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UPPER PERMIAN DEPOSITS OF THE JADAR REGION AND THEIR POSITION WITHIN THE WESTERN PALEOTETHYS

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ABSTRACT

Recent investigations in Jadar region, West Serbia, enabled the recognition of seven levels within the Upper Permian limestone series: *Edmondia permiana* beds, «*Productiis*» limestones, richthofenian bioherms, calcisponge beds, *Waagenophyllum indicum* horizon, *Notothyris* beds and bryozoan-coral-Be/ferop/iorc-echinoderm limestones. Carbonate platform with similar environmental conditions can be reconstructed from Jadar region towards Central Slovenia and Bukk Mts. in Hungary.

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RIASSUNTO

Ricerche sono state recentemente compiute nel Permiano superiore della Serbia occidentale, affiorante lungo il fiume Jadar (affluente di destra della Drina) (figg. 1-2). Tale successione poggia su arenarie e siltiti equivalenti della Fm. di Val Gardena e passa gradualmente, nella parte sommitale, al Trias inferiore. Vi sono state riconosciuti sette orizzonti, con: 1) strati ad *Edmondia permiana* e microfacies ad Alge (*Mizzia*, *Vermiporella*, *Gymnocodium*) e Foraminiferi (*Agathammina*, *Hemigordius* e *Globivalvulina*); 2) calcari a «*Productus*» e ad altri Brachiopodi e microfacies con Alge (*Permocalculus*, *Rectoglandulina*); 3) bioerme a *Richthofenia*; 4) strati a Calcisponge e *Bellerophon*; 5) un orizzonte a Coralli (*Waagenophyllum indicum*); 6) ulteriori strati a Brachiopodi (*Notothyris*); 7) calcari a Briozoi, Coralli *Bellerophon* ed Echinodermi. Nell'unità 2 e in quelle seguenti sono stati rinvenuti numerosi Foraminiferi riferibili a *Reichelina*, *Codonofusiella* e *Robuloides*.

Questa sequenza di piattaforma carbonatica è paragonata e correlata con quella della Slovenia centrale (Zazar) e dei M. Bukk in Ungheria.

A Zazar, ove è assai più potente (fig. 3), essa inizia con un orizzonte a *Palaeofusulina* al disotto di quello ad *Edmondia* e presenta livelli a *Comelicania* (Brachiopodi) subito al disopra dell'orizzonte a *Waagenophyllum indicum*. La presenza di *Comelicania* indica l'esistenza di comunicazioni col bacino Sud-Tirolese.

Una successione simile (senza però *Palaeofusulina*), con talvolta diverse posizioni dei vari orizzonti, è riportata dalla bibliografia per i M. Bükk. La fauna a Brachiopodi ungherese ha il 30% di forme in comune con quella della regione di Jadar (tab. 1) ed è costituita prevalentemente da tipi appartenenti al «gruppo Indo-Armeno» con in aggiunta il genere *Comelicania*.

L'affinità delle successioni del Permiano superiore dello Jadar, di Zazar e dei M. Bükk può essere spiegata con l'originaria vicinanza delle tre aree.

Vengono poi fatte osservazioni schematiche sul Permiano superiore delle Caravanche (Slovenia), del Velebit (Croazia), di Praca (Bosnia) e del Montenegro, ove l'orizzonte a *Comelicania* di Niksic-Zupa può essere correlato con quello di Zazar in Slovenia.

KEY WORDS: *western Paleotethys, Upper Permian, biostratigraphy, correlation, Yugoslavia, Hungary, Jadar Development (western Serbia), Zazar Development (central Slovenia), Bukk Development (Hungary).*

WESTERN SERBIA (JADAR DEVELOPMENT)

The most completely developed Upper Permian sediments in Western Serbia are exposed in the middle course of the Jadar (a right Drina tributary) River. Using the well known geologic and paleontologic features of this area, SIMIĆ (1933) introduced the term «Jadar development» for this type of Upper Permian sediments.

