Geologia Croatica	58/1	1–19	4 Figs.		5 Pls.	ZAGREB 2005

Equatorial Shelf of the Palaeozoic Supercontinent – Cradle of the Adriatic Carbonate Platform

Jasenka **SREMAC**

Key words: Pangaea, Palaeotethys, Equatorial shelf, Carbonate platform, Carbonate producers, Palaeozoic, Croatia.

Abstract

During the Carboniferous and Permian, several carbonate platforms existed along the eastern coast of the supercontinent Pangaea. Croatian Palaeozoic carbonate sediments were produced in this "carbonate factory". The dominant skeletal carbonate producers were calcareous algae, with assistance from foraminifera, molluscs, brachiopods and crinoids. Sporadically, reef structures were built by calcisponges, bryozoans, algal and cyanobacterial encrusters. Variscan and post-Variscan tectonic events strongly influenced the platform existence through uplift and deposition of molasse sediments, while a global catastrophe at the Permian/Triassic boundary only changed the biotic carbonate producers. A significant input of terrestrial material during the Lower Triassic, due to uplift and/or global regression, altered the mode of sedimentation along the shallow Palaeotethyan shelves. Platforms were partly restored during the Middle and Upper Triassic, and existed with short interruptions till the Middle Eocene.

1. INTRODUCTION

Carbonate sediments have been deposited in oceans and seas from the Proterozoic up to the present day. Their palaeogeographic distribution, extent and composition changed substantially through time. Recent carbonate platforms are closely linked with reef constructions, but, during the past, non-reefal carbonate production played an important role in the periods of the depressed reef-growth (KIESSLING et al., 2003).

Under the term "carbonate platform" in Croatia we usually consider the sedimentary environment in the Karst Dinarides from the Late Triassic up to the end of Cretaceous, or even to the Middle Eocene. Nevertheless, the first evidence of shallow-water carbonate platform sedimentation in the western part of equatorial Palaeotethys is related to the Late Viséan (Fig. 1A), with ooids, crinoids and small foraminifera as carbonate producers (VELIĆ et al., 2002; KIESSLING et al., 2003).

Department of Geology and Palaeontology, Faculty of Science, University of Zagreb, Ul. kralja Zvonimira 8, HR-10000 Zagreb, Croatia; e-mail: jsremac@inet.hr

The Late Carboniferous–Early Permian period is defined as the lower cycle of Late- to Post-Variscan sedimentation (KRAINER, 1993; ALJINOVIĆ & TIŠLJAR, 2001). Transgressive–regressive clastic–carbonate sediments from this period reflect the eustatic sea-level fluctuations caused by the Gondwana glaciation.

During the upper cycle (Middle–Late Permian to Early Triassic) sedimentation patterns were more uniform, with similar sedimentary sequences developed in the Southern Alps, Eastern Alps and Dinarides (Fig. 3) (KRAINER, 1993). Carbonate platforms existed in the western part of equatorial and subequatorial Palaeotethys (Fig. 1B) (KIESSLING et al., 2003). Terminal Permian catastrophic event, although killing a high percentage of living taxa on land and in the oceans, did not cause a significant reduction of the carbonate platforms, but Lower Triassic platforms were formed without the contribution of reefal debris. Grains and micrite on the platform were formed by the activity of disaster biota – microbes (cyanobacteria).

2. CARBONIFEROUS AND PERMIAN PALAEOGEOGRAPHY AND CLIMATE

During the Late Carboniferous, and especially in the Permian, continental masses on Earth were united in the largest continent ever existing – Pangaea (Figs. 1A, B, 4). This supercontinent, extending almost from pole to pole, was positioned between the giant Panthalassa Ocean to the west, and the smaller Palaeotethys Ocean to the east. At the end of the Lower Permian a new ocean – Tethys (Neotethys) was born within marginal Gondwana, south of Palaeotethys, extending from Timor to Sicily (Fig. 4) (SCOTESE & LANGFORD, 1995; STAMPFLI et al., 2001; SCOTESE, 2002).

Formation of such a large continental mass resulted in the domination of an arid continental climate and deposition of evaporites in shallow water basins. Carboniferous rain forests were replaced with xerophytic vegetation, and the accumulation of organic matter significantly decreased. The low rate of precipitation diminished the erosion of land. The increased amount of CO_2 in the atmosphere caused the "greenhouse effect" with global warming. Ice caps were melted, causing the

