

Mohorje Formation, Southern Slovenia

Mohorska formacija, južna Slovenija

Stevo DOZET

Geološki zavod Slovenije, Dimičeva ul. 14, SI-1000 Ljubljana, Slovenija,
e-mail: stevo.dozet@geo-zs.si

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Abstract

In this paper a variegated and pretty heterogeneous development of the Carnian stratigraphic sequence with volcanoclastic rocks, we denominated as Mohorje Formation, has been researched and described. The new formation is subdivided in four members, namely: Bošteti Member, Borovnik Member, Rupe Member and Selo at Rob Member. In addition, the primary Carnian volcanism in the Rute Region has been examined in detail. The volcanoclastic succession (Borovnik Member) lies concordantly upon the black platy and bedded bituminous limestones with Carnian lamellibranchs. Transgressively over them and without visible signs of erosive or angle discordance repose typical red Carnian clastic rocks – dolomitic marlstones, quartz and jasper sandstones, conglomeratic sandstones and fine-grained breccioconglomerates, among which red dolomitic marlstones predominate. The Mohorje Formation lies concordantly upon the medium-grey to very light grey, nearly white, massive or thick-bedded, more or less dolomitized *Diplopora* Limestones of Cordevolian age conformably underlying Norian Main Dolomite with gastropods and megalodonts.

Izvleček

Opisan je razvoj karnijskega kamninskega zaporedja, ki je poimenovan kot Mohorska formacija. Predlagana formacija je razdeljena v štiri člene in sicer: boštetiški člen, borovniški člen, ruparski člen in selanski člen. Poleg tega je detajlno raziskan karnijski vulkanizem na območju Rut. Vulkanoklastično zaporedje (borovniški člen) leži konkordantno na črnih ploščastih in plastnatih apnencih s karnijskimi školjkami. Transgresivno na vulkanoklastičnih kamninah leže brez vidnih znakov erozijske ali kotne diskordance rdeče karnijske kamnine – dolomitni laporovci, kremenovi in jaspisni peščenjaki, konglomeratični peščenjaki in drobnnozrnati brečokonglomerati. Mohorska formacija leži konkordantno na srednje sivem do zelo svetlosivem neplastnatem in debeloplastnatem bolj ali manj dolomitiziranem diplopornem apnencu cordevolske starosti z algo *Diplopora annulata* in pod norijskim Glavnim dolomitom s polži in megalodonti.

Introduction

Several ten years ago we were persuaded, that in Slovenia volcanoes were active only in the middle ages of the Earth, the Ladinian epoch respectively. Then being volcanoes ejected lava i.e. volcanic balls, rubble, gravel, sand, ash and dust forming various volcanic rocks distinguishing one from the other with reference to colour and composition. Volcanic reddish brown, greenish grey and greyish green rocks such as keratophyres, quartz porphyrites and porphyry, originated from Ladinian lava, were commonly accompanied by various tuffs, compacted pyroclastic deposits of volcanic ash and dust.

Volcanic ash compacted in tuff rocks has been known for a long time in Carnian beds. Carnian

sediments with tuff interbeds and material are to be found in several places in central and southern Slovenia (GERMOVŠEK, 1955; DUHOVNIK, 1956; BERCE, 1962; RAMOVŠ, 1962; BUSER & HINTERLECHNER-RAVNIK, 1972), but a greater part of researchers believed, the tuffs in Carnian beds were all reseedimented (LIPOLD, 1858; RAKOVEC, 1946; MLAKAR, 1959).

Consequently, the scope of our research work is to define and stratigraphically separate mappable lithologic units as well as to describe a rather colourful and heterogeneous development of Carnian beds of the Mohorje shallow marine-volcanoclastic-sedimentary formation in the Rute area on Bloke plateau (central Slovenia), to collect new evidences for Carnian volcanism in this part of Slovenia, to establish and to describe lithofa-

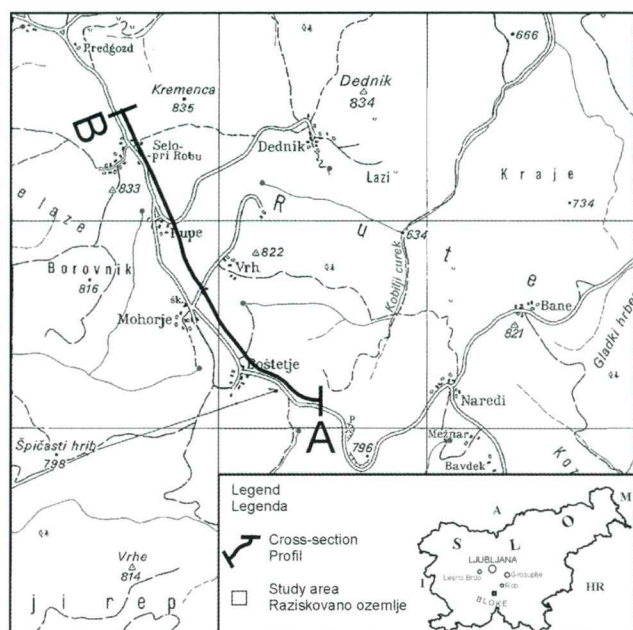


Fig. 1. Location sketch map of the study area and the cross-section through Carnian beds

Sl. 1. Položajna skica obravnavanega ozemlja in profil skozi karnijske plasti

cies of volcanoclastic series, to ascertain and to gather evidences for primary Carnian volcanism, as well as to find new data about eventual volcanoes, type of magma, volcanic eruptions, age of volcanism and to use the obtained data for elaboration of Geological Map of Slovenia on the scale of 1 : 50.000.