The entire Paleozoic of the area, from Valjevo northward to Pocerina, and from Podrinje Mts. eastward to Slovački Visovi heights, consists of Upper Permian sediments. The most instructive sections through these sediments are those at NE slopes of the Sokolska Planina, Jagodnja, and Medvednik mountains, in the general areas of Krupanj, Bela Crkva (Bastavsko Brdo), the Obnica river downstream area, and the Vlašić Mt.

Upper Permian limestones are the best expressed lithologic member, more than hundred metres thick, overlying various sandstones, shales, and siltstones (Grodan equivalents). Stratified fossiliferous Upper Permian limestones are noted to gradually pass into light-gray or ruby stratified limestones of the Lower Triassic.

Through a detail examination, primarily of macrofauna, SIMIĆ (1933) distinguished Edmondian, Productoid, and Coral-bearing zones in the Upper Permian of the Jadar region. Additional investigation resulted in the recognition of seven horizons clearly distinguished in several localities in the region.

The Middle/Upper Permian border in the Jadar region is characterized by dolomitic sediments and shales. In the area of Dolovsko Brdo and Kostajnik, *Mizzia comuta* KOCHANSKY & HERAK and *Permocalculus tenellus* PIA are found in dolomitic limestones.

The Upper Permian deposition begins with more or less well stratified limestones intercalated with gray or purple sandy shales. Limestones are mostly bituminous, composed of fine crystalline calcite, bearing scarce algae and microfauna: *Mizzia velebitana* (SCHUBERT), *Gymnocodium bellerophontis* (ROTHPLETZ), *G. nodosum* O. GORDON, *Agathammina*, *Hemigordius*, *Globivalvulina*. Among macrofossils, *Edmondia permiana* is prevailing, used by SIMIĆ (1933) to introduce the Edmondian zone within Upper Permian limestones. The most instructive outcrops of

these sediments are located in the general area of Krupanj (Obradovici, Tomino Brdo Sklop).

These rocks are overlain with flaglike light-gray dolomitic and marly limestones intercalated with shales and siltstones abounding in macro- and micro-fauna. Brachiopods are dominant among the macrofossils, and are used in determining the «*Productus*» horizon. Specimens of *Tyloplecta*, *Tschernyschewia*, *Orthoietes*, *Derbya*, *Spinomarginifera*, *Leptodus*, and some other genera are the most abundant (see the comparative list of table 1). Calcareous algae also occur in this horizon. Brachiopod fauna occurs only in several strata; it is presumed to have had a hasty appearance, quick bloom and, also, sudden extinction. SIMIĆ (1933) finds the «*Productus*» horizon to be sharply limited, without productoid brachiopods both above and under these strata. Unlike these, calcareous algae are abundant in nearly all Upper Permian horizons in the Jadar region. Several localities, such as Zmajevac, Peovac, Bastavsko Brdo, Crikvenac, and Zlataric, have an extremely rich oryctocenosis with brachiopod fauna. Among microfossils, *Geinitzina*, *Pachyphloia*, and *Hemigordius* are abundant, and calcareous algae: *Vermiporella nipponica* ENDO, *Gymnocodium bellerophontis* (ROTHPLETZ), and *Permocalculus fragilis* PIA.

Several metres thick biohermal limestones, with abundant *Richthofenia*, lie over the «*Productus*» horizon, well exposed at Peovac, Zmajevac, and in the Tamnava River valley near the mouth of the Klenovica. Light-gray to pink limestones crop out at the last mentioned locality. Because of wedging, they seem to be intercalated within the Upper Permian series. Their extent is difficult to estimate due to the rich vegetation and complex tectonic fabric. Besides *Richthofenia*, these sediments contain solitary corals, crinoids, sponges, hydrozoans, foraminifers, and elongated forms of *Dentalium*.

The overlying sediments are represented by several metres thick series with calcareous algae and sponges. *Notothyris* occurs in these sediments at Peovac and Zmajevac. The horizon is named after the calcisponge beds which are also frequent in many localities of the region.

