

# GROWTH AND TERMINATION OF THE UPPER TRIASSIC PLATFORM MARGIN OF THE DACHSTEIN AREA (NORTHERN CALCAREOUS ALPS, AUSTRIA)

Leopold KRISTYN<sup>1)</sup>, Gerhard W. MANDL<sup>2)</sup> & Martin SCHAUER<sup>3)</sup>

<sup>1)</sup> Department of Palaeontology, Vienna University, Althanstrasse 14, A-1090 Vienna, Austria.

<sup>2)</sup> Geological Survey of Austria, Neulinggasse 38, A-1030 Vienna, Austria.

<sup>3)</sup> Klabundgasse 6, A-1190 Vienna, Austria.

<sup>†</sup> Corresponding author, leopold.krystyn@univie.ac.at

## KEYWORDS

Northern Calcareous Alps  
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Donnerkogelkalk  
Dachsteinriffkalk  
Norian-Rhaetian

## ABSTRACT

From the margin of the Dachstein carbonate platform, i.e. the reef rim and slope usually mapped as "Dachsteinriffkalk Formation", conodonts are described that allow an exact stratigraphic dating and a reconstruction of the depositional history. Reef growth starts in the earliest Norian and reaches a peak in the early Rhaetian. Nearly 1000 metres of limestone accumulated in this time interval. Thin pelagic intercalations indicate certain flooding events and allow the distinction of a thick Early Norian, a comparably thin Middle Norian and an again thicker Late Norian to early Rhaetian interval within the Dachsteinriffkalk. Phases of extended reef growth are found in the Early Norian and Rhaetian before the margin get drowned and covered by the pelagic Donnerkogelkalk in middle Rhaetian time. Reef building at the platform margin of the Dachstein area thus ended well before the top of the Triassic and the end-Triassic extinction event.

Aus dem Typusgebiet des Dachsteinkalkes werden vom Riffsaum und vom Hang der Karbonatplattform Conodontenfaunen beschrieben, die eine genaue stratigraphische Datierung und damit eine Rekonstruktion der Ablagerungsgeschichte erlauben. Das Riffwachstum beginnt im untersten Norium und erreicht ein Maximum im frühen Rhätium. Dabei wird ein Schichtstapel von nahezu 1000 Meter Mächtigkeit abgelagert. Dünne pelagische Einschaltungen zeigen mehrere Flutungseignisse an und ermöglichen die Unterscheidung eines mächtigen unternorischen, eines geringer mächtigen mittelnorischen und eines wiederum dickeren obernorisch bis rhätischen Anteiles des Riffkörpers. Phasen von verstärktem Riffwachstum sind im Unter-Norium und im Rhätium zu erkennen, bevor das Riff ertrinkt und im mittleren Rhätium vom pelagischen – hier als lithostratigraphischer Terminus neu eingeführten - Donnerkogelkalk überdeckt wird. Das Riffwachstum am Plattformrand des Dachsteingebietes endet damit innerhalb der Trias und deutlich vor dem end-triassischen Aussterbe-Event.

## 1. INTRODUCTION

During Late Triassic time broad carbonate shelves bordered the northwestern Tethys margin over a lateral distance of more than 1000 km. These shelf carbonates are known as Dachsteinkalk and form large mountain plateaus in the Northern Calcareous Alps of central and eastern Austria (Mandl, 2000). Type locality of the Dachsteinkalk is the Dachstein Massif in the southern Salzkammergut region that consists of cyclical bedded lagoonal limestone with a south- and south-westward transition to a broad reefal rim and adjacent slope. Platform margin and slope were usually mapped together as "Dachsteinriffkalk".

In this paper we call the reefal platform rim plus the adjacent slope deposits "platform margin". The reasons for lumping the two facies belts are twofold. First, the separation is not crucial for the stratigraphic results presented here. Second, reef debris is common in both facies and bedding is very similar: Bedding surfaces in both facies tend to be widely spaced (tens to over 100 meters) and often discontinuous; as a consequence, reef rim and slope facies are often difficult to distinguish in tectonically deformed areas and this is the reason why both facies have usually been mapped as one formation called "Dachsteinriffkalk" in German-speaking

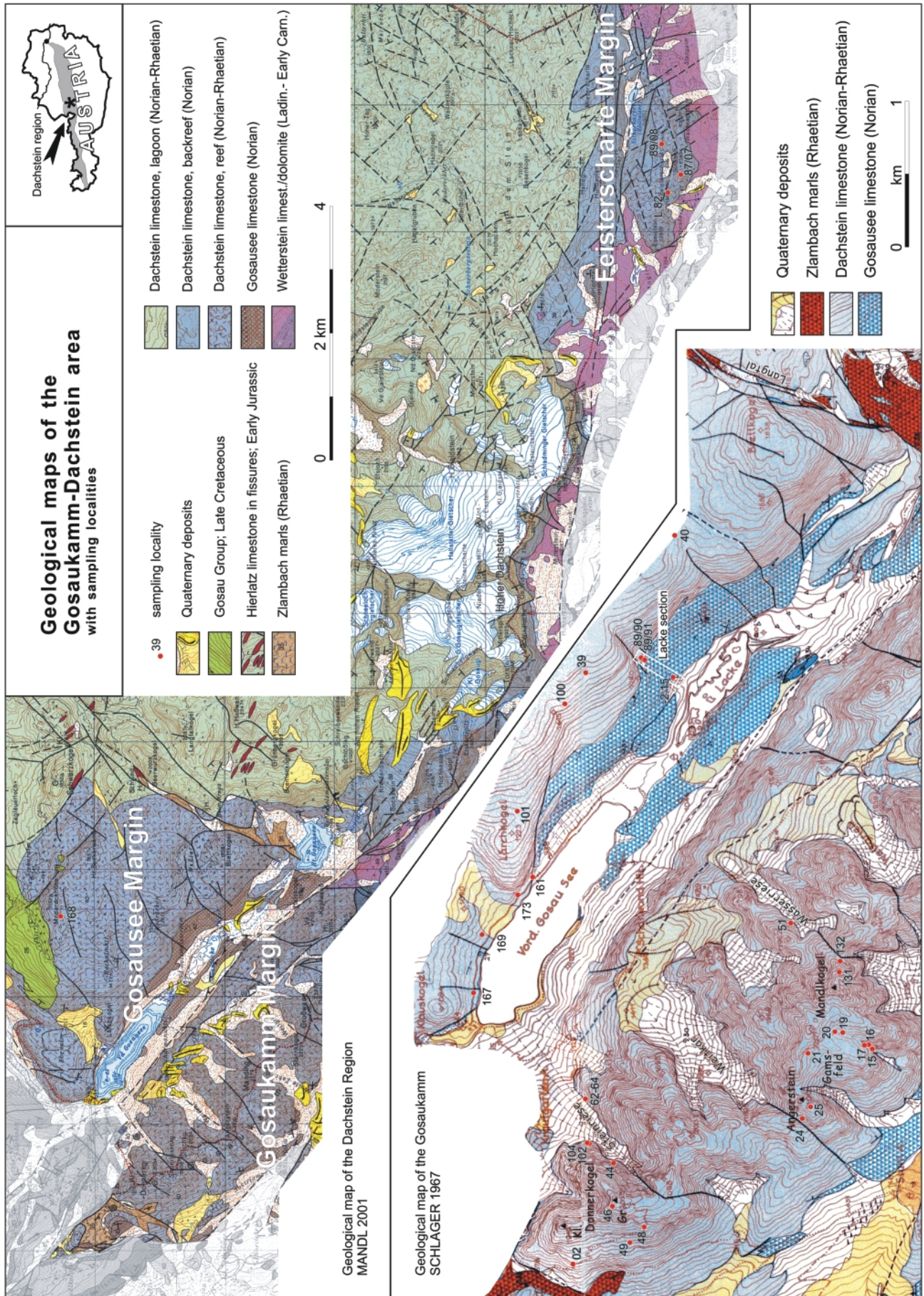
literature. This formation is characterized by poor stratification and locally coarse fossil debris or in-situ boundstones.