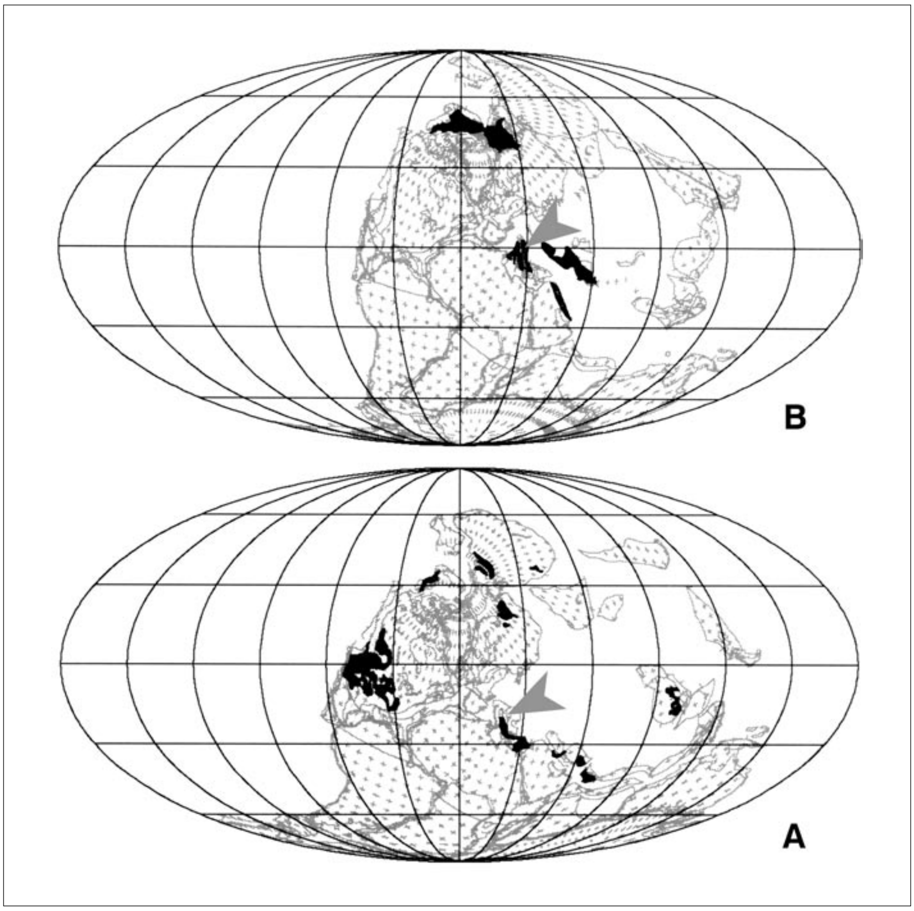


Fig. 1 Global distribution of carbonate platforms (in black): (A) Carboniferous (Viséan); (B) Permian (Guadalupian). Grey arrow shows the area where Croatian Palaeozoic sediments were deposited. After KIESSLING et al. (2003).

additional evaporation of CO_2 into the atmosphere. Cold climate conditions were restricted to the northeastern part of the Siberian land, and southern parts of Australia and Antarctica (BARRON & FAWCETT, 1995).

This hot climate favoured carbonate sedimentation, and enabled the formation of large carbonate platforms, not only in equatorial and subequatorial regions, but also in high subtropical latitudes (Fig. 1) (KIESSLING et al., 2003; ZIEGLER et al., 2003). Platform sedimentation took place over the wide area of the Alps and Dinarides (HERAK, 1991; KIESSLING, 2003), often associated with the formation of reefs, which can be found today in Italy, Hungary, Slovenia, Croatia, Serbia, Montenegro and Greece (FLÜGEL et al., 1984; RAMOVŠ & SREMAC, 1986; RAMOVŠ et al., 1987, 1990; PEŠIĆ et al., 1988; SREMAC, 2001). Porous reef structures at the margin of Palaeotethys and Panthalassa entrapped significant amounts of oil, thus forming world famous oil-fields (Texas, Iran, China) (KLEMME & ULMISHEK, 2001).

3. THE PALAEOZOIC IN CROATIA (FROM THE DEEP OCEAN TO THE CARBONATE PLATFORM)

Palaeozoic sediments in Croatia outcrop sporadically, often in tectonically limited belts (Fig. 2). Although geographically restricted, some of these localities are the treasuries of data from ancient geological history.

Lower Palaeozoic, Pre-Variscan sediments of Croatia were deposited in a deep marine basin, which was part of the Rheic Ocean. They contain fossils of pelagic biota (graptolites, conodonts) and spores, preserved despite subsequent metamorphic processes (ĐURĐANOVIĆ, 1968, 1973; SREMAC & MIHAJLOVIĆ-PAVLOVIĆ, 1981; JERINIĆ et al., 1994). Opening of the Palaeotethys Ocean in the Late Silurian and Devonian positioned this sedimentary basin between these two oceans.

Recent investigations have shown that shallow marine carbonate sedimentation in this area began in the Early Carboniferous (Viséan). Crinoid limestones and carbonate clasts with small foraminifera of this age were found on Medvednica Mt. (ŠIKIĆ, 1995; SREMAC, unpublished) and in the Gorski Kotar region (SREMAC & ALJINOVIĆ, 1997) (Pl. 1, Fig. 1).

Closure of some fore-arc and back-arc basins in the Namurian and Westphalian caused emersion of the shallow-sea environments, and infilling of basins with molasse sediments (KRAINER, 1993; STAMPFLI et al., 2001). Carbonate sedimentation took place contemporaneously on Palaeotethyan shelf areas along the northern Gondwana passive continental margin (RAMOVŠ et al., 1990; KRAINER, 1993; JURKOVIĆ & PAMIĆ, 2001; KIESSLING et al., 2003) (Fig. 1A). Fusulinids, calcareous algae and crinoids were the dom-

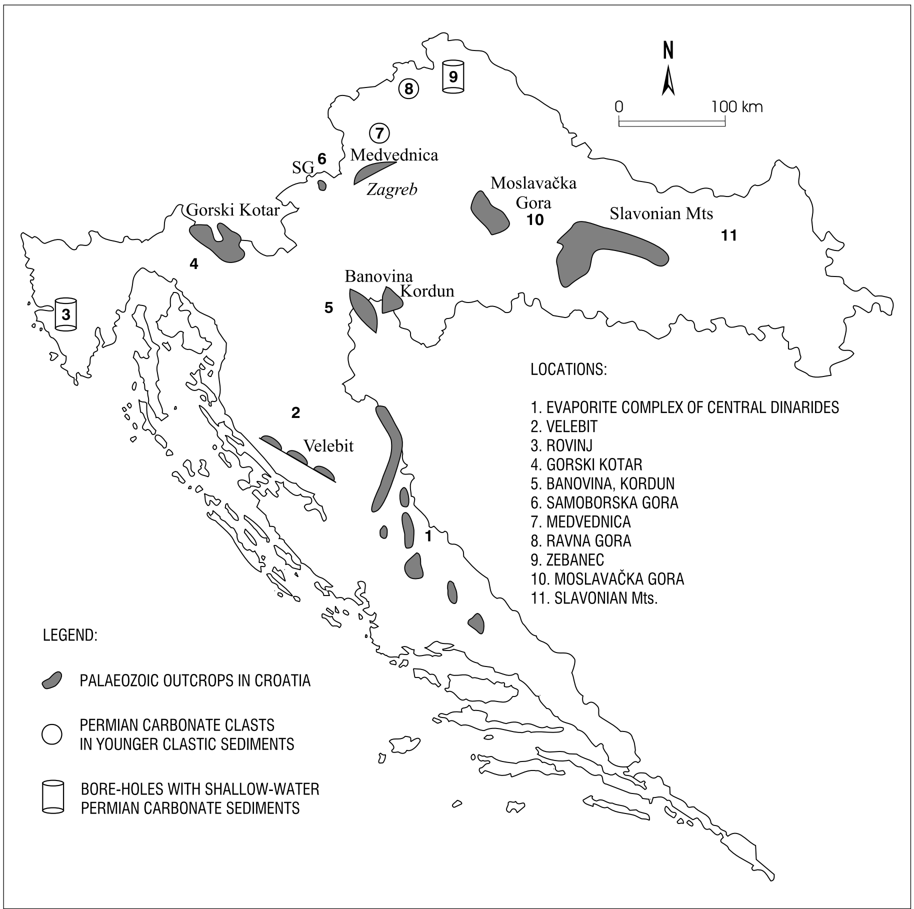


Fig. 2 Schematic map of the Palaeozoic areas in Croatia. After TIŠLJAR (1992) and JURKOVIĆ & PAMIĆ (2001) – modified.

