MILAN HERAK, BRANKO SOKAČ, BISERKA ŠĆAVNIČAR*

CORRELATION OF THE TRIASSIC IN SW LIKA, PAKLENICA AND GORSKI KOTAR (CROATIA)

(Figs. 1—5)

Abstract: Litho- and biostratigraphical investigations of the Triassic in the central and western parts of the Croatian Karst zone have been carried on. New data enable a correlation of facies and reconstruction of the sequence of layers as a consequence of complex geological changes during the Triassic period.

Lithostratigraphical sequence

The Lower Triassic

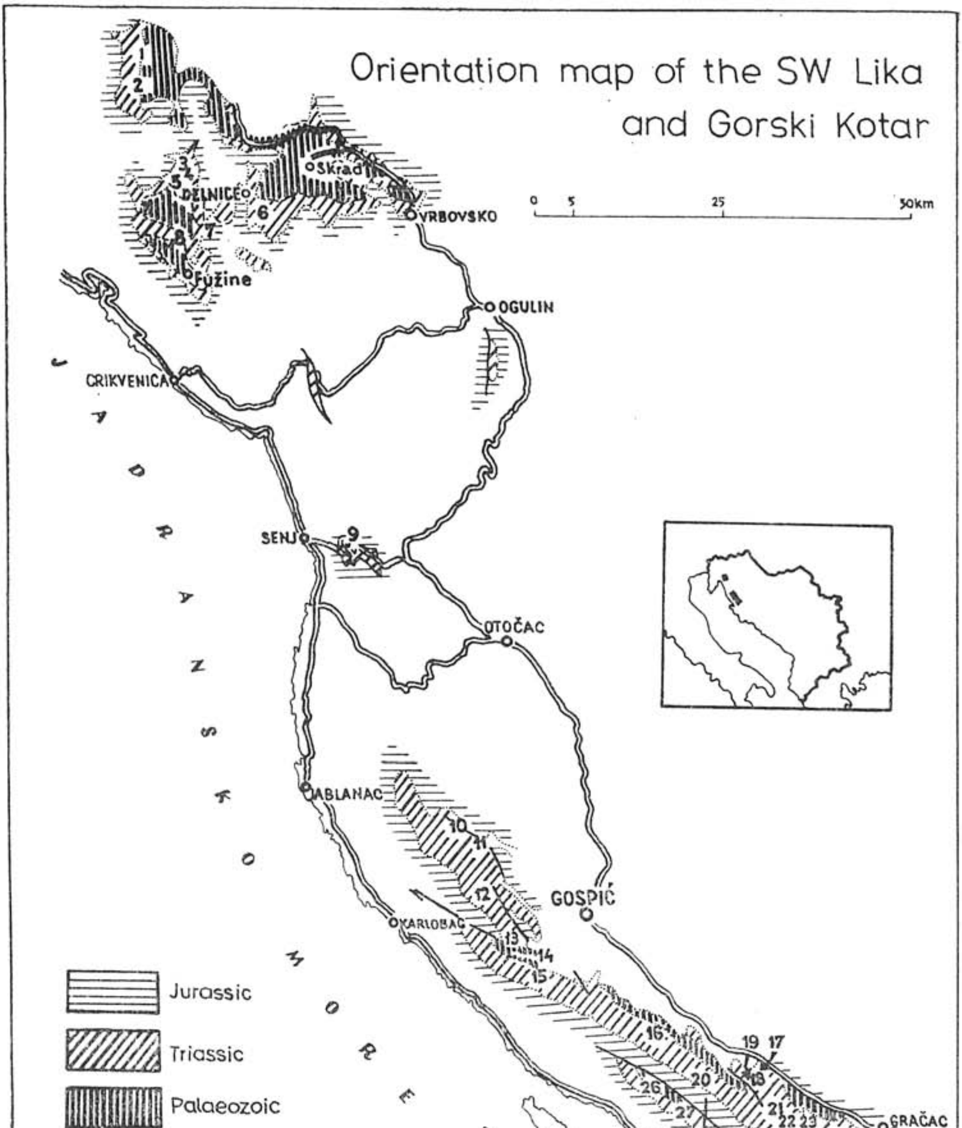
A continuous transition between the Permian and the Scythian in the area of the Velika Paklenica (fig. 3, a—c) and Brušane (all mentioned localities are to be found on the orientation maps — figs. 1, 2), established during the mapping, has been confirmed also by means of sedimentological analyses. The transient zone between Permian dolomites and Scythian siltstones consists of dolomites charged with some terrestrial detritus (fig. 3, a). This implies a change in paleogeographical relations of the suroundings of the area. We find a confirmation of this conclusion at numerous localities in Lika (Bukova Glava, Staro Selo near Sv. Rok, Rizvanuša, Brezik etc.), where an unconformity between the Upper Palaeozoic and the Scythian has been established (fig. 3, d). Basal Scythian layers consist of conglomerates with pebbles of Permian dolomites accompanied by dolomitic pelites and silt-bearing dolomites. The unconformity and change in sedimentation must be connected with the Pfalzian orogenetic phase. Therefore, we consider admixtures of terrestrial detritus in the dolomites in the Paklenica area and at Brušane a sign of the beginning of the Lower Triassic.

The sequence of sediments in the lower part of the Scythian stage shows an increase of terrigeneous components and the formation of a series of thin bedded calcareous sandstones and schistose siltstones. Within this series allochthonous carbonate rocks (in Lika always the dolomitic ones) are also interbedded.

