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Triassic Deposits of Hrvatsko Zagorje

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Abstract

In the area of Hrvatsko Zagorje, Triassic deposits crop-out in the form of tectonic emplacements, forming the cores of all the major mountains. They also underlie Neogene deposits, as proven in numerous boreholes.

During the Triassic period, continuous sedimentation occurred mainly in shallow marine environments, though transient subsidence occurred in the Anisian and Ladinian epochs. In the Lower Triassic, the nearshore clastic and carbonate sediments were deposited, which were succeeded in the Middle and Upper Triassic by shallow-water limestones. The latter for their most part have undergone later dolomitisation. Owing to rapid subsidence during Middle Anisian and Ladinian times, sedimentation of the fine-grained clastics, pelagic limestones and cherts occurred together with local volcanic intrusions.

1. INTRODUCTION

Geological research on the Triassic sediments in Hrvatsko Zagorje was initiated by Austro-Hungarian geologists in the middle of the last century. Many treatises were published on these investigations, the work by HAUER (1868), who distinguished Lower Triassic sediments in the Ivanščica and Strahinščica Mts., and assigned all limestone and dolomite rocks in Hrvatsko Zagorje to "Hallstatter und Esino Schichten", being the most important. The results of previous investigations were collated by GORJANOVIĆ-KRAMBERGER (1902, 1904a, b), including his own works, and published in the form of geological maps, and explanations of the sheets Vinica, Rogatec-Kozje and Zlatar-Krapina. After Gorjanović's works had been published, the regional geological investigations in the area of Hrvatsko Zagorje were terminated.

Some fifty years later, a new cycle of investigation of the Triassic deposits in Hrvatsko Zagorje was commenced by the academician M. Herak. Coworking with M. Malez he proved for the first time, using the discovery of the alga *Teutloporella herculea* (STOPPANI), that Ladinian deposits developed in the carbonate facies also exist in this area (HERAK & MALEZ, 1956). Several years later he described the Ladinian sponges found on the north side of Ivanščica Mt., after which he published a review of Triassic sediments of Yugoslavia, emphasizing the impact of tectonic stages on the sedimentary conditions (HERAK, 1960, 1961). Thirty years later, dividing the tectonic zones of the Dinarides and defining their northern limits, he included Hrvatsko Zagorje in "Supradinaricum" (HERAK, 1986, 1991; HERAK et al., 1990).

Other geological investigations of the Triassic sediments of Hrvatsko Zagorje were related mainly either to work on the sheets of the Basic Geological Maps: Zagreb (ŠIKIĆ et al., 1979), Varaždin (ŠIMUNIĆ et al., 1981), Rogatec (ANIČIĆ & JURIŠA, 1985) and Ivanić Grad (BASCH, 1983), or to some minor works with reference to specific geological problems. These works are referred to in the explanations of the Basic Geological Map, and they will be reviewed later in the text in order to avoid repetition.

It should be emphasized that this paper represents the first attempt to display the Triassic System of Hrvatsko Zagorje integrally. Comprehensive attention is paid to lesser known topics such as the relationships between specific lithostratigraphic units, as well as to geological boundaries, sedimentary conditions, reexamination of stratigraphic determination of clastics with volcanites, and correlation of contemporaneous deposits in the wider region.

2. LITHOSTRATIGRAPHIC CHARACTERISTICS

Triassic sediments form the central parts of the majority of the Zagorje mountains, where they appear in the form of tectonic emplacements, mainly in the cores of the Neogene anticlines (Fig. 1). The exception is Med-