inant carbonate producers. Shallow-marine carbonate sediments with microfossils of Moscovian and Kasimovian age (Pl. 1, Fig. 2), autochthonous or redeposited in younger clastic sediments, outcrop at several localities in Croatia: Velebit Mt., Gorski Kotar, the Banovina region, Medvednica Mt. (KOCHANSKY-DEVIDÉ 1955, 1970; BALAŽ, 1981; MILANOVIĆ, 1981; BELAK et al., 1995; SREMAC & ALJINOVIĆ, 1997). Calcareous algae are especially abundant in these sediments, thus indicating restricted, very shallow lagoonal environments. During the Late Carboniferous, the first reef-building biota occurred in Croatia – corals in the Banovina region (KOSTIĆ-PODGORSKA, 1955) and stromatoporoids on Medvednica Mt. (KOCHANSKY-DEVIDÉ, 1981).

Lower Permian limestones of the Rattendorf group have been found in the Southern Alps, Velebit Mt., Gorski Kotar region, and in clasts of younger sediments on Medvednica Mt. (Pl. 1, Figs. 3–5) (KOCHANSKY-DEVIDÉ, 1959; SALOPEK, 1960; SOKAČ, 1973; GRIMANI et al., 1973; SOKAČ et al., 1976; SREMAC & KOCHANSKY-DEVIDÉ, 1982; ALJINOVIĆ, 1997; SREMAC & ALJINOVIĆ, 1997; KRAINER, 1993). These limestones are relatively thin in the whole area of the Alps and Dinarides, sometimes forming lense-shaped structures within the clastic sediments. At some localities on Velebit Mt. continuous sedimentation from the Upper Carboniferous occurred. In the Gorski Kotar region large blocks of Rattendorf limestones can sometimes be found isolated within shales (SALOPEK, 1960). ALJINOVIĆ (1997) explains these phenomena by intrabasinal erosion of the partly uplifted carbonate sediments and their transportation by fan deltas down toward the steep basin slopes. Numerous clasts of pelagic Gzhelian to Lower Permian limestones with deep water radiolarians (Albaillellacea), indicating water depths of over 500 m are common in the vicinity of Mrzle vodice in Gorski Kotar. These sediments were deposited at the base of slopes along the northern active margin of Palaeotethys (ALJINOVIĆ & KOZUR, 2003). In the Julian Alps, continuous long-lasting carbonate sedimentation began at this time (RAMOVŠ et al., 1990).

Carbonate sediments of the Trogkofel group have been found in the Gorski Kotar region, within the clastic Košna-conglomerates on Velebit Mt., and in clasts of calcareous breccias on Ravna gora Mt. Oil exploratory-wells in Zebanec (Hrvatsko Zagorje) and Újfalu–I (Hungary) also contain carbonate sediments of this age (SALOPEK, 1960; KOCHANSKY-DEVIDÉ, 1973; SOKAČ et al., 1976; BERCZI-MAKK & KOCHANSKY-DEVIDÉ, 1981; SAVIĆ & DOZET, 1985). At the same time, in some neighbouring areas, clastic sedimentation was dominant throughout the whole lower cycle of late to post-Variscan sedimentation (KRAINER, 1993) (Fig. 3).

