Upper Triassic and Lower Jurassic limestones from Mt Kobla in the northern Tolmin Basin: tectonically repeated or continuous succession?

Zgornje triasni in spodnje jurski apnenci na Kobli v severnem Tolminskem bazenu: tektonsko ponovljeno ali zvezno zaporedje?

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Abstract: Successions of the Tolmin Basin (western Slovenian Basin) structurally belong to the Tolmin Nappe of the Southern Alps. The Norian–Rhaetian succession of the Tolmin Basin is characterised mainly by bedded dolomite with chert nodules named the Bača Dolomite. It was recently discovered that in the northern part of the basin, the Upper Norian–Rhaetian limestone succession is preserved above the Bača Dolomite. This succession was studied on Mt Kobla, where it is composed of hemipelagic limestone alternating in the upper part with resedimented limestones. It ends with a distinct horizon of thin-bedded hemipelagic limestone that presumably records the end-Triassic carbonate productivity crisis. The overlying resedimented limestones of the Lower Jurassic Krikov Formation document the recovery of production on the adjacent Julian Carbonate Platform. The horizon of thin-bedded hemipelagic limestone therefore contains the Triassic–Jurassic boundary. The discovery of the succession brings an opportunity to study this boundary that recently attracted widespread scientific attention because it is marked by one of the five major extinction events of the Phanerozoic. The problem arises because the topmost part of the succession appears to be tectonically repeated on Mt Kobla and the distinct horizon of thin-bedded hemipelagic limestone is doubled. Alternatively, the overall succession on Mt Kobla could also be continuous and would in this case contain two horizons of thin-bedded hemipelagic limestone. This paper debates both possibilities and elucidates the data that indicate the first, i.e. tectonic, interpretation as more possible.

Izvleček: Razvoji Tolminskega bazena (zahodnega Slovenskega bazena) strukturno pripadajo Tolminskemu pokrovu Južnih Alp. Norijsko – retijsko zaporedje Tolminskega bazena označuje predvsem plastnat dolomit z gomolji roženca, ki je znan pod imenom Baški dolomit. Nedavno je bilo ugotovljeno, da je v severnem delu bazena nad Baškim dolomitom ohranjeno zgornje norijsko – retijsko apnenčevo zaporedje. To zaporedje je bilo proučeno na Kobli, kjer ga sestavljajo hemipelagični apnenci, ki se v vrhnjem delu menjavajo s presedimentiranimi apnenci. Zaporedje se zaključi z značilnim horizontom tanko plastnatega hemipelagičnega apnenca, ki domnevno odraža krizo v karbonatni produkciji koncem triasa. Višje ležeči presedimentirani apnenci spodnje jurske Krikovske formacije pa odražajo ponovno obnovitev karbonatne produkcije na bližnji Julijski karbonatni platformi. Značilen horizont iz tanko plastnatega hemipelagičnega apnenca tako najverjetneje vsebuje triasno-jursko mejo. Odkritje tega zaporedja tako nudi priložnost za proučevanje te meje, katera je nedavno pritegnila pozornost široke geološke znanosti, saj jo označuje eno od petih velikih izumrtij v fanerozoiku. Vendar pa je vrhnji del zaporedja na Kobli najverjetneje tektonsko ponovljen, saj je horizont tanko plastnatega hemipelagičnega apnenca podvojen. Obstaja tudi možnost, da bi bilo celotno zaporedje na Kobli zvezno in bi v tem primeru vsebovalo dva horizonta tanko plastnatega hemipelagičnega apnenca. Ta prispevek tehta obe možnosti in osvetljuje podatke, ki kažejo, da je tektonska ponovitev zaporedja bolj verjetna.

Key words: Tolmin Basin, Late Triassic, facies analysis, Triassic-Jurassic boundary
Ključne besede: Tolminski bazen, zgornji trias, facielne analize, triasno-jurska meja

Introduction

The Norian–Rhaetian succession of the Tolmin Basin (western part of the Slovenian Basin) was considered to be represented only by Bača Dolomite, a bedded dolomite with chert nodules (Buser, 1986, 1989, 1996). Recently, it was proven that the part of the limestone succession that overlies the Bača Dolomite in the northern part of the basin is still Late Norian to Rhaetian in age (Rožič & Kolar-Jurkovšek, 2007; Rožič et al., in press). This limestone succession was studied in the eastern Bohinj Range; more precisely on Mt Kobla (Figure 1). The study is important for two reasons. Firstly, it contributes to a better understanding of the late Triassic sedimentary evolution of the Tolmin Basin. It is essential especially because the Bača Dolomite experienced intensive diagenetic overprinting (silification and dolomitisation) which reduced the exploration potential of the formation. Secondly, it most probably contains the Triassic–Jurassic boundary. Recently, this biostratigraphic boundary attracted scientific attention because it is marked by one of the five major extinction events of the Phanerozoic (Stanton & Flügel, 1987; Sepkoski, 1996; Tanner et al., 2004). Consequently, numerous sedimentological, paleontological, and geochemical studies have focused on this boundary with the aim of elucidating factors that forced the extensive crisis in the evolution of life that occurred approximately 200 million years ago (Palfy et al., 2001, 2007; Guex et al., 2004; Galli et al., 2005, 2007; and many others).