The study area (Fig. 1) includes several parts of central and southern Slovenia, the Dolenjsko region respectively. Otherwise expressed, it extends from Ljubljana in the north towards the south including Bloke, all lying in the Map Sheet Grosuplje on the scale 1 : 50.000.

The geological data used in this work have been collected during systematic regional mapping for the Geologic Map of Slovenia 1 : 50.000 as well as by stratigraphic measuring of several cross-sections, accompanied by systematic laboratory examinations in the two last years.

From the geotectonical point of view the study area belongs to the External Dinarides (BUSER, 1974, 1989; PLACER, 1998) extending from the Northern Italy across Slovenia towards Croatia. According to BUSER (1974) the considered area is a part of so-called Dolenjska-Notranjska Mesozoic Blocks. This area is built prevalently of Mesozoic rocks, which are cut by several fault systems. The most destroying fault system was the dinaric one (NW-SE). The boundary between the northern lying Southern Alps is of overthrust character, whereas the External Dinarides pass towards the northeast gradually into the pelagic Internal Dinarides (BUSER, 1989; OGORELEC & DOZET, 1997; PLACER, 1998).

Previous investigations

There are only a few published papers treating the Carnian volcanic activity in the southern and

central Slovenia and the most important ones are listed in the bibliography. On the basis of selected papers some definite conclusions can be noted, but it is difficult or even impossible to formulate them precisely, because they are based on different approaches and statements.

The differences exist, first of all, in the determination of age of the Triassic volcanic activity in the southern and central Slovenia. The fact is, the Carnian volcanism in Slovenia is much less examined than the Middle Triassic one. Tuff rocks in the Carnian beds are, otherwise, often remarked and noted, but in opinion of greater part of researchers they were all resedimented from older Ladinian rocks (RAKOVEC, 1946). In his pioneer work on Triassic volcanism, the above-mentioned author quoted all up to that time known literary data and very precisely worked out traces of volcanism in Slovenia. A short review of igneous and metamorphic rocks in Slovenia has been presented by DUHOVNIK (1956). GRAFENAUER and coworkers (1983) researched the Triassic igneous rocks in Eastern Slovenia. Afterwards, GRAFENAUER (1985) explained the origin of Triassic igneous rocks in Slovenia. They have properties of spilitic keratophyre association. According to GRAFENAUER (1985) among the eruptive rocks in Slovenia liparitic and dacitic lavas predominate over andesitic and basaltic ones. Felsitic rocks were emplaced often during violent explosive activities, while the mafic rocks effused to the surface in a quieter way. Lavas flowed at times on land and often into the sea.

JELEN (1990) determined the Carnian bivalve mollusc macrofauna from the locality Lesno Brdo near Drenov Grič. The same year JURKOVŠEK and JELEN (1990) presented a short supplement to the up to that time knowledge of the fossil lamelli-branch fauna from the Carnian beds at Orle near Ljubljana.

Materials and methods

This work is based on data collected during detailed geological mappings, systematic regional geological mapping and stratimetric profilings of the area. The field mapping has been carried out on topographic maps on the scale of 1 : 10.000. Various correlating methods have been used as well. The carbonate rocks are classified according to FOLK's (1959) and DUNHAM's (1962) and clastic rocks considering the PETTJOHN's (1975) classification. Starting material for our research work was the Basic Geological Map of Slovenia 1 : 100.000, the Map Sheet Ribnica with its explanatory text (BUSER, 1969, 1974).

Stratigraphy

Julian and Tuvanian

Mohorje Formation

Previous work and statements. The pioneer merits and best results by the discovering of Carnian