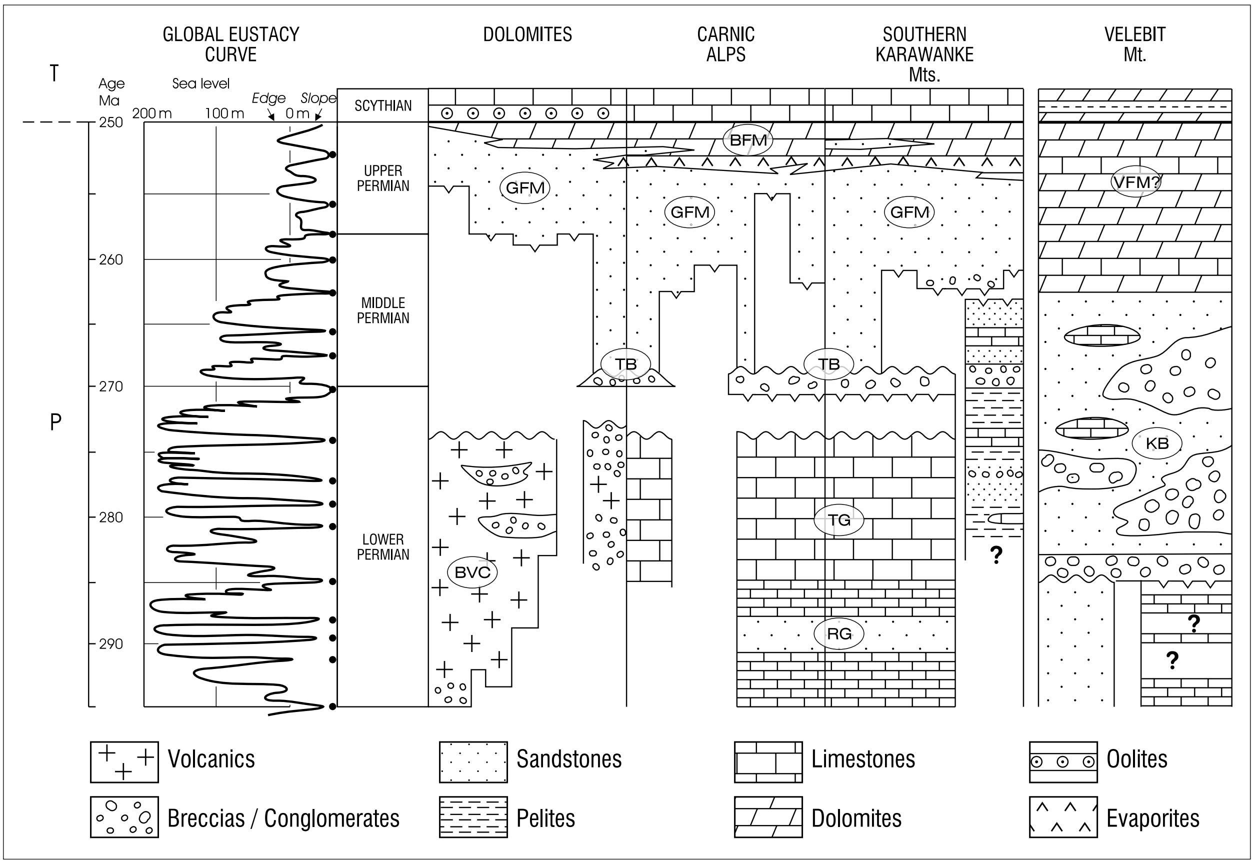


Fig. 3 Global eustacy curve and schematic stratigraphic framework of Post-Variscan sediments of the Southern Alps and Dinarides. Legend: BVC – Bolzano volcanic complex; RG – Rattendorf Group; TG – Trogkofel Group; KB – Košna Beds; TB – Tarvisio Breccia; GFM – Gröden Formation; BFM – Bellerophon Formation; VFM? – Velebit Formation; WFM – Werfen Formation. After KOCHANSKY-DEVIDÉ, 1973; ITALIAN RESEARCH GROUP – from KRAINER, 1993; ROSS & ROSS, 1995b.

During the Middle and/or Upper Permian, carbonate platform conditions were common in Velebit Mt., the Julian Alps, Southern Karavanke Mts., Carnic Alps, and, finally, the Dolomites. A transgression of Palaeotethys from the southeast towards the northwest can be traced (RAMOVŠ et al., 1990; KRAINER, 1993). Dolomite deposits predominate, with intercalations of limestones and evaporites. The longest period of continuous platform sedimentation can be traced in the Julian Alps (during the whole Permian and the lowermost Triassic). On Velebit Mt. carbonate sedimentation took place for approximately 20 million years, producing a sequence of shallow-marine carbonate sediments more than 900 m thick (KOCHANSKY-DEVIDÉ, 1965; SOKAČ et al., 1976).

During detailed mapping of Velebit Mt. and the Lika region performed by Professor M. Salopek and a group of his brilliant students (SALOPEK, 1942, 1948, 1952), a rich collection of Permian fossils was found. These fossils were later subject to detailed study by many Croatian palaeontologists (HERAK & KOCHANSKY-DEVIDÉ, 1960; KOCHANSKY-DEVIDÉ & HERAK, 1960; KOCHANSKY-DEVIDÉ, 1964, 1965; MILANOVIĆ, 1965, 1966a, b, 1968, 1974, 1975; RUKAVINA, 1973; SREMAC & KOCHANSKY-DEVIDÉ, 1982; SREMAC, 1991). The dominant carbonate producers during the Middle Permian were calcareous algae, Dasycladales (*Mizzia*, *Vermiporella*, *Velebitella*, *Salopekiella*, *Connexia*, *Likanella*) or gymnocodiaceans (*Gymnocodium*, *Permocalculus*). Benthic foraminifera were also common (*Staffella*, *Nankinella*, *Chusenella*, *Eoverbeekina*, *Neoschwagerina*, *Agathammina*, *Hemigordius*), and, at some places, calcisponges, corals (*Waagenophyllum*), molluscs (*Tanchintongia* and other bivalves, gastropods, cephalopods), bryozoans (*Fenestella*) and brachiopods (*Enteletes*, *Martinia*, productoids, oldhaminoids). Reconstruction of the platform relief during the Murghabian (*Neoschwagerina craticulifera* zone) has shown that the shallow-sea bottom was overgrown with calcareous algae (Pl. 2, Figs. 1, 2). At several places reef-building and encrusting biota (sponges, bryozoans, cyanobacteria, some brachiopods) built up mounds or patch-reefs (Pl. 3, Figs. 1, 2) (RAMOVŠ & SREMAC, 1986; SREMAC, 1991; MARJANAC & SREMAC, 2000). Intraplatform depressions were filled with clastic material by turbidite currents (Pl. 4, Figs. 1, 2) (SREMAC, 1991). Contemporaneously with the global eustatic changes (ROSS & ROSS, 1995a, b) some shallow parts of the platform were periodically emerged. Vugs and cavities within the sediment, as well as cortoid grains, are reliable evidence of emersions (Pl. 2, Fig. 3). Patch-reefs were occasionally buried in black muddy sediment, similar to the Upper Permian reefs in Sichuan (China). Reef-burial can be connected with oscillations of sea-level, and/or with Permian anoxic events, due to the rapid warming and water stagnation in intraplatform basins.

Middle Permian carbonate clasts have also been found in a bore-hole near Rovinj (KOCHANSKY-DEVIDÉ, 1967), and on Medvednica Mt. (DEVIDÉ-NEDĚLA & KOCHANSKY-DEVIDÉ, 1990). At the same time, in the neighbouring Gorski Kotar region clastic sedimentation prevailed, with scarce limestone intercalations ("*Lyttonia*"–limestones from Križ potok) (SALOPEK, 1960, 1961; KOCHANSKY-DEVIDÉ, 1965; GRIMANI et al., 1973; BUKOVAC et al., 1984; SAVIĆ & DOZET, 1985; ALJINOVIĆ & SREMAC, 1997).

The upper part of the Middle Permian on Velebit Mt. shows no major changes in the composition of sediments or fossil communities. Calcareous algae and foraminifera are still the dominant skeletal carbonate producers. According to the abundance of *Yabeina*, the *Yabeina syrtalis* (DOUVILLÉ) zone was proposed by KOCHANSKY-DEVIDÉ (1965) for these limestones. The brachiopod fauna shows more distinct changes than the microfossil assemblages. New brachiopod genera (*Derbya*, *Streptorhynchus*, *Orthotetes*), as well as some cephalopods (*Temnocheilus*), occur sporadically. Early diagenetic dolomites and dolomitic fossiliferous grainstones–packstones with intercalations of black mudstones and shales are the prevailing sediments (TIŠLJAR et al., 1991).