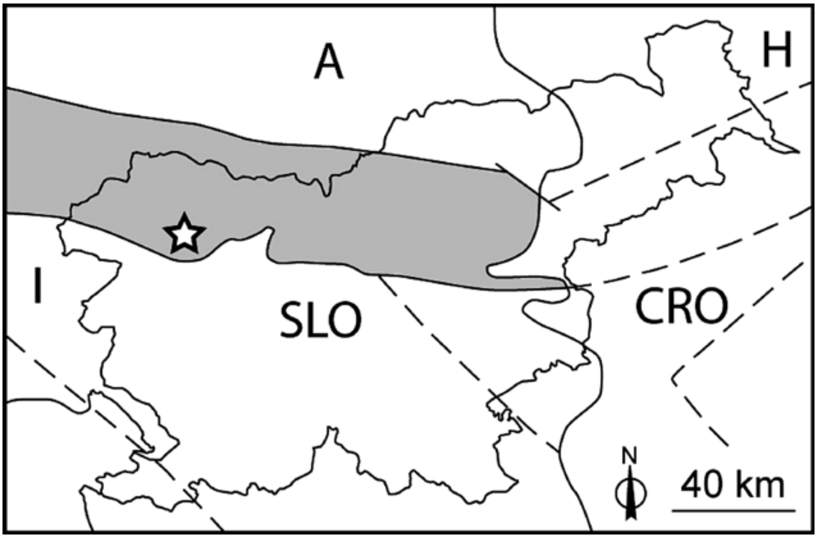

Figure 1. Location of the studied sections (star) and simplified macrotectonic subdivision of Slovenia (after Placer, 1999); the Southern Alps are shaded grey
Slika 1. Lokacija raziskanih profilov (zvezda) in poenostavljena makrotektonska rajonizacija Slovenije (po Placer-ju, 1999); Južne Alpe so obarvane sivo

The Upper Triassic–Lower Jurassic carbonate succession of the Tolmin Basin was investigated in the Kobla sections. It includes the uppermost part of the Bača Dolomite, the Late Triassic limestones and the base of the Early Jurassic Krikov Formation. The transition between the Upper Triassic limestones and the Krikov Formation is characterised by a distinct horizon of thin-bedded limestone with chert nodules, several metres thick. This horizon most probably contains the first known Triassic–Jurassic boundary within basinal succession in Slovenia and therefore offers great potential for boundary studies in this part of the world. The problem arises because this distinct horizon appears to be repeated within the studied succession. The aim of this paper is to distinguish whether the horizon is repeated tectonically or the Late Triassic–Early Jurassic succession is continuous and therefore marked by two horizons of thin-bedded limestone.

Geological setting

The studied succession is located in the eastern Bohinj Range that forms the southern orographic boundary of the Julian Alps (in northwest Slovenia). In the Late Triassic, the Julian Alps were part of the Adriatic continental margin. The whole of western Slovenia was divided into three paleogeographic domains: the Dinaric Carbonate Platform to the south, the approximately east–west extending Slovenian Basin in the middle, and the Julian Carbonate Platform to the north (Buser, 1989, 1996). In the early Jurassic the Julian Carbonate Platform drowned and became the pelagic plateau known as the Julian High (Buser, 1989, 1996; Šmuc, 2005).

In the Norian–Rhaetian both carbonate platforms were characterised by sedimentation on tidal flats, and thick successions of Dachstein Limestone and Main Dolomite formed (Ogorelec & Rothe, 1993; Buser, 1996; Verbovšek, 2008). In the Late Norian and Rhaetian, the southern margin of the Julian Carbonate Platform was locally dominated by coral reefs (Turnšek & Buser, 1991; Turnšek, 1997). The intermediate Slovenian Basin was filled with carbonate material shed from the surrounding carbonate platform. These deposits were mostly dolomitised and silicified during diagenesis, thus forming the Bača Dolomite (Buser, 1989, 1996; Buser et al., 2008). The exception was the northern part of the Tolmin Basin (western Slovenian Basin), where the Upper Norian–Rhaetian succession experienced less intense diagenetic alteration and the limestone succession studied in this paper was preserved.

Structurally, the Julian Alps form the eastern part of the Southern Alps (Figure 1) and consist of two large nappes characterised by southward thrusting: the lower Tolmin Nappe with successions of the Tolmin Basin and the overlying Julian Nappe composed predominantly of Dachstein Limestone of the Julian Carbonate Platform (Placer, 1999; Vrabec & Fodor, 2006). The Tolmin Nappe is thrust over the External Dinarides, which are marked by older, southwest directed thrust displacements (Placer, 1999) and composed of the Dinaric Carbonate Platform successions (Buser, 1989, 1996). The Tolmin Nappe is additionally divided into three lower-order nappes (Buser, 1987); the studied Late Norian to Rhaetian limestone succession is known only from the highest Kobla Nappe. The overall succession of the Kobla Nappe in the studied area ranges from the Carnian to the Lower Cretaceous. The topmost part of the succession (from the Pliensbachian upward) is repeated above a thrust north of Mt Krevl (Figure 2). This succession differs from the classical succession of the Kobla Nappe because it records a long stratigraphic gap (at least Toarcian to Bajocian) and most probably originated on the margins of the Julian High. Further north, shallow-water Late Triassic reef limestone, Jurassic ooidal limestone, the deeper-water Sedlo Formation (Šmuc, 2005; Šmuc & Goričan, 2005), and Biancone limestone of the Julian Carbonate Platform and Julian High are exposed. This succession belongs to the Julian Nappe but the tectonic contact with the regionally underlying Tolmin Nappe in the Mt Kobla area is exceptionally not a thrust but a normal or strike-slip fault (Figure 2).