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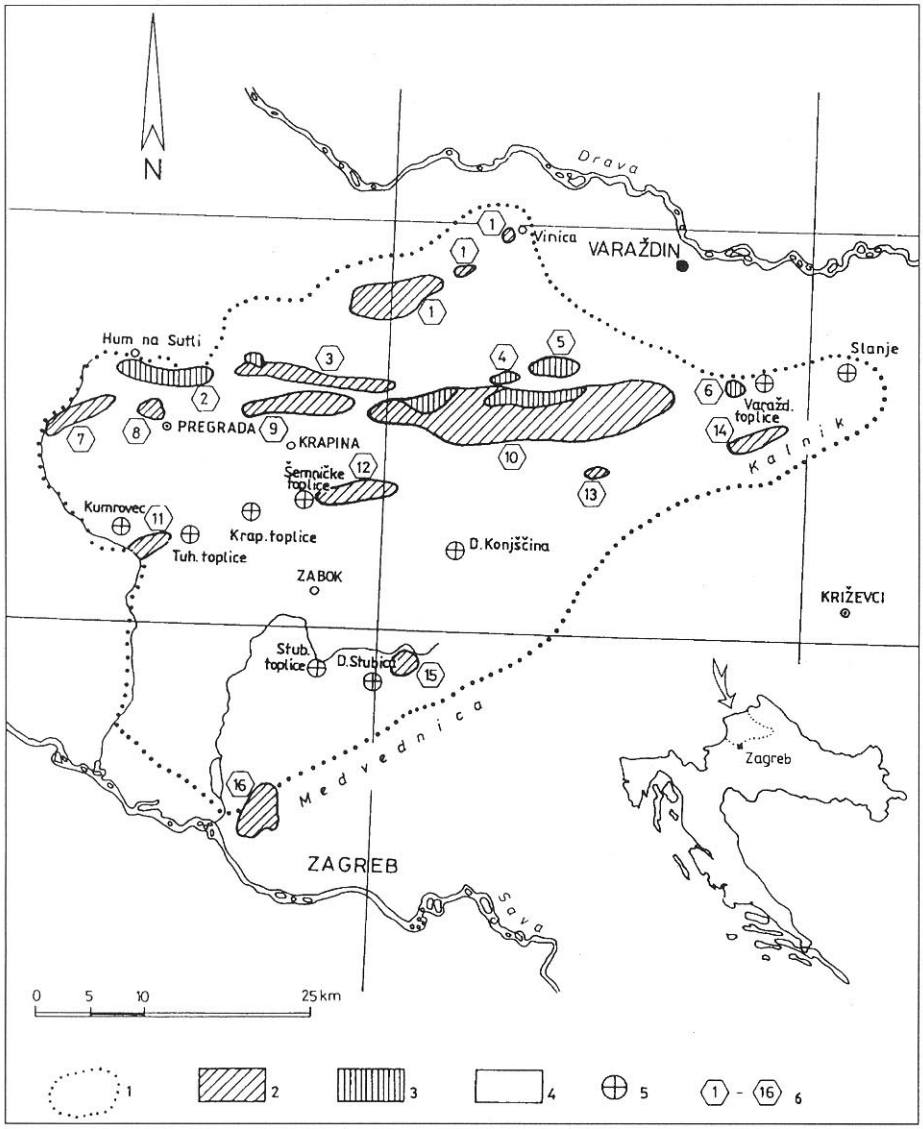

Fig. 1 Distribution of Triassic deposits in the area of Hrvatsko Zagorje. Legend: 1) Study area; 2) Mostly Triassic dolomites and limestones; 3) Mostly Triassic tuffs; 4) Neogene and Quaternary sediments; 5) Deep boreholes with pierced Triassic deposits; 6) Mountains of Hrvatsko Zagorje: 1 - Ravna gora, 2 - Hum, 3 - Brda, 4 - Sv. Duh, 5 - Željeznica, 6 - Varaždinske toplice, 7 - Košt-run, 8 - Kuna gora, 9 - Strahinščica, 10 - Ivanščica, 11 - Cesarsko brdo, 12 - Strugača, 13 - Vučak, 14 - Ljubelj, 15 - Hum-Šagudovec, 16 - Zakičnica.

vednica Mt., where Triassic rocks occur in a much more complicated form, mostly as the remnants of overthrusts (ŠIKIĆ et al., 1979). Furthermore, it is proven by numerous boreholes that in the greater part of Hrvatsko Zagorje Triassic sediments underlie Neogene carbonates and clastics.

The mountains of Hrvatsko Zagorje display a very intricate tectonic configuration, which is the reason why hardly a single tectonically quiescent area can be found to establish the integral geologic column. The given geologic column (Fig. 2) is composed of partially drawn cross sections and data assessed by geological mapping.

On the basis of lithological and palaeontological characteristics, the Triassic of Hrvatsko Zagorje is divided into three major parts. Clastic and carbonate deposits relate to the Lower Triassic, the carbonate and volcano-clastic sediments belong to the Middle Triassic, whereas only the carbonate rocks pertain to the Upper Triassic. Occasionally, one can arrive at more detailed division of the Triassic system into eight lithostratigraphic units, but, due to the major dislocation of sediments and scarcity of fossil findings, it is hardly feasible over the entire area of Hrvatsko Zagorje.