Middle/Upper Permian carbonate sediments from Velebit Mt. are not entirely compatible in age with the fossils and sedimentary features of the "Bellerophon formation" of the Southern Alps. The majority of macrofossils (e.g. brachiopods) belong to the Indo–Armenian type of fauna, while several taxa are endemic (SREMAC, 1986). Continental barriers between these two sedimentary basins were presumed by Simić (SALOPEK, 1942). FLÜGEL (1977 – p. 315) even proposed the category "Velebit-formation" for these sediments (Fig. 3). A similar development of the Upper Permian, named the "Žažar-formation", can be observed in Slovenia (RAMOVŠ, 1958; BUSER et al., 1988; SKABERNE & OGORELEC, 2003).

In central and northern Dalmatia and the southeastern Lika regions evaporitic sediments (gypsum and anhydrite), associated with clastic and carbonate rocks and some volcanics, outcrop at several localities (Fig. 2). Palynological analysis suggest an Upper Permian age for these sediments (ŠUŠNJARA et al., 1992), and they are interpreted as regressive cycles deposited in an arid climate through the progradation of sabkha environments over shallow subtidal lagoons (TIŠLJAR, 1992). According to global palaeogeographical reconstructions (KRAINER, 1993; STAMPFLI et al., 2001; SCOTESE, 2002; IZART et al., 2003; KIESSLING et al., 2003; ZIEGLER et al., 2003) (Figs. 1 and 4) evaporites are partly related to the coastal areas of the western inactive margin of the Palaeotethys ocean (Dolomites, Carnic Alps, Southern Karavanke Mts.), but they also occur within the shallow parts of the inner carbonate platform (e.g. Central Dinarides).

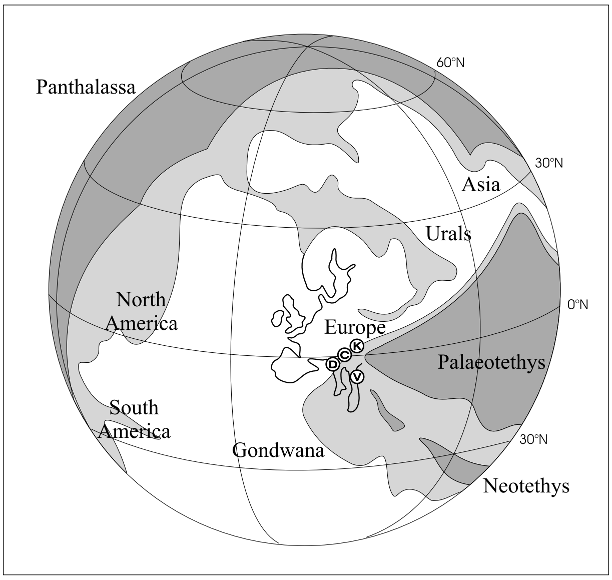


Fig. 4 Palaeogeographic map of the Earth during the Early Permian, with the probable position of the Dolomites (D), Carnic Alps (C), Karavanke Mts. (K) and Velebit Mt. (V). Key: land – white; shallow sea – light grey; ocean – dark grey. Partly after SCOTESE & LANGFORD, 1995 – from IZART et al., 2003, modified.

Upper Permian evaporites have also been found in northwestern Croatia, on Samoborska gora Mt. (Fig. 2), in association with algal limestones (Pl. 1, Fig. 6) and dolomites (HERAK, 1956; HERAK & ŠKALEC, 1967).

4. PERMO–TRIASSIC BOUNDARY IN CROATIA

In the area of the Alps and Dinarides, continuous carbonate sedimentation from the uppermost Permian to the Triassic has been observed at several localities in the Dolomites, throughout the Carnic Alps, Southern Karavanke Mts., Julian Alps, Velebit Mt. and Central Dinarides (Fig. 3).

The Permo–Triassic boundary can be observed at several localities on Velebit Mt. (Brušane–Baške Oštarije, Velika Paklenica) (SALOPEK, 1942, 1952; KOCHANSKY-DEVIDÉ, 1965; SOKAČ, 1973; SOKAČ et al., 1976; RAMOVŠ & KOCHANSKY-DEVIDÉ, 1981; RAMOVŠ et al., 1990; ALJINOVIĆ et al., 2003).

Upper Permian deposits on Velebit Mt. are in most cases represented by early-diagenetic supratidal dolomites, with intercalations of subtidal to intertidal bioclastic grainstones–packstones and lagoonal black shales. Cellular dolomites ("*rauchwacke*") appear occasionally in the late Upper Permian (TIŠLJAR et al., 1991; IBRAHIMPAŠIĆ & SREMAC, 2002). Uppermost Permian "boundary dolomites" (sensu SALOPEK, 1942), sometimes with parallel lamination, contain pyrite crystals and rare microfossils (gymnocodiaceans, foraminifera; Pl. 4, Fig. 4) (RAMOVŠ & KOCHANSKY-DEVIDÉ, 1981; IBRAHIMPAŠIĆ & SREMAC, 2002). WIGNALL et al. (2002) describe similar sediments from China and relate them to the global anoxic event at the end of the Permian. Near the Permo–Triassic boundary, intercalations of red shale became common, and Permian carbonates gradually pass into the sandy yellow-coloured dolomites of the Lower Triassic (SALOPEK, 1942; SOKAČ et al., 1976; RAMOVŠ & KOCHANSKY-DEVIDÉ, 1981; TIŠLJAR et al., 1991).

A similar "continuity" of sedimentation at the Permo–Triassic boundary has been observed in the Karavanke Mts. and in the vicinity of Žažar and Idrija in Slovenia (see DOLENEC et al., 1999, and SKABERNE & OGORELEC, 2003 for older references). Anomalies in $\delta^{13}C$ and $\delta^{18}O$ represent evidence of an abrupt change in organic production and palaeotemperature (DOLENEC et al., 1999, 2001), thus suggesting the possibility of a sudden catastrophe (impact of an extraterrestrial object?).

