

Conodonts and foraminifera from the “Raibl Beds” (Carnian) of the Karavanke Mountains, Slovenia: stratigraphical and palaeobiological implications

Tea KOLAR-JURKOVŠEK, Andrzej GAŹDZICKI and Bogdan JURKOVŠEK



Kolar-Jurkovšek T., Gaździcki A. and Jurkovšek B. (2005) — Conodonts and foraminifera from the “Raibl Beds” (Carnian) of the Karavanke Mountains, Slovenia: stratigraphical and palaeobiological implications. *Geol. Quart.* 49 (4): 429–438. Warszawa.

The micropalaeontology of the “Raibl Beds” of the Košuta Nappe in the western Karavanke Mts., Slovenia, is described. The presence of the conodont apparatus of *Nicoraella? budaensis* Kozur and Mock is demonstrated and together with other fossils it confirms a Carnian age. A comparison of the *Nicoraella* skeletal apparatus with two other Triassic apparatuses is made. The benthic foraminifera *Aulotortus sinuosus*, *A. tumidus*, *Prorakusia salaji*, *Pilamminella kuthani* and *Endothyra kuepperi* are recognized. Their stratigraphical range corresponds to the foraminiferal *Pilamminella kuthani* Interval-Zone. Altogether the palaeontological content of an 85 m-thick section in the upper part of the “Raibl Beds” below Mt. Jepca is described. The diverse fossil content of this section contributes to the intercalibration of Upper Triassic conodont, foraminifer and dasyclad zonation.

Tea Kolar-Jurkovšek and Bogdan Jurkovšek, *Geološki zavod Slovenije, Dimičeva 14, 1000 Ljubljana, Slovenija*, e-mails: tea.kolar@geo-zs.si, bogdan.jurkovsek@geo-zs.si; Andrzej Gaździcki, *Instytut Paleobiologii PAN, Twarda 51/55, PL-00-818 Warszawa, Poland*, e-mail: gazdzick@twarda.pan.pl (received: March 3, 2005; accepted: July 22, 2005).

Key words: Slovenia, Karavanke Mts., Carnian, “Raibl Beds”, biostratigraphy.

INTRODUCTION

The Carnian beds of the southern Karavanke Mts. have been the subject of several geological studies and comparisons with similar developments of Upper Triassic strata in a wider area of the Karavanke Mts. and Julian Alps. The “Raibl Beds” of the southern Karavanke Mts. may be considered as part of two tectonic units, i.e. the Košuta Nappe (Budkovič, 1983, 1999; Buser, 1980; Jurkovšek, 1987a; Ogorelec *et al.*, 1999) and the Hahnkogel Unit (Krystyn *et al.*, 1994).

The stratigraphic development of Triassic strata of the two units differs sharply, especially in the uppermost Carnian and Norian. The Raibl Group of the Hahnkogel Unit consists of the Conzen Formation in the lower part, the terrigenous Julian-Tuvalian “Raibl Beds” in the middle part, and shallow water dolomites in its upper part. There follow the bioturbated dolomites of the Carnitza Formation, and the Bača Dolomite (Bača Formation) followed by the beds of the Frauenkogel Formation above. The latter two formations are Norian in age (Lein *et al.*, 1995).

The Carnian beds situated north of Mojstrana between the Belca valley and Mt. Jepca (1610 m a.s.l.), were placed within

the Košuta Nappe by Jurkovšek (1987a), which, according to his opinion, belongs to the same unit as the Julian Alps Nappe. Ramovš (1993) noted that, only in the Belca area in Karavanke Mts. and in the Beli Potok in the Julian Alps, depositional conditions were identical during the Julian/Tuvalian. Therefore he termed it the Beli Potok development. From the lower part of the Belca succession he recorded also findings of the ammonoids *Trachyceras aonoides* and *Austrotrachyceras austriacum*.

Detailed examinations in a typical development of the “Raibl Beds” in the Raibl area (presently Cave del Predil, Italy) were conducted during the last few decades by Lieberman (1978, 1980) and De Zanche *et al.* (2000). These resulted in a new lithostratigraphic subdivision of the Raibl Group into six formations rested between the Schlern (=Sciliar) Dolomite below, and the Dolomia Principale Formation above. Based on their subdivision, it would be reasonable to redefine some similar Julian-Tuvalian lithostratigraphic developments in the Slovenian part of the Julian Alps, i.e. the Beli Potok development (Ramovš, 1993), the Tamar Formation (Ramovš, 1981, 1985; Ogorelec *et al.*, 1984, Jurkovšek, 1987a), and some other beds that remained undefined (Jurkovšek, 1987a, b).

This study describes the conodont fauna obtained from an 85 m-thick Carnian succession below Mt. Jepca north of

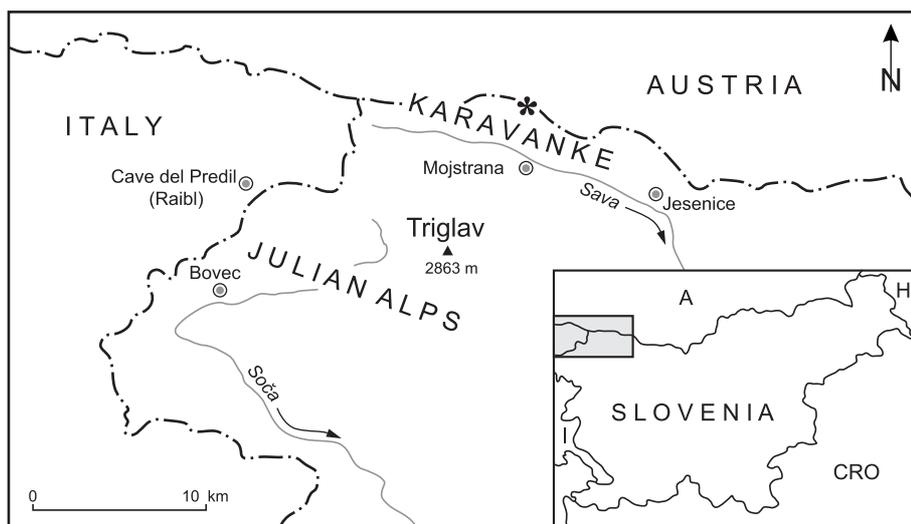


Fig. 1. Geographic sketch map with the location (asterisk) of the section studied in the western Karavanke Mts., Slovenia

