

New data on the progradation of the Dachstein carbonate platform (Kamnik-Savinja Alps, Slovenia)

Novi podatki o progradaciji Dachsteinske karbonatne platforme (Kamniško-Savinjske Alpe, Slovenija)

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Prejeto / Received 24. 9. 2014; Sprejeto / Accepted 24. 11. 2014

Key words: Carnian/Norian, Southern Alps, Kamnik-Savinja Alps, platform progradation, Dachstein carbonate platform, Slovenia

Ključne besede: Karnij/norij, Južne Alpe, Kamniško-Savinjske Alpe, progradacija platforme, dachsteinska karbonatna platforma, Slovenija

Abstract

Upper Triassic basin-platform succession in the Kamnik-Savinja Alps (N-central Slovenia) is similar to the succession known from the Julian Alps (Martuljek Mountain Group). It was part of the same Late Triassic depositional edifice, with the progradation of the Dachstein Platform in the SW-NE direction (recent orientation) from Julian Alps toward the Kamnik-Savinja Alps. Tectonic blocks with the same/similar stratigraphic record, were displaced as a consequence of the Alpine and later tectonic displacements. In the Kamnik-Savinja Alps, the upper part of the Martuljek platy limestone was dated with the conodonts as Late Carnian – Early Norian in the Mt. Kočna. In the Mt. Skuta area, Limestone with chert is positioned above Martuljek platy limestone and under the Dachstein carbonate platform. Uppermost part of the Limestone with chert is Late Norian. Mutual vertical and lateral relationship, age of the lithological units, especially upper part of the deeper-water limestone, points to the progradation of the Dachstein carbonate platform in the Early Norian and possible aggradation in the part of the Middle and in the Late Norian.

Izvleček

Zgornjetriasno bazensko – platformno zaporedje v Kamniško – Savinjskih Alpah (S Slovenija) je zelo podobno zaporedju v Julijskih Alpah (Martuljkova gorska skupina). V mlajšem triasu je tvorilo enoten sedimentacijski prostor s progradacijo dachsteinske platforme v smeri JZ–SV (današnja orientacija) iz Julijskih Alp v Kamniško–Savinjske Alpe. Bloki z istim/podobnim stratigrafskim zapisom so bili kasneje zaradi alpske in mlajše tektonike premaknjeni v današnji položaj. V Kamniško–Savinjskih Alpah je bil zgornji del Martuljskih apnencev v Kočni s konodonti datiran v mlajši karnij – starejši norij. Na območju Skute se nad Martuljskimi apnenci in pod dachsteinsko platformo pojavi še zaporedje apnencev z roženci, katerih vrhnji del je datiran v mlajši norij. Medsebojni vertikalni in lateralni odnos, ter starost litoloških členov, predvsem zgornjega dela globljevodnih apnencev, kaže na progradacijo dachsteinske karbonatne platforme v starejšem noriju, ter možno agradacijo v delu srednjega in v mlajšem noriju.

Introduction

Recent investigations in the northern part of the Julian Alps (Martuljek Mountain Group) (CELARC & OGORELEC, 2006; CELARC & KOLAR-JURKOVŠEK, 2008), together with the previous works (RAMOVŠ, 1986, 1987; JURKOVŠEK, 1987; SATTLER, 1998) established a firm model for stratigraphic and paleogeographic evolution model for this area. It is marked by the widespread drowning of the Middle Carnian carbonate platform (Razor limestone), which formed submarine topographic high, with deposition of the thin horizon of reddish Upper Carnian – Lower Norian pelagic platy or nodular

basinal limestone (Martuljek platy limestone). This topographic high was probably connected with the shallow-water area, from where the rimmed Dachstein carbonate platform started to form and rapidly prograded in the NE direction (1200m/Myr, CELARC & KOLAR-JURKOVŠEK, 2008) towards the basin with well-developed facies zones (slope, coral reef margin and the Lofer cyclic Dachstein Limestone in the peritidal area behind the reef). In the NW face of the Mt. Škrlatica, onlap of the cyclic Dachstein Limestone on the coral reef, slope clinofolds and interfingering of the lower slope with the basinal limestone are well exposed. According to the dip direction of these surfaces, NE progradation