Upper Permian evaporites, carbonate and clastic rocks of Central Dinarides also show a continuous transition from the uppermost Permian to the Lower Triassic (Pl. 5, Fig. 3) (ŠUŠNJARA et al., 1992; TIŠLJAR, 1992). According to global reconstructions (SCOTESE & LANGFORD, 1995; STAMPFLI et al., 2001; SCOTESE, 2002; KIESSLING et al., 2003; IZART et al., 2003), this area was probably a shallow plateau within the carbonate platform, partly emerged during the Late Permian regressions, and submerged during the Early Triassic transgression.

There are different opinions as to the age of the Palaeozoic sediments and the Permo–Triassic boundary in the Gorski Kotar region. Some authors (e.g. ŠĆAVNIČAR & ŠUŠNJARA, 1967; RAFFAELLI & ŠĆAVNIČAR, 1968) propose the continuity of sedimentation from the "Upper Permian" clastic sediments to the Lower Triassic dolomites. Careful reviewing of the published papers and field investigations did not confirm this continuity, because the uppermost Permian fossils have not been found in clasts (ALJINOVIĆ & SREMAC, 1997; SREMAC & ALJINOVIĆ, 1997). It is possible that this area was uplifted in the Late Permian, and again submerged during the Early Triassic transgression (Pl. 5, Fig. 2). A similar situation can be observed in neighbouring parts of Slovenia (RAMOVŠ & KOCHANSKY-DEVIDÉ, 1965; RAMOVŠ, 1968).

Apart from the Karst region, "continuous"(?) sedimentation at the Permo–Triassic boundary has been observed on the Samoborska gora Mt. and in the Banovina region. The uppermost Permian in these areas is represented by clastic sediments with scattered lenses of carbonate or evaporite sediments (Pl. 4, Fig. 3) (HERAK, 1956; RAMOVŠ et al., 1990).

Upper Permian sediments in Croatia show a general shallowing upward trend, in harmony with the global eustatic curve (Fig. 3), but the extreme ideas of more than 200 metres of sea-level falls could not be confirmed in this area. Nevertheless, evidence of occasional emersions, such as laminar structures, stromatolites, vadose cements and highly porous carbonate breccias ("*rauchwacke*"), can be found in Croatia from the Middle Permian, and, particularly in the Upper Permian sediments (SREMAC, 1991; TIŠLJAR et al., 1991; TIŠLJAR, 1992; IBRAHIMPAŠIĆ & SREMAC, 2002; ALJINOVIĆ et al., 2003). Fullerenes and shocked quartz grains, the typical impact markers, have not been found in neighbouring regions, but carbon, sulphur and strontium excursions have been confirmed at many places, including Slovenia (DOLENEC et al., 1999, 2001). Therefore sediments at the P/T boundary in Croatia should be subject to isotope and microelement analysis.

Permian platform sediments in Croatia were less affected by the P/T catastrophic event, than by tectonic movements and uplift, which caused emersion in some parts of the platform. Input of terrestrial material, tectonic instability and sporadic volcanic activity were the main features during the Lower and Middle Triassic. This area was stabilized in the Late Triassic, and platform sedimentation in the Tethyan realm took place up to the Middle Eocene.

5. CONCLUSIONS

The first carbonate platforms in equatorial Palaeotethys existed during the Variscan cycle. In Croatia, Viséan shallow-marine fossils have been found in clasts of younger sediments.

The lower part of the Late to Post-Variscan cycle (sensu KRAINER, 1993) is dominantly represented by molasse sediments. Clastic–carbonate sedimentation was influenced by phases of Gondwanian glaciations. Shallow water carbonate sediments were deposited in the Late Carboniferous (Moscovian–Kasimovian) and Early Permian (Asselian–Sakmarian). The dominant carbonate producers were calcareous algae, foraminifera and crinoids. In Croatia these sediments are the most completely developed on Velebit Mt.

Middle/Upper Permian to Lower Triassic carbonate sediments of the Southern Alps and Dinarides belong to the upper part of the Late to Post-Variscan cycle (sensu KRAINER, 1993). Their lateral and vertical distribution was controlled by transgression of the Palaeotethys from the southeast towards the adjacent shelves. Platform carbonate sediments and evaporites of this age crop out in the Outer Dinarides of Croatia (Velebit Mt., Croatian–Bosnian border), and were also found in clasts of younger sediments (Gorski Kotar region), and in bore-holes (Rovinj). Sporadic occurrences of Palaeozoic shallow water carbonate and evaporite sediments were also found in the Inner Dinarides (Bregana, Medvednica Mt.). The main carbonate producers were calcareous and non-calcareous algae and foraminifera, accompanied by calcisponges, corals, molluscs, bryozoans, brachiopods and echinoderms.

Palaeozoic rocks of Croatia are in most cases in tectonic contact with the surrounding deposits, and it is impossible to estimate their original horizontal and vertical distribution. We can presume that they were deposited either on one large carbonate platform with occasionally emerged areas and intraplatform basins, or, more likely, on several smaller platforms, separated by continental or basinal barriers.

During the Upper Palaeozoic and the Lower Triassic, carbonate sedimentation was interrupted by episodes of uplift, erosion and deposition of molasse sediments. Phases of regression are marked by laminar structures (stromatolites), vadose cements and highly porous carbonate breccias ("*rauchwacke*").

An End-Permian catastrophic event did not cause the collapse of the carbonate platforms, but it strongly affected the carbonate-producing biota. Therefore no visible discontinuity of sedimentation can be traced at the Permo–Triassic boundary, and this event could only be traced through carbon, oxygen, sulphur and strontium anomalies. Cyanobacteria, as the disaster taxa, are blooming around the extinction event. They are the first lithogenetic biota after the cataclysm, soon accompanied by simple, opportunistic, predominantly molluscan communities.

After the phase of instability marked by clastic–carbonate sedimentation and sporadic volcanic activity, platform conditions were stabilized in the Late Triassic and lasted till the Middle Eocene.

During 200 million years of existence, the Palaeotethyan–Tethyan "carbonate factory" produced several thousand metres of fossiliferous carbonate sediments, thus representing a palaeontological and sedimentological treasure for many generations of Croatian geologists and palaeontologists.