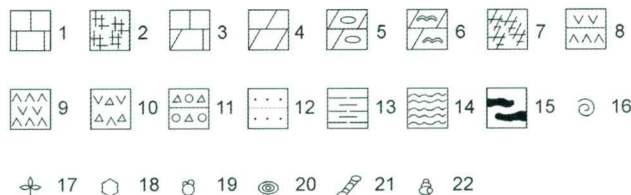
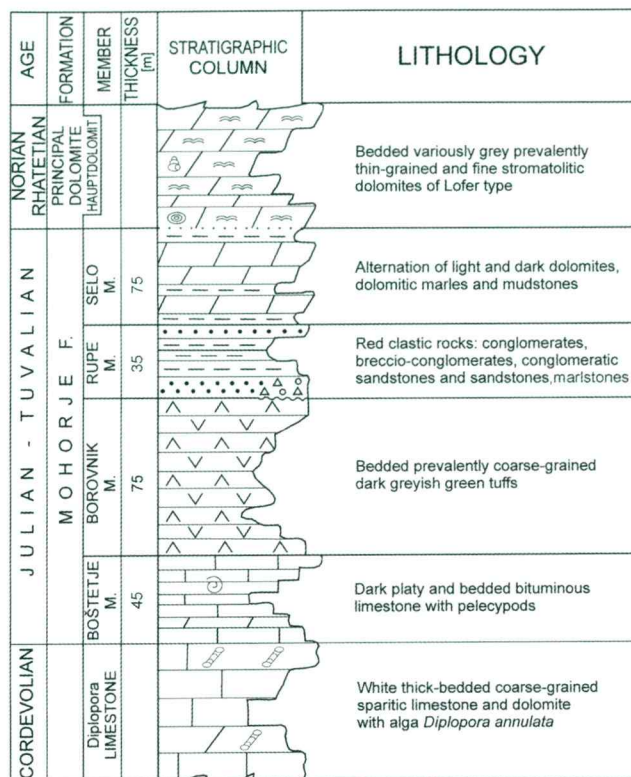
volcanism on the Bloke plateau and in southern Slovenia had the scientists BUSER and HINTERLECHNER-RAVNIK (1972), who researched and described the sedimentary succession of the Carnian beds with repeated sequences of pelitic to very coarse-grained tuffs in the Rute area on Bloke plateau. With respect to the size of tuff particles and regarding the texture of the examined material, they

distinguished pelitic, vitroclastic (0,1–0,3 mm) and crystalline-lithoclastic tuffs. As an evidence that the tuff series is not resedimented, they alleged pretty numerous, typical and well-shaped fragments of vitroclastic tuff as well as the fact, the relatively soft and numerous hypidiomorphic and idiomorphic plagioclase crystals do not show any traces of roundness. The volcanic material is in some places mixed with a sedimentary one. The plagioclase belonged to andesine. The most albitized sample was chemically analysed and belonged according to Niggli's parameters to an alcaligranitic and alcalisyeniticaplitic (albitic) magma. Therefore, they added nonaltered tuffs to porphyry (plagioclase) tuffs. The two authors concluded, that although there were no primary magma volcanic rocks, the primary and nonresedimented tuffs are sufficient evidence for Carnian volcanism in southern Slovenia.

Stratotype and the name of formation. In the northeastern edge of the Bloke plateau in the Rute area several cross-sections of Carnian beds, which we due to a typical development, denominated as Mohorje shallow water-volcaniclastic beds, for short Mohorje Formation, have been researched. The most complete and typical cross-section of these beds is well-exposed in Rute, the area on the northern margin of the Bloke plateau, comprising the small villages Bošteti, Mohorje, Rupe, Selo, Vrh, Neredi, Zgonče and Logarji. Thus, the considered new formation has obtained its name according to Mohorje, lying in the centre of the Rute area.

Stratigraphic position. The stratigraphic sequence of sedimentary and volcanic rocks, denominated Mohorje Formation (Fig. 2), lies concordantly upon the thick-bedded and massive prevalently light grey carbonate rocks with numerous dasycladaceans. Among them the species *Diplopora annulata* SCHAFFHÄUTL and *Diplopora annulatisima* PIA are wide-spread. The original sediment is thick-bedded biostromal *Diplopora* Limestone, that was changed by late diagenesis at some places in more or less dolomitized limestone, and at other places into the late diagenetic Cordevolian dolomite. The Mohorje shallow water-volcaniclastic rocks are overlain conformably by loferitic (FISCHER, 1964) Main Dolomite containing rare interbeds of oncolitic dolomites and lumachelles with megalodontids (*Neomegalodon*, *Magalodus*) as well as gastropods (*Worthenia*).

Carnian beds south, west and east of the Ljubljana Moor have been described by RAMOVŠ (1953), GERMOVŠEK (1955), RAKOVEC (1955), BUSER (1965, 1974), RIBIČIČ (1973) and DOZET (1978, 1979). Hitherto, traces of Carnian volcanism in Slovenia were detected by BERCE (1962), RAMOVŠ (1962), BUSER (1962, 1966) BUSER & RAMOVŠ (1966), and BUSER & HINTERLECHNER-RAVNIK (1972).



EXPLANATION

1 – Bedded limestone, 2 – massive limestone, 3 – dolomitized limestone, 4 – bedded dolomite, 5 – nodular dolomite, 6 – stromatolitic dolomite, 7 – massive dolomite, 8 – platy and bedded tuff, 9 – massive tuff, 10 – tuff breccia, 11 – breccioconglomerate, 12 – bedded sandstone, 13 – marlstone, 14 – shaly mudstone, 15 – anthracite, 16 – macrofauna, 17 – macroflora, 18 – microflora, 19 – microfauna, 20 – oncolites of “*Sphaerocodium*” type, 21 – Dasycladaceae, 22 – gastropods.