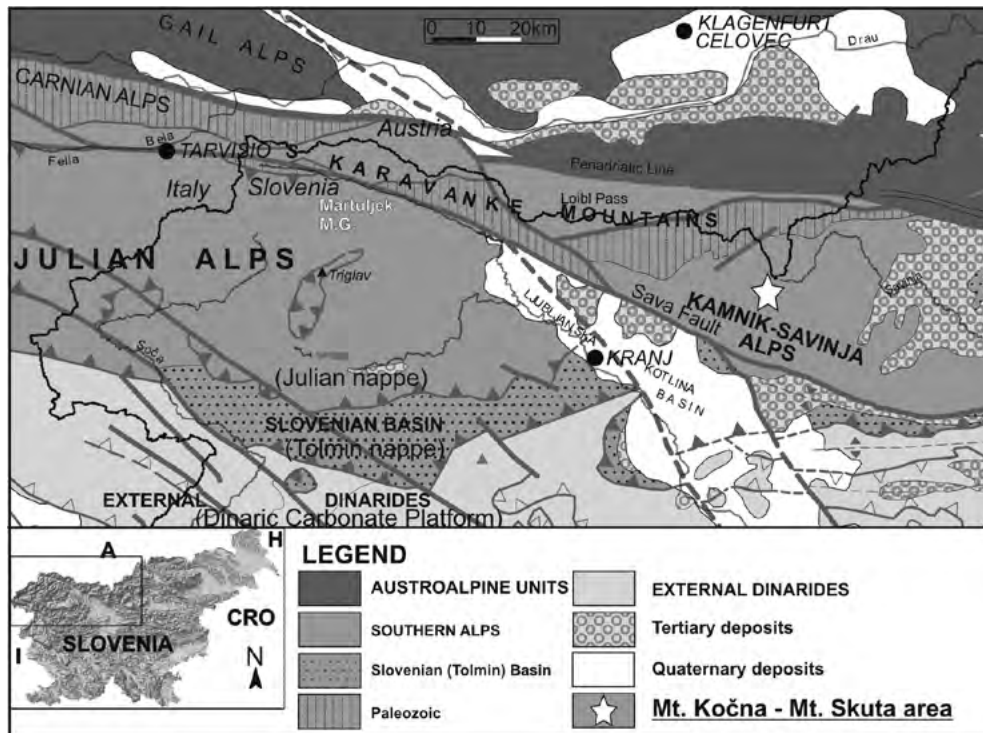


Fig. 1. Structural scheme of the N-central and NW Slovenia. The research area in the Kamnik-Savinja Alps is marked with star. Tectonic units after PLACER (2008).

direction of the platform was established, which was also confirmed by the progressively younger age of the uppermost part of the Martuljek platy limestone in that direction. Similar stratigraphic situation is also reported in the Kamnik-Savinja Alps, more to the east (RAMOVŠ, 1989; JAMNIK et al., 1990; RAMOVŠ & JAMNIK, 1991; JAMNIK & RAMOVŠ, 1993). The horizon with the Martuljek platy limestone of the Carnian age was also discovered there, together with occurrence of Lower Norian bedded basinal limestones with chert nodules. The transition of these limestones to massive coral reef limestones was observed. The lithostratigraphic succession and its spatial position, particularly relationship between Martuljek platy limestone and limestone with chert is, however, unclear. The aim of the study is threefold:

- (1) On the basis of geological mapping to clearly establish spatial position and extent of the mapped formations;
- (2) to test the hypothesis, that progradation in the Kamnik-Savinja Alps is younger than in

the Julian Alps, according to the progradation direction established in the Martuljek Mountain Group;

- (3) to interpret the platform – basin dynamics and propose a paleogeographic position of this system.

Presented results are only of preliminary character, based on the relatively low amount of the collected samples and a small area mapped.

Geological setting

The study area belongs to the central part of the Kamnik-Savinja Alps (Fig. 1), which together with the westerly lying Julian Alps and the northerly lying Southern Karavanke Mountains form the eastern part of the Southern Alps (PLACER, 1999, 2008; VRABEC & FODOR, 2006; CELARC et al., 2013). In the Late Triassic, this area was located on the passive margin of the Neotethys Ocean (HAAS et al., 1995; SCHMID et al., 2008). The research area is part of the Julian Nappe, later dextrally offset along the Sava fault for around 30-40 km with respect to the Julian Alps (PLACER, 1996). The major part of the Julian Nappe is therefore now positioned in the westerly lying Julian Alps. The lower boundary of the Julian Nappe in the K-S Alps is not yet clearly defined and structural investigations are in the progress.

New mapping and lithostratigraphic succession

The research area is positioned along W-E directed ridge between Mt. Kočna (2520 m) and Mt. Koroška Rinka (2433 m) (Fig.2). Southern slopes of this ridge include the prominent plateaus (Veliki podi Plateau, Mali podi Plateau) separated by the NW-SE directed Sleme – Veliki

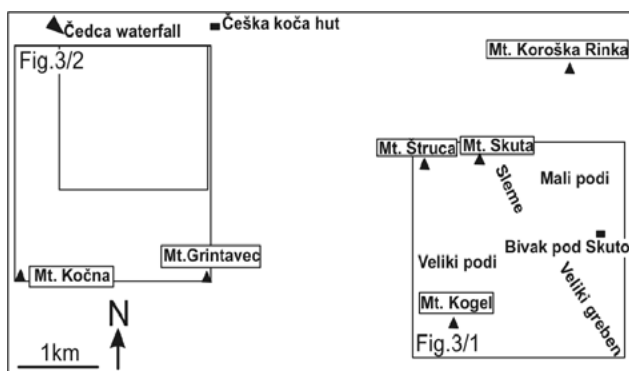


Fig. 2. Position of the geological maps, shown in the Fig. 3.