Acknowledgments

I express my gratitude to Prof. Dr. Ivan GUŠIĆ and the late Prof. Dr. Jakob PAMIĆ, for their support and initial advices. Dr. Ivo VELIĆ and Prof. Dr. Josip TIŠLJAR gave me the most useful suggestions on the early draft of the manuscript. Dr. Heinz W. KOZUR and Prof. Dr. Anton RAMOVŠ improved this paper by critical reading and reviewing. Dr. Julie ROBSON was responsible for careful language editing and useful comments.

6. REFERENCES

ALJINOVIĆ, D. (1997): Facijesi klastičnih sedimenata mlađega paleozoika i starijega trijasa Gorskoga kotara [*Facies of clastic sediments in Late Palaeozoic and Early Triassic of Gorski Kotar* – in Croatian].– Unpubl. PhD Thesis, University of Zagreb, 163 p.

ALJINOVIĆ, D. & KOZUR, W.H. (2003): Resedimented Carboniferous and Lower Permian radiolarians in Roadian (Middle Permian) deepwater clastic complex of Gorski Kotar Region (Croatia).– In: VLAHOVIĆ, I. (ed.): 22nd IAS Meeting of Sedimentology – Opatija 2003, Abstracts, p. 4.

ALJINOVIĆ, D. & SREMAC. J. (1997): The Middle and Upper Permian deposits in Gorski Kotar: facts and misconceptions.– Geol. Croat., 50/2, 231–242.

ALJINOVIĆ, D. & TIŠLJAR, J. (2001): Pretplatformni megafacijesi od karbona do srednjega trijasa krškoga područja Dinarida [*Preplatform megafacies from the Carboniferous to the Middle Triassic in the karst area of Dinarides* – in Croatian].– In: DRAGIČEVIĆ, I. & VELIĆ, I. (eds.): 1. Znanstveni skup "Karbonatna platforma ili karbonatne platforme Dinarida", Zagreb 1–2. 10. 2001. Knjiga sažetaka, 9–16.

ALJINOVIĆ, D., SREMAC, J. & IBRAHIMPAŠIĆ, H. (2003): Permian and Lower Triassic facies of Velebit Mt. and the Gorski Kotar region (NW part of External Dinarides).– In: VLAHOVIĆ, I. & TIŠLJAR, J. (eds.): Evolution of Depositional Environments from the Palaeozoic to the Quaternary in the Karst Dinarides and the Pannonian Basin. Field Trip Guidebook, 22nd IAS Meeting of Sedimentology – Opatija 2003, 185–206.

BALAŽ, E. (1981): Carboniferous gastropods of Lika and Velebit.– Palaeont. Jugosl., 26 (1980/3), 1–23.

BARRON, E.J. & FAWCETT, P.J. (1995): The climate of Pangea: a rewiew of climate model simulations of the Permian.– In: SCHOLLE, P.A., PERYT, T.M. & ULMER-SCHOLLE, D.S. (eds.): The Permian of Northern Pangea. Vol. 1. Paleogeography, Paleoclimates, Stratigraphy. Springer-Verlag, Berlin–Heidelberg, 37–52.

BELAK, M., SREMAC, J., CRNKO, J. & KOLAR-JURKOVŠEK, T. (1995): Paleozojske stijene niskog stupnja metamorfizma na jugoistočnoj strani Medvednice (sjeverozapadna Hrvatska) [*Palaeozoic low-metamorphic rocks at the southeastern part of the Medvednica Mt.* – in Croatian].– In: VLAHOVIĆ, I., VELIĆ, I. & ŠPARICA, M. (ur.): 1. hrvatski geološki kongres (First Croatian Geological Congress), Zbornik radova (Proceedings), 1, 71–74.

BÉRCZI-MAKK, A. & KOCHANSKY-DEVIDÉ, V. (1981): Marine Lower and Middle Permian in the oil exploratory well Újfalu–I (SW-Hungary).– Acta Geol. Acad. Sci. Hungar., 24/1, 117–128.

BUKOVAC, J., POLJAK, M., ŠUŠNJAR, M. & ČAKALO, M. (1984): Osnovna geološka karta SFRJ, 1:100000. Tumač za list Črnomelj L33–91 (Basic Geological Map of SFRJ 1:100000. Geology of sheet Črnomelj).– Geol. zav. Zagreb & Geol. zav. Ljubljana (1983), Sav. geol. zav., Beograd, 63 p.

BUSER, S., GRAD, K., OGORELEC, B., RAMOVŠ, A. & ŠRIBAR, L. (1988): Stratigraphical, paleontological and sedimentological characteristics of Upper Permian beds in Slovenia, NW Yugoslavia.– In: CASSINIS, G. (ed.): Permian and Permian–Triassic Boundary in the South Alpine segment of the Western Tethys. Mem. Soc. Geol. It., 34, 195–210.

DEVIDÉ-NEDĚLA, D. & KOCHANSKY-DEVIDÉ, V. (1990): Neoschwagerinen fund im Medvednica-Gebirge (Zagrebačka Gora) [*Findings of Neoschwagerina in the Medvednica Mt.* – in German, Croatian abstract].– Rad Jugosl. akad. znan. umjet., 449, 29–33, Zagreb.

DOLENEC, T., LOJEN, S., BUSER, S. & DOLENEC, M. (1999): Stable Isotope Event Markers Near the Permo–Triassic Boundary in the Karavanke Mountains (Slovenia).– Geol. Croat., 52/1, 77–81.

DOLENEC, T., LOJEN, S. & RAMOVŠ, A. (2001): The Permian–Triassic boundary in Western Slovenia (Idrijca Valley section): magnetostratigraphy, stable isotopes and elemental variations.– Chemical Geol., 175, 175–190.

ĐURĐANOVIĆ, Ž. (1968): Conodonten des Unterdevons und Unterkarbons westlich von Dvor na Uni (Kroatien–Jugoslawien) [*Lower Devonian and Lower Carboniferous conodonts west from Dvor na Uni (Croatia, Yugoslavia)* – in German].– Geol. vjesnik, 21 (1967), 83–103.

ĐURĐANOVIĆ, Ž. (1973): About the Paleozoic and the Triassic of Medvednica Mountain and the area near Dvor na Uni on the basis of conodonts.– Geol. vjesnik, 25 (1971), 29–51.