LEGENDA

1 – Plastnat apnenec, 2 – masiven apnenec, 3 – dolomitiziran apnenec, 4 – plastnat dolomit, 5 – gomoljast dolomit, 6 – stromatoliten dolomit, 7 – masiven tuf, 8 – ploščast in plastnat tuf, 9 – masiven tuf, 10 – tufska breča, 11 – brečokonglomerat, 12 – plastnat peščenjak, 13 – laporovec, 14 – skrjav glinavec, 15 – antracit, 16 – makrofavna, 17 – makroflora, 18 – mikroflora, 19 – mikrofavna, 20 – onkoidi tipa “*Sphaerocodium*”, 21 – Dasycladaceae, 22 – polži.

Fig. 2. Mohorje Formation, its lithology, dismembering and stratigraphic position

Sl. 2. Mohorska formacija, njena litološka sestava, razčlenitev in stratigrafska lega

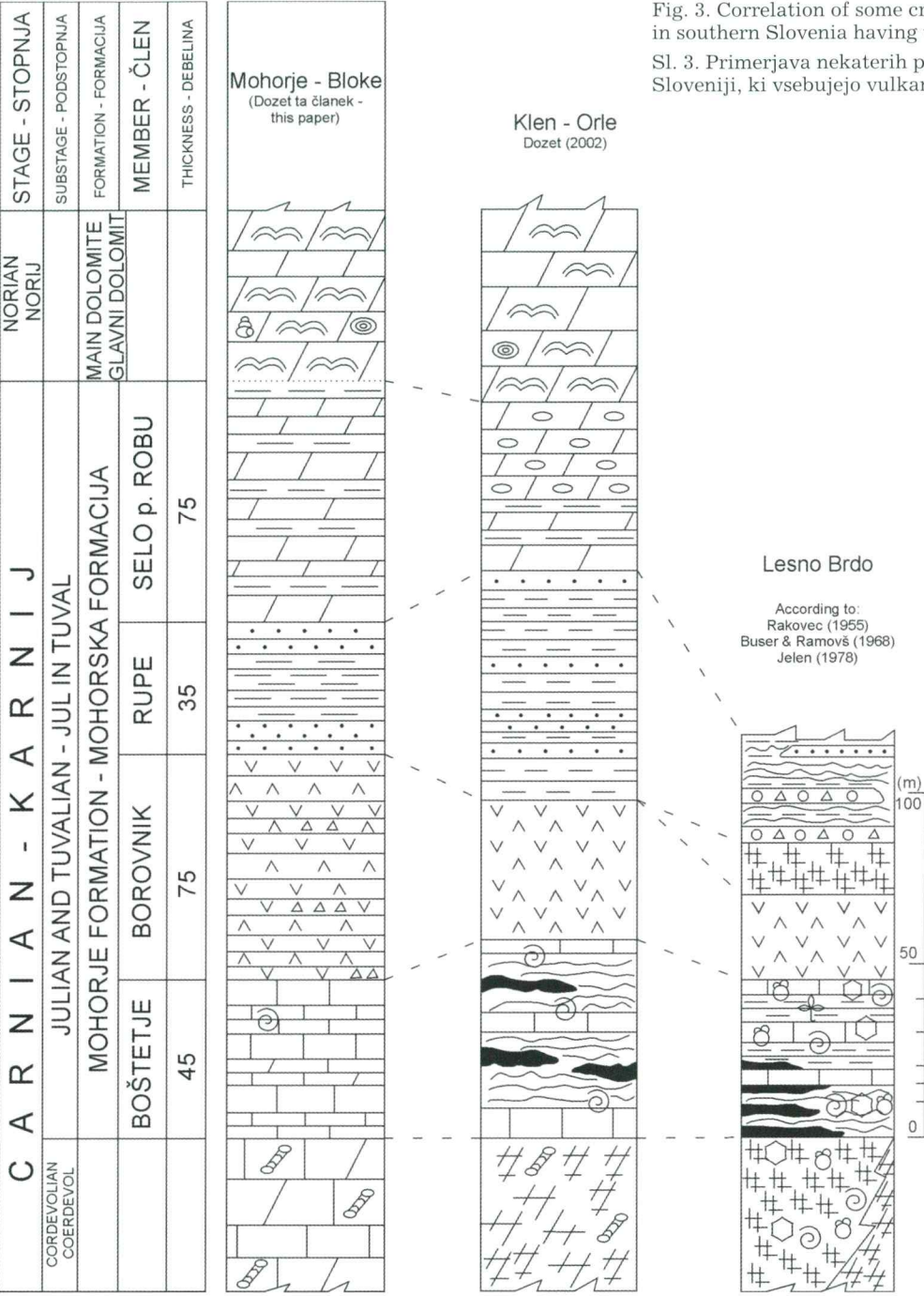


Fig. 3. Correlation of some cross-sections of Carnian beds in southern Slovenia having volcanoclastic member
Sl. 3. Primerjava nekaterih profilov karnijskih plasti v južni Sloveniji, ki vsebujejo vulkanoklastični člen

Lithostratigraphic dismembering

Rock succession of the Mohorje Formation consists of carbonate, clastic and volcanoclastic rocks. Among sedimentary rocks various limestones and marls are present, but there are dolomites, conglomerates, breccio-conglomerates, sandstones and shaly claystones as well. Conglomerates and sandstones occur in the form of rare interbeds in the upper part of the Carnian lithological column. With reference to the Mohorje Formation and considering the rules of superposition this stratigraphic sequence can be separated into four lithostratigraphic members, namely: Boštetje Member, Borovnik Member, Rupe Member and Selo at Rob Member.

