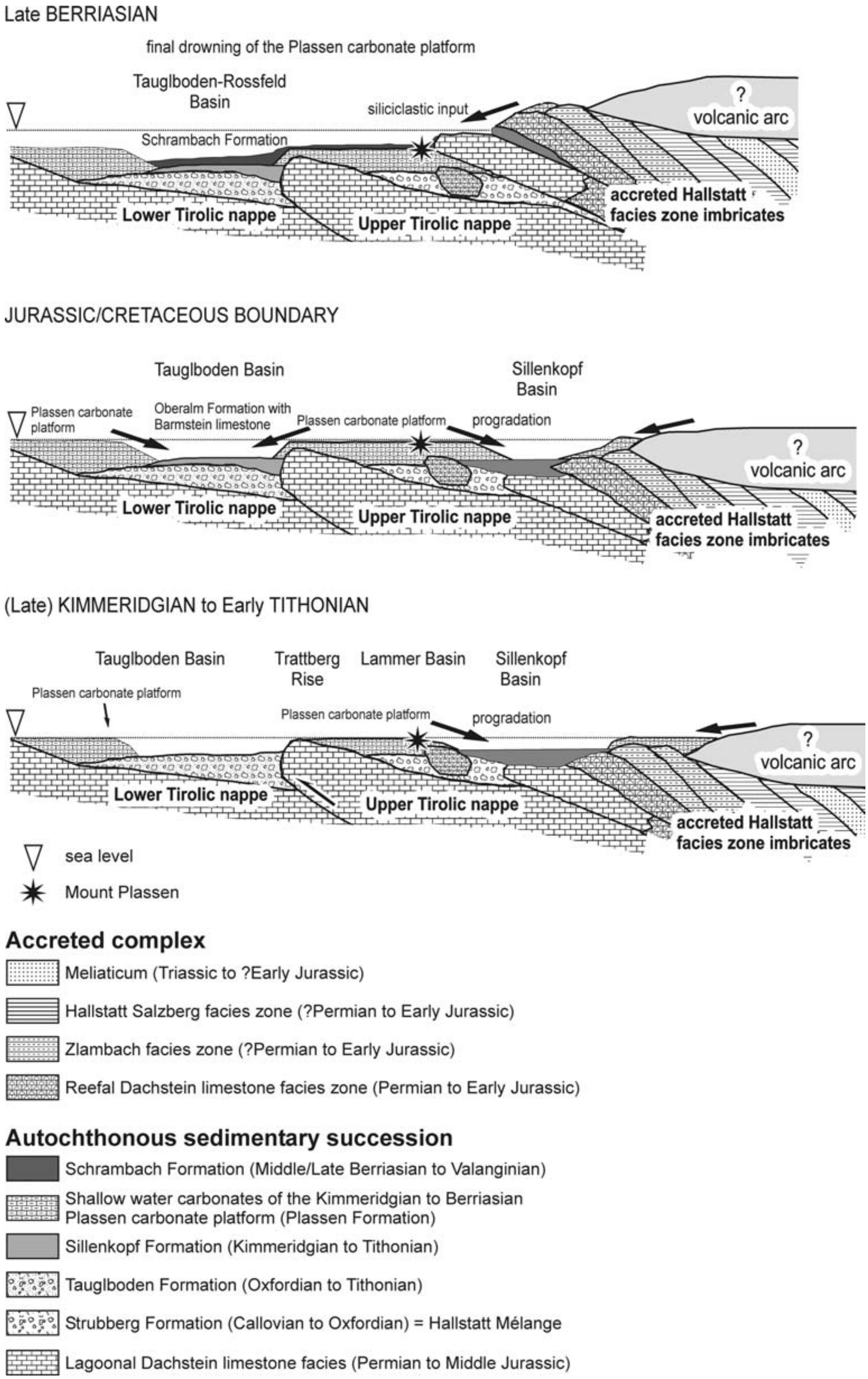


Fig. 7 Reconstruction of the Kimmeridgian to Berriasian evolution of the Plassen Formation and the source area of the Schrambach Formation (Gawlick et al. 2005 added). Explanations of the facies zones and formations in Gawlick (2000a, b) and Gawlick and Frisch (2003)

Discussion

In the Northern Calcareous Alps, the Late Berriasian is represented by the Schrambach Formation, termed "Neokom-Aptychen-Schichten" in the western parts of the Northern Calcareous Alps (e.g., Weidich 1990: Fig. 2). The Schrambach Formation occurs also in the Tannheim/Losenstein Basin that formed as a deep-marine piggy back trough along the northernmost part of the orogenic wedge of the Eastern Alps (Wagreich 2001). There the Schrambach Formation underlies the Tannheim Formation (Late Aptian to Middle Albian).