At the Gosaukamm, the more than 800 m thick limestones of the platform margin (Wurm, 1982) prograde during Norian time over the adjacent Hallstatt basin in the southwest (Schlager, 1967; Kenter & Schlager, 2009). In other parts of the Dachstein Massif, the platform margin is still in normal sedimentary contact with the lagoon. At the Gosaukamm, this contact has been severed by alpidic strike slip movement and the range is thought to be displaced to the northwest by about 7 km with respect to main part of the Dachstein Massif (Mandl, 1984).

Due to an exceptionally diverse Norian-Rhaetian reef biota the Dachsteinkalk of the NCA has become a classical palaeontological study site (Flügel, 1963; Zankl, 1969, 1981; Wurm, 1982; Roniewicz, 1989, 1995). Its facial and sedimentological characters (Fischer, 1964; Zankl, 1971; Wurm, 1982; Satterley, 1994; Enos and Samankassou, 1998; Schwarzacher, 2005; Haas et al., 2007) are equally important for comparisons with similar Late Triassic shallow-water carbonate platforms. Dachstein-like reefs and lagoonal carbonates are widespread along the Tethys margins and known from the Carpa-



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**FIGURE 1:** a) Geological map of southwestern Dachstein massif with location of the studied platform margins at Feisterscharte, Gosaukamm and north of Gosausee. b) Map of Gosausee area with conodont sampling sites; prefix "GK" in Gosaukamm sample numbers omitted.



thians, Dinarids, Greece, Turkey, Oman, till the Indonesian Islands (Flügel et al., 1996a,b; Flügel and Bernecker, 1996). Any new stratigraphic information is therefore of broader interest for many other Tethyan regions where this facies occurs.

A more general Norian to Rhaetian age assignment of the Dachsteinriffkalk dates back to the late nineteenth century (Bittner, 1884) and has not seen much age refinement since then (see Tollmann, 1976a). At the Gosaukamm, even the attempts to separate Norian and Rhaetian parts failed due to the low stratigraphic resolution of the available macrofossils (Zapfe, 1967, 1973). Age information was therefore rather poor before publication of the first conodont records (Krystyn, 1972; Schauer, 1984). Here we present a comprehensive biostratigraphic documentation of the growth history of the platform margin in the southwestern area of the Dachstein Massif between Feisterscharte in the east and the Gosaukamm and the Gosausee (= Lake Gosau) region in the west (Fig. 1). The age constraints are based on conodonts from hemipelagic Hallstatt-type limestones within the platform margin, or immediately overlying the margin. During the last decades, conodonts have turned out as powerful tool for fine-tuning stratigraphy in basinal sediments where they co-occur with ammonoids and can be calibrated against the ammonite-based time scale (Orchard and Tozer, 1997).

## 2. REGIONAL GEOLOGY

As parts of the Eastern Alps, the Northern Calcareous Alps (NCA) represent the sediments of an approximately 300 km wide and 500 km long sector of the northwestern margin of the former Tethys ocean. Along this, as well as in other parts of the Upper Triassic Tethyan passive margin, belts of marine sedimentation were arranged in a characteristic shore-parallel fashion. This is illustrated in particular by the spatial arrangement of classical Upper Triassic sedimentary environments, see Haas et al. (1995), Mandl (2000). The most landward zone was the Keuper belt, dominated by redbeds and evaporites. Seaward followed a wide belt of carbonate platforms with supratidal to subtidal deposits (Hauptdolomit and bedded Dachsteinkalk formations). The platform was flanked at its southwestern rim by reefs facing deeper, openwater. The Dachstein platform produced large masses of skeletal and non-skeletal carbonate detritus, which were deposited mostly along the platform slopes and on the proximal basin floors. Further offshore only a small amount of periplatform sediments reached the pelagic Hallstatt facies belt.

In the course of Alpine orogeny the Permian to Eocene sedimentary succession became detached from its continental basement and transformed into a complex fold-and-thrust-belt. The plate tectonic closure of the Tethyan ocean is not well documented in the Eastern Alps and poorly understood. Nevertheless, it is clear that large masses of rocks of the southern Dachstein and Hallstatt facies belt became detached from their basement at the level of the Permian evaporites, and were transformed to gravitational nappes, sliding blocks, olisthostromes and turbidites moving northward into the Jurassic radiolarite basins above the drowned platforms. During the Early Cretaceous a succession of several tectonic events and associated syntectonic clastic sedimentation created the NCA nappe stack (e.g. Tollmann, 1987; Faupl and Wagreich, 2000; Mandl, 2000). In this way the Dachstein Massif and Gosaukamm became part of the so-called Dachstein nappe, a major component of the Juvavic nappe system. The latter forms the uppermost nappe structures in the classical tectonic terminology of the NCA, see Tollmann (1976 b; 1985). A different tectonic classification has recently been proposed by Frisch and Gawlick (2003).