2.1. THE LOWER TRIASSIC (SCYTHIAN)

The Lower Triassic sediments occur on almost all mountains of Hrvatsko Zagorje, except for the Kalnik and Strugača Mts. Their greatest exposure is on the Ravna Gora Mt., while elsewhere they appear in the form of narrow zones, erosional remnants, or enclosed tectonic blocks. During hydrothermal research, their extension was also established beneath the surface, as they are partially drilled in Krapinske Toplice at a depth of 650-720 m, and in Stubičke Toplice at depths of 260-390 m.

Due to later tectonic movements, the exposure of Lower Triassic clastics is irregular and unpredictable. Sometimes they are accumulated in a single place resulting in deposits several hundred metres thick, while sometimes they can be found only in traces. Inte-

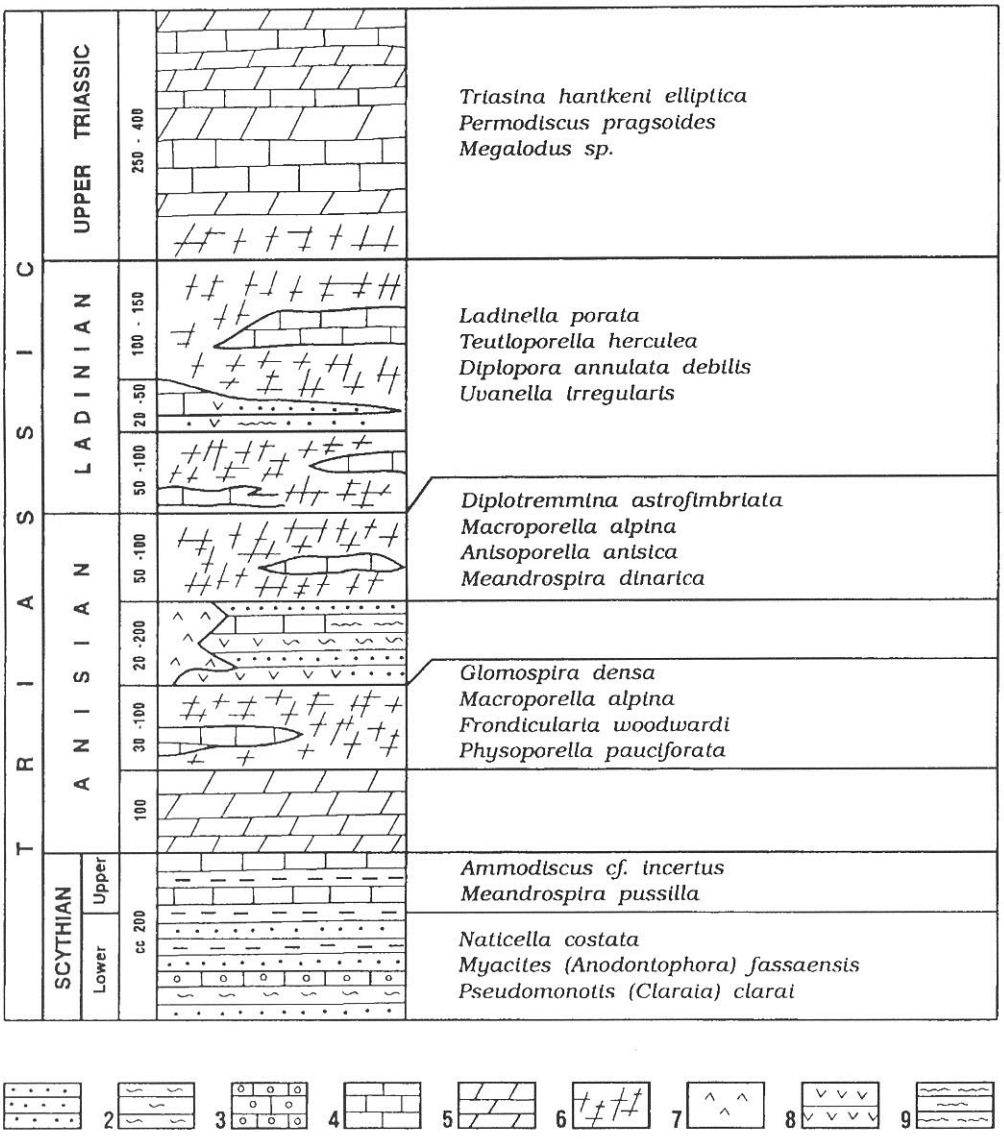

Fig. 2 Schematic geological column of the Triassic deposits in Hrvatsko Zagorje. Legend: 1) micaceous sandstones and siltites; 2) shales; 3) oolitic limestones; 4) limestones; 5) bedded dolomites; 6) massive dolomites; 7) andesite-basalts; 8) tuffs; 9) cherts.

nsive folding is particularly evident on the thrust fronts as, for example, near Jablanovec on the Medvednica Mt., in the vicinity of the road tunnel on the Strahinščica Mt., and in the crests of folds in the Ravna Gora Mt. or at Hromec village in the line of Hum na Sutli - Lepoglava - Beletinec.