Description of Kobla sections

The succession of Mt Kobla was included in some earlier geological surveys. The first extensive geological work of the area was carried out during the construction of the Bohinjska Bistrica–Podbrdo railway tunnel that penetrates the eastern Bohinj Range directly below Mt Kobla (Kossmat, 1907). The overall carbonate succession of the Tolmin Basin was described as Jurassic, although an Late Triassic Bača Dolomite had already been recognised in other parts of the basin. The Bača Dolomite in this area was recognised later, during geological mapping of the Julian Alps (Buser, 1986, 1987). On Mt Kobla, the same section as is

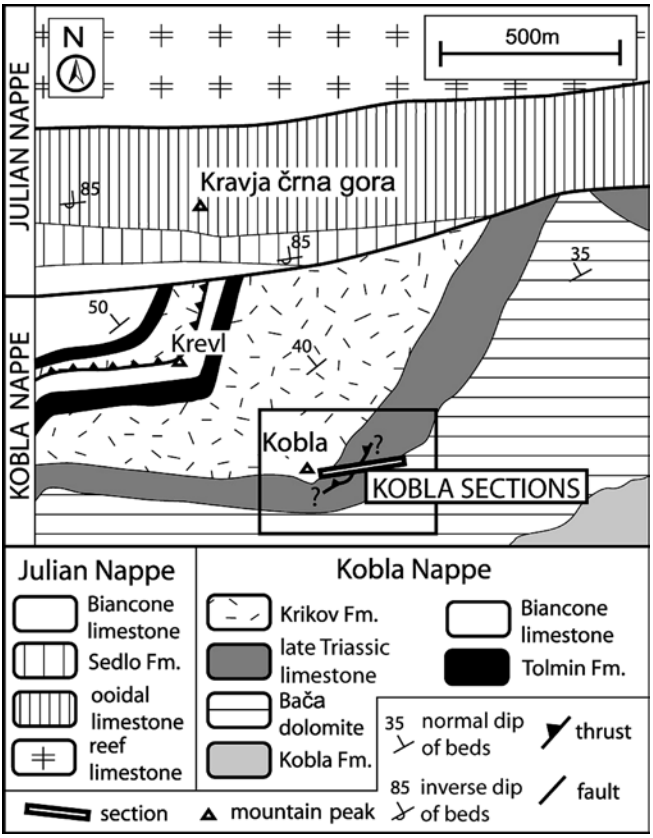

Figure 2. Geological map of the Mt Kobla area and the general location of the studied sections. The boxed area is enlarged in Figure 3.
Slika 2. Geološka karta območja Koble in približna lokacija preiskanih profilov. Del karte v okvirju je povečan na sliki 3.

described in the present paper was studied for the purpose of stratigraphic ordering. The overall limestone succession overlying the Bača Dolomite was assigned to the Jurassic, although Buser (1986) pointed out that no characteristic Jurassic fossils were found in the lower part of the succession. The author mentioned the foraminifers *Galeanella panticae*, *Ophtalmidium* sp. and the dasyclad alga *Thaumatoporella parvovesiculifera*, whereas the Jurassic *Involutina farinacciae* was found only in the topmost part of the section.

The studied succession is located on the old path that climbs the eastern slope of Mt Kobla (y = 5420550, x = 5121590, 1498 m above sea level) and was investigated in three sections (Figure 3 and Plate 1; Fig.1). The main section is 112 m thick and beds in this section dip towards the northwest (Figures 3 and 5). The second section investigates 18 m of beds that overlie the main section, are sub-vertical, and extend in an east–west direction (Figures 3 and 5). Sedimentary structures in these beds indicate that succession becomes younger towards the south. The third section is 23 m thick and covers the uppermost beds exposed along the path. These beds dip similarly to beds in the main section (Figures 3 and 5).

Main section

The section begins with a few metres of the Bača Dolomite, a bedded dolomite with chert nodules (Figure 4). The boundary with the overlying limestone succession is covered but most probably sharp. The following 90 m are characterised by bedded (10 to 50 cm), grey, occasionally wavy, and even laminated hemipelagic limestone (Plate 1; Fig. 2). The microfacies is wackestone composed of pellets and fossils, of which the most abundant are calcified radiolarians. Other fossils are sponge spicules, echinoderms, bivalves, brachiopods, ostracods, benthic foraminifers, gastropods, and juvenile ammonites (Plate 1; Fig. 4). Beds usually contain replacement chert nodules. Especially in the upper part of this succession (above 70 m in the section), hemipelagic limestone alternates with coarser beds; i.e. calcarenite and limestone conglomerate (Plate 1; Fig. 3). Calcarenite is mostly medium- to