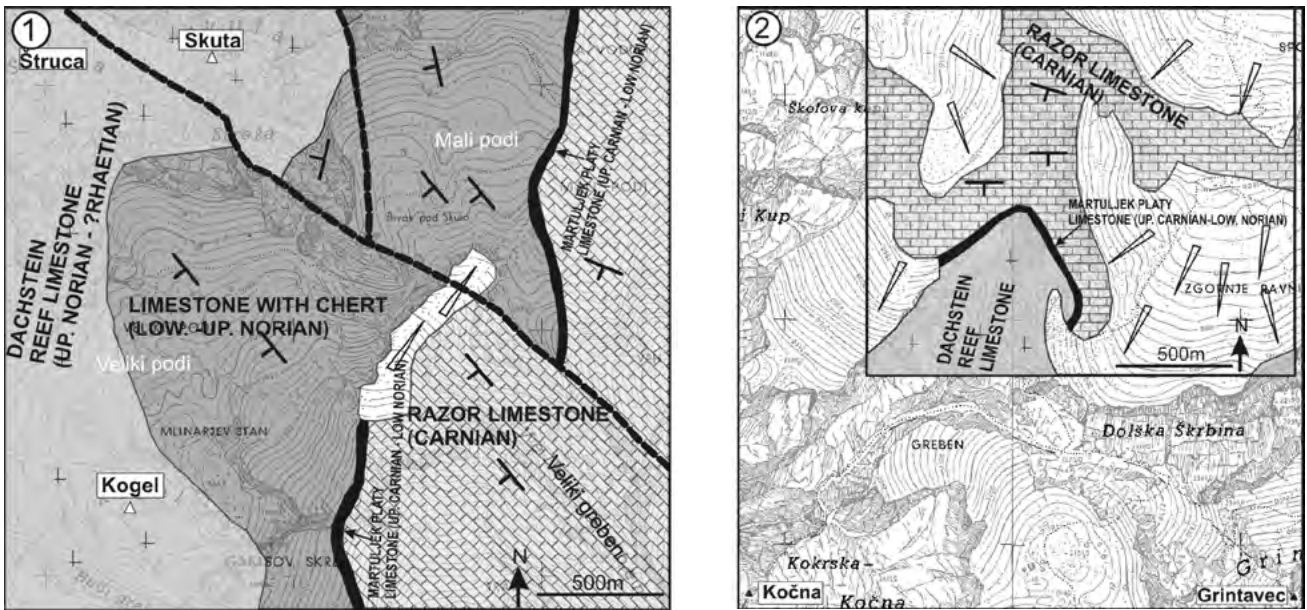


Fig. 3. Geological maps of the selected areas in the Mt. Kočna – Mt. Koroška Rinka ridge (Kamnik-Savinja Alps). 1 – Mt. Skuta area; 2 – Mt. Kočna slopes above the Češka koča hut.

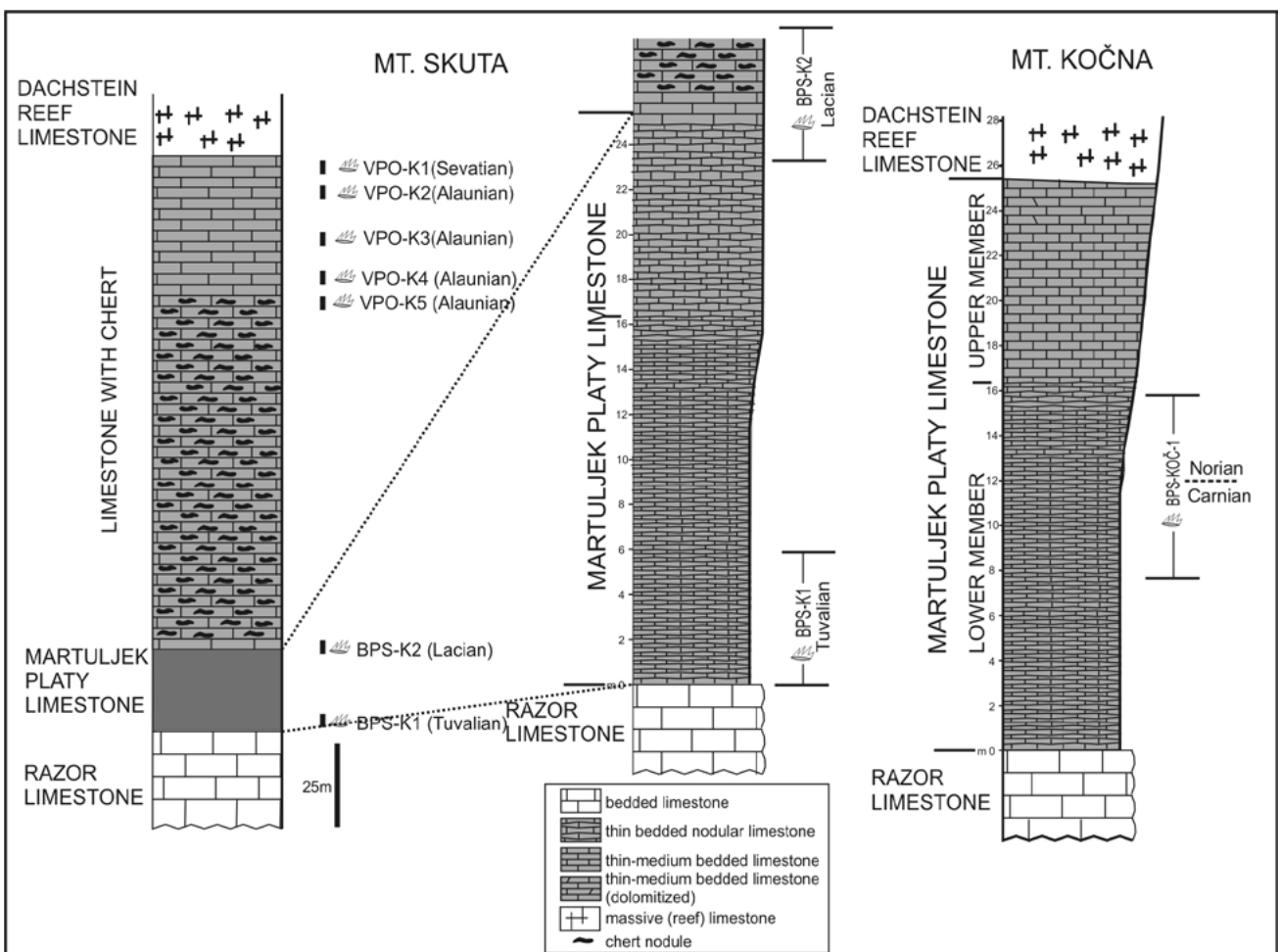


Fig. 4. Stratigraphical columns with conodont samples. 1 – Mt. Kočna; 2 – Mt. Skuta area.

greben ridge. Southern part of the Veliki podi Plateau is confined with Mt. Kogel (2100 m) and its SW face. The new mapping was limited to the Mt. Skuta area with Veliki and Mali podi Plateaus, lower part of the Mt. Kogel SW face

(Fig. 3/1) and Mt. Kočna slopes above the Češka koča hut (Fig. 3/2), and is still in progress. The strata generally dip to the SW in the Mt. Skuta area and to the S in the Mt. Kočna, respectively, with moderate to the medium-steep inclination.