Up to the present time various opinions exist concerning the nature of the geological boundary between the Upper Permian and Lower Triassic. On the sheets of the Basic Geological Map of Varaždin and Rogatec, this boundary is deduced as an uninterrupted sequence, while on the sheets of Zagreb and Ivanić Grad it appears as an erosional unconformity. Recent investigations have shown that the undisturbed relationship between the Upper Permian and Lower Triassic only rarely occurs in Hrvatsko Zagorje, while for the most part the boundary appears as an erosional unconformity.

The scarce outcrops in the western part of Ivanščica Mt., and in the area of Strahinščica Mt. reveal that Lower Triassic clastics overlie the brown-red conglomerates and coarse-grained sandstones, or the so-called "Gröden deposits" (Permian). The layers are mutually concordant making their appearance on the terrain as the normal transition of Permian into Lower Triassic clastics. Such a boundary, regardless of the absence of angular discordance can not be considered as an uninterrupted sequence because in the Lower Triassic sandstones the content of terrigenous material changed as the particle size reduced, and the quantity of muscovite increased. This was caused by significant palaeogeographic modifications which brought about a change in provenance of the clastic material, a reduction in relief, and longer transportation distances.

In the eastern part of Ivanščica Mt. and on Cesarsko Brdo Mt., a 1-2 m thick layer of grey porous dolomite sporadically appears at the boundary of Palaeozoic black shales and sandstones with overlying brown-red Werfenian (Lower Triassic) sediments. The occurrence of dolomite, sometimes with salt or gypsum, shows that the input of clastic material was sporadically interrupted, with emergence of a lagoon where the evaporitic

sediments had been formed. There is a well-known salt deposit on the northern slopes of Medvednica Mt., in Slani Potok (Salt Creek). The salt appears at the border between metamorphic rocks and Lower Triassic sandstones. Near Rude, in neighbouring Samoborska gora Mt., well-known deposits of gypsum can be found, whereas in the valley of the Bregana brook dolomite occurs instead of gypsum, containing the Upper Permian calcareous algae (HERAK & ŠKALEC, 1967).

In the area of Hrvatsko Zagorje, the Lower Triassic sediments maintain the overall uniform development and can be divided into two parts: the Lower (clastic) and Upper (carbonate) Werfenian.

In the Lower Triassic, which can be considered as an equivalent of the Lower Werfenian sediments, the recurrent alternations of micaceous sandstones, mica siltites, shales, marls and, more rarely, oolitic limestones has been observed. Their colour is mostly red-brown, brought about by the content of haematite and limonite. Long ago, the iron ore was mined in these rocks, leaving on the slopes of Medvednica Mt. numerous pits, remnants of smelting furnaces, and even the traces of slag at some places. Sediments without the iron content are yellow, grey or greenish-grey in colour.

Red-brown, micaceous sandstones occur as the most extensive lithological member of the Lower Triassic sediments. They are determined as sublithic arenites and quartz arenites. The main components of sublithic arenites are quartz, feldspars (albite and andesine) and muscovite, while quartz prevails in the quartz arenites. The sandstone cement is variable in composition: sometimes it is quartz and limonite, or haematite and limonite with additional sericite, and sometimes it is calcite with a mixture of limonite. Among the heavy minerals, rounded apatite and zircon prevail, while garnet and epidote occur more rarely. The sandstones sometimes appear schistose as a result of the parallel orientation of foliate minerals, and they sometimes display vestiges of metamorphosis. Ripple-marks and smooth laminations are common.

Fine-grained sandstones and siltites are very micaceous, sometimes containing ferruginous substances. The black and grey varieties of these are enriched in carbon.

The sandstones and marls are interbedded with thin layers or lenses of oolitic limestones. The main components are ooids varying in size between 0.04-0.5 mm, with mixtures of non-carbonate and arenitic particles. The ooid core can be a microfossil, a fragment of macrofossil or intraclast. The limestone cement is composed of the fine-grained calcite which envelops the ooids and fills the interstices.