Basic components of Lower Scythian sediments are micaceous sandstones and their fine-grained equivalents. The often mentioned „schistosity" of those sediments is due to the arrangement of micaceous minerals parallelly to the bedding plane. Sporadically, cross-bedding of small scale and ripple-marks on the upper bedding-plane of sandstones are also present.

Detrital particles of sandstones are fine-grained, well sorted but often irregularly distributed in basal carbonate cement. The particles are of a terrestrial and subaqueous (intrabasinal) origin. The formes are composed of angular quartz grains, feldspars (acid plagioclases), muscovite, chlorite, and, rarely, biotite and particles of sedimentary rocks. The intrabasinal detritus consists of subrounded and rounded calcareous particles of an inorganic and organic origin (pseudoolites, oolites, organic fragments). The cement is most often dolomitic, rarely composed of quartz, iron oxide, or clay. These sandstones are classified as micaceous subarkose, calcarenitic subarkose, and some of them as protoquartzites.

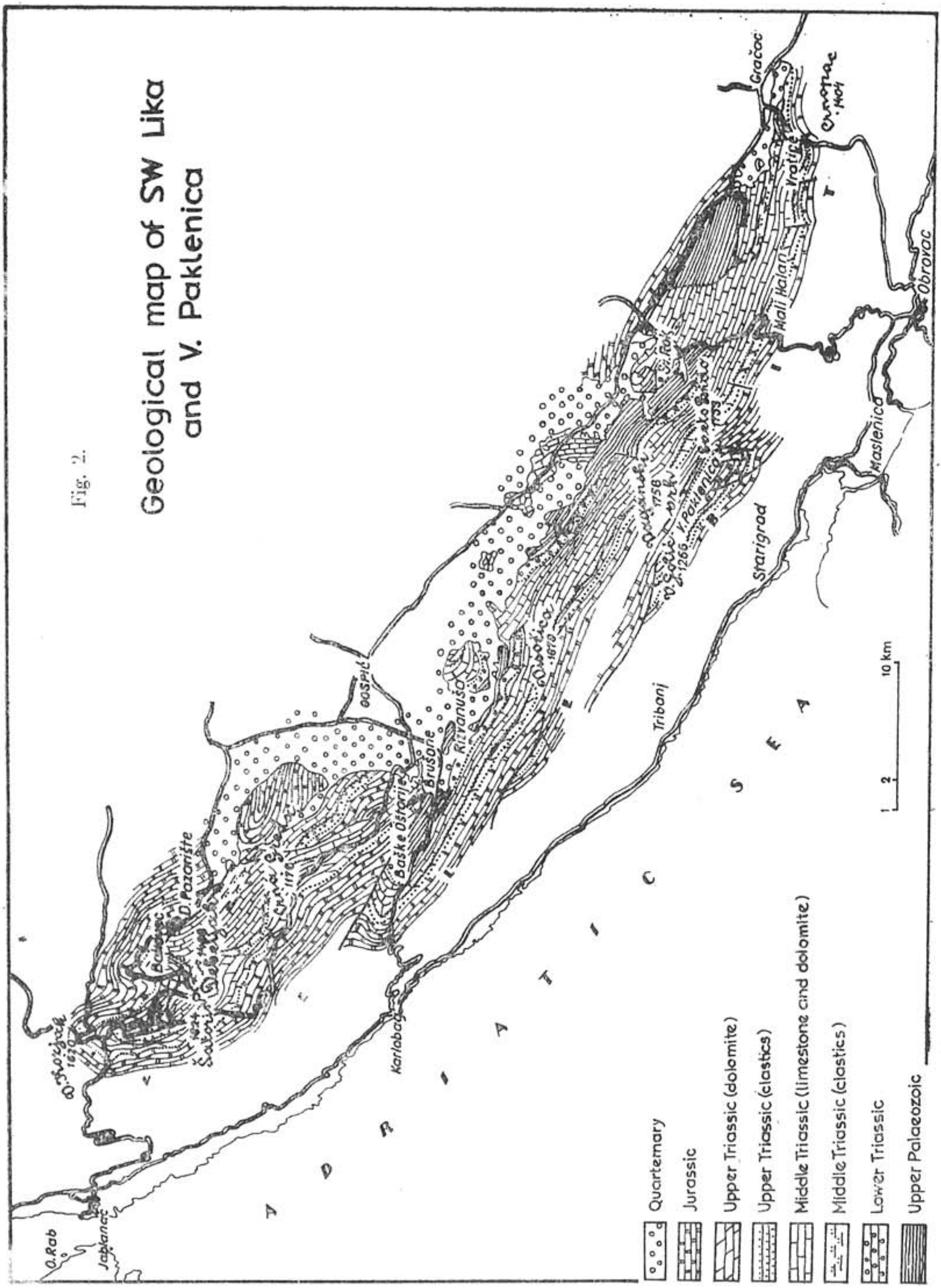
* Prof. D. M. Herak, Geološko-paleontološki zavod Zagreb, Socijal. Revol. 8. Mr. geol. B. Sokač, B. Ććavničar, Institut za geološka instraživanja, Zagreb, Kupska 2.