## 3. BIOSTRATIGRAPHY

A new definition of most Triassic stages is currently under consideration by the International Commission on Stratigraphy (ICS). Independent of any future agreement on the respective boundary definitions, we follow here the Tethyan Late Triassic ammonoid standard developed by Krystyn (1980, 1982, 1987) for a cross-correlation of our conodont data (Fig. 2). As such the base of the Early Norian (Lacian substage) is defined by the *Guembelites jandianus* Zone, that of the Middle Norian (Alaunian substage) by the *Cyrtopleurites bicrenatus* Zone and that of the Late Norian (Sevatian substage) by the *Sagenites quinquepunctatus* Zone. The Rhaetian starts with *Paracochloceras suessi* and the correlative *Sagenites*

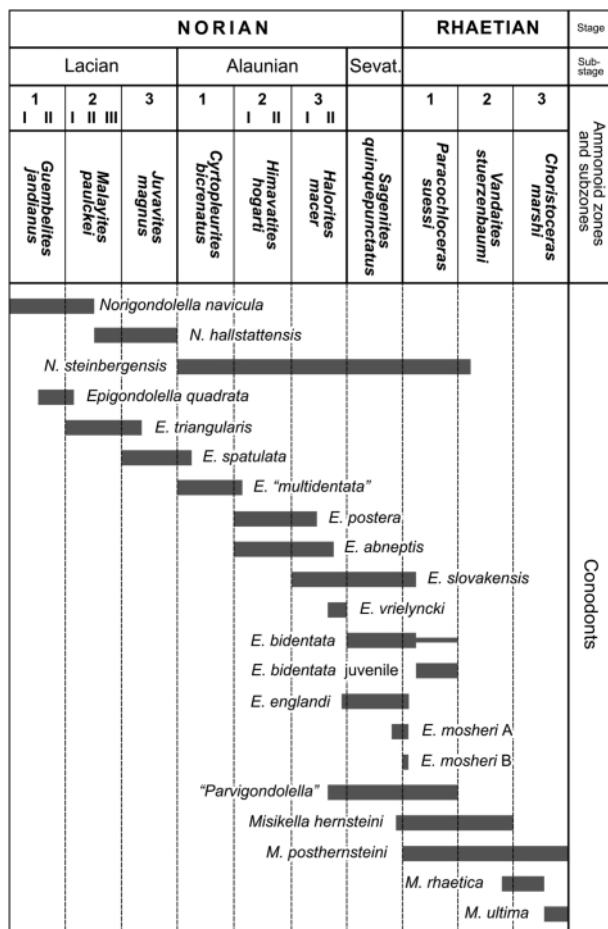


FIGURE 2: Conodont ranges plotted against the ammonoid zonation. Note position of Norian-Rhaetian boundary below *P. suessi* Zone.

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*reticulatus* Zone (Krystyn et al. 2007a, b) and contains two other zones, the *Vandaites stuerzenbaumi* Zone in the middle and the *Choristoceras marshi* Zone at the top. The exclusion of the *Paracochloceras* zone from the Norian has not only led to a shortening of the Sevatian substage (Krystyn et al., 2002), but also to a considerable lowering of the Norian-Rhaetian boundary in the Dachstein reefs.

Biostratigraphically relevant macrofossils including ammonoids and pelagic bivalves (*Halobia*, *Monotis*) are cited from many Dachsteinkalk platform margins of the NCA. However, these macrofossils are not common and most were collected in recent scree at the foot of the large mountain cliffs. From

the Gosaukamm (Steinriese area) talus findings of *Monotis*, halobiids (*H. norica*, *H. plicosa*), the ammonoid *Rhabdoceras suessi* and the enigmatic hydrozoan *Heterastridium* are mentioned by Zapfe (1967) and discussed for their stratigraphic significance but without a definite age conclusion for the reef. Zapfe (1967) also placed the *Halorella*-bearing brachiopod fauna (Kittl, 1916) of the Gosausee (locality GK 167 in fig. 1) erroneously low in the Norian though geologically it belongs to the top part of the Dachsteinriffkalk.

Stratigraphic ranges of conodonts are shown in figure 2 and most of the species are illustrated in figure 4. Geographic location, lithology and microfacies (Fig. 5) of conodont bearing