The main components of shale are clay, muscovite and sericite, while quartz, chlorite and calcite occur rather rarely. In the marls, the quantity of microcrystalline calcite, together with previously quoted components, amounts to 65% of the rock.

Stratigraphic determination of the Lower Triassic clastics is established from the abundant fossil content found in almost all the Zagorje mountains. The following species of lamellibranchiata and gastropoda have been determined: *Myacites (Anodontophora) fassaënsis* WISSMAN, *Pseudomontis (Claraia) clarai* EMMRICH, and *Naticella costata* (MÜNSTER) (LIPOLD, 1862; ŠIKIĆ et al., 1979; ŠIMUNIĆ et al., 1980; ANIČIĆ & JURIŠA, 1985; BASCH, 1983).

The Upper Werfenian consists of dark-grey, tabulate and thin to middle-bedded limestones that outcrop on the Ravna Gora Mt. and in the Ivanščica - Strahinščica - Koštrun Mt. range. On other mountains their thickness is small (10-20 m), which is why they are generally not displayed on geological maps.

On the Ravna Gora Mt., a gradual transition has been observed from the Lower to the Upper Werfenian. In the upper levels of the Lower Werfenian clastics intercalations of the dark-grey limestones appear, which afterwards completely prevail. This boundary is rather interesting in a geological sense since it points to the initial deposition of carbonates which, although intermittent through the Anisian and Ladinian, proceeded into the Jurassic.

The limestones along the lower boundary can also contain mixtures of quartz and limonitic-clayey material, while fine-grained, microsparite calcite gradually prevails in the upper levels. The following types of limestones are determined: microsparites, fossiliferous microsparites and crinoidal microsparites. Frequently there appear "schistose" or "breccia-like" textures, which are associated with the disposition of joints, thin veins and microstylolites, being caused by post-Triassic tectonic activity.

In the area of Ravna Gora, the fossiliferous microsparites are abundant with foraminifera, crinoid debris and mollusc shells, while intraclasts, pellets and ooids are sparse. Crinoidal limestones, specifically crinoidal microsparites, also frequently occur. These rocks are formed exclusively from the crinoid stems and foraminifera, while ooids, mollusc shells and non-carbonate arenitic components are sparse.

Calcareous dolomites and black shales may occur in alternation with the limestones. Dolomites are thin-bedded, fine-grained, and sometimes contain mixtures of clay and limonite. In the upper parts of the Upper Werfenian deposits, the number and thickness of dolomite layers ever increase up to the absolute prevailance of dolomites at the Anisian boundary.

From the Upper Werfenian limestones of the Ivanščica and Ravna Gora Mts. the following species of microfossils were determined by M. Milanović (in ŠIMUNIĆ et al., 1980): *Meandrospira pusilla* (HO), *Ammodiscus incertus* (d' ORBIGNY) and *Glomospira* sp.

2.2. THE MIDDLE TRIASSIC

During the Middle Triassic shallow-water limestones were predominantly deposited, their origin related to a "carbonate platform". Today these rocks are for the most part dolomitised and tectonically displaced,

though on the basis of rare fossil finds and their mutual superposition they can be divided into the Anisian and Ladinian series.

In the middle of the Anisian and Ladinian epochs the fine-grained clastics, cherts and tuffs were deposited, with sporadic occurrences of volcanic intrusions. The origin of the clastics and volcanites is related to the abrupt and relatively short-lived periods of subsidence with subsequent reccurrence of sedimentation in the shallow-water marine basins.

The Anisian dolomites and limestones form most of the Ivanščica - Strahinščica - Ravna Gora - Koštrun Mts. range, but they can also be found on the other mountains (except Mt. Kalnik). Almost all thermal water boreholes have reached the Triassic dolomites and dolomite breccias (Fig. 1). Up to the present, a continuous sequence of sedimentation from the Upper Scythian to the Anisian has only been discovered on Ravna Gora Mt., while on the other mountains the said boundary is tectonically dislocated or concealed. A similar geological cross section near Rimske Toplice in Eastern Slovenia (RAMOVŠ & ANIČIĆ, 1995) proves this to be, at any rate, not an isolated phenomenon.