Localiteties: 1 TRŠĆE, 2 GEROVO, 3 MALO SELO, 4 CRNI LUG, 5 ZELIN CRNOLUŠKI, 6 DEDIN, 7 LOKVE, 8 LOKVARSKE LAZE, 9 VRATNIK, 10 VELIKA PLANA, 11 DONJE PAZARIŠTE, 12 GRGIN BRIJEG, 13 KOŠNA, 14 BRUŠANI, 15 RIZVANUŠA, 16 BREZIK, 17 OPSENICA, 16 SV. ROK, 19 STARO SELO, 20 BUNOVAC, 21 VELIKA VRŠINA, 22 BUKOVA GLAVA, 23 VRŠILJAK, 24 RASTOVAČA, 25 GOLIĆ, 26 VELIKA PAKLENICA, 27 VELIKA MOČILA

Fig. 1.

Fig. 2.


Geological map of SW Lika and V. Paklenica
Quarternary
Jurassic
Upper Triassic (dolomite)
Upper Triassic (clastics)
Middle Triassic (limestone and dolomite)
Middle Triassic (clastics)
Lower Triassic
Upper Palaeozoic
10 km
ADRIATIC SEA
O. Rab
Jablanac
Karlobag
Baške Oštarije
Brušane
Ričvanuša
GOSPIĆ
D. Pazarište
Tribanj
Starigrad
V. Paklenica
Sv. Rok
Mali Halan
Vratice
Gračac
Maslenica
Obrovac

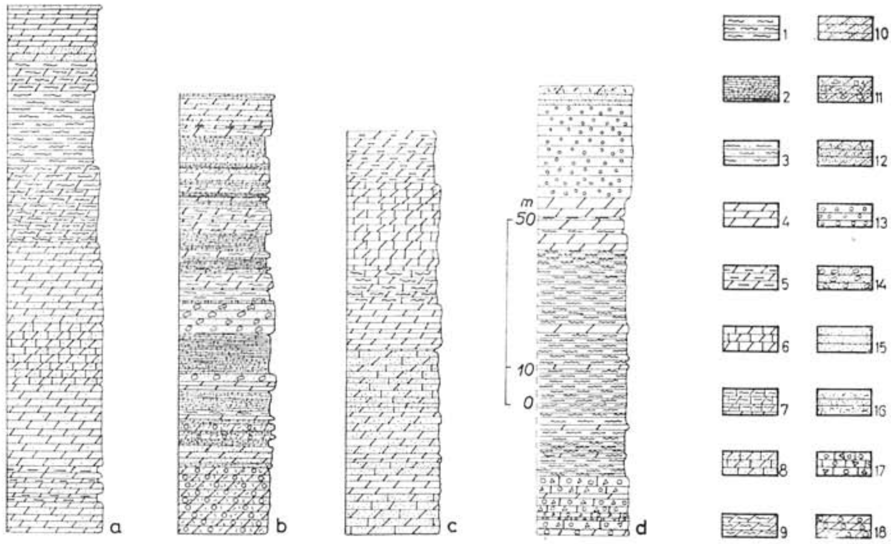


Fig. 3. Geological columns of the Scythian: a-b — the Lower Scythian at V. Paklenica (a — the lower mainly dolomitic beds, b — the upper clastic beds); c — the Upper Scythian at Velika Paklenica; d — the Lower Scythian at Sv. Rok; 1 — micaceous siltstone, 2 — micaceous sandstone; 3 — shale; 4 — dolomite; 5 — dolomite with clay; 6 — calcitic dolomite; 7 — silty calcitic dolomite; 8 — sandy calcitic dolomite; 9 — silty dolomite; 10 — sandy dolomite; 11 — dolomitized oolitic calcarenite with detrital quartz grains; 12 — dolomitic quartz calcarenite; 13 — quartz conglomerate; 14 — subarkose-protoquartzite; 15 — quartz sandstone; 16 — calcareous sandstone; 17 — breccia-conglomerates; 18 — dolomite mit *Neoschwagerina*.

Micaceous siltstones, interbedding with mentioned sandstones, may be poorer by carbonate, but richer by mica or micaceous-clay minerals.

The heavy mineral suite of both sandstones and micaceous siltstones is characterized by the domination of rounded flakes of chlorite containing hematite inclusions, then subrounded brown tourmaline and rounded apatite, rutile, zirkon, and rarely, brookite, epidote, and garnet.

Within the described series of sediments dolomitic oolitic calcarenites are also interbedded. They sontain oolites, organie fragments, rounded shells filled with calcareous mud, and terrestrial detrital materials. These sediments are medium-grained, and locally cross-bedded. They are partially or completely dolomitized. Depending on the stage of the dolomitization of oolites, they have preserved a more or less concentric texture.

Marks of postdepositional diagenetic and epigenetic changes, due to pressure and solution, are often established (deformations of oolites, microstylolites, compaction and removed of cement).

After the described sedimentary series at the localities Bukova Glava, Staro Selo, Velika Paklenica a 1—25 m. thick horizon of orthoquartzitic conglomerates and sandstones follows, consisting of chert, quartz, and quartzite grains. Main components of these sediments are identical with those of Permian sandstones and conglomerates (Gröden, Košna), which suggests resedimentation.

The upper part of Scythian sediments is characterized by a gradual diminishing of terrestrial detritus, by an overwhelming deposition of calcareous rocks, and by the formation of fine-grained dolomites (fig 3. c). The origine of the dolomites is due to the dolomitization of calcilutites. Some of them contain spheric particles (pellets) and may be classified as dolomitic calcisiltites or calcarenites. But they always contain some admixtures of fine-grained or pelitic components, at least as traces.