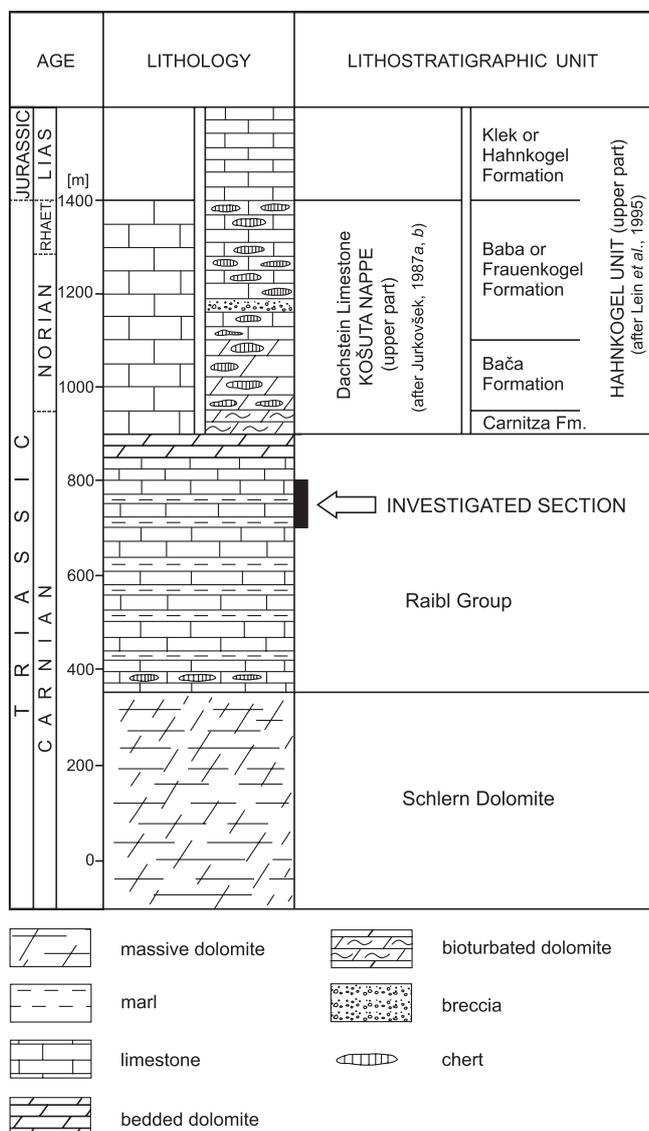


Fig. 2. Schematic lithostratigraphic column of formations in the Košuta Nappe and in the Hahnkogel Unit

Mojstrana (Figs. 1 and 3). The stratigraphic section is situated in the upper part of the “Raibl Beds” of the Košuta Nappe in the southern Karavanke Mts. area (Fig. 2). As part of a biostratigraphic study, 37 limestone samples, each between one to two kilograms in weight, were collected and treated for conodonts. Fifteen samples produced microfossils consisting of calcareous algae, sponge spicules, ostracods, holothurians, and fish teeth. Among them only three samples yielded the conodonts reported on in this paper.

Representative conodont specimens were photographed with a scanning-electron microscope at the Institute of Biology, University of Ljubljana. All recovered conodont specimens have been catalogued and

deposited at the Geološki zavod Slovenija (Geological Survey of Slovenia), under catalogue numbers GeoZS 3063, 3066, and 3082. The foraminifer collections investigated (thin sections) are housed at the Geological Survey of Slovenia (GeoZS 61319, 61321, 61322, 61323) and at the Institute of Palaeobiology of the Polish Academy of Sciences, Warszawa (ZPAL F.51).

DESCRIPTION OF THE EXAMINED SECTION

The “Raibl Beds” of the Košuta Nappe north of Mojstrana attain a thickness of some few hundred metres (Fig. 2). They are mainly built of platy limestone that contains lenses and nodules of chert in the Belca valley. Layers and sheets of marly limestone and marl, as well as beds of breccia, frequently occur between the limestone beds.

Detailed collecting and sampling of an 85 m-thick Carnian succession was conducted on the south-west slope of Mt. Jepca (between 1420 and 1530 m height above sea level) in 1994 after previous repeated unsuccessful spot sampling for conodont research. At this particular locality there is an alternation of dark gray limestone and marly limestone with marl intercalations. Thicker marl beds occur rarely. The limestone is platy to medium bedded, and generally has an internally laminated biomicrite texture, or is rarely calcarenitic or brecciated. Breccia beds, 30 to 40 cm thick, are also present in the section (Fig. 3).

Thin-shelled valves of *Posidonia* are most frequent among macrofossils and they typically appear in abundance. As a rule, the valves are articulated and the convex side is turned down indicating a quiet sedimentary environment. Posidonids are present in both marl and limestone beds. Plant fossils, among which the genus *Voltzia* dominates (Dobruskina *et al.*, 2001), and fossil fishes are restricted to more marly beds of the lower part of the section.

Conodont elements of the genus *Nicoraella?* (samples 11, 20/1, 21) in association with sponge spicules, ostracods, holothurians and fish remains were found in the lower part of the section. A few samples from the upper part of the section also yielded isolated whorls and segments of thalli of the alga *Clypeina besic* Pantić (Kolar-Jurkovšek and Jurkovšek, 2003a, b).

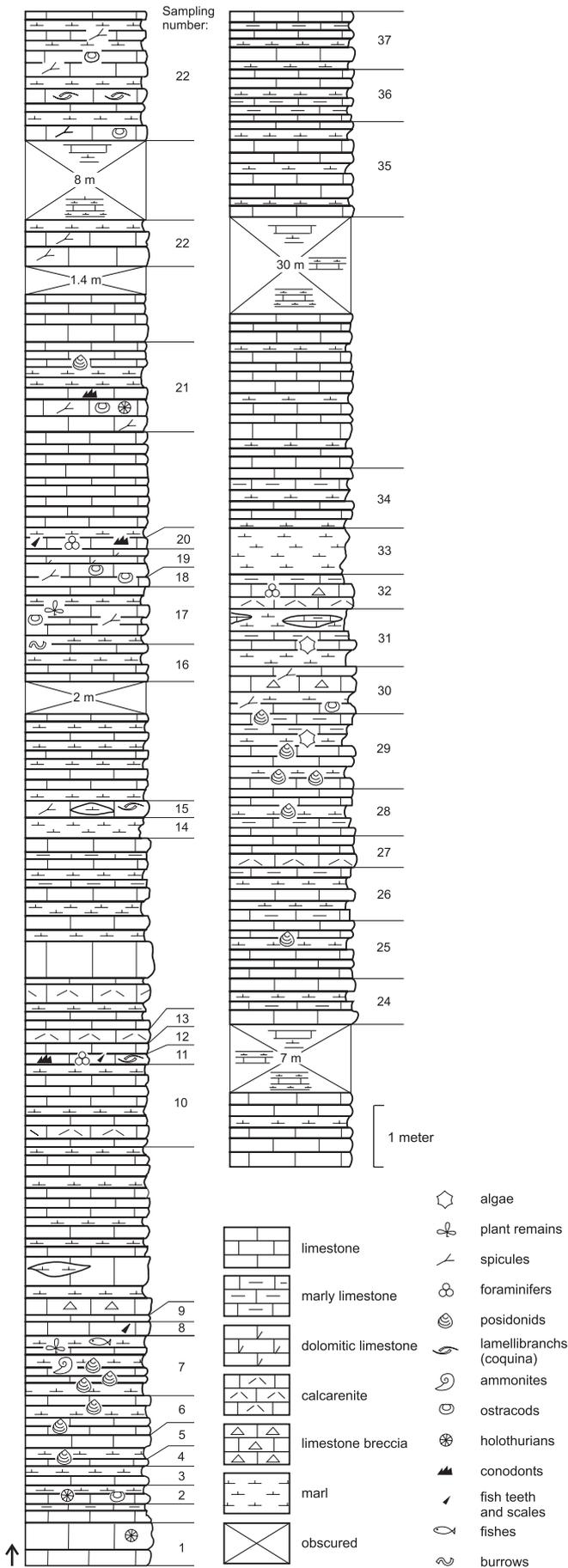


Fig. 3. Lithostratigraphic column of the section investigated in the western Karavanke Mts., Slovenia

The “Raibl Beds” carbonates, well-exposed in the Belca section, contain involutinid, ammodiscid and endothyrid foraminifera. These were studied in thin sections made from the samples 11, 20 and 32 (see Fig. 3).

TAXONOMIC DESCRIPTION

Nicoraella Kozur, 1980

R e l a t i o n s h i p. — According to Kozur (1989) the genus *Nicoraella* evolved from *Neospathodus* during the early Anisian by forward shifting of the basal cavity.

Nicoraella kockeli (Tatge) is an index form for the Pelsonian, but its relationship with *Nicoraella postkockeli* Kozur, described from the Cordevolian of Hungary, is not certain (Kozur, 1993). The P1 element of *Nicoraella? budaensis* Kozur and Mock (middle Carnian) differs from the P1 element of the two stratigraphically older *Nicoraella* species by the lack of a posterior blade.