The geological succession is composed from bottom to top of 5 lithostratigraphic units, which names are informal and are the same as in the Martuljek Mountain Group of the Julian Alps (CELARC & KOLAR-JURKOVŠEK, 2008), except for the limestone with chert, which is only present in the Kamnik – Savinja Alps:

- Razor limestone (Lower Carnian)
- Martuljek platy limestone (Upper Tuvalian – Lower Norian)
- Limestone with chert (Lower Norian – Upper Norian)
- Dachstein reef limestone - reef rim, reef slope (Lower Norian – Upper Norian)
- Dachstein Limestone (Norian – Rhaetian).

Two stratigraphical sections were measured. The Kočna section comprises the upper part of the Razor limestone, the Martuljek platy limestone and lower part of the Dachstein reef limestone (Fig.4/1).

The Mt. Skuta area section contains the upper part of the Razor limestone, the Martuljek platy limestone, Limestone with chert the and lower part of the Dachstein reef limestone (Fig. 4/2).

Razor limestone (Lower Carnian)

Razor limestone represents a footwall unit of the described succession. Its sedimentological characteristics haven't been studied yet in the Kamnik-Savinja Alps. Based on the first investigations, they are similar to the Razor bedded limestone from the Julian Alps (RAMOVŠ, 1987; CELARC & KOLAR-JURKOVŠEK, 2008). The Razor reef limestone, which is known from the Julian Alps, is not present in the Kamnik-Savinja Alps. The Razor limestone appears as thick-bedded peritidal limestone, organized into 1–1.5 m thick asymmetric cycles. Subtidal parts are composed of packstones and grainstones with abundant pellets and intraclasts. Upper parts of the subtidal beds are predominately composed oncoids. The supratidal facies contains microbial laminites, fenestral pores and small cavities filled with laminated crusts. Exposure surfaces are rarely overlain with thin horizons of the rip-up clasts. This unit is very similar to the younger Dachstein Limestone and can be easily mistaken for it, if the exact stratigraphic position of the unit is not known.

Martuljek platy limestone (Upper Tuvalian – Lower Norian)

This, around 25 m thick unit (Plate 1, Figs.1, 2), is represented by red and grey pelagic limestone with wavy to planar bedding (Plate 1, Fig. 3). It is positioned with the sharp and almost planar contact on the underlying Razor limestone (Plate 1, Fig. 4). This surface represents a major drowning event in the Julian Alps (GIANOLLA et al., 1998; SATTLE, 1998; DE ZANCHE et al., 2000; GIANOLLA et al., 2003; CELARC & KOLAR JURKOVŠEK, 2008). In the Kamnik-Savinja Alps it was first described in the Mt. Skuta area, some 50 m west of Bivak pod Skuto locality (RAMOVŠ, 1989). The actual extent of this unit was unknown until recent mapping of the area, when new outcrops were found in the SW face of the Mt. Kogel (Gamsov skret locality, south from Mt. Skuta), and on the Veliki podi below the south face of Mt. Skuta. From the Bivak pod Skuto, this unit extends towards the Mt. Kranjska Rinka (Plate 1, Fig. 2). Isolated outcrops in the form of erosional remains were found in the Veliki greben ridge. The outcrop belt of this unit is also positioned on the slopes of Mt. Kočna, above the Češka koča hut and above the Čedca waterfall (Plate 1, Fig. 1). Similar limestones were already described by Teller (1898) from the scree below Mt. Kočna, but the in situ outcrop was discovered now for the first time. In the Mt. Kočna, two members (the Lower and the Upper Member), very similar as in the Julian Alps (CELARC & KOLAR-JURKOVŠEK, 2008), could be distinguished (Fig. 4), while in the Mt. Skuta area, the composition is similar to the whole thickness of the Martuljek platy limestone (Fig. 4). The Lower Member (Mt. Kočna) and the whole succession (Mt. Skuta area) is composed of the indistinctly reddish, in the upper part more greyish, wavy, thin bedded, slightly dolomitized packstone with glauconite, with rare fragments of the bivalves, filaments, lagenide foraminifers and peloids (Plate 1, Fig. 5). In the upper part, fine grained bioclastic packstone, with transition to wackestone prevails, with filaments, brachiopods and foraminifers (Plate 1, Fig. 6). Bedding planes are undulating in the lower part, giving nodular