Upwards in the stratigraphic column limestones pass into flaglike limestones in-

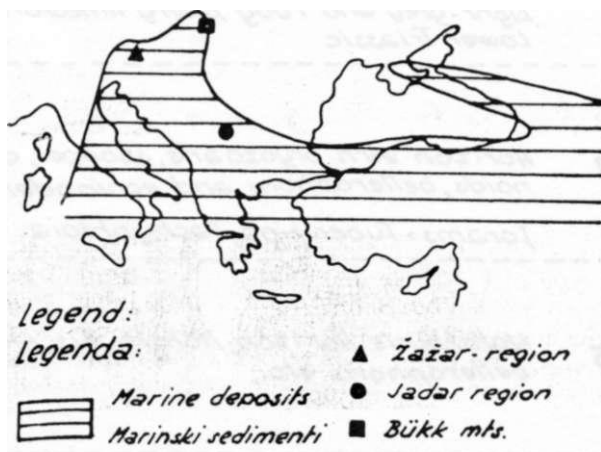


Fig. 1 - Paleogeography of SE Europe during Upper Permian (partly after NAIRN & SMITHWICK, 1976).

cluding coral banks with *Waagenophyllum indicum* WAAGEN, together with algae, bellerophons, foraminifers, etc.

An instructive section of black, flaglike, bituminous limestones, exposed near the Konjusica River mouth in the Jadar River valley, reveals abundant *Notothyris*, *Spiriferua*, and *Permocalculus*.

These sediments are overlain with black argillaceous and sandy limestones with bryozoans, corals, bellerophons and echinoids, and, in the uppermost part, with light-bluish or pink stratified limestones poor in fossils, which mark the beginning of Triassic sedimentation.

From the upper Upper Permian (from «*Productus*» horizon to the Triassic) in the localities of Peovac and Blizonjski Vis, PANTIC (1969) determined many foraminifers: *Agathammina*, *Hemigordius*, *Pachyphloia*, *Nodosaria*, *Reichelina*, *Codonofusiella*. Species of calcareous algae found are the following: *Permocalculus fragilis* (PIA), *Gymnocodium bellerophontis* (ROTHPLETZ), *Vermiporella nipponica* ENDO, and *Atractyliopsis* sp.

CENTRAL SLOVENIA (2A2AR DEVELOPMENT)

Upper Permian deposits in central Slovenia show a great similarity with the sediments of Jadar region. They lie on sandstones and shales with intercalations of yellowish-brown dolomites, representing an equivalent of the upper Groden beds. Similar sediments are developed under the Upper Permian complex in the Jadar region.

Upper Permian deposition begins in central Slovenia with a *Palaeofusulina* horizon with brachiopod fauna of Caucasian type (*Spinomarginifera*, *Linoproductus*).

These are overlain with limestones bearing *Edmondia permiana*, succeeded by *Tyloplecta* horizon with a *Tschernyschewia* level in the upper part of the horizon.

These sediments are overlain in several places with richthofenian bioherms of various shapes and sizes. *Richthofenia* is always associated with large bryozoans, while *Notothyris* is a common brachiopod.

These deposits lie under a biostrome with *Waagenophyllum indicum*, some 20 cm thick, which had a large distribution during the Upper Permian in the region of central Slovenia. Fauna of this horizon is Asian in character and most of it can be compared with analogous fauna in western Serbia. Nearly fifty percent of the common species occur in the «*Productus*» horizon (see the comparative list of table 1). However, *Palaeofusulina* and tabulate corals have not been found in the Jadar region, while *Richthofenia* always occurs below the coral horizon (see columnar sections in figs. 2 and 3).

Coral biostrome is overlain with a horizon with South-Tyrolian type of fauna (*Comelecania* sp. div.) which indicates a short communication with this sedimentation basin. This horizon is not developed in western Serbia.

The upper part of the limestone series notably differs from the uppermost Permian sediments in the Jadar region. Brachiopod fauna is mixed (South-Tyrolian/Indo-Armenian) and gradually dies out. Three horizons can be distinguished. The horizon with calcareous algae, foraminifers, bellerophons, and echinoderms has the greatest thickness and extent. A similar horizon, only some 20 m thick, occurs in places in the Jadar development near the Triassic boundary.