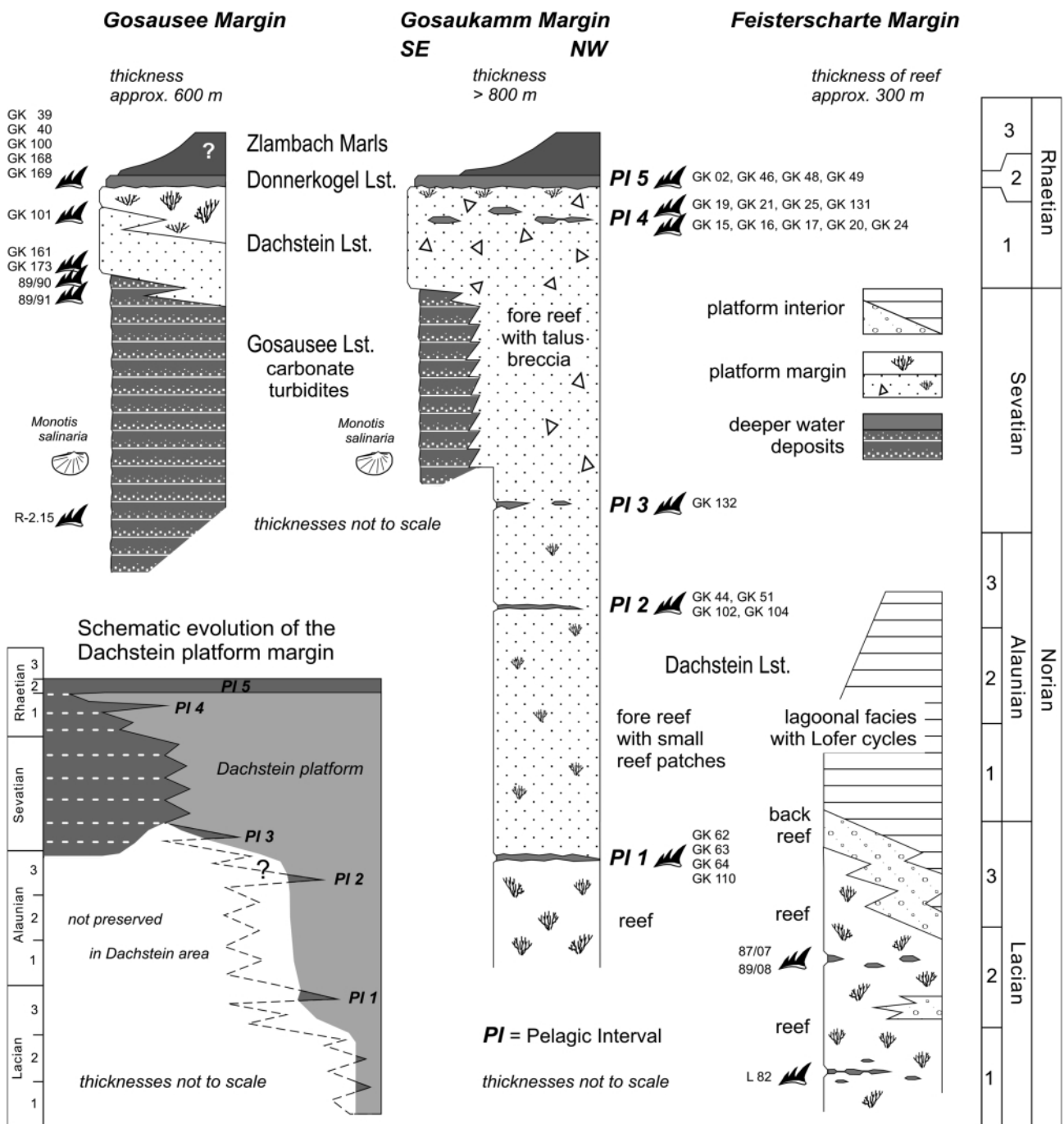


FIGURE 3: Stratigraphic and facial architecture of the Dachsteinriffkalk combined from Feisterscharte, Gosaukamm and northern Gosausee area.

samples are listed in table 1, and their relative position within the Dachsteinkalk sequence is shown in figure 3. On average 3-5 kg of rock had to be dissolved in acetic acid to obtain stratigraphically meaningful conodont faunas. The conodont and facies data of this paper are mainly based on the results of a doctoral thesis carried out by one of the authors (Schauer, 2002), except for the Feisterscharte region which was recently investigated by Roniewicz et al. (2007). Schauer's unpublished study of the Gosaukamm and other Alpine Dachstein reefs has demonstrated widespread, synchronous drowning of the platform margin in Rhaetian time with the termination of Dachstein reefs well before the end of the Triassic.

### 3.1 DACHSTEINRIFFKALK

The oldest reefs currently known are from the Feisterscharte region where the conodonts *Epigondolella quadrata* (Fig. 4-1) in sample L 82 and *E. triangularis* in samples 89/08 (Fig. 4-2) resp. 87/07 (Fig. 4-3) prove the onset of platform margin growth in early Lacyan time (Roniewicz et al., 2007). Platform progradation and concomitant migration of facies belts subsequently led to deposition of lagoonal carbonates in the area (Fig. 3). The late Lacyan platform margin is also exposed in the Gosaukamm in the basal parts of the NE-facing cliffs above the Gosausee. It consists there of massive, variably coarse to finer grained slope deposits with small isolated buildups, dominated by calcareous sponges embedded in arenitic sediment (Schauer, 2002). A 2-3 metres thick interval of hemipelagic limestone made up of filament- and crinoid-bearing wackestones (Fig. 5-2, 3) marked as pelagic interval 1 (= *PI 1* in fig. 3) covers the margin and can be traced along strike over a lateral distance of 4 km at the footwall of the Großwand (sample GK 110, Fig. 1) in 1830 m. In the Steinriese it occurs in an altitude of 1340-1350 m (samples GK 62 to GK 64). Pelagic interval *PI 1* contains *Epigondolella spatulata* (Fig. 4-4) indicating a late Lacyan age of this distinct flooding event. It is overlain by ca. 200 m of slope sediments similar to the Lacyan ones, again with small mound-like patch reef buildups (Schauer, 1984). The next pelagic interval, *PI 2*, is of late Alaunian age and only 20 cm thick, built of red micritic limestone accompanied by micritic-lithoclastic beds without reefal debris. *PI 2* follows 100 to 200m above *PI 1*. This indicates that the Alaunian interval is considerably thinner than the Lacyan or Sevatian to lower Rhaetian reef limestones whose thickness amounts to >300 and >500 m respectively. The *PI 2* contains *Norigondolella steinbergensis*, *E. postera* (Fig. 4-5) and *Epigondolella ex E. abneptis* group (Fig. 4-6) and is recorded in samples from the Steinriese in 1430m (GK 102, GK 104) and 1550m (GK 44) and in the Wasserriese in 1795m (GK 51).

The following part of the Gosaukamm between *PI 2* and *PI 3* consists of frame building reef facies with up to 50% framestones (Schauer, 2002) interfingering with massive, more or less coarse grained forereef limestone. Lithofacies changes above *PI 3* to coarse-grained slope breccias with a SW dipping decametric bedding interpreted as clinofolds by Kenter