Scythian sediments established recently in Gorski Kotar at Gerovo, Lokvarske Laze, and Zelin Crnoluški (B. Šćavničar and A. Šušnjara 1966a, b) are composed of the same main elements as those of Lika: calcarenitic micaceous sandstones and oolitic or fine-grained, always sandy dolomites. But neither basal conglomerates nor sandstones were registered. It remains to explain whether they are missing because of different sedimentary environments or because of the tectonics.

The Middle Triassic

1. At most localities in Lika Anisian sediments follow Scythian dolomites without any interruption, which makes it rather difficult to determine a proper limit between the Scythian and the Anisian (Opsenica near Sv. Rok, Staro selo, Rizvanuša etc.). Exceptionally, the Anisian may be in contact with older sediments due to transgression.

The Anisian is represented predominantly by limestones and dolomites. But, moreover, lenses of clastics at different horizons are found. A general view of the sequence of the Anisian deposits is given in fig. 4, a.

A detailed analysis of the Anisian was performed in the area of Rizvanuša, in the surroundings of Gospić. Fine-grained dolomites continue also during the first phase of the Anisian (the limit is unclear). Intergranularly they contain also silt-quartz, muskovite, clay-particles, relic calcareous material, and pyrite. Terrestrial admixtures gradually diminish and finally disappear, and a pure carbonate sedimentation is continued.

In the lower part of the Anisian crystalline dolomites with a granoblastic texture (fine to coarse-grained anhedral mosaic) are mostly found. They are interbedded with some dolomite layers characterized by organic structure with a crinkled lamination of cryptocrystalline, probably algal, carbonate.

At Rizvanuša the described dolomites are followed by a horizon of dolomitic limestones and finally by pure limestones. Anisian limestones are more often partially recrystallized. Nearer genetic classification is not obvious, but it seems that we have to do with biocalcarenites or bioaccumulated limestones.

At different horizons of the Anisian smaller or larger lenses of clastic sediments also occur. Those of the profiles Golići-Vršilja and RW Rastovača (-◇-843) were analysed. Most frequently they are pelitic sediments (calcareous shale). They consist of quartz, illite, chloride with or without plagioclases. In the upper part of the clastic sediments limestone-conglomerate occurs, consisting of pebbles of different types of calcareous rocks and containing some quartz, chert and muscovite.

2. The Ladinian follows after the Anisian without any interruption (fig. 4, b). It consists predominantly of limestones and dolomites substituting each other laterally and vertically. Clastic lenses also occur. In the area of the Velika Paklenica there are no Ladinian sediments (primarily reduced and eroded).

Ladinian limestones and dolomites have similar compositional and textural characteristics as those of the Anisian. Therefore, no comment is necessary.

More interesting are two profiles with clastic rocks representing larger or smaller parts of the Ladinian.

The most interesting profile is the one of Donje Pazarište, already studied by dif-

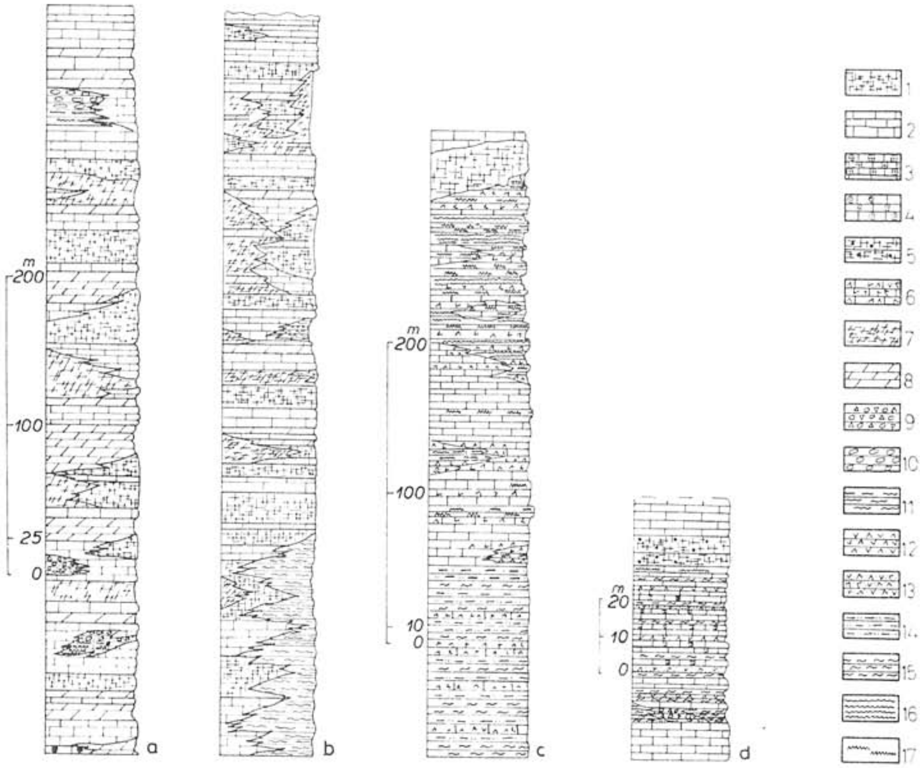


Fig. 4. Geological columns of the Middle Triassic of the Velebit region: a — general schematic column of the Anisian; b — general schematic column of the Ladinian; c — tuffaceous clastics and limestones of the Lower Ladinian at D. Pazarište; d — tuffaceous clastics of the Ladinian at V. Vršina; 1 — nonbedded limestone; 2 — bedded limestones; 3 — limestone with Crinoids; 4 — limestone with Ammonites; 5 — limestone with small knots of chert; 6 — tuffaceous limestone; 7 — nonbedded dolomite; 8 — bedded dolomite; 9 — breccia-conglomerace; 10 — conglomerace; 11 — fine-grained clastics; 12 — tuff; 13 — tuffaceous sandstone; 14 — sandstone and siltstone (volcanic graywacke); 15 — shale; 16 — clay; 17 — lenses of chert.

ferent authors (M. Salopek 1918, S. Bahun 1963, etc.). On the basis of new petrological investigations, two different groups of sediments may be distinguished: one consisting of sandstones and pelites and the other composed of limestones, tuffs, and variegated cherts.