The Upper Permian terminates with a thin horizon containing sulphur bulbs, which has been described only from Slovenia, and a thin dolomitic limestone horizon with calcareous algae and sporadic *Waagenophyllum* sp.

Triassic boundary is clearly marked by a thin clay or marl intercalation. Porous dolomites and light-gray flaglike dolomites overlying this intercalation were earlier assigned to the uppermost Permian (RAMOVŠ, 1958).



Fig. 2 - Schematic column Upper Permian from Jadar area.

NE HUNGARY (BUKK Mts.)

The Upper Permian Nagyvisnyo Limestone Formation of the Bukk Mts. is underlain by the lagoonal, sandstone-shale-evaporite-dolomite sequence of the Szentlelek Formation, from which it develops with a gradual transition.

BALOGH (1964), who already emphasized its great similarity with the Zazar and Jadar developments, distinguished on the basis of fossil-content 6 horizons in it:

1. Horizon with calcareous algae, forams and *Oxytoma*.

It is necessary to mention here, however, that calcareous algae (*Gymnocodium bel-*

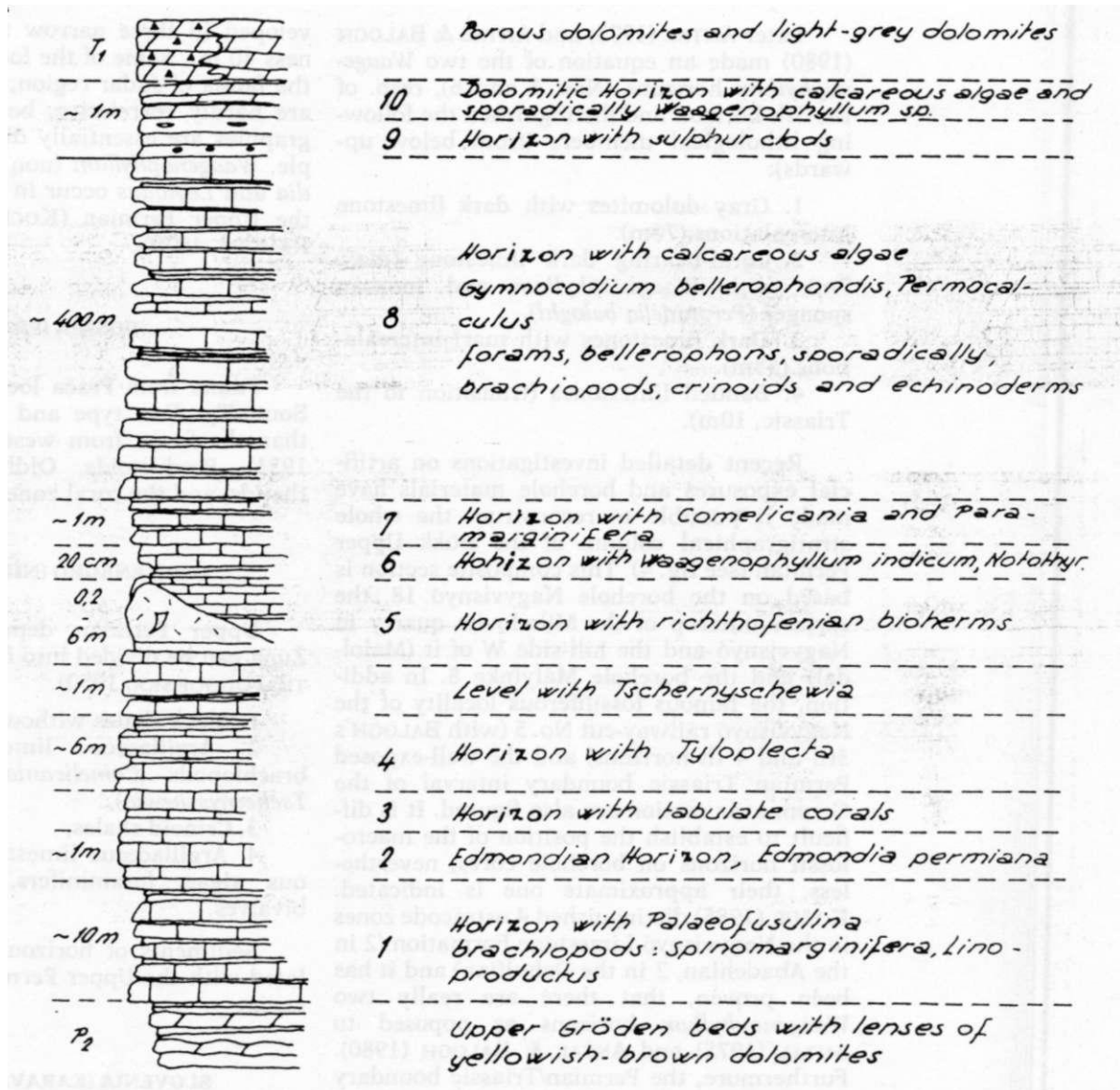


Fig. 3 - Schematic column Upper Permian from central Slovenia.

lerophontis, *Mizzia velebitana*, *Permocalculus fragilis*, *P. tenellus*, *Vermiporella nipponica*, *V. serbica* and others) and small forams occur throughout the sequence of the Nagyvisnyó limestone.

2. *Nautiloidea*-*Waagenophyllum* horizon, with *Waagenophyllum indicum*, *Tyloplecta yangtzensis*, *Bellerophon* sp., *Brachycycloceras? cyclophorum*, *Tirolonutilus* sp.

3. *Edmondia*-*Nautiloidea* horizon with *Edmondia permiana*, *Brachycycloceras? cyclophorum*, *Pseudorthoceras? obliqueannulatum*,

Tainoceras sp., *Tirolonutilus* sp., *Oxytoma wahnneri*, *Bellerophon* sp.

4. *Tschernyschewia*-*Leptodus* horizon with a very rich brachiopod fauna (see comparative list of table 1, among them *Leptodus nobilis*, *Comelicania vultur*, *Notothyris warthi buekkensis*, *Richthofenia* sp.) and a few trilobites (*Pseudophyllipsia hungarica*).