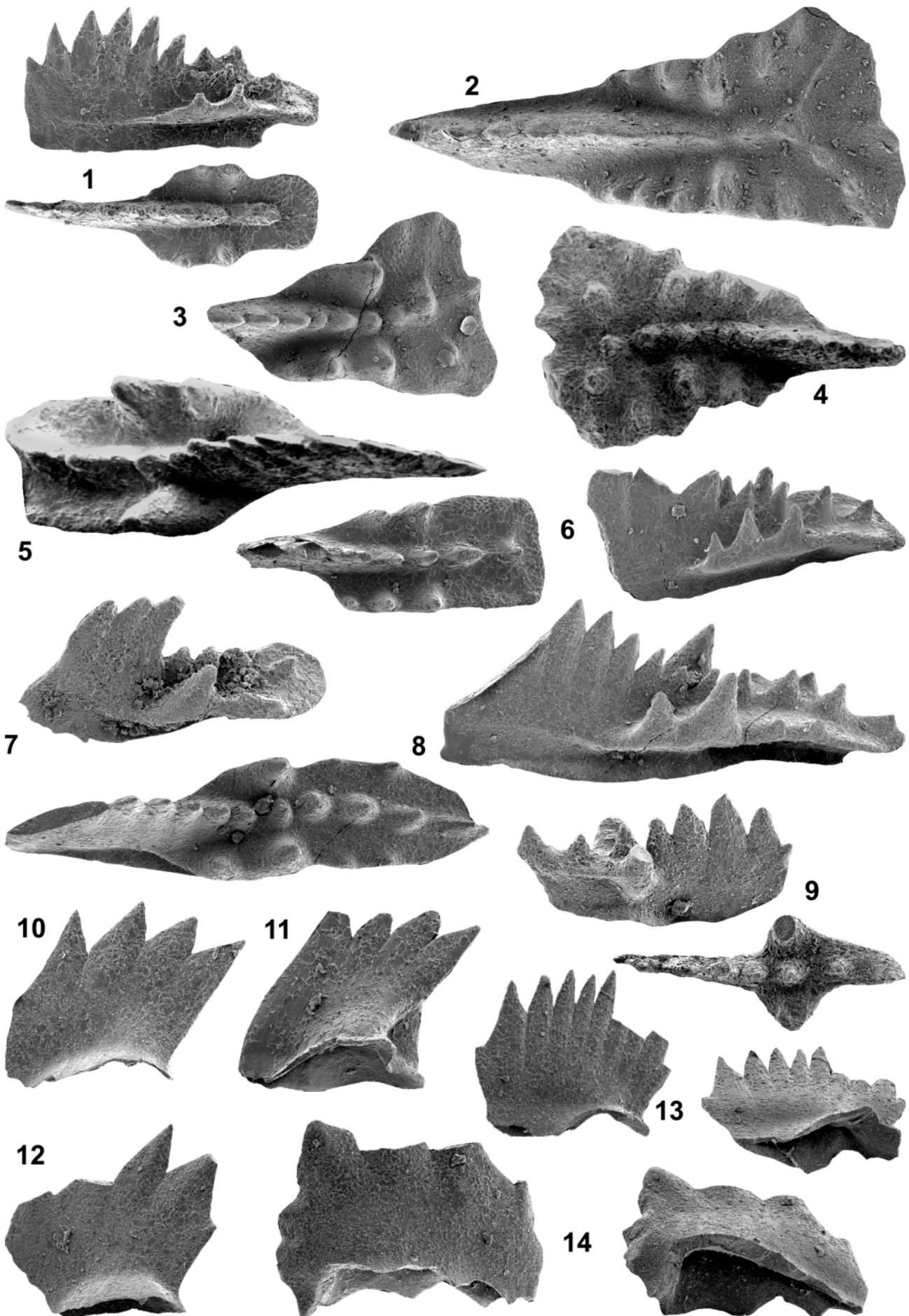
and Schlager (2009, this volume). Along these bedding surfaces occur discontinuous, thin lenses of red micritic limestone which have delivered locally conodont faunas of Sevatian to early Rhaetian age. These patchy occurrences are shown as *PI 3* and *PI 4* in fig. 3. Due to their small size they could be easily overlooked and especially *PI 3* was difficult to detect. A single lens has been found at Mannkogel in 2200 m (GK 132) where it bears *E. bidentata*, *E. slovakensis* and *N. steinbergensis*. In Steinriese, an up to 5 m thick interval of grey thin-bedded bioclastic wacke- to packstone package exposed in 1850 m is, from the stratigraphic position, thought to equal the *PI 3* but has not delivered a fauna. Early Rhaetian conodonts (*Misikella hernsteini*, *M. posthernsteini*, *N. steinbergensis*) occur in *PI 4* close to the top of the reef limestone. *PI 4* is a more widespread developed level of pelagic lenses found near the Angerstein in 2060 m (GK 24) resp. 2090 m (GK 25), in the Gamsfeldklamm between 1915 and 2060 m (GK 15 to GK 19), in the Gamsfeld in 2000 m (GK 20) and 2150 m (GK 21), and east of the Mannkogel (spelled Mandlkogel in the official map) in 2270 m (GK 131). The pelagic interval *PI 4* could not be located in the Steinriese, probably because of sampling difficulties in the very steep and rough terrain.

Age and facies development of the presently exposed platform margin north of the Gosausee differ from that of the Gosaukamm. Due to a palaeogeographically more terminal position it starts considerably later and is underlain by a sequence of calciturbiditic and cherty limestones of about 200m thickness that contains at several places (Schlager, 1967) Sevatian bivalves (*Monotis salinaria*) and, in the Lacke section (fig. 2, 3) also conodonts of Sevatian age: in 1050m (sample -2.15) *E. bidentata* and *E. slovakensis* (Fig. 4-7), in 1230m (89/91) *E. bidentata* and *M. hernsteini*. This so-called Gosauseekalk is therefore timely equivalent to the Gosaukamm margin from the *PI 3* to below the *PI 4* interval. Slightly higher, in 1250 m (Fig. 2), follows the transition to the Dachsteinriffkalk where sample 89/90 indicates an early Rhaetian age by the presence of common *M. hernsteini* together with dwarfed platform-less *Epigondolella bidentata* (= *Parvigondolella andrusovi* sensu Kozur). Other productive samples from the Dachsteinriffkalk base in 940 m near the road along the lake at the foot of the Lärchkogel (Fig. 1) have produced *E. bidentata* and *E. mosheri* A (Fig. 4-8) in GK 173 and *Epigondolella bidentata* (Fig. 4-9), *M. hernsteini*, *M. posthernsteini* and *Oncodelella paucidentata* in GK 161. A younger, still early Rhaetian, age based on the co-occurrence of *N. steinbergensis* and *M. hernsteini* is reported from the higher part of the Dachsteinriffkalk along the forest road to the Lärchkogel in 1230m (GK 101), allowing a correlation with the *PI 4* of the Gosaukamm.