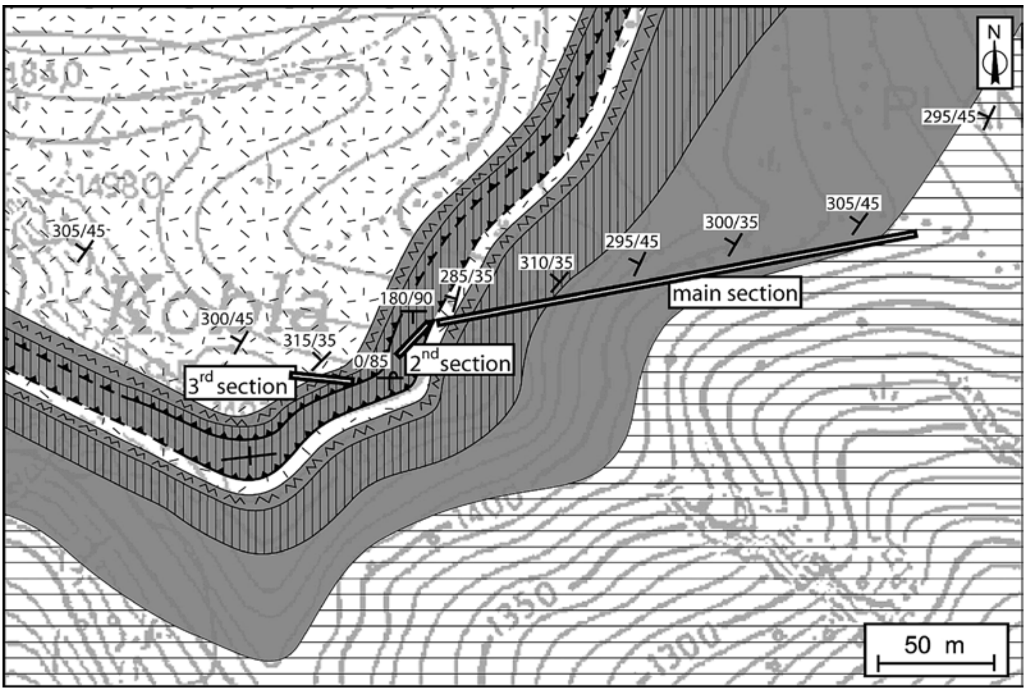

Figure 3. Detailed geological map of Mt Kobla with the exact position of sections. The legend is the same as for Figure 2. Within the Upper Triassic limestone succession the horizon with abundant resedimented limestones is outlined with vertical lines and the horizon of thin-bedded hemipelagic limestone with a zigzag pattern.

Slika 3. Natančna geološka karta Koble s točnimi lokacijami profilov. Legenda je ista kot pri sliki 2. Znotraj zgornje triasnega apnenčevega zaporedja je horizont z obilnimi presedimentiranimi apnenci izdvojen z navpičnimi črtami in horizont tanko plastnatega hemipelagičnega apnenca s cikcak vzorcem.

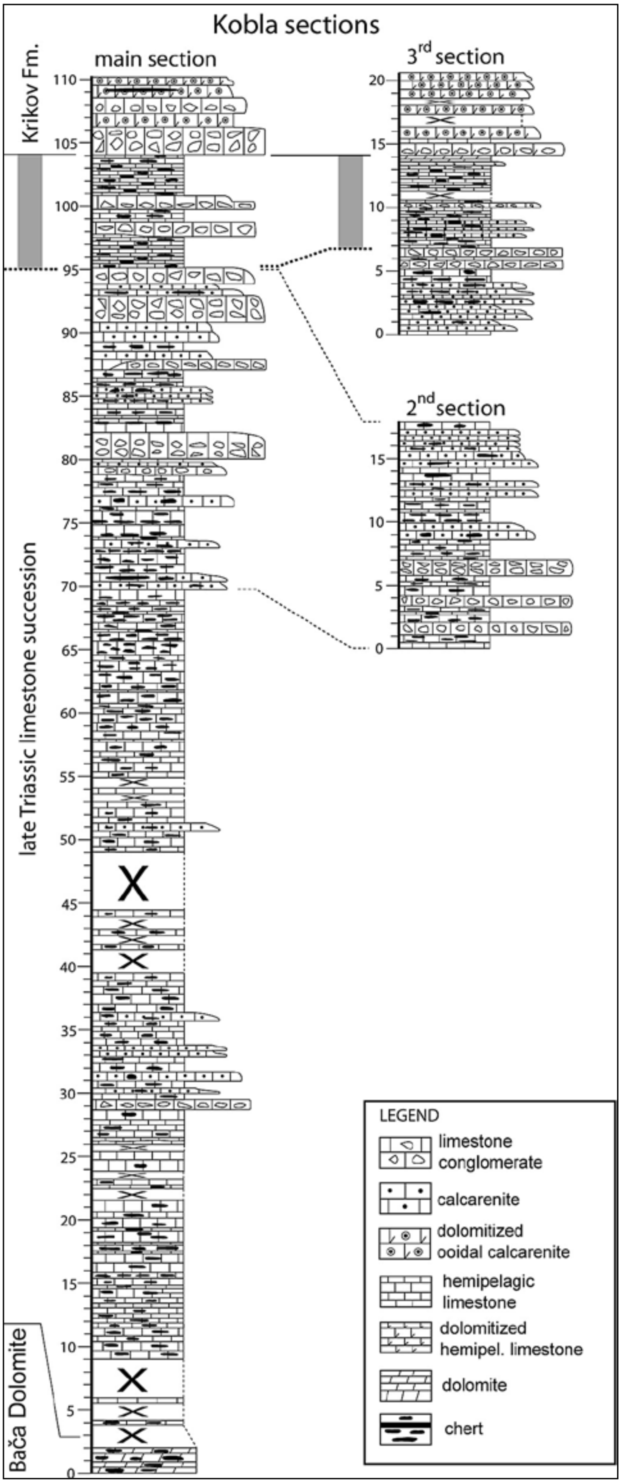

Figure 4. Kobla sections: the main section consists of the Bača Dolomite at the base, the Upper Triassic limestone succession in the major part, and the Krikov Formation at the top. The second section exhibits a similar composition to the main section between 70 and 95 m (where coarser limestone beds are abundant), whereas the third section generally correlates well to the topmost part of the main section. The distinctive horizon of thin-bedded hemipelagic limestone is indicated by grey stripes.