5. *Waagenophyllum* horizon with *W. indicum*, *Bellerophon* sp., *Temnocheilus? sp.*

6. Banded limestone horizon (transition to the Triassic).

Later ANTAL (1975) and ANTAL & BALOGH (1980) made an equation of the two *Waagenophyllum* horizons (Nos. 3 and 6), resp. of the 5th horizon and distinguished the following lithological members (from below upwards):

1. Gray dolomites with dark limestone intercalations (70'm).
2. Coral-bearing dark limestone (max. 7m), with *Waagenophyllum* and inozoan sponges (*Peronidella baloghi*).
3. Dark limestones with marl intercalations (55m).
4. Banded limestones (transition to the Triassic, 10m).

Recent detailed investigations on artificial exposures and borehole materials have made it possible to reconstruct the whole stratigraphical column of the Biikk Upper Permian (see fig. 4). This composite section is based on the borehole Nagyvisnyo 18, the surface outcrop of the Mihalovits quarry in Nagyvisnyo and the hill-side W of it (Maloldal) and the borehole Malyinka 8. In addition, the famous fossiliferous locality of the Nagyvisnyo railway-cut No. 5 (with BALOGH'S 3rd and 4th horizons) and the well-exposed Permian Triassic boundary interval of the Gerennavar section are also figured. It is difficult to establish the position of the macrofossil horizons on borehole cores, nevertheless, their approximate one is indicated. KOZUR (1985) distinguished 4 ostracode zones in the Nagyvisnyo Limestone Formation (2 in the Abadehian, 2 in the Dzhulfian) and it has been proven, that there are really two *Waagenophyllum* horizons as opposed to ANTAL (1975) and ANTAL & BALOGH (1980). Furthermore, the Permian/Triassic boundary lies about 6m above the lithostratigraphical one (with a few cm thick sandy-marly horizon) in the Gerennavar section (see fig. 4). The «banded limestone horizon» of BALOGH (1964), however, already belongs to the overlying, mostly oolitic lowermost Triassic Gerennavar Limestone Formation and its banded nature was caused by metamorphism.