The platform margin north of Gosausee forms a large and coherent entity with a length of 5 km and a width of up to 3 km (Mandl, 2001) still in normal sedimentary contact with the well-bedded lagoon facies to the NE (Fig. 1). It shows indistinct decametric beds dipping about 20° towards SW that could be interpreted as clinofolds in analogy to the Gosaukamm. Reefal



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boundstones are common between Brettkogel, Roßbrücken, Lärchkogel and Ebenforstalm, and specifically well exposed along the forest road to the Ebenforstalm (Fig. 1). Significant is the high amount of micritic sediment between the reef builders. The latter consist mainly of calcareous sponges, *Solenopora*, Spongiostromata and corals *Retiophyllia*, *Distichophyllia* or *Actinastrea*. Especially the hermatypic *Retiophyllia* is more common than in the Norian Gosaukamm reef mounds (Schauer, 2002). Coarse reef debris is relatively infrequent and about 50% of the framebuilders are still in growth position. Rudstones and breccias are almost absent in the surrounding matrix and it is therefore assumed that reefal growth occurred in a sheltered position or in a water depth deep enough to escape storm and wave-induced destruction and reworking. Between the northwestern end of the lake and the start of the Ebenalm forest road thin-bedded bioclastic wacke- and brachiopod bearing packstones interfinger directly with the buildups without slope deposits in between. These preserved geometries of the Gosausee margin seem to fit better to a (distally steepened?) ramp position in contrast to the steep, brecciarich margin type of the Gosaukamm (Wurm, 1982; Kenter and Schlager, 2009, this volume).

Details of sedimentology and cyclicity of the Gosauseekalk in the Lacke section are described by Reijmer and Everaars (1991). According to them the variations in turbidite composition can be attributed to fluctuations in sea level resulting in flooding or exposure of the platform. The so caused variation of platform sediment production and basinward transport could be matched with Milankovitch quasi-periodicities allowing an approximate timing of the 100 m thick studied part to about 1 Ma (Reijmer et al., 1994: 338). Assuming a more

or less constant sediment accumulation rate of the all in all 200 m thick Upper Norian in the Lacke section results in an estimated duration of 2 Ma for the Sevatian substage.

### 3.2 DONNERKOGELKALK

Corresponding to the *PI 5* interval, this fine grained hemipelagic sequence of red to pale grey limestones follows abruptly and discontinuously above both the Gosausee and Gosaukamm margin. Crinoid-bearing wackestones (Fig. 5-5, 7) are dominating and fill the primary relief of the reef and slope and, rarely, the interspace of deeper water reef patches growing at the top of the Dachsteinriffkalk. Intercalated crinoid-brachiopod and/or reworked(?) reef debris bearing packstones (Fig. 5-8) with coquina layers indicate episodic higher energetic current events. The unit is often eroded, usually not more than 1m thick, but occasionally it can reach up to 5 m, for instance along the Donnerkogel path in 1850m, the type locality of this newly introduced lithostratigraphic unit. Biostratigraphic data – i.e. co-occurrence of *M. posthernsteini* and *M. rhaetica* in the sequence as well as the presence of late Rhaetian ammonoids (*Choristoceras* div. sp.) in the base of the overlying Zlambachmergel (Spengler, 1914; Zapfe, 1960) – suggest a duration of one ammonoid zone. Compared to similarly thin and condensed Hallstatt fossil accumulations, a considerably reduced sedimentation rate or temporary non-deposition may also be assumed as reasons for the reduced thickness of the Donnerkogelkalk.

Conodonts described by Krystyn (1972) had all been recovered from Donnerkogelkalk outcropping spottily on the southwestern flank of the Gosaukamm, especially between Kleiner and Großer Donnerkogel (Fig. 1). Most productive samples have been found along the path to the Großer Donnerkogel in 1840 m (GK 49) and 1920 m (GK 48), and at its top (GK 46), containing a middle Rhaetian, post-*Norigondolella* fauna with *M. hernsteini* (Fig. 4-10), *M. posthernsteini* (Fig. 4-11), *M. koessenensis* (Fig. 4-12), *O. paucidentata* and *Zieglericonus rhaeticus*. Patches of Donnerkogelkalk are widespread on top of the Gosausee margin and common between the Ebenforst road (GK 169) in the west, the Modereck (GK 168) in the north and the Roßbrücken (GK 39, GK 40, GK 100) in the east. These red biomicritic limestone lenses often have been treated as Jurassic Hierlatzkalk but contain *Misikella*-dominated conodont faunas and are therefore of Triassic age. The presence of *M. rhaetica* (Fig. 4-13, 14) in some of the samples and the close neighborhood to Zlambachmergel points to a corresponding middle Rhaetian age as in the Gosaukamm cover.

The Zlambachmergel of the Langtal S of Brettkogel are here interpreted in analogy to the Gosaukamm sequence (localities Donnerkogel: Schlager, 1967:60 and pl. 3; Schnecken graben: Tollmann and Kristan-Tollmann, 1970:97) as the upper Rhaetian (Hillebrandt, written comm.) normal stratigraphic cover of the Dachsteinriffkalk, witnessing that growth of the Dachstein reefs terminated well before the end of the Triassic. The presently limited occurrence of Zlambachmergel NE and E of the Gosausee is explained by widespread erosion due to the soft sediment character. Except for the Koglgassenalm occurrence