R e m a r k s. — The middle Carnian *Nicoraella* representatives are characterized by very small P1 elements compared with Anisian to lower Carnian ones. Some specimens of *N.? budaensis* still display a rudimentary posterior process and they might be a link with the probable ancestor *N. postkockeli* (Kozur, 1993). At present, a relationship between the *Nicoraella* species is not clear due to inadequate information. It is also difficult to ascertain common homeomorphy in conodonts, including in the genus *Neospathodus* (Clark, 1981).

In Kovacs’s opinion, the phylogenetically distinct genera *Merrillina* Kozur, *Nicoraella* Kozur, *Mosherella* Kozur, *Neocavitella* Budurov and Sudar, *Misikella* Kozur and Mock would have to be united in a single genus *Neospathodus*, as the oldest available generic name due to several hypothetical links with supposed ancestor (Kovacs in Kristan-Tollmann *et al.*, 1991).

In view of these unsolved problems, the segminate elements discussed in this paper are assigned to the genus *Nicoraella?*. Thus, the original generic designation for the previously known species (*Nicoraella? budaensis*) is retained.

Nicoraella? budaensis Kozur and Mock, 1989 (Fig. 4A–L, Fig. 5A–E)

Nicoraella? budaensis Kozur, 1989, pl. 19, figs. 1–10.
Nicoraella? budaensis Kozur and Mock, 1991, p. 275–276, pl. 1, figs. 1–5, pl. 2, figs. 1–6, 8, 9, pl. 3, figs. 1–11, pl. 4, fig. 1, 3–8.

R e p o s i t o r y. — Sample 11 (GeoZS 3066), sample 21 (GeoZS 3082).

R e m a r k s. — According to Kozur and Mock (1991) the apparatus is composed of spathognathodiform, modified ozarkodiniform, modified hindeodelliform (metaprioniodiform), modified prioniodiniform (cypridodelliform), enantiognathiform and hibbardelliform elements; the apparatus includes two types of pectiniform elements that occupied the P1 and P2 positions.

P1 element very small with slightly downcurved posterior basal margin. Blade with 4–6 denticles. Cusp distinct, situated

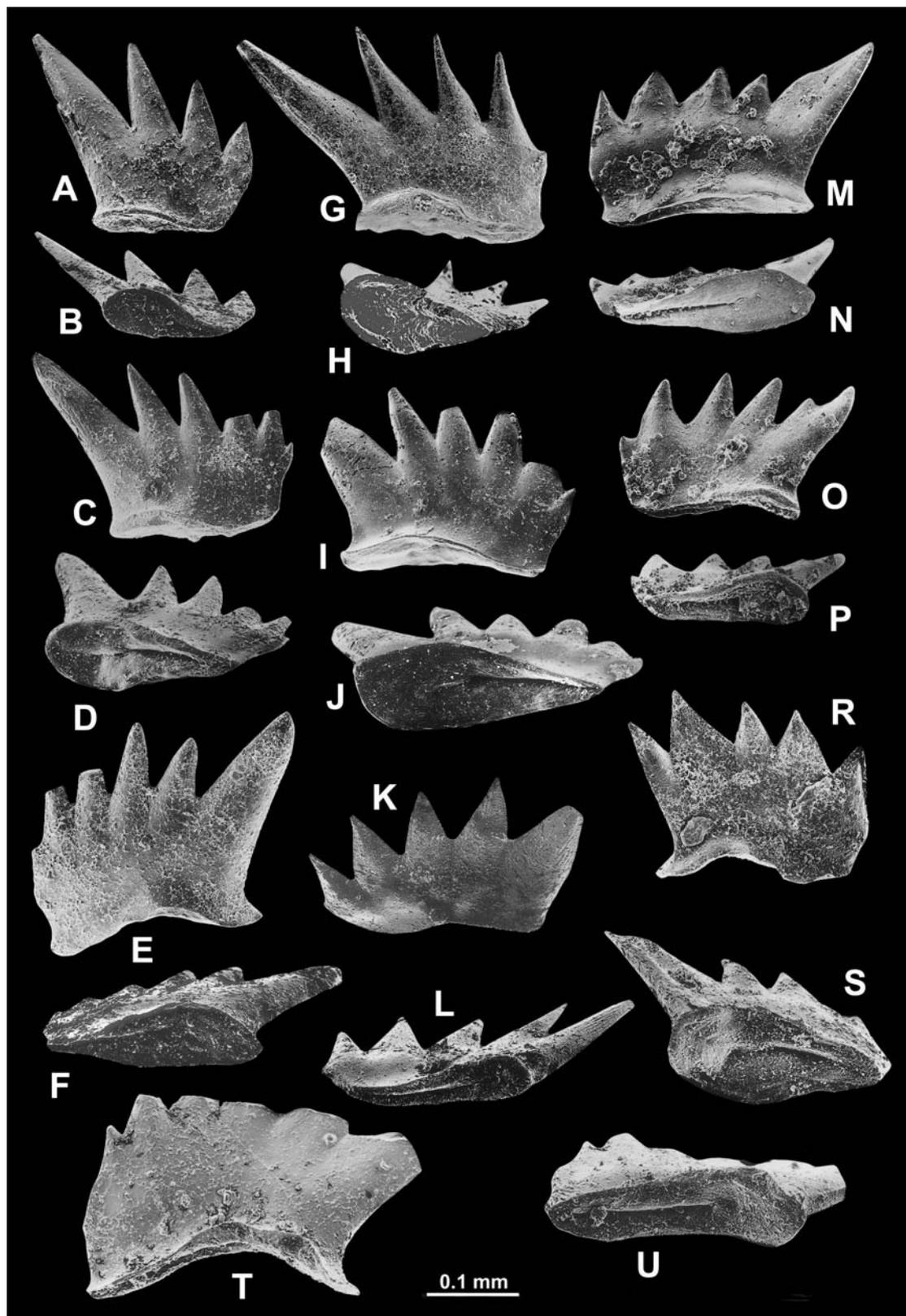


Fig. 4. Conodonts from the "Raibl Beds", Belca section, Karavanke Mts., Slovenia, Carnian

A–L — *Nicoraella? budaensis* Kozur and Mock: A–J — P1 elements, sample 11 (GeoZS 3066), K–L — ?P2 element, sample 11 (GeoZS 3066); M–P — *Nicoraella?* sp. form B, P1 elements, sample 21 (GeoZS 3082); R–S — *Nicoraella?* sp. form A, P1 element, sample 11 (GeoZS 3066); T–U — *Nicoraella?* sp., P1 element, sample 20/1 (GeoOZS 3063)

terminally and posteriorly inclined. Other denticles with subequal height or gradually decreasing anteriorwards. Lower surface broad and reaching beyond the posterior end of the blade. Excavation of the lower surface is rather shallow.

In Kozur’s view the modified ozarkodiniform element (P2 element) is very similar to the spathognathodiform element and is interpreted as a homeomorph to the spathognathodiform element (Kozur, 1989). The study material from Slovenia includes very few specimens with subterminal position of the basal cavity, and displays a narrow basal area that does not reach beyond the posterior end of the blade. Such elements are questionable designated as P2 elements (Fig. 4K–L). Other recovered elements are interpreted to occupy the S0, S1, S2 or S1, S3 and ?M positions (Fig. 5A–E).