CROATIA (VELEBIT MT.)

In the area of Mt. Velebit and Lika district, the Middle and Upper Permian are represented by dolomites. Limestones are de-

veloped in three narrow zones (max. thickness 40 m). Some of the fossils correspond to the fauna of Jadar region, but the two arecs are hardly correlative, because their stratigraphies are essentially different. For example, *Waagenophyllum* (non *indicum*), *Edmondia* and *Leptodus* occur in the Middle, not in the Upper Permian (KOCHANSKY-DEVIDE & RAMOVŠ, 1979).

BOSNIA (PRAČA)

Fauna from Prača locality, Bosnia, is of South-Tyrolian type and generally younger than the fauna from western Serbia (SIMIĆ, 1933). Productoids, Oldhaminoids, Orthothetids, and the coral zone are missing.

MONTENEGRO (NIKŠIĆ ŽUPA)

Upper Permian deposits from Nikšić Župa can be divided into four horizons (KOSIĆ-PODGORSKA, 1950).

1. Black shales without fossils,
2. Argillaceous limestones with few brachiopods (*Comelicania*, *Paramarginifera*, *Tschernyschewia*),
3. Crinoid shales,
4. Argillaceous limestones with calcareous algae, foraminifers, gastropods, and bivalves.

Sediments of horizon (2) can be correlated with the Upper Permian of central Slovenia.

SLOVENIA (KARAVANKE MTS.)

The Upper Permian in Slovenian part of the Julian Alps and Karavanke Mts. is developed in a dolomitic facies with evaporites, and shows no similarity with Jadar region. A similar development is described in the Julian Alps on the territory of Yugoslavia.

GREECE (HIDRA ISL.)

In gray and black stratified limestones of the Upper Permian at Hydra and some other localities, *Palaeofusulina*, *Tyloplecta*, *Leptodus*, *Waagenophyllum*, and *Reichelina* have