Slika 4. Profili Koble: glavni profil se začne z Baškim dolomitom, glavni del sestavlja zgornje triasno apnenčevo zaporedje, konča pa se s Krikovsko formacijo. Drugi profil je sestavljen podobno kot glavni profil med 70 in 95 m (kjer so pogosti presedimentirani apnenci), medtem ko tretji profil ustreza vrhnjemu delu glavnega profila. Značilen horizont tanko plastnatega hemipelagičnega apnenca je označen s sivima trakovoma.

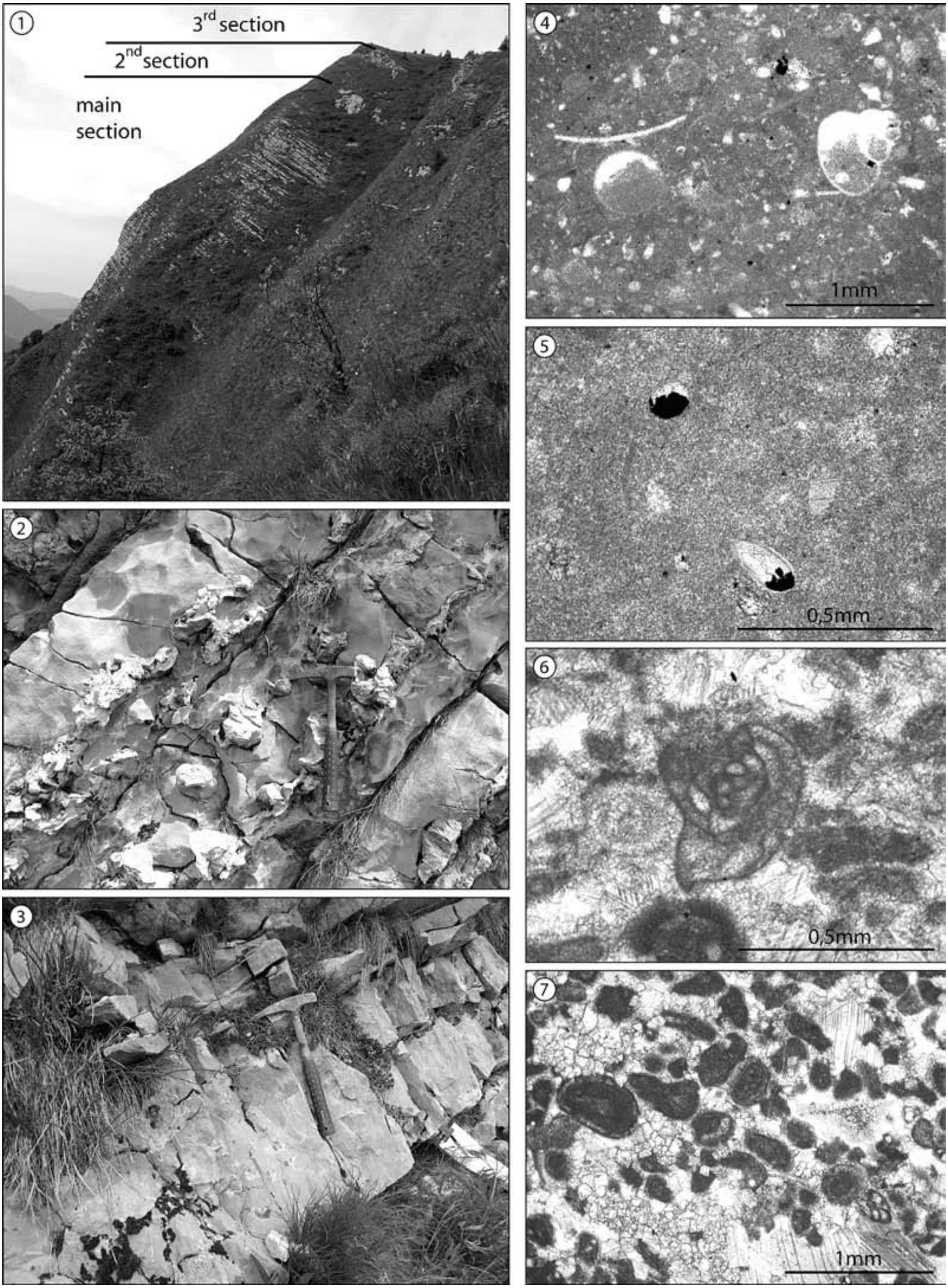
1
3rd section
2nd section
main section
2
3
4
1mm
5
0,5mm
6
0,5mm
7
1mm

Plate 1. Fig. 1. View of Mt Kobla from the eastern side with the location of the studied sections; Fig. 2. Hemipelagic limestone with irregular chert nodules from the middle part of the main section; Fig. 3. Thicker limestone conglomerate beds alternating with thinner beds of hemipelagic limestone just below the distinct horizon of thin-bedded hemipelagic limestone (at approximately 95 m in the main section); Fig. 4. Wackestone composed of calcified radiolarians and sponge spicules, pellets, bivalve-shells, and gastropods with a geopetal structure (at 18.5 m in the main section); Fig. 5. Mudstone to wackestone with "ghosts" of calcified radiolarians, echinoderm fragments, and ostracods geopetally filled with an opaque mineral, most probably pyrite (at 102.3 m in the main section); Fig. 6. Medium-grained grainstone with foraminifer *Galeanella tollmanni* Kristan-Tollmann; other grains are echinoderm fragments, pellets, and intraclasts (at 1.8 m in the third section); Fig. 7. Medium-grained, partially dolomitised grainstone with ooids, peloids, and rarer fossils, predominantly echinoderm fragments and foraminifer (at 16.5 m in the third section).