C o m p a r i s o n. — A great morphological variety of the *N.?* *budaensis* P1 element was illustrated by Kozur and Mock (1991) and can be also observed in the material collected from Slovenia. This is evident in shape (height/length ratio), denticulation (the height of denticles varying between 1/3 and

1/2 of the total height of the elements, but the elements with needle-shaped denticles are rather rare), and size of cusp. Yet, there exists great similarity in the basal area features (compare P1 elements — pl. 2, fig. 5 and 6 in Kozur and Mock, 1991 with Fig. 4D, F and H in this paper; compare P2 element — pl. 1, fig. 4b in Kozur and Mock, 1991 with P2? element, Fig. 4L in this paper).

There are also some forms that are difficult to place within the intraspecific variation of *N.?* *budaensis* and are thus determined at a generic level (Fig. 4M–U). However, two morphological forms can be distinguished. The two forms do not co-occur but are associated with *N.?* *budaensis* at two separate levels.

Specimens of *Nicoraella?* sp. form A (Fig. 4R–S) display P1 elements with subequal denticles and with no cusp, but the penultimate denticle is larger (?cusp). Denticles are nearly uniform in shape and size, slightly decreasing anteriorwards; the height of their tips is approximately 1/4 of total height of the elements. The last two denticles are inclined towards the posterior end, whereas remaining denticles show almost no inclination. The lower surface is

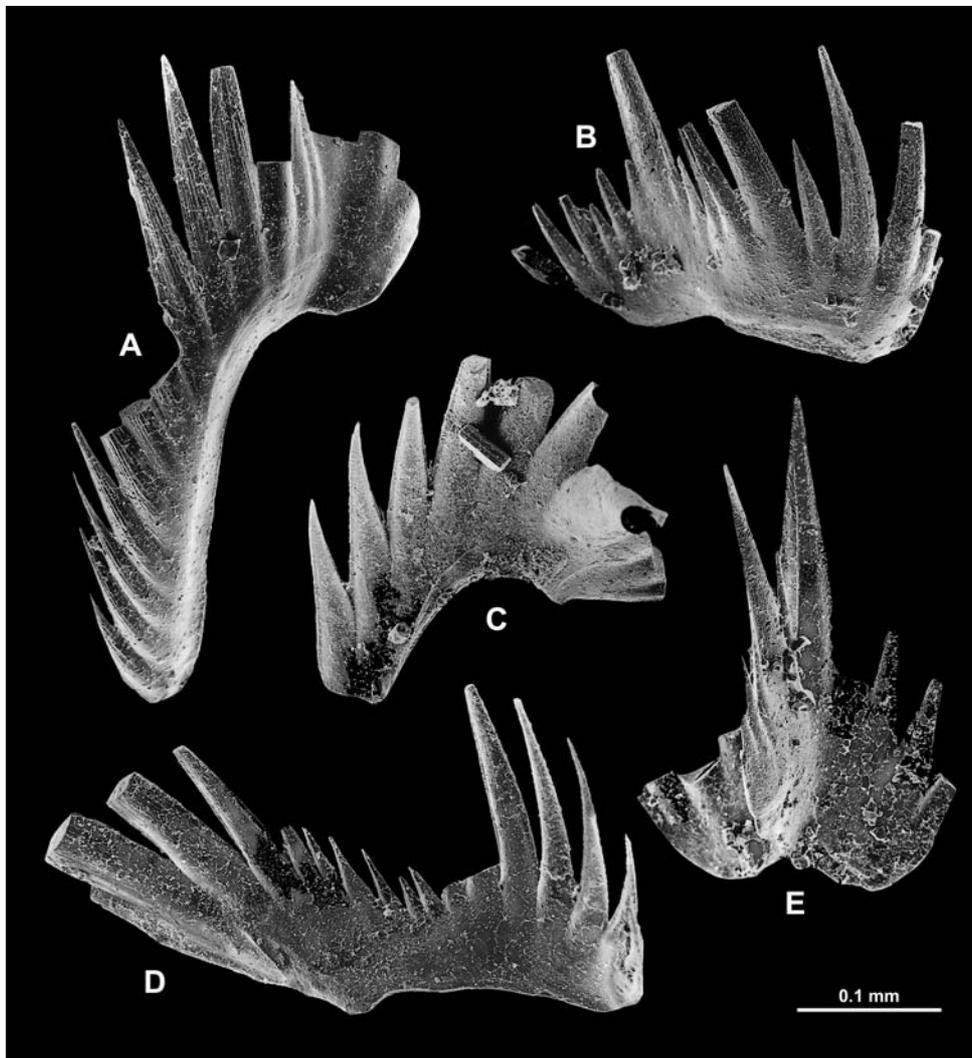


Fig. 5. Conodonts from the “Raibl Beds”, Belca section, Karavanke Mts., Slovenia, Carnian

A–E — *Nicoraella?* *budaensis* Kozur and Mock: A — S2 or S1 element, sample 11 (GeoZS 3066), B — S3 element, sample 11 (GeoZS 3066), C — ?M element, sample 21 (GeoZS 3082), D — S1 element, sample 21 (GeoZS 3082), E — S0 element, sample 11 (GeoZS 3066)

broadly excavated and reaches beyond the posterior edge; it is marked by a distinct and moderately deep basal furrow ending at a distance approximately 1/3 of the total length from the posterior end.

Specimens of *Nicoraella?* form B (Fig. 4M–P) are characterized by the P1 element with a length/height ratio ranging from 1/1.6 to 1/1.8. The terminally situated cusp is developed as the strongest denticle, bearing a characteristic protuberance or being fused with the next denticle, and inclined posteriorly. Other denticles are of nearly the same shape and size reaching approximately 1/3 of the total height; they stand perpendicularly to the basal edge. Lower surface ovaloid, widest below the cusp, and marked with a distinct furrow. A protuberance of the cusp in *Nicoraella* has been documented (compare the ozarkodiniform element of *N. postkockeli* specimen illustrated in Kozur, 1993, fig. 3).

RECONSTRUCTION OF THE *NICORAELLA* APPARATUS

According to Kozur (1993), the *Nicoraella* apparatus, besides the spathognathiform and ozarkodiniform elements, surely includes also enantiognathiform, hindeodelliform, prioniodiniform and hibbardelliform elements.

The samples examined from the “Raibl Beds” of Slovenia produced a conodont fauna yielding segminate elements of a single genus, *Nicoraella*. An apparatus reconstruction can be attempted, at least to a certain extent, yet the small number of recovered conodont elements renders a reliable statistical reconstruction difficult. Consequently, a comparison with two other gondolellid apparatuses, i.e.

Neogondolella (Orchard, 1998, 2005; Orchard and Rieber, 1999) and *Cratognathodus* (Koike, 2000) is feasible. Koike (2000), comparing some skeletal apparatuses, observed basically the same morphology of the Pb, M, Sa and Sb1 elements in *C. multihamatus* (Huckriede) as those of the Middle Triassic *Neogondolella* sp., and the Pennsylvanian *Gondolella pohli* von Bitter and Merrill (1998). According to Kozur (1989) *Neogondolella* and *Gondolella* have the same apparatus, but similar apparatuses with modified ozarkodiniform elements are present among several other Triassic gondolellids, including *Nicoraella*. Recently, Orchard (2005) published a new multielement reconstruction of several conodont species and concluded that the Triassic Gondolelloidea were composed of seven paired element types and one unpaired symmetrical element.

A great similarity in composition of the three Triassic apparatuses is shown in Table 1. The element notation introduced by Purnell *et al.* (2000) is adopted here, but the previous notation is present in brackets, as it was used by the authors who earlier studied Triassic multielement species.