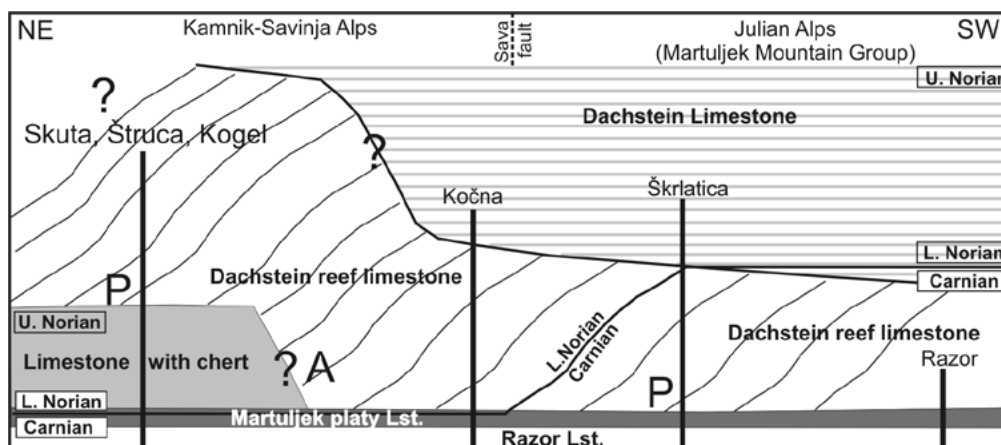
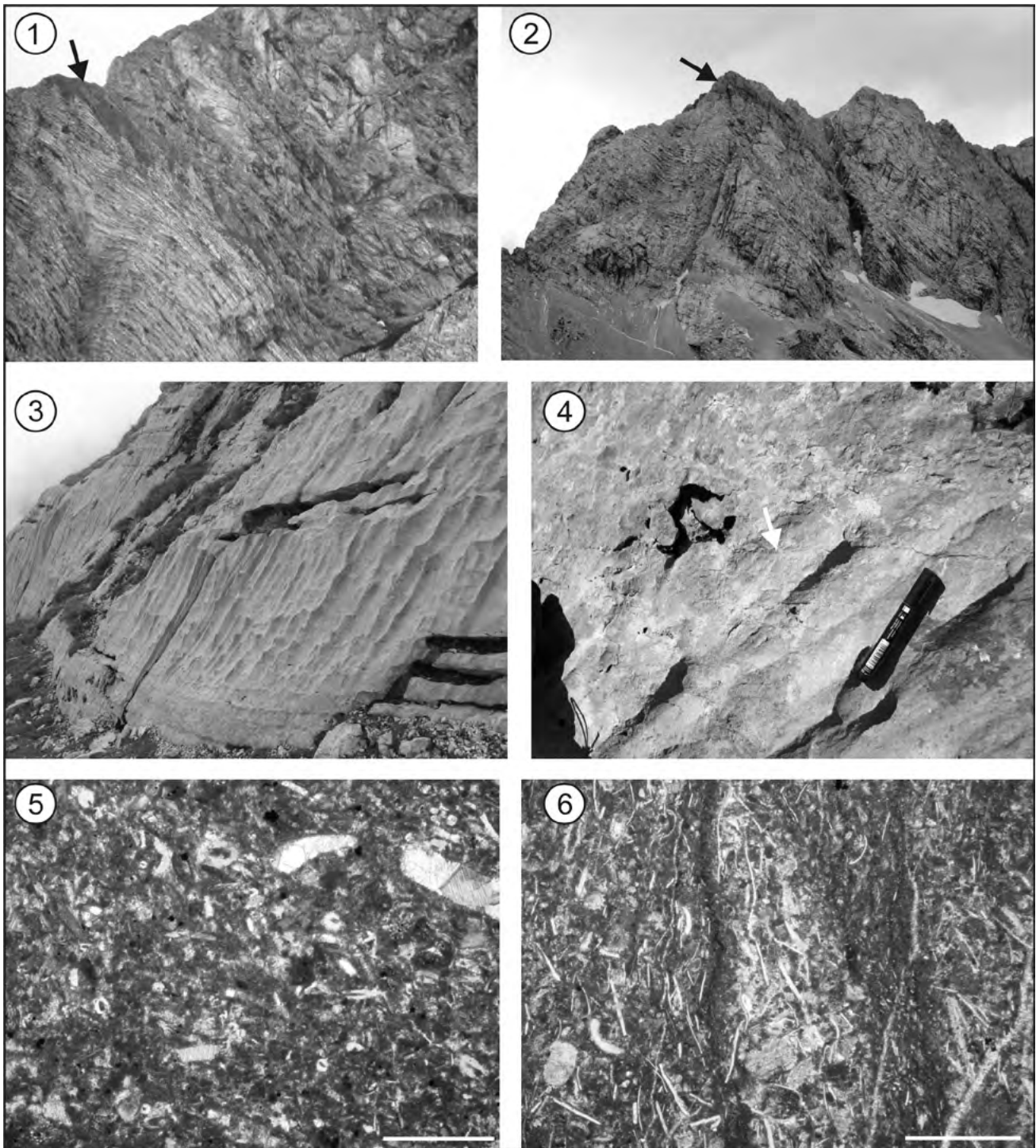


Fig. 5. Schematic cross-section of the SW – NE progradation of the Dachstein carbonate platform from Julian Alps towards Kamnik-Savinja Alps. (A: aggradation; P: progradation). Razor profile according to the RAMOVŠ (1987) and SATTLE (1998), Škrlatica profile according to the CELARC & KOLAR-JURKOVŠEK (2008).

PLATE 1



- 1 – Slopes of the Mt. Kočna above the Čedca waterfall, the Martuljek platy limestone is marked with arrow (grass covered ledge);
- 2 – Mt. Štajerska Rinka, Martuljek platy limestone (darker belt) is marked with arrow;
- 3 – Indistinctly wavy bedding of the lower part of the Martuljek platy limestone;
- 4 – Drowning surface (marked with the arrow) between the underlying Razor limestone and the overlying Martuljek platy limestone;
- 5 – Microfacies of the Martuljek platy limestone (lowermost part): slightly dolomitized packstone with glauconite (Mt. Kočna area), scale bar = 1 mm;
- 6 – Microfacies of the Martuljek platy limestone (uppermost part): bioclastic packstone, with transition to the wackestone with filaments (Mt. Skuta area), scale bar = 1 mm.

appearance of the limestones and becoming more planar in the upper part.