Tabla 1. Sl. 1. Pogled na Koblo z vzhodne strani z lokacijami raziskanih profilov; Sl. 2. Hemipelagični apnenec z nepravilnimi roženčevimi gomolji v srednjem delu glavnega profila; Sl. 3. Menjavanje debelih plasti apnenčevega konglomerata s tanjšimi plastmi hemipelagičnega apnenca tik pod značilnim horizontom tanko plastnatega hemipelagičnega apnenca (približno 95 m glavnega profila); Sl. 4. Vekston s kalcitiziranimi radiolariji in spongijskimi spikulami, peleti, školjčnimi lupinami in polži z geopetalno teksturo (18,5 m glavnega profila); Sl. 5. Madston do vekston z "duhovi" kalcitiziranih radiolarijev, drobci iglokožcev in ostrakodi, ki so geopetalno zapolnjeni z neprosojnim mineralom, najverjetneje piritom (102,3 m glavnega profila); Sl. 6. Srednje zrnati greinston s foraminifero *Galeanella tollmanni* Kristan-Tollmann; preostala zrna so drobci iglokožcev, peleti in intraklasti (1,8 m tretjega profila); Sl. 7. Srednje zrnat, deloma dolomitiziran greinston z ooidi, peloidi in manj pogostimi fosili, predvsem drobci iglokožcev in foraminifer (16,5 m tretjega profila).

coarse-grained, grey, bedded (3 to 45 cm), normally graded, even, and wavy laminated grainstone composed predominantly of intraclasts and fossils; i.e. echinoderm fragments and rarer benthic foraminifers, fragmented shells of bivalves, brachiopods, and ostracods, gastropods, and codiaceans. The limestone conglomerate is bedded (12 to 150 cm) and occasionally graded. Beds are even or rarely channelised. The thickest beds are abruptly overlain by graded calcarenite. Clasts in the conglomerate are dm-sized, well rounded, elongated, and oriented parallel to the bedding planes. Clasts are almost exclusively basinal intraclasts (mud-chips) and of the same composition as the surrounding hemipelagic limestone, whereas the matrix consists of the calcarenite described above.

Above 95 m in the section, coarser beds become rare, while hemipelagic limestone becomes very thin-bedded and exhibits less diverse composition, with calcified radiolarians as predominant grains; other fossils are rare ostracods and echinoderm fragments (Plate 1; Fig. 5). This distinct, thin-bedded horizon is above 104 m in the section overlain by bedded (up to 80 cm) limestone conglomerate and calcarenite. Clasts in the conglomerate are again mostly basinal intraclasts, whereas the composition of calcarenite (which also forms the matrix in conglomerate) changes significantly. It is grainstone composed of ooids, peloids, and rare fossils, among which echinoderms and codiaceans prevail. These beds are partially dolomitised. The topmost bed in the main section is tectonically altered; i.e. dissected by numerous calcite veins and fissures oriented generally parallel to the bedding planes.

The main section was sampled for conodonts (Rožič & Kolar-Jurkovšek, 2007; Rožič et al., in press). The last conodonts were retrieved below the horizon of thin-bedded hemipelagic limestone. Conodont assemblages indicated that the limestone succession below this horizon was Late Norian to Rhaetian in age.

Second section

The second section consists of hemipelagic limestone alternating with limestone conglomerate and calcarenite (Figure 4). It is similar to the succession from 70 to 95 m in the main section, although limestone conglomerate beds are generally thinner (up to 90 cm). The composition of these beds is the same as that of corresponding beds from the main section.

Third section

The section begins with a 5 m thick horizon dominated by calcarenite (Figure 4). The microfacies and composition are equal to that of the calcarenite researched below 95 m in the main section (Plate 1; Fig. 6). Above this horizon hemipelagic limestone starts to prevail. In the first two metres, beds are still up to 25 cm thick and are overlain by rather thin limestone conglomerate beds. Upwards thin-bedded hemipelagic limestone dominates the succession. It is interbedded with very rare, thin calcarenite beds and composed similarly to the thin-bedded hemipelagic limestone from the main section. The thickness of this horizon is eight metres. It is overlain by 10 m of bedded (up to 50 cm) calcarenite and limestone conglomerate. The microfacies and composition are the same as those of the coarse beds of the topmost part of the main section (Plate 1; Fig. 7).

Similarly, these topmost beds also exhibit partial dolomitisation. Upwards the outcrops become poor, but it is evident that the following succession is dominated by ooidal/peloidal calcarenite while limestone conglomerate becomes rarer.