Further studies of the genus *Nicoraella*, mainly based on statistical methods, should demonstrate the existence of the S4 element. Another problem to be solved concerns the P2 element. The material from Slovenia yields only few elements with a narrow basal area that does not reach beyond the posterior end of the blade, and the posterior blade is not present. According to Kozur and Mock (1991) the P2 (=Pb) element is represented by a modified ozarkodiniform element interpreted as homeomorphic to the spathognathodiform element. The loss of posterior blade owing to evolution needs explanation, but it is also possible that the P2 element does not exist in the *Nicoraella* apparatus.

Table 1

Comparison of skeletal apparatuses of *Neogondolella*, *Cratognathodus* and *Nicoraella?*

Apparatus element	<i>Neogondolella</i>		<i>Cratognathodus</i>	<i>Nicoraella?</i>
	Orchard (1998)	Orchard and Rieber (1999); Orchard (2005)	Koike (2000)	present study
P1 (Pa)	segminiplanate neogondolelliform	segminiplanate neogondolelliform	segminate neospathodiform	segminate neospathodiform
P2 (Pb)	angulate xaniognathiform	angulate xaniognathiform	angulate ozarkodiniform	?angulate modified ozarkodiniform
S0 (Sa)	alate hibbardelliform	alate hibbardelliform	alate diplododelliform	alate hibbardelliform
S1 (Sb1)	breviform digyrate enantiognathiform	breviform digyrate enantiognathiform	breviform digyrate enantiognathiform	breviform digyrate enantiognathiform
S2 (Sb2)	dolobrate grodelliform or synprioniodiniform	dolobrate or similar grodelliform or cypridodelliform	extensiform digyrate prioniodiniform	?breviform digyrate enantiognathiform or dolobrate
S3 (Sc1)	bipennate cf. hindeodelliform	resembles tertiopedate cf. hindeodelliform; bipennate with bifid anterior process	bipennate hindeodelliform	bipennate hindeodelliform
S4 (Sc2)	resembles tertiopedate cf. hindeodelliform with bifurcate anterior process	bipennate cf. hindeodelliform	bipennate hindeodelliform	?
M (M)	breviform digyrate cypridodelliform	breviform digyrate cypridodelliform	breviform digyrate cypridodelliform	digyrate ?prioniodiniform

THE FORAMINIFER ASSEMBLAGE AND ITS AGE

Five species belonging to the genera *Aulotortus*, *Prorakusia*, *Pilamminella* and *Endothyra* were recognized (Figs. 6–8). A few duostominid forms are also present. They have been used to erect a local zonation (Salaj, 1969; Gaździcki, 1983) and they may also be of prime importance in regional biostratigraphic and palaeogeographic correlations (Zaninetti, 1976; Gaździcki and Smit, 1977; Gaździcki and Stanley, 1983; Salaj *et al.*, 1983; di Bari and Baracca, 1998; Rettori *et al.*, 1998).

The assemblage recognized comprises:

Involutinidae Bütschli, 1880

Aulotortus sinuosus Weynschenk, 1956

(Fig. 6C, Db; Fig. 7A–H)

A. tumidus (Kristan-Tollmann, 1964)

Prorakusia salaji di Bari and Laghi, 1994

(Fig. 6Da; Fig. 7I, J)

Ammodiscidae Reuss, 1862

Pilamminella kuthani (Salaj, 1967)

(Fig. 8A, B)

Endothyridae Brady, 1884

Endothyra kuepperi Oberhauser, 1960

(Fig. 8C, D)

The two most abundant species in this assemblage are *Aulotortus sinuosus* Weynschenk and *Prorakusia salaji* di Bari and Laghi (Fig. 6D), whilst *A. tumidus* (Kristan-Tollmann), *Pilamminella kuthani* (Salaj) and *Endothyra kuepperi* Oberhauser (Fig. 8C–D) as well as duostominids are represented by a few specimens. The assemblage permits assignment of the sequence investigated of the "Raibl Beds" of the Karavanke Mts. to the Carnian. This age is indicated in particular by the presence of *Pilamminella kuthani*, an index fossil of the *P. kuthani* Interval-Zone (Salaj *et al.*, 1983, 1988; see also di Bari and Baracca, 1998).

The Carnian foraminifera of the Belca section studied are similar to the contemporaneous assemblages of the Tethys realm and are known from the Julian Alps (Ogorelec *et al.*, 1984),

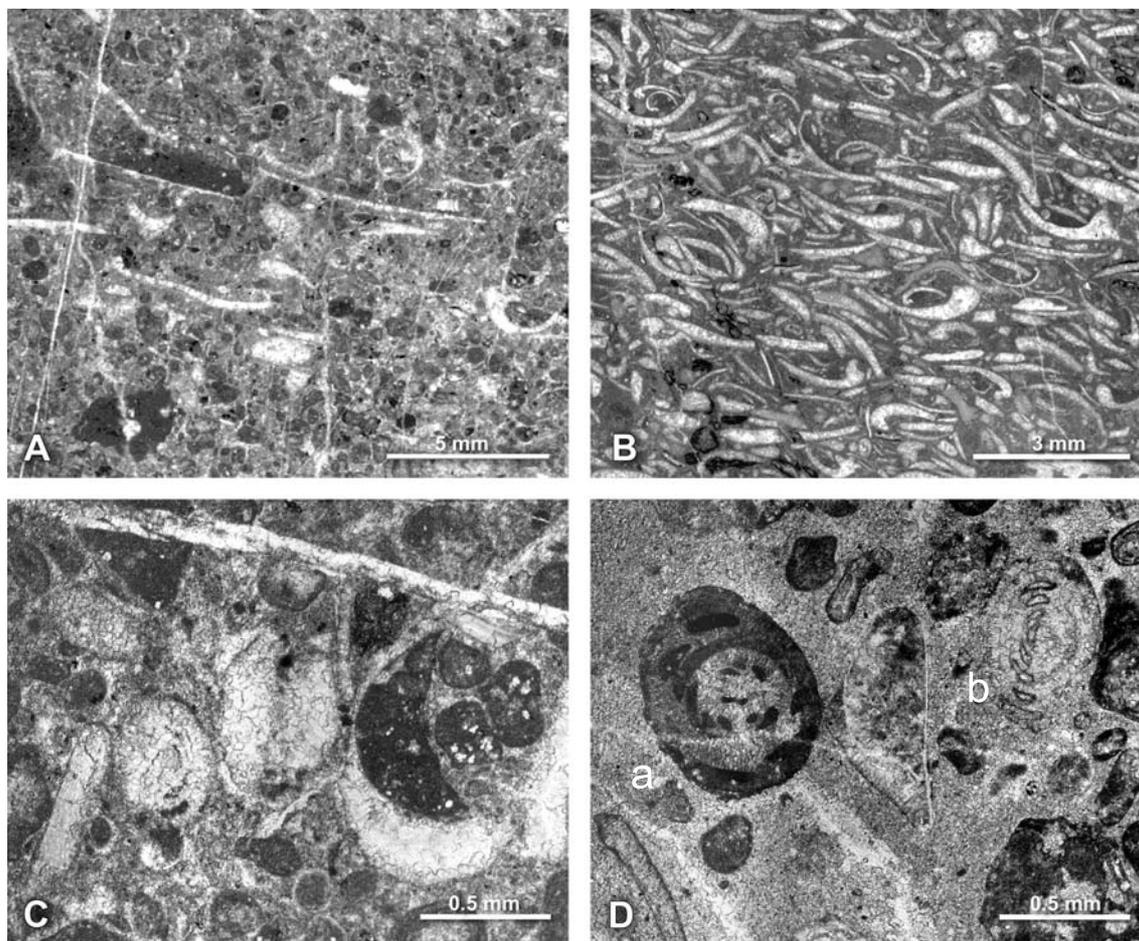


Fig. 6. Microfacies of the "Raibl Beds", Belca section, Karavanke Mts., Slovenia, Carnian