The Upper Member occurs only in the Mt. Kočna (Fig. 4) and is very similar to the Upper Member from the Julian Alps (CELARC & KOLAR-JURKOVŠEK, 2008). It contains a lot of redeposited shallow-water elements, particularly reef debris from the adjacent platform. It is composed of thin to medium bedded light grey limestones (coral and crinoid grainstones in the lower part and coral rudstones in the upper part). Bedding planes are planar and sharp. Some rare beds of the pelagic limestone without shallow-water elements are found between beds with reef detritus. Transition to the massive Dachstein reef limestone in the hangingwall is sharp. The thickness of the Upper Member is less than 10 m.

Limestone with chert (Lower Norian – Upper Norian)

According to the new mapping, this around 150 m thick unit is positioned with the sharp transition above the Martuljek platy limestone in the Mt. Skuta area. It is not present in the Mt. Kočna, and the nature of the lateral pinching-out of this unit was not yet observed. Although TELLER (1898) and SEIDL (1907) already mentioned occurrences of chert among the Dachstein Limestone in this area, they were not described on the Basic Geological Map of the (former) SFRJ (MIOČ et al., 1983). This unit was therefore described only later (RAMOVŠ & JAMNIK, 1991; JAMNIK & RAMOVŠ, 1993). They established an Early Norian age based on the conodont dating and compared it with the Hallstatt facies of the Northern Calcareous

Alps. The stratigraphic position of this unit, particularly the relationship with the Martuljek platy limestone was unclear (JAMNIK & RAMOVŠ, 1993).

Two members could be distinguished in this unit. The Lower Member is composed of the medium bedded limestone with brown chert nodules and lenses (Plate 2, Fig. 1). Its composition and microfacies is uniform through the succession and is composed predominately of fine grained bioclastic packstone with filaments. Wackestone with brachiopods, crinoids, peloids, spicules and radiolarians are also present (Plate 2, Figs. 2, 3).

The Upper Member is slightly more thick-bedded, chert nodules and lenses are not present any more. Bioclastic, intraclastic, peloidal grainstone (Plate 2, Fig. 4) intercalations are common between pelagic beds. In the uppermost part, rudstone (reef breccia) is common. The transition to the Dachstein reef limestone is gradual.

Dachstein reef limestone

The large masses of massive reef limestones (Plate 2, Fig. 5) are positioned above the Martuljek platy limestone in the Mt. Kočna or above the Limestone with chert in the Mt. Skuta area. Reef crest and slope, there built of the redeposited reef material are macroscopically almost impossible to distinguish. Corals are the most important and prevailing reef builders, sponges and hydrozoans are subordinate. The coralites are overgrown with sponges, microbialites and microproblematica (*Baccanella floriformis*). The most common