Dark-grey dolomites are the most frequent and most identifiable member of the lower part of the Anisian stage in Hrvatsko Zagorje. Fragments of crinoids can often be found in these rocks, suggesting that these dolomites originated by the process of dolomitisation of the crinoidal limestones. This rules out any significant palaeogeographic variations having occurred at the Upper Werfenian - Lower Anisian boundary. Not only did sedimentation of carbonates never cease but, conversely, layers of considerable thickness have been produced. On the basis of chemical analyses it has been determined that the dark dolomite colouring derives from an increased concentration of organic matter. Sometimes, these rocks include the intercalations of chert of mm-cm dimensions which are supposed to be diagenetic in origin (ŠIMUNIĆ & ŠIMUNIĆ, 1980).

It can be observed at outcrop that dolomites abruptly change from black to grey, which is most probably a consequence of regressive movements in the sedimentary basin which caused algal limestones to be deposited instead of crinoidal ones. Sedimentary-petrographic analyses have determined that these dolomites belong to the middle-grained calcareous, stromatolite and algal types. They have arisen by dolomitization of algal limestones, allowing for all possible transitions in appearance.

Major bodies of limestones, not affected by dolomitization, crop out on the Ravna Gora and eastern part of Ivanščica Mts., but these can also be seen in minor exposures in other Zagorje mountains. They are very important for the clarification of stratigraphic relationships, having been the only source of determinable fossils. The following species of algae and foraminifera have been determined by M. Milanović (in ŠIMUNIĆ et al., 1980): *Meandrospira dinarica* KOCHANSKY-DEVIDÉ & PANTIĆ, *Glomospira densa* (PANTIĆ), *Macroporella alpina* PIA, *Pacentella hexaster* (PIA), *Physoporella pauciforata* (GÜMBEL).

On the northern slopes of the Ivanščica and Strahinščica Mts. great bodies of grey and dark-grey dolomite breccia are exposed. These originated from crushing of dolomites and their subsequent recementing. They are intersected by numerous joints filled with recrystallized dolomite and calcite. Large slickensides, tracing major faults, fault zones, or thrust planes, can be found in these rocks. Due to their great porosity, these breccias have proven to be very good fresh-water and thermal water aquifers (Šemničke Toplice, Vratno)

In the Middle Anisian an abrupt change in sedimentation occurred with deposition of deep-water clastics and volcanites instead of shallow-water carbonates. These rocks are present in almost all the mountains of Hrvatsko Zagorje, having been drilled near Konjščina at depths of 3,850-4,250 m (DRAGIČEVIĆ et al., 1995), and near Krapinske toplice at 550 m. The stratigraphic position of these rocks was variously interpreted in the works of previous authors and subsequent explanations of the Basic Geological Maps, while their supposed age extended roughly from the Palaeozoic to the Lower Miocene.

Among the sedimentary rocks, the most common are the black and red shales, black and grey siltites, and red-brown radiolarian cherts. In addition, the grey, fine-grained limestones with radiolaria and filaments, as well as tuffitic limestones with radiolaria, tuffs and andesite-basalts sporadically occur (ŠIMUNIĆ & ŠIMUNIĆ, 1980/81). Great expanses of tuffs and basic effusives are present on the northern slopes of Ivanščica Mt., but they can also be found on Strahinščica, Kuna Gora, and Koštrun Mts. They are intercalated with dolomites, and vary in thickness from 20-200 m.

GORJANOVIĆ-KRAMBERGER (1904a, b) considered the clastics with volcanites in the area of Ivanščica, Strahinščica and Koštrun Mts. as being of Palaeozoic age, while similar rocks on Kuna Gora Mt. were classified as an Anisian "coquina" on the basis of the ammonite fossils. SALOPEK (1918) studied the collected cephalopod fauna of Kuna Gora Mt. and came to the conclusion that it indicated an Upper Anisian age. TUĆAN (1922) supposed the andesites and basalts on Ivanščica to be older than "Carboniferous slates" and "Werfenian schists" on the basis of the latter being without evidence of contact metamorphism.