A — biotrapelaparenite composed of pelecypod and gastropod debris, sample 11; B — pelecypod biomicrite, sample 20; C — foraminifer bioplelsparite with *Aulotortus sinuosus* Weynschenk, sample 2; D — the foraminifers *Prorakusia salaji* di Bari and Laghi (a) and *A. sinuosus* Weynschenk (b) in biotrapelaparenite, sample 32; all ZPAL F.51

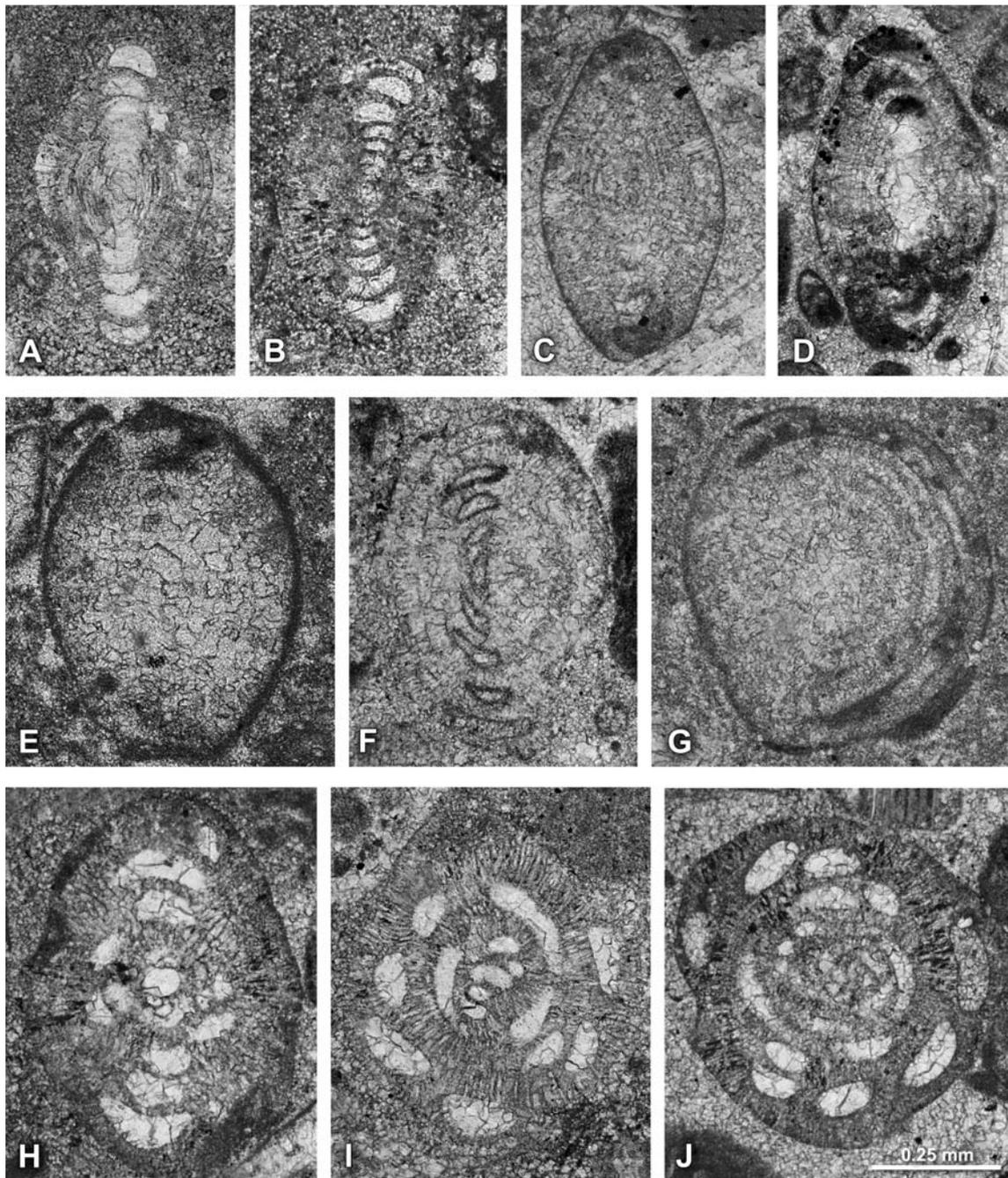


Fig. 7. Involutinid foraminifera from the "Raibl Beds", Belca section, Karavanke Mts., Slovenia, Carnian

A–H — *Aulotortus sinuosus* Weynschenk: A–D, F, H — sample 32, E — sample 20, G — sample 11, A–F, H — axial and subaxial sections, G — subequatorial section; I–J — *Prorakusia salaji* di Bari and Laghi, sample 32, equatorial and subequatorial sections; all ZPAL F.51

Dolomites (di Bari and Laghi, 1994; di Bari and Baracca, 1998; Broglio Loriga *et al.*, 1999), Calcare de Predil, northeastern Italy (Rettori *et al.*, 1998), Southern Appenines (Ciarapica and Zaninetti, 1984), Northern Calcareous Alps (Zaninetti, 1976), Hungary (Oravecz-Scheffer, 1987), West Carpathians (Salaj *et al.*, 1967, 1983; Jendrejáková, 1970), Turkey (Altiner and Zaninetti, 1980), Southern Israel (Benjamini, 1988) and China (He and Norling, 1991).

DISCUSSION AND CONCLUSION

Nicoraella? budaensis was first described from the middle Carnian (Julian) bituminous limestone of Pesthidegkút Kálváriahegy, northernmost Buda Mts. in Hungary, but it has been reported also from the locality of Pilisvörösvar, Pilis Mts., Hungary and Papparino near Palermo, Sicily (Kozur and

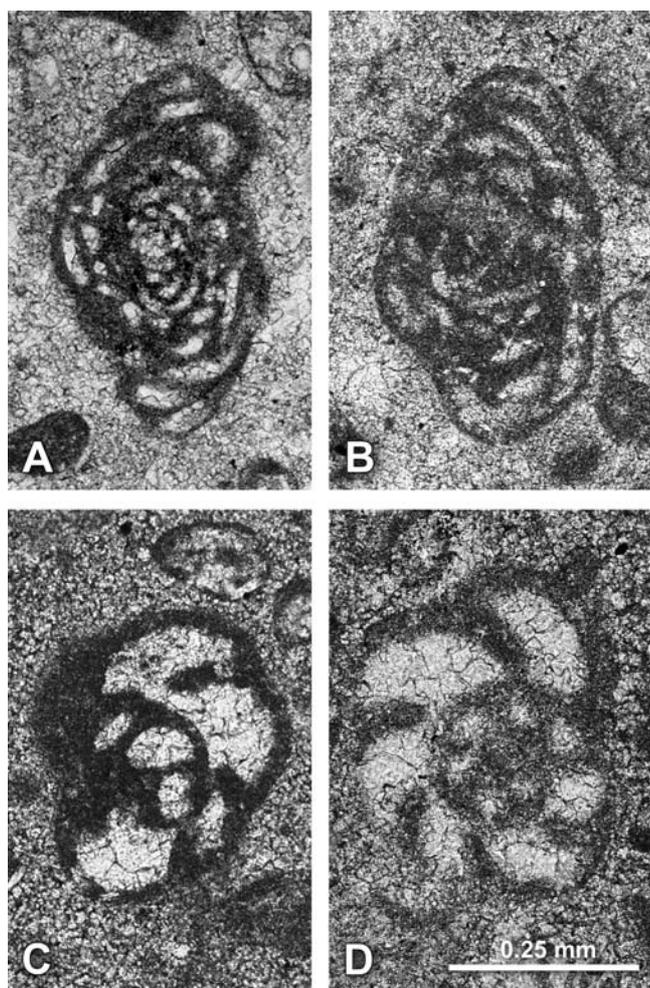


Fig. 8. Foraminifera from the "Raibl Beds", Belca section, Karavanke Mts., Slovenia, Carnian

A–B — *Pilamminella kuthani* (Salaj), sample 20; C–D — *Endothyra kuepperi* Oberhauser, sample 32; all ZPAL F.51

Mock, 1991). The latter noted that this species occurs in Hungary as the only conodont species in the restricted basin facies, but in the pelagic sediments of Sicily it is accompanied by *Gladigondolella* (Kozur and Mock, 1991).