Discussion

The lower part of the main section is dominated by hemipelagic limestone. The composition of these beds indicates deposition in a deeper-water sedimentary environment. Because carbonate plankton was scarce until the late Jurassic (Bartolini et al., 2002; Pittet & Mattioli, 2002), the lime mud must have been shed especially from the adjacent Julian Carbonate Platform. Upwards the coarser beds start to occur more abundantly. Sedimentary textures in these beds indicate deposition by gravity flows, predominantly turbidites. In the calcarenite, the foraminifers *Galeanella panticae* Brönnimann and *G. tollmanni* Kristan-Tollmann were determined (Plate 1; Fig. 6). The presence of these foraminifers indicates that reefs were present in the source area (Schäfer, 1979; Senowbari-Daryan, 1980; Senowbari-Daryan et al., 1982). Coarser beds in the upper part of the main section indicate the progradation of the sedimentary environment. Namely, the facies association is characteristic of the basin plain and changes upwards to the lower slope.

The horizon of thin-bedded limestone records a sudden biotic decrease and may be related to the biocalcification crisis that marks the Triassic–Jurassic boundary (Palfy et al., 2001, 2007; Ward et al., 2004; Galli et al., 2005, 2007). Although no Jurassic fossils have yet been found in the overlying ooidal/peloidal calcarenite and limestone conglomerate, the ooidal beds most probably belong to the Hettangian–Pliensbachian Krikov Formation and

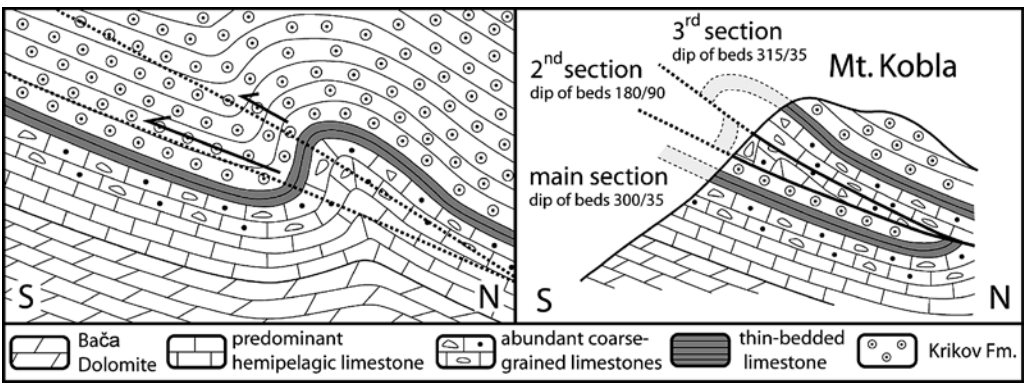

Figure 5. Sketch of the tectonic interpretation. Left: the tectonic compression resulted first in an asymmetric fold that was later dissected by minor thrusts. Right: a present-day geological cross-section of Mt Kobla with the position of the studied sections.

Slika 5. Skica tektonske interpretacije. Levo: kot posledica tektonske kompresije je najprej nastala nesimetrična guba, ki je bila kasneje pretrgana z manjšimi narivi. Desno: današnji geološki prerez Koble z lokacijami preiskanih profilov.

record the recovery of production on the adjacent Julian Carbonate Platform.

The main purpose of this paper is to determine whether the second and third sections represent a tectonically repeated upper part of the main section or form a continuous succession. It seems likely that the first, tectonic explanation is correct. The arguments for this interpretation are the presence of the following: a) the same superposition of different facies in the main and the third section, namely, from alternating hemipelagic and coarse-grained resedimented limestones through thin-bedded hemipelagic limestone to the subsequent change to ooidal/peloidal calcarenite and limestone conglomerate; b) the change in dips of beds from northwest dips in the main and third sections to sub-vertical, east–west extending beds in the second section; and c) the fissures and calcite veins at the top of the main section that indicate intense tectonic deformation oriented approximately parallel to the bedding plains; i.e. thrust displacement.

The repeated succession on Mt Kobla is explained as a consequence of compression that resulted in asymmetric fold originating during thrust fault propagation (Davis & Reynolds, 1996). The fold limbs were additionally displaced by minor thrust (Figure 5). East–west extending beds in the second section indicate that the compression is related to South-Alpine south-verging thrusting (Placer, 1999; Vrabec & Fodor, 2006; Kastelic et al., 2008). As indicated by numerous fissures and calcite veins at the top of the main section, the displacement was greater along the lower thrust. The second section is structurally located in the sub-vertical; i.e. southern fold limb. The succession investigated in this section corresponds to the succession between 70 and 95 m of the main section (Figures 4 and 5). Under such structural setting, the third section is located in the low-dip; i.e. northern fold limb. In this section the topmost part of the main section is repeated (Figures 4 and 5). The Triassic foraminifer *Galeanella tollmanni* Kristan-Tollmann was determined at the base of this section (Plate 1; Fig. 6). Because Buser (1986) reports Jurassic *Involutina farinacciae* at 140 m in his section, it seems likely that this occurrence corresponds to the top of the third section. Therefore, we can presume that the Triassic–Jurassic boundary lies within the horizon of thin-bedded hemipelagic limestone that marks the top of the main section but is repeated due to thrusting in the third section. Minor differences between the second and third sections with corresponding parts of the main section are explained by lateral variations caused by deposition in the lower slope sedimentary environment.