From the common microfacies and stratigraphic level, the Calpionellid limestones at Mount Plassen resemble the Schrambach Formation. The Schrambach Formation, however, occurs above the Oberalm Formation forming the sedimentary cover of the Tauglboden Formation (= Lower Tirolic unit sensu Frisch and Gawlick 2003).

A formal lithostratigraphic definition of the Schrambach Formation at the type-locality has been recently provided by Rasser et al. (2003). The stratigraphic range of the latter at the Schrambachgraben near Hallein, Salzburg, has been specified as Middle/Late Berriasian to Early Valanginian. The underlying unit, as one of the definition parameters, is the Oberalm Formation, known as typical basinal deposits containing reef debris (Barmstein limestone) from the Plassen carbonate platform in the south. However, at Mount Plassen, the Late Berriasian Calpionellid limestones are underlain by slope deposits of the Plassen Formation. Hence, if the provided formal definition is strictly accepted, these sediments cannot be termed Schrambach Formation although they show equivalent microfacies characteristics and same age (e.g., Rasser et al. 2003: Fig. 7c). From a paleogeographical point of view, it can be concluded that the Late Berriasian obviously was a time with a more or less widespread homogeneous depositional realm (“unifacies conditions”) with reduced sea floor topography after the elimination of the Late Jurassic platform-through configuration. In opinion this would justify the usage of nomenclatorial common lithological terms.

It is also remarkable that in the Reichraming Nappe of Upper Austria, Vasicek and Faupl (1999, p. 621) reported on a change from whitish platty limestones (Maiolica type) to an alternance of grey to grey-green spotted marly limestones and marls that took place in the *Calpionellopsis* Zone, a time when the former shallow-water carbonate platform areas were covered by basin sediments. The Schrambach Formation in turn is followed by the “flysch-like” Rossfeld Formation typically representing a coarsening upwards sequence, deposited in connection with “pre-Gosau” nappe stacking (Faupl and Tollmann 1979; Frisch and Gawlick 2003, Fig. 6c). Worth mentioning is the occurrence of sandstones, partly in fissures of the Plassen Formation, also in the northern part of Mount Plassen that may be remnants of Rossfeld type sediments.

The re-investigation of the Plassen Formation type-locality has revealed thick shallow-water limestones (Schlagintweit et al. 2003) that roughly equal the concomitant basin facies succession of the upper Tauglboden Formation and the Oberalm Formation in thickness (e.g., Garrison and Fischer 1969). This observation clearly indicates a high subsidence rate during the whole Tithonian, a time-span tectonic quiescence has been assumed for (Mandl 1982, 2000; Tollmann 1985 with references). Further investigations are, however, necessary for a more precise paleogeographic reconstruction and for a better understanding of the interplay of carbonate platform and basin evolution.

Conclusions

The whole sedimentary cycle of the Plassen Formation from the Early Kimmeridgian until the Late Berriasian lasted about 14 million years. Within this interval, shallow-water limestones (~ 0–10 m water depth) are known from the Late Kimmeridgian to the Jurassic/Cretaceous-boundary, that is, approximately 9 million years. The Plassen Formation of the type locality comprises a complete sedimentary cycle from a shallow-water carbonate platform until its drowning. It is therefore an ideal type section. Most of the other occurrences of the Plassen Formation in the Northern Calcareous Alps show incomplete successions.

The Berriasian deepening upward succession represents the final phase of the Plassen carbonate platform. The transition from the platform to basinal facies coincides approximately with the lithological change from the pure carbonatic Oberalm Formation to the marly-carbonatic to fine-siliciclastic Schrambach Formation at the Middle/Late Berriasian boundary in the northern part of the Northern Calcareous Alps (Lower Tirolic unit, Bavaric units). This time synchroneity documents that the causes for the great thicknesses of the Oberalm Formation were both tectonic subsidence and the shedding of huge masses of carbonate material from the platform areas of the Plassen carbonate platform rather than enhanced nannoplankton productivity in the whole Tethys (e.g., Colacicchi and Bigozzi 1995). Whereas in the basin facies there is no lithological change except the increase in the amount of reefal debris (Barmstein limestone—Gawlick et al. 2005) around the Jurassic/Cretaceous-boundary, which is contemporaneous to the turning point in the platform area, marking the final drowning: coral-stromatoporoid reefal limestones of a platform margin environment have been progressively replaced by slope and finally by basin facies lithologies. The Late Berriasian-condensed (hemi-) pelagic limestones on top of the Plassen Formation are equivalent to the time-equivalent Schrambach Formation in the northern part of the Northern Calcareous Alps. The Schrambach Formation reflects the gradual lithological change from carbonate rocks to siliciclastic-influenced carbonates. The pelagic limestones on top of the Plassen Formation Schrambach Formation are named as well as the change to uniform facies conditions in the whole area of Northern Calcareous Alps starting in Late Berriasian times are documented. Therefore the Schrambach Formation marks the beginning of a new sedimentary cycle characterized by a high siliciclastic input (Rossfeld-Tannheim cycle in the sense of Schlager and Schöllnberger 1974).