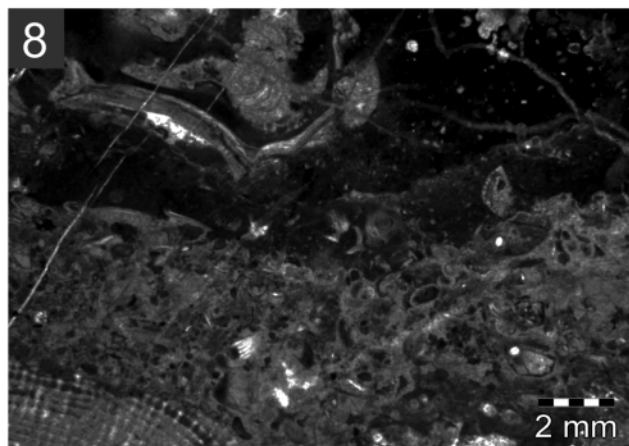
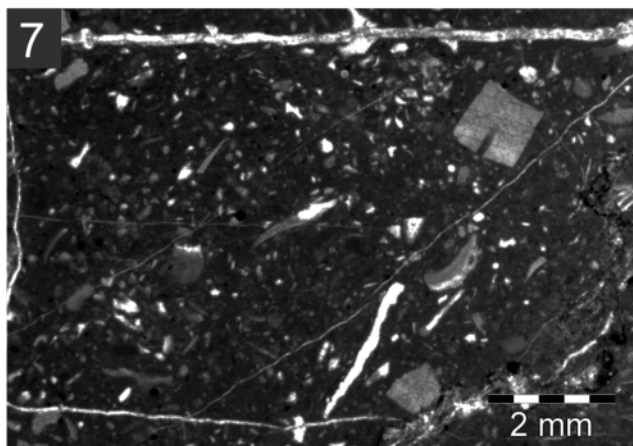
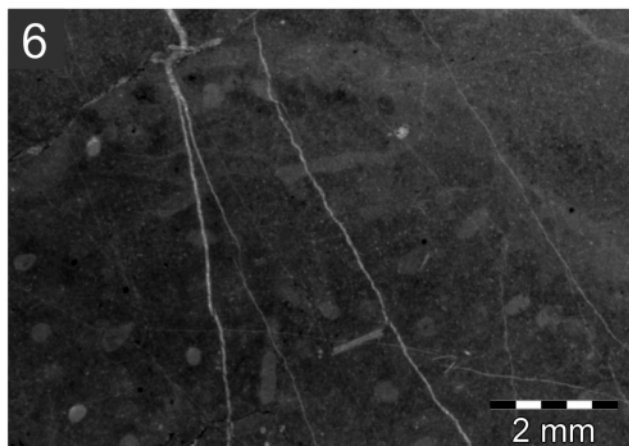
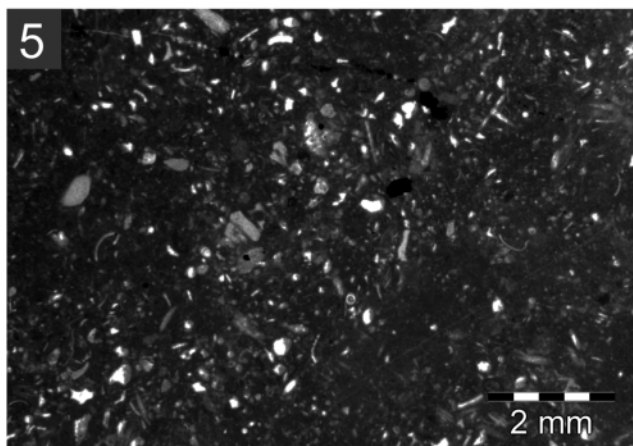
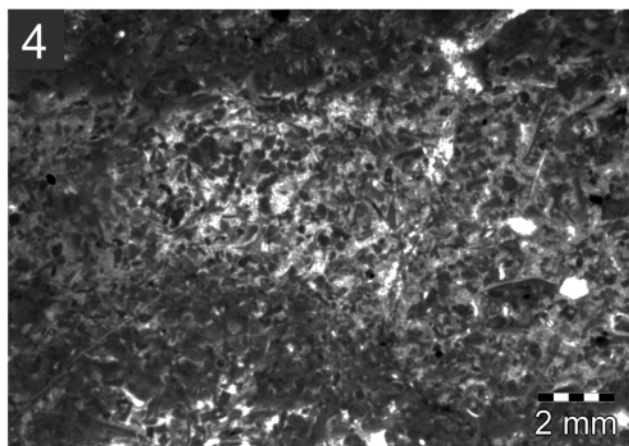
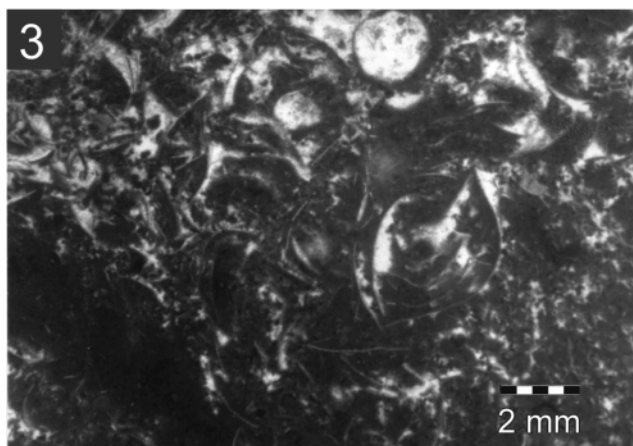
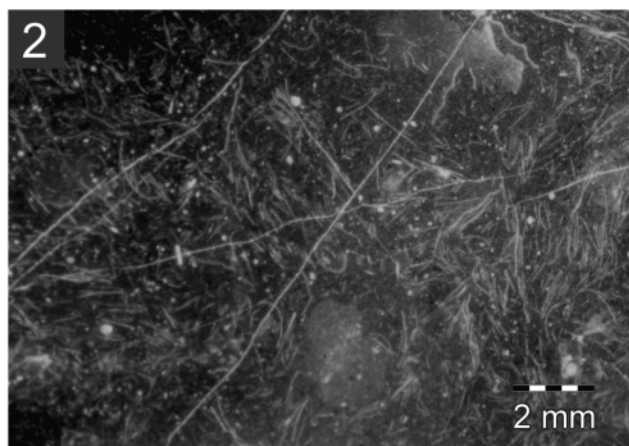
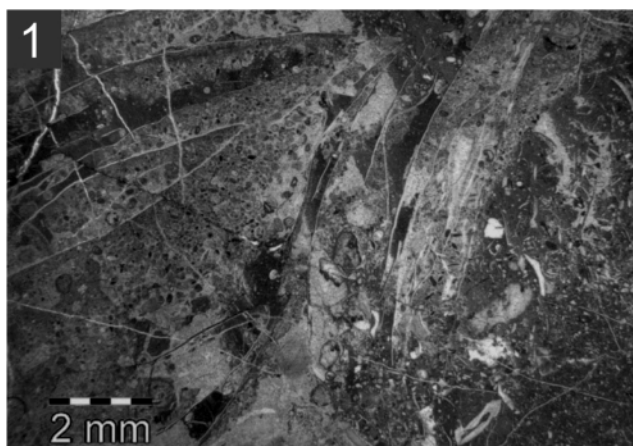
**FIGURE 4:** Conodonts of the Dachsteinriffkalk and the Donnerkogelkalk; Magnification: 2 - 4: 100 x; 1 and 5 - 14: 160 x