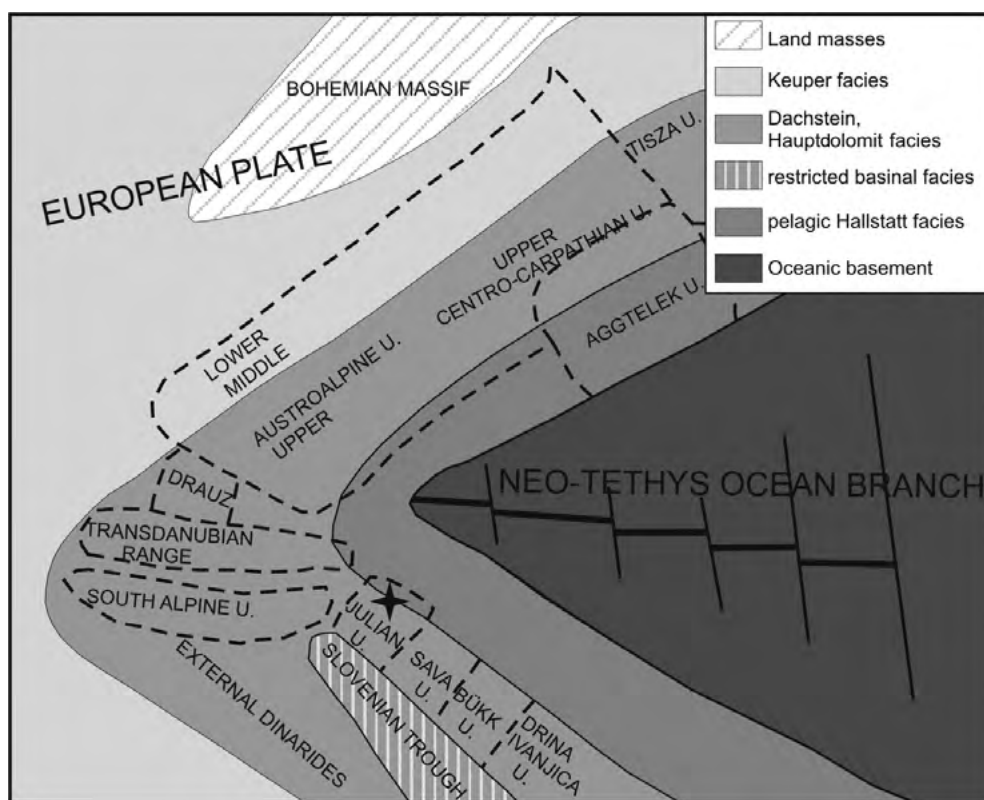
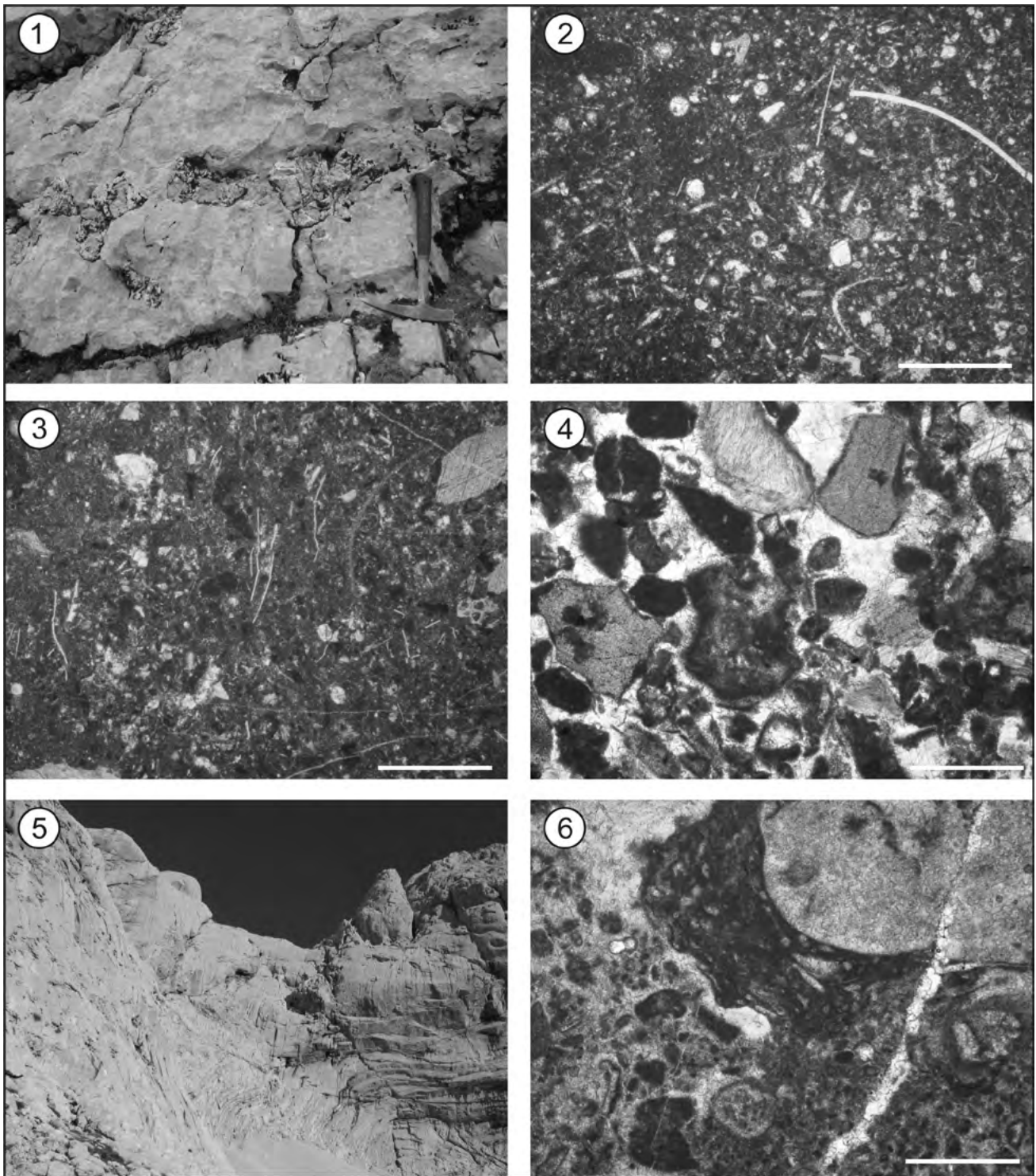


Fig. 6. Paleogeographic reconstruction of the western Tethys in the Norian time (modified after Haas et al., 1995). Proposed position of the Julian Alps – Kamnik-Savinja Alps Late Carnian - Norian basin-platform system is marked with star.

PLATE 2



- 1 – Limestone with chert - field view;
 2 – Microfacies of the Limestone with chert: wackestone with peloids, spicules and radiolarians, scale bar = 1 mm;
 3 – Microfacies of the Limestone with chert: wackestone with peloids, spicules, rare radiolarians and crinoids, scale bar: 1 mm;
 4 – Upper Member of the Limestone with chert: bioclastic, intraclastic, peloidal grainstone, scale bar = 1 mm;
 5 – Reef limestone (reef crest and slope) of the Mt. Skuta and Mt. Kočna;
 6 – Bafflestone from the reef crest, redeposited along the slope, scale bar = 1 mm.

microfacies is bafflestone from the reef crest, which in this case delivered along the slope in the form of the ?boulder (Plate 2, Fig. 6).

The thickness of the Dachstein reef limestones in the Mt. Kočna is estimated at around 300 m. In the Skuta area it seems thicker (more than 400 m), but the exact thickness could not be determined, due to the lack of the hangingwall (Dachstein Limestone above the reef).

Dachstein limestone

Peritidal Dachstein Limestone is according to the new mapping, the dip of the strata and present day surface, present only on the top and on the NW slopes of the Mt. Kočna. The mapping of this area is still in progress. Based on the view from the distance, bedding attitude is the same as in the Martuljek Mountain group from the Julian Alps (CELARC & KOLAR-JURKOVŠEK, 2008). The nature of the lower boundary with the reef limestone is also not (yet) evident. Nevertheless, the spatial extent and the stratigraphic position of the Dachstein Limestone are now clearly established in the Kamnik-Savinja Alps. It comprises significantly less spatial extent and thickness as in the Julian Alps.