The lower part of the Ladinian clastic series at Donje Pazarište (fig. 4, c) is characterized by the rhythmic interbedding of two members: one pelitic (dark grey shale), the other psamitic (sandstone). The pelitic member has a uniform composition consisting of quartz, acid to intermediate plagioclases, kaolinite, and illite. The content of $CaCO_3$ varies from 0—20 %.

The sandstones are mainly composed of fragments of volcanic rock. These particles consist of microlites of plagioclases which have a sub-parallel orientation and are included in feebly polarizing or chloritic groundmass. Feldspar grains are represented by albite. Quartz is rare. Chlorite occurs as a product of alteration and as a part of matrix. Calcite partially replaces feldspars and matrix. These sandstones may be classified as volcanic graywackes. The rhythmic interbedding of graywackes and shales makes this association similar to flysch assemblage. Products of erosion of a volcanic relief (emerged or submarine) are accumulated in quiet deeper water in rather reducing environments (dark colour of sediments).

Clastic sediments in the higher part of the sequence at Donje Pazarište are more complex. Calcareous, argillaceous, pyroclastic, and silicious deposits are to be found there, in exchange. The presence of pyroclastic components attributes an essential characteristic to sedimentation. We encounter bedded limestones as the first element of the series. Usually they are detrital calcareous rocks: graded bedded calcarenites, fine-grained calcilutite and argillocalcareous rocks. This calcareous sedimentation was interrupted by temporary explosive submarine eruptions. On such occasions acid tuffs were formed, interbedded with sedimentary material or mixed with it, forming tuffaceous sediments. By volcanism sea water was enriched with silica (SiO_2) which has caused a deposition of chert, made a convenient biotope for *Radiolaria*, anabled a silification of clays, etc. The tuffs are composed of angular grains of quarz and acid to intermediate plagioclases (albite to andesine) included to the matrix of devitrified volcanic glass.

More frequent are the tuffaceous sediments (tuffaceous calcarenites, clay, etc.), which contain pyroclastic material as admixtures in all proportions.

A frequent member in the upper part of the Ladinian clastic series is chert (usually Radiolarian one). It is composed of cryptocrystalline SiO_2 (chalcedon, quartz). Red and reddish-brown varieties contain fine dispersed hematite and the green ones pyrite. Cherts are most frequently interbedded with tuffs. Even, they may contain grains of pyroclastic feldspar and quartz; or relics of vitroclastic texture are visible in them, which proves a genetic relation to submarine eruptions.

In the area of Velika Vršina near Sv. Rok (fig. 4, d) the Ladinian is mainly represented by limestones. But there are also smaller or larger lenses of clastics similar to those of Donje Pazarište.

In the district of Gorski Kotar Middle Triassic sediments have not been established so far.

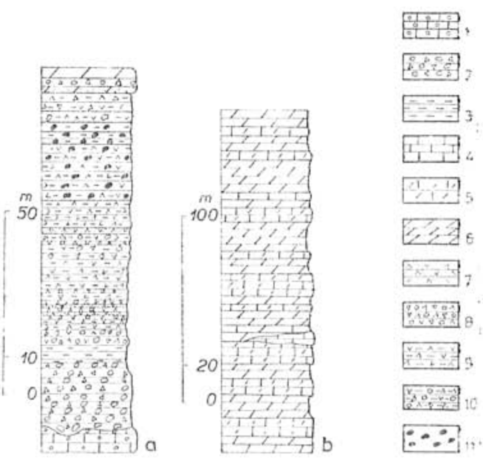


Fig. 5. Geological schematic columns of the Upper Triassic of SW Lika: a — clastics of the lower part; b — dolomites of the upper part; 1 — algal limestone (Ladinian); 2 — calcirudite (lithocalcirudite); 3 — marlstone; 4 — limestone; 5 — partially dolomitized limestone; 6 — dolomite; 7 — tuff; 8 — tuffaceous breccia; 9 — tuffaceous marlstone with larger broken pyroclastic fragments; 11 — calcareous concretions.

The Upper Triassic

In Lika and Paklenica there is always an unconformity between the Middle and Upper Triassic. Basal deposits of the Upper Triassic are usually clastics (fig. 5, a) and only exceptionally dolomites. Clastics were established at numerous localities mainly in the depressions of paleokarst.

Upper Triassic clastic sediments have been analysed at Bunovac, Grgin Brijeg and partially at Velika Plana and Vratnik.

At all localities the Upper Triassic (the Carnian stage) begins with limestone conglomerates, unconformable to Middle Triassic sediments. Limestone pebbles dominate (mostly Middle Triassic limestone), but there are rare grains of quartz. The pebbles are often in concave-convex or sutured contacts. Matrix is sparse, and as to its composition, it is argillaceous and ferruginous or calcareous.