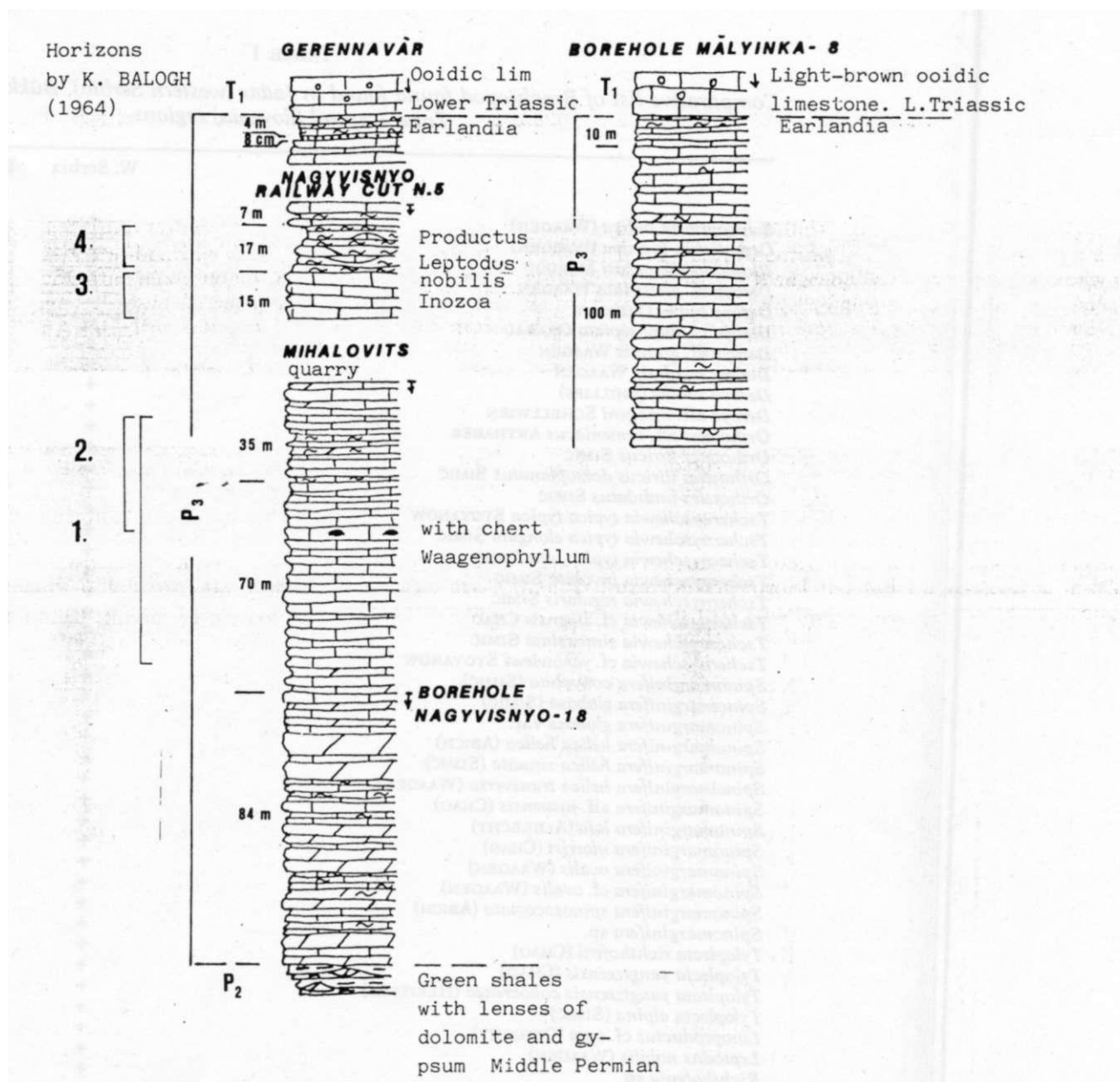


Fig. 4 - Composite section of the Bukk Upper Permian.

been found, suggesting likely associations with Zazar and Jadar developments. Unfortunately, detailed horization of the deposits has not been made.

SUMMARY

Over hundred metres thick series of Upper Permian sediments lies in Jadar re-

gion over Middle Permian clastic deposits. Bedded bituminous or biohermal carbonate sediments predominate, sporadically containing intercalations of shales and siltstones. Carbonate sedimentation continues into the Lower Triassic.

Recent investigations enabled a reconstruction of the detailed stratigraphic column with seven fossiliferous horizons:

TABLE 1

Comparative list of Brachiopod fauna found in Jadar (western Serbia), BiXkk Mts. (Hungary) and Zazar (central Slovenia) regions