- 1: *Epigondolella quadrata* Orchard, lateral and upper view; L 82. Feisterscharte, Dachsteinriffkalk, Lacion 1/II.
- 2-3: *Epigondolella triangularis* (Budurov and Stefanov), upper view; 2: 89/08, 3: 87/07. Feisterscharte, Dachsteinriffkalk, Lacion 2.
- 4: *Epigondolella spatulata* Hayashi, upper view; GK 62. Gosaukamm, Steinriese, Dachsteinriffkalk, *PI 1*, Lacion 3.
- 5: *Epigondolella postera* (Kozur); upper view, GK 51. Gosaukamm, Wasserriese.
- 6: *Epigondolella abneptis* (Huckriede); lateral and upper view, GK 104. Gosaukamm, Steinriese, Dachsteinriffkalk, *PI 2*, Alaunian 3.
- 7: *Epigondolella slovakensis* Kozur and Mock, lateral view; 89/99. Gosausee, Lacke section, Gosauseekalk, Sevatian.
- 8: *Epigondolella mosheri* (Kozur and Mostler) morphotype A Orchard, 1994, lateral and upper view; GK 173. Gosausee road, Dachsteinriffkalk, upper *PI 3*, Sevatian.
- 9: *Epigondolella bidentata* Mosher, lateral and upper view; GK 161. Gosausee road, Dachsteinriffkalk, Sevatian.
- 10: *Misikella hernsteini* (Mostler), lateral view; GK 40. Roßbrücken, Donnerkogelkalk, *PI 5*, Rhaetian 2.
- 11: *Misikella posthernsteini* Kozur and Mock, lateral view; GK 46. Gosaukamm, Donnerkogel, Donnerkogelkalk, *PI 5*, Rhaetian 2.
- 12: *Misikella koessenensis* Mostler, lateral and upper view; GK 49. Gosaukamm, Donnerkogel, Donnerkogelkalk, *PI 5*, Rhaetian 2.
- 13-14: *Misikella rhaetica* Mostler, lateral and upper view; 13: GK 39, 14: GK 40. Roßbrücken, Donnerkogelkalk, *PI 5*, Rhaetian 2.

Specimens are housed in the micropalaeontological collection of Department of Palaeontology of Vienna University.



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(Schlager 1966, p. 102), preservation has been restricted to tectonic slivers in the Langtal fault zone (Fig. 1).

#### 4. SEDIMENTARY EVOLUTION OF THE DACHSTEIN PLATFORM MARGIN

An early Laciian onset of reef growth is indicated by the ages obtained from the oldest parts of the margin facies in the Dachstein area. This fits well with data from the Tennengebirge (Krystyn, 1985), the Gesäuse (Dullo, 1980) and, beyond the NCA, from the Muran plateau in the Western Carpathians (Krystyn et al., 1990) and the Triglav, Slovenia (Schlaf, 1999).

Progradation of this early platform margin comes to a halt in the Gosaukamm in the late Laciian when the margin is draped by a thin pelagic cover (*PI 1*). The subsequent return to slope facies suggests a stable margin during the Alaunian along a more or less aggrading platform. Slow progradation may be indicated in the Sevatian of both the southwestern Gosaukamm and the Gosausee margin (Lacke section) by increasing carbonate debris input into the proximal basin. Margin progradation accelerates in early Rhaetian time both in the Gosaukamm and north of Gosausee where the laterally most expanded margin area spreads over the proximal basin (Fig. 1, 2). The middle Rhaetian Donnerkogelkalk phase (*PI 5*) marks the drowning of the Dachsteinriffkalk and the end of the Dachstein reef building not only in the type area but also in other parts of the NCA, at the Hochkönig (Heissel, 1953; Schauer, unpubl. data), the Jenner (Krystyn, unpubl. data) and Hohe Göll (Zankl, 1969; Braun, 1998) in Berchtesgaden, and the Tonion (Schauer, unpubl. data) in Styria. The event is also recorded on top of the Dachsteinriffkalk in the Drnava (=Pleskovy Pramen) locality of the Western Carpathians where crinoid limestones rich in shelly fauna contain ammonoids of the *Vandaites stuerzenbaumi* ammonoid Zone (Kollarova-Andrusovova and Kochanova, 1973).

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**FIGURE 5:** Thin sections of pelagic intercalations in the Dachsteinriffkalk (1-4) and Donnerkogelkalk (5-8).

- 1: Sample 89/08, *Feisterscharte*; grey Halobiid-biomicroite/-sparite.
- 2: Sample GK 62, *PI 1*; red wackestone with abundant filaments.
- 3: Sample GK 51, *PI 2*; red wackestone with Halobiids.
- 4: Sample GK 161; light red bioclastic pack- to wackestone.
- 5: Sample GK 169, *PI 5*; light red wackestone with echinoderms and spiculae.
- 6: Sample GK 49, *PI 5*; red bioturbated mudstone.
- 7: Sample GK 02, *PI 5*; red bioclastic wackestone with echinoderms.
- 8: Sample GK 02, *PI 5*; contact between grey bioclastic grainstone (reef debris) and red bioclastic wackestone.

of the Gosaukamm area and R. Lein for permission to reproduce conodont material from Feisterscharte (L 82); layout of fig. 4 we owe to R. Gold.

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Leopold KRYSZTYN<sup>1)</sup>, Gerhard W. MANDL<sup>2)</sup> & Martin SCHAUER<sup>3)</sup>

<sup>1)</sup> Department of Palaeontology, Vienna University, Althanstrasse 14, A-1090 Vienna, Austria.

<sup>2)</sup> Geological Survey of Austria, Neulinggasse 38, A-1030 Vienna, Austria.

<sup>3)</sup> Klabundgasse 6, A-1190 Vienna, Austria.

<sup>†</sup> Corresponding author, [leopold.krystyn@univie.ac.at](mailto:leopold.krystyn@univie.ac.at)

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