In the sequence limestone pebbles diminish, matrix becomes dominant, and these coarse limestone clastics pass to argillaceous calcilutites and calcareous shales with sparsely distributed pebbles. Red pigmentation dominates in Carnian clastics. In this part of the sequence at Bunovac admixtures of volcanic particles start, forming tuffaceous sediments and tuffs.

Tuffaceous pelites are represented by red calcareous shales with 17—49 % of $CaCO_3$. In them quartz, kaolinite, chlorite, plagioclase, hematite and traces of montmorillonite were identified by X-ray method. At the localities Velika Plana and Grgin Brijeg the clay mineral is more frequently illite than kaolinite, and feldspars do not belong to the high temperature type. Admixtures of medium grains of pyroclastic quartz and feldspars are always to be found.

Tuffaceous sandstones and breccias contain medium and coarse-grained pyroclastic particles (quartz and feldspar) mingled in all proportions with epiclastic materials.

Tuffs and volcanic breccias are crystal-vitric pyroclastics. They consist of fragments of volcanic quartz, plagioclases, particles of volcanic glass and of lithic tuff. Grains of epiclastic origine are rare. Matrix of volcanic glass is partially replaced by calcite. Pyroclastic particles are represented by fractured grains, angular chips, or resorbed grains. Quartz contains inclusions of gass or fluid and it is corroded with deep embayments filled with glass. Feldspars are plagioclases with 29—40 % An (andesine, rarely oligoclase). Measurements of feldspars were performed on the samples of Bunovac.

The higher part of the clastic series is characterized by a gradual reduction of pyroclastic components and by the domination of pelitic and calcareous sediments.

In the area of Grgin Brijeg, further on NNW of Velika Plana and at Vratnik the sequence of clastics is similar to that of Bunovac: first limestone conglomerates, then tuffaceous sandstones and pelites.

In Gorski Kotar petrographic investigations were performed in the surroundings of Gerovo, Crni Lug, Zelin Crnoluški, Tršće, Lokve, and Dedin. Here similarly to Lika, specific assemblage of red clastic rocks are also developed in the lower part, and calcareous rocks in the upper part, of the Carnian stage. At Gerovo, Lokve, and Crni Lug there are obvious alternations of medium and fine-grained clastic rocks and continuous transitions into dolomites. In the lower horizonts at Gerovo, Zelin Crnoluški and Dedin petromict and tuffaceous conglomerates are present, which, besides pyroclastic quartz and feldspars, contain numerous rock particles and therefore represent a coarse-grained equivalent of sub-graywackes. Among the rock particles limestones (of the Upper Permian and the Lower Triassic), cherts, quartzites, sandstones, low-grade schistes, were registered. The cement is calcite, fine to coarse-grained.

Sandstones are a very frequent member. They consist of: quartz, feldspars, grains of myrmekite, rock particles, chlorite and muscovite. Owing to a high content of feldspars ($> 20\ \%$) they may be classified as arkosic sandstones. Some of them are tuffaceous sandstones. Feldspars are identical with those of Velika Plana, Grgin Brijeg and Vratnik, i. e., anhedral or subhedral grains of albite, pink, clouded due to alternation, and sometimes replaced by calcite. They are found even more often than at the mentioned localities of Lika. Rock particles in some horizons exceed feldspars and, consequently, the sandstones are considered as sub-graywacke. The cementing material is iron oxid or carbonate (calcite or dolomite). Quartz cement, deposited as a secondary overgrowth on quartz grains, was registrated at Crni Lug (Malo Selo). Heavy minerals extracted from Carnian sandstones are: magnetite, hematite, ilmenite, zircon, tourmaline, rutile, corundum and traces of apatite, brookite, and garnet.

Pelitic sediments are interbedding with the sandstones. They are similar to those of Lika (for example at Grgin Brijeg), but often very dolomitic. They may continuously pass to compact dolomitic beds. Small quantities of sandy detritus are the same as in sandstones.

Alternating series of sandstones and pelites are gradually substituted by dolomites. Sandstones fall out first. As to polites, a change of pigment occurs first, i. e., instead of the red ones there are greyish-green and white-grey pelitic intercalations. In the lower part dolomites are argillaceous, fine-grained, and interbedded into the pelites. Then follow compact grey dolomites (fig. 5, b). They contain some sandy detritus, which desappears towards the top of the series. In sedimentary environment the change of redox potential from oxidizing to reducing is proved by the disappearing of hematite pigmentation and the presence of autigenic pyrite in grey pelites and dolomites.

The common characteristic of Upper Triassic dolomites is the fact that they are more or less uniform within a broad area including Lika and Gorski Kotar. Three general types may be distinguished:

a) Dolomites with an organic irregular laminated structure are rather widespread. This structure is ascribed to algal action (blue-green algae of the sediment-binding type). Interbedded are also algal calcarenites which represent a product of the mechanical deformation and fragmentation of the mentioned sediments.

b) The second type of dolomites are dolomitic calcarenites which have preserved more or less their primary texture of calcarenites depending on the degree of dolomitization or recrystallization.

c) Finally medium- to coarse-grained fully recrystallized dolomites are present which display a granoblastic texture forming a porous mosaic with anhedral or rhomboedral grains. These dolomites are genetically undefined.

Sequence of fossils

Remains of macrofossils are relatively rare in the investigated areas. In the Lower Triassic remains of *Anodontophora fassaensis* Wissmann were locally established. It is interesting to point out that Lower Triassic Ammonites have not been registered, though they are relatively frequent in Dalmatia and occur even in Northern Croatia. We have not established any emendation in this respect.