Boštetje Member: dark platy and bedded bituminous limestones (predominate), dolomites and cherts

Description. The basal member of the Mohorje Formation (Fig. 4) got its name according to the small village Boštetje. It consists of 45 to 75 metres thick rather monotonous packet of platy and bedded micritic and sparitic bituminous limestones, dolomitized limestones and dolomites (rarely), that are often fine-laminated and/or banded. The lamination occurs due to different granularity of rocks, different contents of organic substance and because of dolomitization of coarser-grained laminae.

Fossils and age. In the limestones fossil remains have been found in the Rute area. However, more macrofossils in dark marlstones and limestones have been found in an equivalent development in the cross-section between Drenov Grič and Lesno Brdo. HAUER (1857), KOSSMAT (1910), WAAGEN (1907), RAKOVEC (1955) and JELEN (1990) described the following more or less typical Carnian lamelibranchs there: *Trigonodus carniolicus* BITTNER, *T. problematicus problematicus* (KLIPSTEIN), *T. bittneri* WAAGEN, *T. serianus* PARONA, *T. rablensis* (GREDLER), *Myophoria kefersteini kefersteini* (MÜNSTER), *M. kefersteini gornensis* VARISCO, *M. kefersteini lombardica* (WAAGEN), *M. kefersteini typica* WAAGEN, *Heminajas woehrmanni* WAAGEN, *Bakevella (Bakevelloides) bouei* (HAUER), *Lopha montiscaprilis* (KLIPSTEIN), *Pachycardia rugosa* HAUER and *Myophoricardium lineatum* WÖHRMANN. In the thick-bedded biomicritic limestone from Lesno Brdo the calcareous algae *Cypeina besici* PANTIĆ was found as well. Much less has been known and noted down on fossil lamelibranch findings in the Carnian limestones and marls from the abandoned coal-mine Klen at Orle near Ljubljana, where SEDLAR et al. (1948), RAKOVEC (1955) as well as JURKOVŠEK and JELEN described and quoted the following species: *Trigonodus carniolicus* BITTNER, *T. problematicus problematicus* (KLIPSTEIN), *T. bittneri* WAAGEN, *T. abdominalis* JELEN, *Myophoria kefersteini lombardica* (WAAGEN), *M. kefersteini gornensis* VARISCO, *M. kefersteini kefersteini* (MÜNSTER), *M. kefersteini typica* WAAGEN and *Pachycardia rugosa* HAUER.

Environment. Carnian lamelibranchs collected in the alternating sedimentary succession of micritic and biomicritic (foraminifers, algae, molluscs) limestones, silty marlstones as well as shaly and marly mudstones originated in a restricted shelf, a temporary lagoon respectively, with temporary supply from the Carnian land.

Borovnik Member: tuffs, peperites, tuffites

Description. This member is denominated according to 795 metres high Borovnik hillock, built of Carnian tuffs (Fig. 5), that are most exposed in the small pretty deep Borovnik Ravine. The Borovnik hillock is built of 75 metres thick stratigraphic sequence of various volcanoclastic platy, bedded and massive volcanic rocks of pelitic, psammitic and pseftic texture. In the relatively deep small valley between Borovnik (785 m) and the hillock 816 m, pelitic, fine-grained and medium-grained tuffs alternate with coarse-grained tuffs and fine tuff breccias belonging to medium-acid igneous rock. With reference to the grade of weathering the volcanoclastic tuffs of Borovnik occur in various shade of black and green colour.

The Borovnik Member begins with a small rhyolitic lava flow that underwent mixing with a wet unconsolidated silt. Overlying pyroclastic sequence is fining-upward and consists of bedded and laminated coarse- and fine-grained rhyolitic tuffs. The magma underwent strong fractionation;



Fig. 4. Dark, platy and bedded often laminated bituminous Carnian limestone (Bošteti Member)

Sl. 4. Temen, ploščast in plastnat, često laminiran bituminozen karnijski apnenec (boštetski člen)

plagioclase and alkali feldspar phenocrysts were accumulated in the late volcanic magmas and imparted them virtual dacitic character. The late-stage dacitic magmas were emplaced as shallow intrusives and underwent mixing with unconsolidated surrounding sediments and tuffs producing dacite/siltstone and dacite/rhyolitic tuff peperites. The peperite composition depends on the quantity of admixed sediment and differs from dacitic composition in the abundance of major oxides and trace elements.