Conodont dating of the Martuljek platy limestone and Limestone with chert.

Conodont composite samples were collected in the Martuljek platy limestone and Limestone with chert (Fig. 4) in order to test the age of those lithostratigraphic units.

Martuljek platy limestone

In the Mt. Kočna only one composite sample was taken (Fig. 4; BPS-KOČ-1) and it yields *Epigondolella* ex gr. *abneptis* (Huckriede), *Metapolygnathus primitius* (Hayashi) and *Metapolygnathus polygnathiformis* (Budurov & Stefanov). The age of the sample is Late Carnian – Early Norian. The uppermost part of the Martuljek platy limestone hasn't been sampled, and could be younger, probably late Early Norian age.

In the Mt. Skuta profile (Fig. 4), two composite samples were taken, one in the lower part (BPS-K1) with *Neocavitella cavitata* (Sudar & Budurov), *Paragondolella polygnathiformis* (Budurov & Stefanov), *Paragondolella* cf. *tadpole* (Hayashi) of Carnian (Tuvalian) age, and one in the uppermost part (BPS-K2) with *Epigondolella* ex gr. *abneptis* (Huckriede) and *Epigondolella* sp., of the Early Norian (Lacian) age.

Limestone with chert

5 composite conodont samples were collected in the upper part of the Limestone with chert unit (Fig. 4) in order to test the age of the uppermost part of this unit. Samples yielded the

following stratigraphically important species: *Epigondolella bidentata* (Mosher) in the uppermost sample (VPO-K1) (Late Norian – Sevatian) and *Epigondolella postera* (Kozur & Mostler) in all the other four samples (VPO-K2 to the VPO-K5) below (Middle Norian – Alaunian).

Discussion and conclusions

The Carnian – Norian lithostratigraphic development in the Kamnik-Savinja Alps bears a significant resemblance with the successions in the Julian Alps (Martuljek Mountain Group). The Mt. Kočna succession is almost completely the same as in the Julian Alps. According to the age of the Martuljek platy limestone, it correlates well with the NE-most profiles in the Martuljek Mountain Group (CELARC & KOLAR-JURKOVŠEK, 2008; ŠP and JG profiles). Even the subdivision of the Martuljek platy limestone in the two members is the same in both areas, owing to similar depositional processes.

The most striking difference is the presence of the relatively thick succession of the Early – Late Norian Limestone with chert in the Kamnik-Savinja Alps (Mt. Skuta area). The other difference is the fact, that Martuljek platy limestone contains no shallow water elements, where the Limestone with chert is positioned directly above it. The age of the uppermost part of the basal sequence below the prograding reef is here significantly younger (Late Norian – Sevatian) with comparison to the NE-most part of the Martuljek Mountain group, where it is established as Lacian. There are no clear geometrical evidences yet of the platform progradation direction in the Kamnik-Savinja Alps, against the clinofom-based SW-NE orientated progradation, established in the Julian Alps (CELARC & KOLAR-JURKOVŠEK, 2008). However, the age of the uppermost part of the basal sequence in the Kamnik-Savinja Alps is younger in the roughly W-E direction (Early Norian in the W and Late Norian in the E). Without other indicators (geometry, planar and not only rather linear position of the age-measurements points) this is of course only an apparent progradation direction. Nevertheless, it closely resembles directions from the Julian Alps and some basic reconstructions could be made (Fig. 5). If the position of the Kamnik-Savinja Alps is palinspastically corrected in respect to the Julian Alps (Martuljek Mountain Group), the distance would amount 20 km from the SW-most part (Mt. Razor, Mt. Škrlatica), to the NE-most part (Mt. Skuta area). The age of the uppermost part of the basal succession in the SW-most part is Late Tuvalian and the age of the NE-most part is Sevatian. The time span of the Norian is roughly 20 Myr (GRADSTEIN et al., 2012) and the progradation rate is calculated to 1000 m/Myr, which is in agreement with the rates established in the Martuljek Mountain Group (1200 m/Myr; CELARC & KOLAR-JURKOVŠEK,

2008). The lateral extent and the thickness changes of the Limestone with chert is unknown in the Kamnik-Savinja Alps. The Martuljek platy limestone shows no significant changes in its thickness in the lateral direction, while Limestone with chert reaches thickness up to 150 m, but laterally it thins out. This kind of geometry points to the aggradation of the system in the Middle Norian. Similar aggradation of the same age was reported also from the Carnian Prealps (Italy) connected with the Middle-Late Norian extensional tectonic activity, related to the aborted westward opening of the Neotethys Ocean and the incipient rifting phase of the Ligurian-Piedmont Ocean (CARULLI et al., 1998; COZZI, 2000; COZZI, 2002; COZZI & HARDIE, 2003). The Alaunian aggradation is also reported from the Northern Calcareous Alps (BERRA, 1995; KRYSZYN et al., 2009).

If the platform aggraded in the Middle and Late Norian, then the progradation in the Late Carnian – Early Norian could be even faster. New preliminary findings in the Kamnik-Savinja Alps open new perspectives in the research of the Carnian-Norian progradation of the Dachstein carbonate platform. Besides the progradation – aggradation dynamics and the age control of the Dachstein reef, reflected in the basin, the fundamental question is, if this system was directly connected with the Hallstatt facies of the deep shelf bordering the Neo-Tethys Ocean branch (Fig. 6). In the next phase of our research, further mapping and denser re-sampling of this very interesting area are planned.

Acknowledgements

This paper is result of the Program number P1-0011, financed by the Slovenian Research Agency. We thank Marija Petrović and Mladen Štumergar from Geological Survey of Slovenia for preparation of samples.

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