The most frequent macrofossils of the Middle Triassic in Lika are Ammonites themselves. Two famous localities were described by M. Salopek i. e., at Kunovac Vrelo and Donje Pazarište. At Kunovac Vrelo M. Salopek (1914) determined the following forms: *Ceratites (Popinites) bispinosus* Hauer var. *licanus* Salopek, *C. (Popinites) bosnensis* Hauer, *Proarcestes* cf. *quadrilabiatus* Mojs, *P.* ex aff. *boeckhi* Mojs., *P.* aff. *subtridentinus* Mojs., *P.* cf. *pannonicus* Mojs., *Pinacoceras* ex aff. *damesi* Mojs., *Gymnites palmai* Mojs.. *G.* ex aff. *humboldti* Mojs.. *G.* cf. *bosnensis* Hauer, *G.* cf. *incultus* Mojs.. *Ptychites flexuosus* Mojs., *Pt. profugus* Salopek, *Pt. acutus* Mojs., *Pt.* cf. *uhligi* Mojs., *Pt.* ex aff. *eusomus* Beyr. and *Pt. garjanović-krambergeri* Salopek. Also determined were Nautiloids: *Pleuronautilus mosis* Mojs., *Mojsvaroceras* aff. *bulogense* Hauer and *Orthoceras campanile* Mojs. Though this fauna was rich it has been impossible to draw an obvious limit between the Anisian and the Ladinian stage. M. Salopek considers the mentioned fauna a transient one, with more inclination to consider it the basis of the Ladinian (Buchenstein beds). At Donje Pazarište M. Salopek (1918) determined *Dinarites dinaricus* Salopek, *Halilucites haugi* Salopek, *H.* aff. *obliquus* Hauer, *H.* aff. *plicatus* Hauer, further on, remains of the genera *Arcestes*, *Ptychites*, and Nautiloid *Orthoceras*. The age has been determined as Ladinian.

We found also some Ammonites in the area of Velika Vršina near Sv. Rok. But the remains were not favourable for determination. It is interesting that a remain very similar to *Ceratites trinodosus* Mojs. was found in the higher part of the Ladinian. Whether it was brought by flow or should we rather believe that *C. trinodosus* has a broader stratigraphical range, this will remain unsolved.

Exceptionally, the plant *Voltzia recubariensis* Schenk is found in Ladinian clastics (M. Herak 1965b).

In Upper Triassic sediments mainly the *Megalodontidae* have been established so far. No detailed investigations have been performed.

Our attention was mainly paid to microfossils. In connection with the Lower Triassic, we have only to cite V. Kochanski-Devidé and S. Pantić (1966), who compiled the data of the Foraminifer *Meandrospira iulia* (Premoli Silva). This Foraminifer probably appears already in the lower part of the Scythian (at Lokvarske Laze in Gorski Kotar together with *Anodontophora fassaensis* Wissmann and *Ammodiscus*), but it usually frequently occurs in the Upper part of the Scythian stage accompanied by *Ammodiscus incertus* (d'Orb.), rarely *Frondicularia woodwardi* Howchin, further on, Ostracods etc. So far we have not established any determinable calcareous algae.

On the contrary, in the Middle Triassic calcareous algae represent the most applicable fossil group for stratigraphical determination.

The family Dasycladaceae occupies the dominant place among them. The forms established in the investigated areas may be seen in table 1. It is visible that numerous forms are present only in the Anisian, and others only in the Ladinian. By means of them it has been possible to draw the limit between these two stages in spite of lithological similarity or even identity. This fact has been most important for local stratigraphy in Lika because other fossils applicable to this purpose are absent or very rare. Some forms are found in both stages but, nevertheless, they are very useful for establishing the limit between the Middle and the Upper Triassic.

Although dasyclad algae are excelent index fossils, our results show that their stratigraphical range is more or less larger then it was considered. They are mostly not confined within the substages.

Beside dasyclad algae in the Middle Triassic, some foraminiferal forms are also present. Among them very useful index fossils are *Meandrospira dinarica* Kochansky-Devidé and Pantić. established at numerous localities in Lika. *Pilammina*

Table 1. Triassic Calcareous Algae of SW Lika, Paklenica and Gorski Kotar

	Anisian	Ladinian	Upper Triassic
Chlorophyta — *Dasycladaceae:*			
Teutloporella herculea		····——	
Teutroporella triasina		—	
Teutroporella tabulata	——		
Teutroporella nodosa	——	——	
Macroporella beneckei		——····	
Macroporella alpina	- - -——		
Macroporella perforatissima?	+		
Gyroporella cf. *ampleforata*		—	
Gyroporella maxima		—	
Gyroporella vesiculifera			——
Oligoporella pilosa var. *pilosa*	—		
Oligoporella pilosa var. *varicans*	- ——		
Oligoporella pilosa var. *semivaricans*	—		
Oligoporella pilosa var. *intusannulata*	····—		
Poikiloporella duplicata	+		
Physoporella likana	? +	?	
Physoporella pauciforata var. *pauciforata*	———		
Physoporella pauciforata var. *undulata*	—		
Physoporella varicans	—		
Physoporella prealpina	—		
Physoporella croatica	+		
Physoporella pauciforata var. *undulata*	—— —		
Physoporella lotharingica	······	—	
Diplopora annulata		? ——	
Diplopora annulatissima	——	———	
Diplopora hexaster subsp. *hexaster*	——		
Diplopora hexaster subsp. *helvetica*	+		
Diplopora subtilis var. *subtilis*	—		
Diplopora proba	—···		
Diplopora philosophi	+		——
Griphoporella curvata	+		
Acicularia			
Rhodophyta:			
Thaumatoporella			+
Cyanophyta:			
Sphaerocodium bornemanni			———

——————— frequent; — — — — — rare; . . . . probable;
+ present in undetermined horizon

semiplana Kochansky-Devidé and Pantić, and *Pilammina densa* Pantić, all established only in Anisian sediments.