Sedimentation of the Middle Triassic clastics with volcanites occurred suddenly, which is not easy to explain in the face of familiar sedimentary processes. Previously they were supposed to be deposited in a eugeosyncline, but recently the majority of geologists are of the opinion that thay have arisen during the birth of a "rift valley". Thus, indeed, the swift subsidence and sedimentation of the deep-sea deposits can be explained, but it is not easy to elucidate the rapid regression and recurrent sedimentation of shallow-water carbonates. Were the "rift valley" closed by compression, the rocks within would have been compressed too, and

could certainly not be preserved. The low-angle thrust can also be inferred which, owing to its immensity, resembles an overlying rock mass, though it is not easy to assume it will always affect the same stratigraphic level. In other words, an arrangement of strata such as this, along with periodic thickening or thinning of the clastics and volcanites, can be traced from Ivanščica to Koštrun Mts. (about 50 km). Perhaps the most acceptable is Boillot's concept (BOILLOT, 1983) whereby similar phenomena are explained by subduction on a carbonate platform. After the subduction processes had been terminated, the entire area was uplifted with subsequent recurrence of the sedimentation of the shallow-water carbonates.

Light-grey, fine-grained, intensely silicified tuffs, extending from Rogatec through Lepoglava to Varaždinske Toplice, are also included in the Middle Triassic (Fig. 1). They are determined as vitric, crystallo-vitric, crystallic and lithic tuffs and tuffites. These are sometimes "pierced" by the altered spilitized diabase and sporadically interbedded with quartz schists. They often overlie Lower Miocene clastics which is why they were assigned to the Lower Miocene by GORJANOVIĆ-KRAMBERGER (1904a), while KIŠPATIĆ (1909) never considered these rocks as tuffs, but as fine-grained quartz rocks instead. Even on the separate sheets of the Basic Geological Map of Varaždin and Rogatec these are variously interpreted. More recent research has shown the presence of two types of tuffs in this series. Earlier tuffs usually include in their basal part the Lower Triassic deposits overlain sporadically by Anisian dolomites and limestones. In addition, they are proven to be occasionally thrusted over Lower Miocene clastics, which made earlier authors assign them to the Lower Miocene. Later tuffs are of the andesite-dacite type, being weakly lithified and placed at the Egerian-Eggenburgian boundary (ŠIMUNIĆ & PAMIĆ, 1993). Therefore, there are two groups of volcanic rocks in the "Gorjanović andesite line" which points to the instability of the area and a reccurrence of the volcanic activity.

In the upper part of the Anisian sedimentation of algal limestones continued which were later mostly dolomitised. However, in the eastern part of Ivanščica Mt., only a few metres above the clastics, blue-green algae have been found.

The following species have been determined from the Belski Dol area by Milanović (in ŠIMUNIĆ et al., 1980): *Diplotremina astrofimbriata* KRISTAN-TOLLMANN, *Macroporella alpina* PIA, *Anisoporella anisica* (ZANIN-BURI), *Mendrospira dinarica* KOCHANSKY-DEVIDÉ & PANTIĆ.

According to the geological map and partially established geologic columns one can suppose the total thickness of the Anisian deposits to be 400-500 m. Herein a zone of tuffs running from Hum na Sutli - Lepoglava - Beletinec - to Varaždinske Toplice must be sorted out, the thickness of which occasionally exceeds 400 m.

Sedimentation of shallow-water limestones continued through the Ladinian and these were later largely dolomitised and recrystallized. This extensive mass of grey, fine- to medium-grained dolomites infrequently contains relic blocks of limestones. The limestones are fine-grained, often recrystallized, and sporadically silicified. Their occurrence is important for stratigraphic determination because they are the only source of the determinable fossil remnants. For the time being the Ladinian sediments have been proven only in the area of Ivanščica Mt. The first Ladinian fossils found there had been decribed by HERAK & MALEZ (1956) and HERAK (1960), but they were subsequently discovered elsewhere. The following species have been determined by Milanović (in ŠIMUNIĆ et al., 1980): *Uvanella irregularis* OTT, *Dictyocoelia manon* (MÜNSTER), *Ladinella porata* OTT, *Teutloporella herculea* (STOPPANI), *Diplopora annulata debilis* PIA and other.

On the southwestern slopes of Ivanščica Mt., a narrow and intermittent zone of shales, siltites and weathered pyroclastics has been observed within the shallow-water carbonates. The pyroclastics are determined as vitric and crystallo-lithic tuffs, testifying by their presence volcanic activity within the same basin.

At the moment, the true thickness of Ladinian deposits remains unknown due to continuous sedimentation into the Upper Triassic, while both their great extent and intensive tectonics did not allow direct field measurements. According to the geological map and cross sections, the thickness of Ladinian deposits is assumed not to exceed 300 m.