All these observations support the idea of the ongoing tectonic shortening, which started in Callovian times by forming the Hallstatt Mélange in the Lammer Basin (Gawlick et al. 1999; Gawlick and Frisch 2003) and corresponds to the generally accepted climax of basin subsidence, breccia formation and water depth attained in the Callovian/Oxfordian (e.g., Diersche 1980; Tollmann 1987; Gawlick and Frisch 2003). First input of siliciclastic detritus and ophiolitic debris occurred in the Late Kimmeridgian Sillenkopf Basin which, was situated in a southern position (Missoni 2003). The Plassen carbonate platform north of the Sillenkopf Basin (Fig. 7) shielded the northern parts of the Northern Calcareous Alps from this siliciclastic input. In the Tithonian times subsidence increased in the northern part of the Upper Tirolic (Lammer Basin) and in the Lower Tirolic unit (Tauglboden Basin) due to the tectonic load caused by thrusting and tectonic shortening in the south. Around the Jurassic/Cretaceous boundary coarse-grained reefal material (Barmstein limestone) from the southern Plassen carbonate platform was re-sedimented into the Tauglboden Basin (Gawlick et al. 2005 with references) contemporaneous with the deepening in the Plassen area. In the Late Berriasian increasing siliciclastic input stopped the carbonate production and resulted in final drowning.

Thus, the observed deepening event was probably due to enhanced subsidence in connection with increasing siliciclastic input and not to the eustatic sea-level rise after the widespread latest Jurassic to earliest Cretaceous regressive phase (e.g., Jacquin et al. 1998). In the Tithonian during preponderance of restricted lagoonal facies conditions, however, increased subsidence or relative sea-level rise could be balanced by enhanced carbonate production. Therefore, these sediments have their widest distribution at the present-day Plassen mountain massif. The overall subsidence history of the Plassen carbonate platform can be directly linked with the huge masses of Barmstein limestones that have been shed into the northern Tauglboden basin during the Late Tithonian to Early/Middle Berriasian (Gawlick et al. 2005 for discussion). The results show also the Kimmeridgian to Early Berriasian isolation of the Plassen Formation of Mount Plassen from siliciclastic input affecting the southern radiolarite basin (Sillenkopf Basin) since the Kimmeridgian (Missoni et al. 2001). The Lammer Basin and northern parts of the Sillenkopf Basin were completely filled by sediments during Late Kimmeridgian to Early Tithonian time due to platform progradation in southern direction. As a consequence of ongoing tectonic shortening in the southern part of the Northern Calcareous Alps and uplift of the accretionary wedge (= accreted Hallstatt facies zone units—Fig. 7) in the Early Berriasian (Gawlick, Schlagintweit, Missoni, unpublished data), siliciclastic material was shed into the northern Lammer Basin area with its Plassen Formation cover and led to final drowning of the carbonate platform. In the Late Berriasian, the sedimentation in the Northern Calcareous Alps became rather uniform until the start of the coarsening-upward cycle of the Rossfeld Formation, which contains also ophiolitic detritus from obducted ultrabasites (Faupl and Tollmann 1979; Faupl and Pober 1991). The siliciclastic-influenced carbonates of the Schrambach Formation and Rossfeld Formation sealed the late Middle to Early Late Jurassic carbonate clastic radiolarite basins and the highly differentiated Plassen carbonate platform.

Summarizing, a generally accepted model of a Kimmeridgian to Berriasian phase of tectonic quiescense during the evolution of the Plassen carbonate platform (Mandl 1982; Tollmann 1985, 1987; Mandl 2000) cannot be confirmed from our observations. The Plassen carbonate platform did not only seal the relief caused by Callovian to Oxfordian tectonics but was also deposited in a mobile tectonic environment as to expect in an active continental margin setting. Though, the exact scenario of the onset, evolution and drowning of the Plassen carbonate platform is still far from being completely understood and there is still strong need of further area-wide investigations of the platform sequence and its underlying radiolaritic flysch and overlying carbonate siliciclastic sedimentary succession, respectively.

Acknowledgements We are indebted to the Austrian Science Foundation (FWF project P 16812) for financial support of this study. We are thankful to Dr. Matthias Auer and Dr. Sigrid Missoni for reading the manuscript. We are very grateful to the reviewers, Prof. Wolfgang Frisch and Anonymus, for their very constructive comments on the manuscript.

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