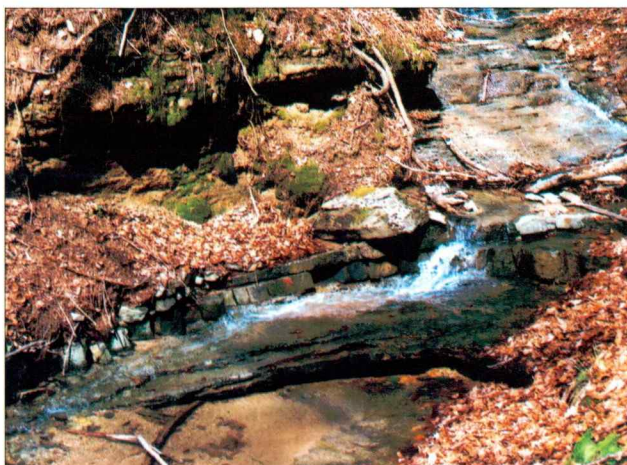


Fig. 5. Alternation of Carnian tuffs of various granulation in the Borovnik Ravine in the Rute area (Bloke Plateau). The tuffs belong to the Borovnik Member of the Mohorje Formation

Sl. 5. Menjavanje karnijskih tufov različne zrnivosti v grapi pod Borovnikom na območju Rut (Bloška planota). Tufi pripadajo borovniškemu členu Mohorske formacije

Petrographical, geochemical and lithological composition as well as Bloke Carnian volcanism are described more in detail in the article of KRALJ and DOZET (this volume).

Rupe Member: Red elastic rocks – conglomerates, breccioconglomerates, conglomeratic sandstones, sandstones, dolomitic marlstones

Description. The third member of Mohorje Formation is denominated according to the hamlet Rupe, where in the upper part of the small and pretty steep ravine the contact between the underlying volcanoclastic succession and transgressively overlying succession of variegated, prevalently red clastic rocks (Fig. 6) is exposed. Among clastics prevail greyish red dolomitic marlstones. Gay-coloured conglomerates, breccio-conglomerates, conglomeratic sandstones as well as coarse- and very coarse-grained sandstones appear in the form of up to several metres thick interbeds in the lowermost and middle part as well as just in the uppermost part of the red clastic succession (Rupe Member). Psammitic and psefitic interbeds are thick-bedded and rarely thin-bedded or thick-plated. The thickness of the Rupe Member varies from 35 to 50 metres.

Variegated calcareous-tuff rudites (conglomerates, breccias) are composed of rosy, reddish and red fragments of various size (up to 1,0 cm). Most fragments are microcrystalline calcite. Pretty numerous are also silicate lithic fragments (microcrystalline and fine-grained volcanic glass and fragments of vein quartz). Lithic fragments are rounded or completely irregular (angular). Next to lithic fragments there are quartz and feldspar grains (0,2 mm – 0,5 mm) in the considered rocks as well. Feldspars are pretty changed kaolinized and impregnated with limonite dust. They belong to acidic plagioclases.

The calcareous-tuff sandstones have a similar composition like afore-described rudites. They are different only in the fact that in the calcareous breccias and conglomerates limestone fragments are predominant, while in the sandstones fragments of silicate tuff material prevail.

In the dolomitic marlstones in some places up to several meters thick interbeds of very compact dolomitic marlstone with numerous up to several centimeters big nodules composed of grayish, greenish grey, bluish grey and rosy limestone can be found. These are, in fact, limestone concretions in the dolomitic marlstone. For the dolomitic marlstones is very typical a splinter disintegration as well.

Environment. Heterogeneity of red Carnian sediments indicates an erosion of uplifted parts of shortlived dry land, after which followed a transgression and sedimentation of red Carnian sediments, which was in the beginning under strong influence of the dry land.

In the sedimentary basin, at first, gravelly and coarse-grained sandy material was transported from the dry land with an agitated relief and se-



Fig. 6. Red bedded and platy Carnian clastic rocks (quartz and jasper sandstones and breccioconglomerates) of the Rupe Member of Mohorje Formation.

Sl. 6. Rdeči plastnati in ploščasti karnijski klastiti (kremenovi in jaspisni peščenjaki in brečokonglomerati) ruparskega člena Mohorske formacije

miarid climate. Geologic events and processes on the dry land gradually calmed, the relief lowered, the transgression progressed and the influence of the dry land on the sedimentation was reduced.

Very coarse-grained clastic sediments were followed by more and more fine-grained terrigenous material, especially silt and clay, that was mixed with increasing carbonate prevalently dolomite sedimentation, that in the Norian stage entirely prevailed.

Selo at Rob Member: Yellowish grey dolomitic marlstones and mudstones, clayey and marly dolomites

Description. Red clastic Carnian rocks do not pass upwards directly into the Main Dolomite, but there is between both still from 35 to 75 metres thick stratigraphic sequence of alternating clayey dolomite, dolomitic marlstone, marly dolomite as well as shally and limy marlstone (Fig. 7). The member got his name according to the small village Selo at Rob. Dolomites are more or less clayey or marly, brownish, yellowish or medium grey. Limy and shally marlstones are yellowish and medium grey, gently pinkish grey, yellowish orange to medium-dark grey. If soft, they can be very dark grey. Upwards, the considered alternating sediments pass gradually into the bedded sparitic, intrasparitic and fine-stromatolitic Main Dolomite with rare horizons of oncolitic dolomite.