Conodonts from the Raibl Group have been reported also from the Raibl area (Cave del Predil, Italy) as the type-sequence for Carnian stratigraphy. The conodont fauna: *Enantiognathus zieglerti* (Diebel), *Neohindeodella triassica* (Müller), *Prioniodina* sp. and *Neospathodus* n. sp. obtained from the upper part of the Tor Formation indicates a post-Julian age, while the elements *Paragondolella polygnathiformis* (Budurov and Stefanov) and *Epigondolella nodosa* (Hayashi)

were recovered from the Carnitza Formation (Tuvalian 2 and 3; Lieberman, 1978, 1980).

Based on the conodont species *Nicoraella? budaensis* Kozur and Mock it is not possible to establish the precise age of the beds studied within the Carnian interval, as the entire stratigraphic range of this species is unknown. Further study of conodonts in the upper part of the section (and in the overlying strata) could probably provide additional information for more precise dating. Certainly, a complete comparison of conodont associations from the "Raibl Beds" of Karavanke Mts. and those from neighbouring areas would be interesting.

The Carnian age of the beds examined is confirmed also by the alga *Clypeina besici* Pantić (Kolar-Jurkovšek and Jurkovšek, 2003a, b), an index-species of the taxon-range zone (Grgasović, 1997). It has been reported as frequent in several locations in Slovenia; it occurs also in the Tamar Formation (Nadiža profile) that was deposited in the more reducing environment of a very shallow restricted shelf with lagoons where carbonate deposition was periodically interrupted by supply of a detrital component (Ogorelec *et al.*, 1984).

Benthic foraminifera of the families Involutinidae, Ammodiscidae, Endothyridae and Duostominidae are geographically extensive in their distribution. They have been recorded from shallow water and basin carbonate facies of the Tethys, mostly from foraminiferal bioclastic limestones (di Bari and Baracca, 1998; Broglio Loriga *et al.*, 1999). Their rapid species evolution makes them useful for biostratigraphic zonation and regional correlations (Salaj *et al.*, 1988). The foraminifer assemblage studied of the Belca section in the Karavanke Mts. belongs to the Carnian *Pilamminella kuthani* Interval-Zone (Salaj *et al.*, 1988). Together with the conodonts and algae, it indicates Carnian age of the strata studied.

The diverse fossil content of this section in the Karavanke Mts. (partly presented herein) makes possible a wide biostratigraphic correlation, and contributes to the intercalibration of the Upper Triassic conodont, foraminifer and dasyclad zonations.

Acknowledgements. We are indebted to M. Orchard (Vancouver) and N. Preto (Padova) for critical reviews, and M. Narkiewicz (Warszawa) for editing the manuscript. One of the authors (TKJ) wishes to extend her thanks to M. Orchard and T. Koike for their helpful suggestions and communications regarding the conodonts. Facilities and technical staff of the Geological Survey of Slovenia and the Institute of Palaeobiology of the Polish Academy of Sciences are gratefully acknowledged. The investigation was financially supported by the Slovenian Research Agency (programme number P1-0011 and project number J1-6665). This is a contribution to IGCP-Project 467: *Triassic time and trans-Panthalassan correlation (2002–2006)*.

REFERENCES

- ALTINER D. and ZANINETTI L. (1980) — Le Trias dans la région de Pinarbasi, Taurus oriental, Turquie: unités lithologiques, micropaléontologie, milieux de dépôt. Riv. Ital. Paleont. Strat., **86** (4): 705–760.
- BENJAMINI C. (1988) — Triassic foraminifera from Makhtesh Ramon, Central Negev, Southern Israel. Rev. Paleobiol., Vol. Spec., **2** (1): 129–144.