	W. Serbia	Hungary	Slovenia
<i>Schizophoria indica</i> (WAAGEN)	+	+	+
<i>Orthotichia incisiva</i> (WAAGEN)	+		+
<i>Rhipidomella pecosi</i> MARCOU	+	+	
<i>Derbya</i> cf. <i>altestriata</i> WAAGEN	+		
<i>Derbya bucht</i> ORBIGNY	+ •	+	
<i>Derbya</i> cf. <i>dupliseptata</i> GRABAU	• +		
<i>Derbya</i> cf. <i>grandis</i> WAAGEN	+	+	
<i>Derbya regularis</i> WAAGEN	+	+	
<i>Derbya senilis</i> (PHILLIPS)	+	+	
<i>Derbya</i> äff. <i>waageni</i> SCHELLWIEN	+		
<i>Orthotetes</i> äff. <i>armeniacus</i> ARTHABER	+		
<i>Orthotetes iliricus</i> SIMIC	+		
<i>Orthotetes iliricus dorsoplanatus</i> SIMIC	+		
<i>Orthotetes iindulatus</i> SIMIC	+		
<i>Tschemyschewia typica typica</i> STOYANOW	+	+	+
<i>Tschemyschewia typica elongata</i> SIMIC	+	+	+
<i>Tschemyschewia typica lata</i> SIMIC	+	+	+
<i>Tschemyschewia involuta</i> SIMIC	+	+	+
<i>Tschemyschewia regularis</i> SIMIC	+		+
<i>Tschemyschewia</i> cf. <i>sinensis</i> CHAO	+		+
<i>Tschemyschewia sinuissima</i> SIMIC	+		+
<i>Tschemyschewia</i> cf. <i>yakowlewi</i> STOYANOW	+	+	+
<i>Spinomarginifera convoluta</i> (SIMIC)	+		+
<i>Spinomarginifera globosa</i> (SIMIC)	+		+
<i>Spinomarginifera globosa</i> var.	+		
<i>Spinomarginifera helica helica</i> (ABICH)	+	+	+
<i>Spinomarginifera helica sinuata</i> (SIMIC)	+		
<i>Spinomarginifera helica transversa</i> (WAAGEN)	+	+	
<i>Spinomarginifera</i> äff. <i>jusuensis</i> (CHAO)	+		
<i>Spinomarginifera lata</i> (ALBRECHT)	+		+
<i>Spinomarginifera morrissi</i> (CHAO)	+		
<i>Spinomarginifera ovalis</i> (WAAGEN)	+		+
<i>Spinomarginifera</i> cf. <i>ovalis</i> (WAAGEN)	+		
<i>Spinomarginifera spinosocostata</i> (ABICH)	+		+
<i>Spinomarginifera</i> sp.	+		
<i>Tyloplecta richthofeni</i> (CHAO)	+		+
<i>Tyloplecta yangtzeensis</i> (CHAO)	+		+
<i>Tyloplecta yangtzeensis callocrenea</i> (HERITSCH)	+	+	+
<i>Tyloplecta alpina</i> (SIMIC)	+		+
<i>Linoproductus</i> cf. <i>cora</i> (ORBIGNY)	+	+	+
<i>Leptodus nobilis</i> (WAAGEN)	+	+	+
<i>Richthofenia</i> sp.	+	+	+
<i>Spiriferina omata</i> WAAGEN	+		
<i>Reticularia lineata</i> MARTIN	+	+	
<i>Notothyris dienen</i> SIMIC	+		+
<i>Notothyris minuta</i> WAAGEN	+		+

- horizon with *Edmondia permiana*;
- «*Productus*» horizon;
- horizon with richthofenian bioherms;
- calcisponge horizon;
- *Waagenophyllum indicum* horizon;
- *Notothyris* horizon;
- horizon with bryozoans, corals, bellerophonids, and echinoderms.

Great similarity with Upper Permian sediments in central Slovenia (Zazar region) has been observed. Recent investigations of the brachiopod fauna has indicated more than fifty percent of common species. Some differences are noted in the lowermost part of the column (*Palaeofusulina* and rugose corals are not found in western Serbia). The

horizon with *Comellicalla* in Slovenia indicates an opening of the communication with the South-Tyrolian sedimentation basin.

A similar development, only with somewhat different position of horizons, has been described from the Upper Permian of the Biikk Mts. in Hungary. Brachiopod fauna is very similar (37 percent of species is common) with the fauna from Jadar region (tab. 1). Brachiopods predominantly belong to Indo-Armenian group, with the addition of South-Tyrolian genus *Comellicania*.

The connection of the Biikk Late Paleozoic to the Dinarides was formerly explained through the narrow, hypothetical «neck» of the so-called «Igal-Bukk eugeosyncline». This zone is interpreted now, however, as a transform fault zone, along which southern and northern Tethyan units got into an inverse position (see Kovacs & Peró, 1983 and Brezsnianszky & Haas, 1985). Therefore the conspicuous similarity of the Jadar, Zazar and Biikk Permian developments can be explained by their original proximity.

During the Upper Permian, the whole of Southeastern Europe formed a carbonate platform with more or less similar environmental conditions. The discovery of *Comellicania* in «*Productus*» limestones of Montenegro is strongly suggesting that a South-Tyrolian gulf, in middle Late Permian, extended southwards to the area of Montenegro leaving aside the Jadar region in the east.

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