Fossils and age. In transitional Carnian beds no fossil remains have been found in the Bloke cross-



Fig. 7. Selo at Rob Member: Alternation of pale brownish and yellowish grey bedded dolomite with stick paralelepiped disintegration and yellowish brownish and greenish grey to medium dark grey dolomitic marlstones in the Rute area (Bloke plateau)

Sl. 7. Selanski člen: Menjavanje blede rjavkasto- in rumenkastosivega plastnatega dolomita s paličasto paralelepipedsko krojitvijo ter rumenkasto, rjavkasto in zelenkasto sivih do srednje temnosivih dolomitnih laporovcev na območju Rut (Bloška planota)

sections. These beds are, as a rule, very scarce of fossils elsewhere in southern Slovenia as well. In the transitional Carnian beds of southern Slovenia fossils have been found, hitherto, only in the central part of Dolenjska (BUSER, 1974). This author discovered a lumachelle with megalodontids among which Vegh-Neubrandt determined the species *Neomegalodon (Rossiodus) arthaberi* Kutassy that ranges the considered transitional beds in the Tuvallian substage.

Correlations and Discussion

The cross-section, where the Julian-Tuvallian lithologic column consists in the lower part of dark to black platy and bedded limestones, in the middle part of volcanoclastic rocks and in the upper part of red clastic rocks is not an unique case in southern Slovenia, on the contrary, it occurs in adjacent and wider surroundings of the Rute area, and even more, similar cross-sections can be found in other places in Rute as well.

Pretty similar cross-section as at Mohorje is exposed (Fig. 3) along the road Drenov grič-Lesno Brdo (JELEN, 1990). Discordantly upon the Cordevolian massive limestone with algae *Diplopora annulata* SCHAFHÄUTL repose there grey silty and sandy marlstone, mudstone, siltstone and cross-bedded fine sandstone with bauxitic oolites, conglomeratic breccia and anthracite at the base (Figs. 3, 4). The lowermost Julian rocks are overlain by the grey thick-bedded sparry limestone, biomicrite, with alga *Clypeina besici* PANTIĆ, as well as marlstone and shaly mudstone. These beds are rich in lamellibranch macrofauna. Upwards follow the Julian green tuffaceous sandstone and black shaly marlstone.

Nearly alike cross-section of the Carnian beds as at Lesno Brdo is exposed in the Grosuplje and Klen-Orle coal-mine surroundings (Fig. 3). In the lower Grosuplje-Orle paralic-shallow water dark limestone member the lamellibranchs *Trigonodus carniolicus* BITTNER, *T. bittneri* WAAGEN, *T. abdo-*

minalis WAAGEN, *T. problematicus problematicus* (KLIPSTEIN), *Pachycardia rugosa* HAUER and *Myophoria kerfersteini* MÜNSTER have been determined (PETRASCHECK, 1927; SEDLAR et al., 1948; JURKOVŠEK & JELEN, 1990). Lithostratigraphically, the Grosuplje-Orle Beds are subdivided in five members (DOZET, 2002): basal dark limestone and marlstone with anthracite, fossiliferous limestones with tuffitic and marly interlayers, dark greyish green tuffs, red clastic rocks and transitional dolomite-marlstone sequence passing upwards gradually into the Main Dolomite (Hauptdolomit).

The stratigraphic sequence of Carnian beds resembling to the Mohorje one is exposed also in the Bajdinski potok at Turjak, where between the black bedded limestone and red clastic rocks there is several ten metres thick horizon of strongly weathered orange brown tuff as well. The same succession of Carnian members can be observed in the valley of Črni potok south of Rob and in Črni potok south of Mala Slevca at Dvorska vas. In the lower part of Julian-Tuvallian succession there is a black, bedded limestone with chert. Upwards follow volcanoclastic rocks and in the upper part, there are red clastic rocks passing upwards into the Main Dolomite. Somewhat different was the coarse of sedimentation in the Zgonče-Vintarji-Perovo area, where the volcanoclastic rocks repose directly upon the Cordevolian carbonate rocks with diploporas (BUSER, 1969, 1974).

In Carnian stratigraphic sequence in the Idria area CIGALE (1978) distinguished five members (from bottom to top). The brownish grey dolomite, dark grey limestone and the first Carnian clastic horizon are assigned to the Julian substage. They are overlain by the light grey ribboned limestone and the second Carnian clastic horizon belonging both to the Tuvallian substage. The Carnian-Norian geologic boundary is transitional in nature.

Finally, primary Carnian volcanoclastic rocks between the underlying dark bedded and platy bituminous limestones and overlying red clastic rocks are recorded in the cross-sections Zgonče-Kobilji curek and along the road Rob-Selo too.

The superposition of typical Carnian lithological units, the concordant stratigraphic position between the overlying Main Dolomite with gastropods and megalodonts and underlying coarse crystallized Cordevolian dolomite with diploporas and other dasyclads, the stratigraphic position of the volcanoclastic rocks, their petrography and geochemistry, analogy and correlation of the considered cross-section with other southern Slovenia Carnian much more fossiliferous cross-sections, give us enough evidences for the Carnian (Julian a. Tuvanian) age of the Mohorje Formation, its volcanoclastic Borovnik Member and Carnian volcanism.