- BROGLIO LORIGA C. CIRILLI S., DE ZANCHE V., DI BARI D., GIANOLLA P., LAGHI G. F., LOWRIE W., MANFRIN S., MASTANDREA A., MIETTO P., MUTTONI G., NERI C., POSENATO R., REICHICHI M., RETTORI R. and ROGGI G. (1999) — The prati di Stuoeres/Stuoeres wiesen Section (Dolomites, Italy): a candidate Global Stratotype Section and Point for the base of the Carnian stage. *Riv. Ital. Paleont. Strat.*, **105** (1): 37–78.
- BUDKOVIČ T. (1983) — Geologische Profile zur Geologischen Karte der Westlichen Karawanken zwischen Wurzenpass und Kahlkogel, 1:25 000. Amt der Kärntner Landesregierung und MOP, Ljubljana.
- BUDKOVIČ T. (1999) — Geology of the Slovene Part of the Karavanke Road Tunnel. *Abh. Geol. Bundes.*, **56** (2): 35–48.
- BUSER S. (1980) — Osnovna geološka karta SFRJ 1:100 000. Tolmač lista Celovec (Klagenfurt). Zvezni Geološki Zavod. Beograd.
- CIARAPICA G. and ZANINETTI L. (1984) — *Aulotortus praegaschei* (Koehn-Zaninetti, 1968): revision taxonomique et stratigraphique sur la base du material-type. *Rev. Paléobiol.*, **3** (1): 53–61.
- CLARK D. L. (1981) — Biological considerations and extinction. In: *Treatise of Invertebrate Paleontology. Part W, Miscellanea, Supplement 2, Conodonts* (eds. D. L. Clark *et al.*): 83–87. Geol. Soc. Am. Univ. Kansas. Boulder and Lawrence.
- DE ZANCHE V., GIANOLLA P. and ROGGI G. (2000) — Carnian stratigraphy in the Raibl/Cave del Predil area. *Eclogae Geol. Helv.*, **93**: 331–347.
- DI BARI D. and BARACCA A. (1998) — Late Triassic (Carnian) foraminifers of northeastern Cortina d' Ampezzo (Tamarin, San Cassiano Fm., Dolomites, Italy). *Ann. Mus. Civ. Rovereto, Sez.: Arch., St., Sc. Nat.*, **12**: 117–146.
- DI BARI D. and LAGHI G. F. (1994) — Involutinidae Bütschli (Foraminiferida) in the Carnian of the northeastern Dolomites (Italy). *Mem. Sc. Geol.*, **46**: 93–118.
- DOBROUSKINA I. A., JURKOVŠEK B. and KOLAR-JURKOVŠEK T. (2001) — Upper Triassic flora from "Raibl Beds" of Julian Alps (Italy) and Karavanke Mts. (Slovenia). *Geologija*, **44** (2): 263–290.
- GAŽDZICKI A. (1983) — Foraminifers and biostratigraphy of Upper Triassic and Lower Jurassic of the Slovakian and Polish Carpathians. *Palaeont. Pol.*, **44**: 109–169.
- GAŽDZICKI A. and SMIT O. E. (1977) — Triassic foraminifers from the Malay Peninsula. *Acta Geol. Pol.*, **27** (3): 319–332.
- GAŽDZICKI A. and STANLEY G. D. (1983) — First report of Involutinidae (Foraminifera) in marine Triassic rocks of North America. *N. Jb. Geol. Paläont. Mh.*, **2**: 80–90.
- GRGASOVIĆ T. (1999) — Upper Triassic Biostratigraphy and Algae from Žumberak (Croatia). *Geol. Croat.*, **50** (2): 201–214.
- HE Y. and NORLING E. (1991) — Upper Triassic Foraminiferida and stratigraphy of Mianzhu, Sichuan province, China. *Sver. Geol. Unders. Ser. Ca.*, **76**: 1–47.
- JENDREJÁKOVÁ O. (1970) — Foraminiferen der oberen Trias des Slowakischen Karsten und des Murán-Plateaus. *Geol. Zbor. Geol. Carpath.*, **21** (2): 343–350.
- JURKOVŠEK B. (1987a) — Osnovna geološka karta SFRJ 1:100 000. Tolmač listov Beljak in Ponteča. Zvezni Geološki Zavod. Beograd.
- JURKOVŠEK B. (1987b) — Osnovna geološka karta SFRJ 1:100 000, list Beljak in Ponteča. Zvezni Geološki Zavod. Beograd.
- KOIKE T. (2000) — Apparatus of a Triassic conodont species *Cratognathodus multihamatus* (Huckriede). *Paleont. Res.*, **3** (4): 234–248.
- KOLAR-JURKOVŠEK T. and JURKOVŠEK B. (2003a) — *Clypeina* in the Belca section of the Karavanke Mts., Slovenia. In: *Seventh International Symposium on Fossil Algae*. (eds. X. Mu, X. Yuan and S. Kershaw). Abstracts: 33–34.
- KOLAR-JURKOVŠEK T. and JURKOVŠEK B. (2003b) — *Clypeina besici* Pantić (Chlorophyta, Dasycladales) from the "Raibl Beds" of the western Karavanke Mountains, Slovenia. *Geol. Carpath.*, **54** (4): 237–242.
- KOZUR H. (1989) — The Taxonomy of the Gondolellid Conodonts in the Permian and Triassic. *Courier Forsch.-Inst. Senckenberg*, **117**: 409–469.
- KOZUR H. (1993) — *Nicoraella postkockeli* n. sp., a new conodont species from the Lower Carnian of Hungary. *N. Jb. Geol. Paläont. Mh.*, **7**: 405–412.
- KOZUR H. and MOCK R. (1991) — New Middle Carnian and Rhaetian Conodonts from Hungary and the Alps. Stratigraphic Importance and Tectonic Implications for the Buda Mountains and Adjacent Areas. *Jb. Geol. Bundes.*, **134** (2): 271–297.
- KRISTAN-TOLLMANN E., HAAS J. and KOVACS S. (1991) — Karnische Ostracoden und Conodonten der Bohrung Zsambek-14 im Transdanubischen Mittelgebirge (Ungarn). *Jubiläumsschrift 20 Jahre Geol. Zusammenarbeit Österreich-Ungarn*, **1**: 193–219.
- KRYSTYN L., LEIN R., SCHLAF J. and BAUER F. K. (1994) — Über ein neues obertriadisch-jurassisches Intraplattformecken in den Südkarawanken. *Jubiläumsschrift 20 Jahre Geol. Zusammenarbeit Österreich-Ungarn*, **2**: 409–416.
- LEIN R., SCHLAF J., MÜLLER P. J., KRYSTYN L. and JESINGER D. (1995) — Neue Daten zur Geologie des Karawanken-Strassentunnels. *Geol. Paläont. Mitt. Innsbruck*, **20**: 371–387.
- LIEBERMAN H. M. (1978) — Carnitza Formation — ein neuer Begriff für Oberkarnische Beckenkalkale der südlichen Kalkalpen bei Raibl (Cave del Predil, Italien). *Mitt. Ges. Geol. Bergbaustud. Österr.*, **25**: 35–60.
- LIEBERMAN H. M. (1980) — The suitability of the Raibl sequence as a stratotype for the Carnian Stage and the Julian Substage of the Triassic. *Newsl. Strat.*, **9** (1): 35–42.
- OGORELEC B., JURKOVŠEK B., ŠRIBAR L., JELEN B., STOJANOVIČ B. and MIŠIČ M. (1984) — Karnijske plasti v Tamarju in pri Logu pod Mangartom. *Geologija*, **27**: 107–158.
- OGORELEC B., OREHEK S. and BUDKOVIČ T. (1999) — Lithostratigraphy of the Slovenian Part of the Karavanke Road Tunnel. *Abh. Geol. Bundes.*, **56** (2): 99–112.
- ORAVECZ-SCHEFFER A. (1987) — Triassic foraminifers of the Transdanubian Central Range. *Geol. Hung.*, **50**: 3–331.
- ORCHARD M. J. (1998) — Triassic multielement gondolellids. In: *ECOS VII*, (ed. G. Bagnoli). Abstracts: 82–83.
- ORCHARD M. J. (2001) — Multielement conodont apparatuses of Gondolelloidea. *Spec. Pap. Palaeont.*, **73**: 73–101.
- ORCHARD M. J. and RIEBER H. (1999) — Multielement *Neogondolella* (Conodonts, upper Permian-middle Triassic). *Boll. Soc. Paleont. It.*, **37** (2–3): 475–488.
- PURNELL M. A., DONOGHUE P. C. J. and ALDRIDGE R. J. (2000) — Orientation and anatomical notation in conodonts. *J. Paleont.*, **74**: 113–122.
- RAMOVŠ A. (1981) — Nova spoznanja o razvoju julskih in tuvalskih plasti v severnih Julijskih Alpah. *Rud.-met. zbor.*, **28** (2–3): 177–181.
- RAMOVŠ A. (1985) — Geološke raziskave severnih Julijskih Alp in njihov biostratigrafski razvoj. *Jeklo in ljudje, Jeseniški zbornik*, **5**: 391–428.
- RAMOVŠ A. (1993) — Stratigrafski razvoj triasa v severnih Julijskih Alpah in zahodnih Karavankah — korelacija. In: *II Del: Zgornji trias. Rud.-met. zbor.*, **40** (1–2): 103–114.
- RETTORI R., LORIGA C. and NERI C. (1998) — Lower Carnian foraminifers from the type locality of the Calcarea del Predil (Raibl Group, northeastern Italy). *Riv. Ital. Paleont. Strat.*, **104** (3): 369–380.
- SALAJ J. (1969) — Essai de zonations dans le Trias des Carpathes Occidentales d'après les foraminifères. *Geol. Pr. Spr.*, **48**: 123–128.
- SALAJ J., BIELY A. and BYSTRICKY J. (1967) — Trias-Foraminiferen in den Westkarpaten. *Geol. Pr. Zpr.*, **42**: 119–136.
- SALAJ J., BORZA K. and SAMUEL O. (1983) — Triassic Foraminifers. *Geologický Ústav Dionýza Stura. Bratislava*.
- SALAJ J., TRIFONOVA E. and GHEORGHIAN D. (1988) — A biostratigraphic zonation based on benthic foraminifera in the Triassic deposits of the Carpatho-Balkans. *Rev. Paleobiol., Vol. Spec.*, **2** (1): 153–159.
- VON BITTER P. H. and MERRILL G. K. (1998) — Apparatus composition and structure of the Pennsylvanian conodont genus *Gondolella* based on assemblages from the Desmoinesian of northwestern Illinois, USA. *J. Paleont.*, **72** (1): 112–132.
- ZANINETTI L. (1976) — Les Foraminifères du Trias. Essai de synthèse et corrélation entre les domaines mésogéens européen et asiatique. *Riv. Ital. Paleont. Strat.*, **82** (1): 1–258.