Upper Triassic sediments contain relatively rare fossil remains applicable to a detailed stratigraphical classification.

Only two forms of dasyclad algae have been established, i. e., *Gyroporella vesiculifera* (Gümbel) and *Griphoporella curvata* (Gümbel), both near one another in Norian limestones.

Representatives of blue-green algae, mostly *Sphaerocodium bornemanni* Rothpletz. are more frequent in Upper Triassic dolomites. Recent investigations have shown that they are present in different horizons of the Upper Triassic and that their abundance depends more on the facies then on the horizon. They are most frequent in dolomites following clastics (M. Herak 1952, 1957, I. Gušić, V. Jelaska and D. Nenadović 1965).

In the recent time the genus *Thaumatoporella* (red alga) has also been established in the Upper Triassic, which means a further enlargement of its stratigraphical range.

Reconstruction of geological processes

The Pfalzian orogenetic phase between the Permian and the Triassic was active more or less in Lika and Northern Dalmatia as well as in Gorski Kotar. Hence either an unconformity between these two systems or a mere change in the sedimentation characterizes the limit between them. Subsequent geologic history in the mentioned three areas is uniform in general, but different in detail.

In SW Lika a continuous sedimentation had occurred until the end of the Ladinian. During the Lower Triassic there was a rhythmic change of terrestrial clastics and intrabasinal carbonate sediments, as well as a mingling of particles of both terrestrical and subaqueous origin. The source area of detritical material was a more distal and mildly lifted continent. Hence the fine-grained and well sorted particles. Types of heavy minerals, as well as their morphological features (roundness of some resistant minerals) suggest that source rocks were, at least partially, preexisting sediments. The existence of subangular grains of zircon, tourmaline, rutile, apatite, epidote, and garnet suggests an origin from acid igneous and metamorphic rocks.

As stated before, between the Lower and the Middle Triassic there were no interruptions in sedimentation. During the Anisian there were more or less quiet environments with carbonate sedimentation and with some sporadical local accumulation mainly of pelites, and, near at the beginning of the upper Anisian, also of carbonate pebbles.

During the Ladinian, conditions were changed in the sense that clastic lenses (deposited locally) were a product of increasingly unstable tectonic conditions. Along new fractures smaller submarine flows on the sea floor occured, concurrently with sedimentation. In the investigated areas of Lika volcanic activity was of explosive nature, which resulted in the sedimentation of pyroclastic rocks (acid tuffs) and anabled the formation of siliceous sediments (Radiolarian chert), as well as of hybrid (mixed) ones. During the intervals of the cessation of volcanic activity there was a normal sedimentation of detrital calcareous rocks. The existence of phases of relative quietness is proved by skeletons of calcareous algae, which are present in limestones and rarely in dolomites and fine-grained sandstones. Minute as they are, they are not damaged to a greater extent. Carbonate sedimentation in larger areas of Lika testifies that tectonic changes were limited to individual places.

Near the end of the Ladinian, diastrophic movements resulted in the emergence of all the investigated country.

The consequence is an unconformable relation between the Middle and Upper Triassic. The latter starts usually by the sedimentation of clastics, which are partial products of explosive volcanic activity (primary tuffs) and of an erosion of preexisting sediments or a relief of acid igneous rocks emerging by some orogenetic movements. The compositional immaturity implies an accelerated erosion. The uplift was accompanied by volcanic ejecta (pyroclastic particles mingled with ordinary sedimentary detritus). The rising movements, as well as the volcanic activity, were not continuous.

The decreasing volume of clastic and pyroclastic sediments and the domination, first of all, of pelitic sediments, and then of carbonate rocks in the Upper Triassic, indicate the quiescence of movements and volcanism, flat relief, and tectonical stable conditions of sedimentation.

In the area of the Velika Paklenica the difference of geological activity during the Triassic is visible especially in the reduced sedimentation of Ladinian deposits, which were completely eroded before the sedimentation of the Carnian occurred. Therefore Carnian deposits lie unconformably directly on the Anisian ones.

All visible data concerning lithostratigraphical sequence in Lika and Velika Paklenica suggest a conception of relative authochthony. The inverse attitude of stratigraphical members is noticed only exceptionally.

In Gorski Kotar, on the contrary, obvious allochthony has been recognized, which make difficult the reconstruction of paleogeographical relations in some districts. Inverse relations have been established in the wider surroundings of Gerovo, normal ones at Crni Lug, Zelin Crnoluški, and Lokve. Nevertheless, at all the mentioned localities the Scythian stage has been recognized. The presence of the Middle Triassic is still in question. The uplift of the territory occurred most probably, and hence the conception of a hiatus in marine sedimentation during the Middle Triassic. The presence of Permian pebbles and of fragments of Scythian oolithic calcarenite in Carnian conglomerate at Gerovo and Crni Lug speaks in favour of such a conception.

In general, in the explored areas the reduction of Triassic sediments increases from SW to NE. Consequently, in that direction we have to look for source areas of terrestrial components of Triassic clastics. This conclusion is in accordance with the results of the exploration of NE Lika performed by M. Šušnjar and his collaborators.

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