Alternatively, the second and third sections could represent a stratigraphically continuous succession above the main section. In this case, the sub-vertical dip in the second section would originate from a synsedimentary fold caused by slumping. The overall succession (comprising all three sections) would be marked by two horizons of thin-bedded hemipelagic limestone each overlain by ooidal/peloidal calcarenite and limestone conglomerate. Such an interpretation is less probable when the sedimentary succession of the Julian Carbonate Platform, which was a source area of resedimented carbonate material, is taken into consideration. The Triassic–Jurassic boundary on the platform has not yet been studied in detail, but is generally placed below the first occurrence of ooidal limestone that overlies the Dachstein Limestone or, in platform margins, lies above the reef limestone (Buser 1986; Jurkovšek et al., 1990; Ogorelec & Buser, 1997). Similar Late Triassic to Early Jurassic depositional change is also observed in the Julian Carbonate Platform succession located in the northern part of the Mt Kobla area (Figure 2), where the Late Triassic is represented by reef limestone (Turnšek & Buser, 1991; Turnšek, 1997) and Early Jurassic by ooidal limestone. Although the contact in this area is tectonic, the fault dips parallel to the bedding and disruption of the sedimentary succession is most probably minor. Therefore the prominent change in the composition of resedimented limestones in the studied basinal sections records the main sedimentary change on the Julian Carbonate Platform: i.e. from tidal flats or reefs to ooidal shoals. A similar main change is reported from the Lombardian Basin located in the western Southern Alps. In the Lombardian Basin the Late Triassic Zu Limestone Formation is represented predominantly by marl/micritic limestone alternations, whereas in the upper part of the formation coral limestones are present as a consequence of the basin shallowing (Jadoul et al., 1994, 2007; Gaetani et al., 1998; Gianolla & Jacquin, 1998). Although rare ooidal limestone beds are reported already from the upper Zu Limestone Formation the main change is reserved for the Early Jurassic, when Bahamian-type carbonate platform peloidal and ooidal limestones of the Albenza Formation started to deposit (Jadoul et al., 2007). Furthermore, the interval between the Zu Limestone and Albenza Formations is marked by a succession that is very similar to thin-bedded limestone horizons from the Kobla sections. This distinct interval from the Lombardian Basin (which records a major transgression) is known as topmost Zu Limestone or Malanotte Formation and was proven to contain a Triassic–Jurassic boundary (Galli et al. 2005, 2007; Jadoul, 2007). The correlation with the Lombardian Basin additionally suggests only one, tectonically repeated thin-bedded limestone horizon in the Kobla sections and furthermore indicates that this horizon offers great potential for studies of the Triassic–Jurassic boundary in the Tolmin Basin.

Conclusions

In the northern part of the Tolmin Basin the Late Triassic succession is exceptionally represented by limestones, whereas in the major part of the basin the entire Norian–Rhaetian interval consists of dolomite (Bača Dolomite). This limestone succession was studied at Mt Kobla and is composed predominantly of hemipelagic limestone alternating in the upper part with resedimented limestones, i.e. calcarenite and limestone conglomerate. The change of facies association indicates a progradation of sedimentary environments from the basin plain to the lower slope. The Triassic succession ends with a distinct, few-metres-thick horizon of thin-bedded, hemipelagic limestone. This distinct horizon records the end-Triassic productivity crisis. The overlying resedimented limestones, mostly ooidal/peloidal calcarenites

of the Krikov Formation, document the early Jurassic recovery of carbonate production on the adjacent Julian Carbonate Platform. Apart from the main section, the uppermost Triassic–Early Jurassic succession was additionally studied in two sections that overlie the main section. Microfacies analysis, geological mapping data, brittle deformations of sections margins, and correlation with the Julian Carbonate Platform and the Lombardian Basin successions indicate that the studied succession at Mt Kobla is tectonically repeated due to minor thrust displacement.

Povzetek

Zgornje triasni in spodnje jurski apnenci na Kobli v severnem Tolminskem bazenu: tektonsko ponovljeno ali zvezno zaporedje?

V severnem delu Tolminskega bazena zgornje triasno zaporedje izjemoma sestavljajo apnenci, medtem ko v preostalih delih bazena celotno norijsko-retijsko obdobje predstavlja dolomit (Baški dolomit). Apnenčevo zaporedje je bilo raziskano na Kobli. Sestavljajo ga predvsem hemipelagični apnenci, ki se v zgornjem delu menjavajo s presedimentiranimi apnenci, in sicer kalkareniti in apnenčevimi konglomerati. Sprememba v faciesni združbi dokazuje progradacijo sedimentacijskega okolja iz bazenske ravnice v spodnje pobočje. Triasno zaporedje se konča z značilnim, nekaj metrov debelim, horizontom tanko plastnatega hemipelagičnega apnenca. Ta horizont odraža krizo v karbonatni produkciji, ki označuje konec triasa. Višje ležeči presedimentirani apnenci, predvsem ooidno/peloidni kalkareniti Krikovske formacije kažejo na obnovitev karbonatne produkcije na bližnji Julijski karbonatni platformi. Poleg glavnega sedimentološkega profila je bilo zgornje triasno do spodnje jursko zaporedje preučeno še v dveh profilih, ki se nahajajo neposredno nad glavnim profilom. Analiza mikrofaciesov, rezultati geološkega kartiranja, lomne deformacije na robovih profilov in korelacija z zaporedji Julijske karbonatne platforme ter Lombardijskega bazena kažejo, da je preučeno zaporedje na Kobli zaradi premikov ob manjših narivih tektonsko ponovljeno.

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