Conclusions

About 230 metres thick stratigraphic sequence of sedimentary and volcanoclastic rocks of Julian and Tuvanian (Middle and Upper Carnian) age in the Rute area on the northeastern margin of Bloke plateau (Dolenjska, central Slovenia) is denominated after the small village Mohorje "Mohorje shallow marine-volcanoclastic beds", for short "Mohorje Formation".

From the lithostratigraphic point of view the Mohorje Formation is subdivided in four members (from bottom to top): Boštetje Member, Borovnik Member, Rupe Member and Selo at Rob Member.

The considered formation is in lowermost part composed of dark to black, platy and bedded, laminated, micritic and sparitic limestones, here and there with cherts (Boštetje Member), passing upwards into the prevalently black and green volcanoclastic tuffs (Borovnik Member). Volcanoclastic rocks are transgressively overlain by variegated prevalently red clastic sediments – quartz and jasper sandstones and conglomerates as well as dolomitic marlstones (Rupe Member). In the uppermost part of the Mohorje Formation yellowish grey dolomites, dolomitic marlstones, clayey dolomites as well as shaly and marly mudstones alternate passing upwards gradually into the Main Dolomite – Hauptdolomit (Selo at Rob Member).

The age of the Mohorje Formation is defined on the basis of concordant position between the underlying Cordevolian and overlying Norian carbonate rocks, further on, with respect to sedimentological characteristics of individual members and according to the correlation with similar Carnian cross-sections in southern Slovenia having richer contents of index-fossils. In the underlying Cordevolian carbonate rocks the dasyclad *Diplopora annulata* Schafhäütl has been determined and in the overlying Norian Main Dolomite the gastropods *Worthenia* cf. *solitaria* Benecke and *Worthenia* cf. *escheri* Stoppani as well as megalodont bivalves *Neomegalodon* (*Neomegalodon*) *complanatus* Gümbel and *Megalodus* sp. have been collected.

The total thickness of the Mohorje Formation varies from 205 to 265 metres. Individual members have the following thickness: Boštetje Member 45–75 metres, Borovnik Member 75 metres, Rupe Member 35 to 50 metres and Selo at Rob Member 35–75 metres.

With reference to sedimentological and paleontological data the considered area was a part of a restricted shelf, sometimes with a lagoon character and episodically with volcanic eruptions.

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Povzetek

- Okoli 230 m debelo zaporedje sedimentnih in vulkanoklastičnih kamnin julsko-tuvalske starosti na območju Rut na severovzhodnem robu Bloške planote smo po kraju Mohorje poimenovali Mohorske plitvodno-vulkansko-sedimentne plasti, oziroma Mohorska formacija.
- Mohorsko formacijo smo v litostratigrafskem pogledu razdelili na štiri člene (od spodaj navzgor): 1) – boštetski člen, 2) – borovniški člen, 3) – ruparski člen in 4) – selanski člen.
- Obravnavana formacija je v spodnjem delu sestavljena iz črnih ploščastih in plastnatih mikritnih, laminiranih in sparitnih apnencev ter apnencev z roženci (boštetski člen), ki navzgor prehajajo v pretežno črnozelene vulkanske klastite (borovniški člen). Nad vulkanskimi klastiti leže transgresivno pisani, pretežno rdeči klastični sedimenti (ruparski člen), v vrhnjem delu formacije pa se menjavajo rumenkastosivi dolomiti, dolomitni laporovci in skrilavi glinavci (selanski člen), ki prehajajo navzgor postopno v Glavni dolomit.
- Borovniški člen, ki vsebuje vulkanoklastične kamnine, leži konkordantno in brez znakov prekinitve sedimentacije na črnih apnencih in laporovcih s školjkami, ki so uvrščeni v boštetski člen, in konkordantno pod rdečimi klastiti, ki pripadajo ruparskemu členu Mohorske formacije.
- Mohorsko sedimentno, karbonatno in vulkansko zaporedje leži konkordantno na apnencih, dolomitiziranih apnencih in dolomitih s preseki diplopor in drugih dazikladacej, navzgor pa postopno prehaja v Glavni dolomit z redkimi onkolitnimi horizonti, megalodonti in polži.
- Starost mohorskih plasti je določena na podlagi konkordantne lege med cordevolskimi diplopornimi (*Diplopora annulata* Schafhäütl) karbonatnimi sedimenti in Glavnim dolomitom s horizonti onkoidov tipa "*Sphaerocodium bornemanni*", polžema *Worthenia* cf. *solitaria*, Benecke in *Worthenia* cf. *escheri* Stoppani ter megalodonti *Neomegalodon* (*Neomegalodon*) *complanatus* Gümbel in *Megalodus* sp.
- Skupna debelina mohorskih plasti se giblje od 205 m do 265 m, posamezni členi pa imajo sledeče debeline: boštetski člen 45–75 m, borovniški člen 75 m, ruparski člen 35 m do 50 m in selanski člen 35 m do 75 m.
- Po sedimentoloških in paleontoloških podatkih sklepamo, da je bilo obravnavano ozemlje del

zaprtega šelfa oziroma lagune z občasnimi vulkanskimi erupcijami.

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