2.3. THE UPPER TRIASSIC

The Upper Triassic deposits are most extensively exposed in the central and eastern parts of Ivanščica Mt., but more rarely on the northern slopes of Kalnik Mt. and in the western part of Medvednica Mt. The Upper Triassic dolomites and limestones encountered elsewhere in the Zagorje mountains only occur in the form of isolated blocks. Most of the Upper Triassic rocks on the southwestern slopes of Medvednica and southern slopes of Ivanščica Mts. represent the remnants of thrust faults (ŠIKIĆ et al., 1979; ŠIMUNIĆ et al., 1981).

Due to occurrence of largely dislocated rocks, continuity of sedimentation from the Middle to the Upper Triassic has never been proven in the field, whereas it can be assumed on the basis of the unaltered lithological composition of the sediments.

In the Upper Triassic, the stromatolitic, intraclastic, fine- to medium-grained dolomites dominate over the algal, peloidal and, more rarely, oncoidal limestones. Dolomite and calc-dolomite breccias can be frequently found, being occasionally interbedded with dolomites. Moreover, in the area of the Kalnik and Medvednica Mts. cherts and radiolarian shales have been found, the Karnian and Karnian-Norian age of which have been determined on the basis of radiolaria (HALAMIĆ & GORIČAN, 1995).

In the area of the Ivanščica and Kalnik Mts., findings of megalodonts have been known since the times of Austro-Hungarian geologists (FOETTERLE, 1861/62), and were later found on a few different sites. Occurrences of Upper Triassic fossils are abundant only on the southern slopes of Strahinščica Mt. The following species have been determined by Milanović (in ŠIMUNIĆ et al., 1980): *Triasina hantkeni elliptica* MAJZON, *Permodiscus pragosides* (OBERHAUSER), *Glomospira* sp., *Trocholina* sp. and other.

The most detailed geological cross section through Upper Triassic deposits in Northwestern Croatia was discovered in a quarry near Podsused, in the northwestern part of Medvednica Mt., but later, unfortunately, completely destroyed due to mining. For 200 metres across the site, a rhythmic sequence from cryptocrystalline through microcrystalline dolomite and dolomicrite, to LLH stromatolite and fenestral stromatolite, as well as dolomicrite was determined. Investigation of this geological cross section allowed the sparse fossil assemblage to be documented, but only the foraminifera *Triasina hantkeni* was determined (FUČEK et al., 1995).

In the area of Hrvatsko Zagorje, detailed division of the Upper Triassic stage could never have been performed because of dolomitisation, recrystallization, scant fossil findings, and extensive tectonic disruptions. Furthermore, true thickness has not been determined, although, according to field observations and representation on the geological map, it can be inferred to be approximately 250-400 m.

3. CONCLUSION

The Triassic deposits form the central parts of most of the Zagorje Mountains, with the exception of Medvednica Mt., where these rocks are thrusted over younger deposits. Besides, the Triassic rocks also underlie Neogene clastics, which is proven by numerous boreholes.

During Triassic sedimentation was continuous, mostly within shallow marine basins, whereas the intermittent subsidence occured during the Anisian and Ladinian. In the lower part of the Scythian, fine-grained clastics were deposited, whereas in the Upper Scythian sedimentation of carbonate rocks began which, regardless of temporary cessations, continued into the Liassic. Deposition of the carbonate rocks was temporarily interrupted in the middle Anisian and in the Ladinian, when deep-sea clastics, cherts and pyroclastics were deposited along with sporadic intrusions of volcanites.

In Hrvatsko Zagorje the existence of all the Triassic series has been proven due to the fossil occurrences, but because of intensive tectonism, no single area could be found to establish the complete geological column. Nevertheless, on the basis of the aforementioned characteristics, the Triassic sediments of Hrvatsko Zagorje can be divided into eight lithostratigraphic units that will be displayed on the new Geological Map of the Republic of Croatia, scale 1:50.000, which is currently being compiled.

On the Ivanščica Mt. the Lower, Middle and Upper Triassic has been proven, though the conformity is only incompletely established.

It is supposed that all the series of the Triassic exist on the Medvednica Mt., but only their lower and upper parts are proven palaeontologically.

The Lower and Upper Triassic deposits are proven on Ravna Gora, Strahinščica, Kuna Gora, Koštrun and Cesarsko Brdo Mts., as well as in the Hum na Sutli - Lepoglava - Beletinec - Varaždinske Toplice range of hills.

In the area of Mt. Kalnik, the Middle and Upper Triassic was determined, whereas on Strugača Mt. no fossil remains were found aided the stratigraphic determination of the grey dolomites which was the reason of their assignation to the Middle Triassic.

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