FLÜGEL, E. (1977): Environmental models for Upper Paleozoic benthic calcareous algal communities.– In: FLÜGEL, E. (ed.): Fossil Algae. Springer-Verlag, Berlin–Heidelberg, 314–343.

FLÜGEL, E., KOCHANSKY-DEVIDÉ, V. & RAMOVŠ, A. (1984): A Middle Permian calcisponge/algal/cement reef: Straža near Bled, Slovenia.– Facies, 10, 179–256.

GRIMANI, I., ŠUŠNJAR, M., BUKOVAC, J., MILAN, A., NIKLER, J., CRNOLATAC, J., ŠIKIĆ, I. & BLAŠKOVIĆ, I. (1973): Osnovna geološka karta SFRJ 1:100000. Tumač za list Crikvenica L33–102 (Basic Geological Map of SFRJ, 1:100000. Geology of sheet Crikvenica).– Inst. geol. istraž. Zagreb (1963), Sav. geol. zav., Beograd, 47 p.

HERAK, M. (1956): Geologija Samoborskog gorja [*Geology of the Samobor Mts.* – in Croatian, German abstract].– Acta geol., 1, 49–73.

HERAK, M. (1991): Dinaridi. Mobilistički osvrt na genezu i strukturu [*Dinarides. Mobilistic view of the genesis and structure* – in Croatian].– Acta geol., 21/2, 35–117, Zagreb.

HERAK, M. & KOCHANSKY-DEVIDÉ, V. (1960): Gymnocodiacean calcareous algae in the Permian of Yugoslavia.– Geol. vjesnik, 13 (1959), 185–196.

HERAK, M. & ŠKALEC, D. (1967): Kalkalgen im Perm des Samoborer Gebirges [*Calcareous algae in the Permian of the Samobor Mts*. – in German].– Geol. vjesnik, 20 (1966), 37–39.

IBRAHIMPAŠIĆ, H. & SREMAC, J. (2002): End Permian regression – evidence from meiobenthic communities from the Velebit Mt. (SW Croatia).– In: YANKO-HOMBACH, V. (ed.): The Third. Intern. Congr. EMMM 2002, Wien, 101–103.

IZART, A., STEPHENSON, R., VAI, G.B., VACHARD, D., LE NINDRE, Y., VASLET, D., FAUVEL, P-J., SÜSS, P., KOSSOVAYA, O., CHEN, Z., MASLO, A. & STOVBA, S. (2003): Sequence stratigraphy and correlation of late Carboniferous and Permian in the CIS, Europe, Tethyan area, North Africa, Arabia, China, Gondwanaland and the USA.– Palaeogeogr., Palaeoclimat., Paleoecol., 196, 59–84.

JERINIĆ, G., PAMIĆ, J., SREMAC, J. & ŠPANIĆ, D. (1994): Palynological and organic–petrographic data on very low and low grade metamorphic rocks in the Slavonian Mountains (Northern Croatia).– Geol. Croat., 47/2, 149–155.

JURKOVIĆ, I. & PAMIĆ, J. (2001): Geodynamics and metallogeny of Variscan complexes of the Dinarides and South Tisia as related to plate tectonics.– Nafta, 52/9, 267–284.

KIESSLING, W., FLÜGEL, E. & GOLONKA, J. (2003): Patterns of Phanerozoic carbonate platform sedimentation. Lethaia 36, 195–226.

KLEMME, H.D. & ULMISHEK, G.F. (2001): Effective petroleum source rocks of the World: Stratigraphic distribution and controlling depositional factors.– energy.er.usgs.gov/products/papers/world_oil/aapg/bulletin/tab_01.htm.

KOCHANSKY-DEVIDÉ, V. (1955): Karbonske i permske fuzulinidne foraminifere Velebita i Like I. Opći dio i karbon [*Carboniferous and Permian fusulinids of the Velebit Mt. and Lika region. Introduction and Carboniferous* – in Croatian].– Rad jugosl. Akad., 305, 5–62, Zagreb.

KOCHANSKY-DEVIDÉ, V. (1959): Karbonske i permske fuzulinidne foraminifere Velebita i Like. Donji perm. [*Carboniferous and Permian fusulinids of the Velebit Mt. and Lika region. Lower Permian* – in Croatian].– Palaeont. jugoslavica, 3, 1–62, Zagreb.

KOCHANSKY-DEVIDÉ, V. (1964): Die Mikrofossilien des jugoslawischen Perms [*Microfossils of the Yugoslav Permian* – in German].– Paläont. Z., 38/3-4, 180–188.

KOCHANSKY-DEVIDÉ, V. (1965): Karbonske i permske fuzulinidne foraminifere Velebita i Like. Srednji i gornji perm [*Carboniferous and Permian fusulinids of the Velebit Mt. and Lika region. Middle and Upper Permian* – in Croatian].– Acta geol., 5, 101–137, Zagreb.

KOCHANSKY-DEVIDÉ, V. (1967): Neoschwagerinenschichten einer Tiefbohrung in Istrien (Jugoslawien) [*Neoschwagerina-beds from a bore-hole in Istria (Yugoslavia)* – in German].– N. Jb. Geol. Paläont. Abh., 128/2, 201–204.

KOCHANSKY-DEVIDÉ, V. (1970): Die Kalkalgen des Karbons vom Velebit-Gebirge (Moskovien und Kassimovien) [*Carboniferous calcareous algae from the Velebit Mt. (Moscovien and Kasimovien)* – in German].– Palaeont. jugoslavica, 10, 1–32, Zagreb.

KOCHANSKY-DEVIDÉ, V. (1973): Trogkofel-Ablagerungen in Kroatien [*Trogkofel Beds in Croatia* – in German].– Geologija, 16, 357–378, Ljubljana.

KOCHANSKY-DEVIDÉ, V. (1981): Karbonische Stromatoporoidea und Bryozoa von Markuševec in Medvednica-Gebirge [*Carboniferous stromatoporoidea and bryozoa from Markuševec in Medvednica Mt.* – in German].– Geol. vjesnik, 34, 15–17.

KOCHANSKY-DEVIDÉ, V. & HERAK, M. (1960): On the Carboniferous and Permian dasycladaceae of Yugoslavia.– Geol. vjesnik, 13, 65–96.

KOSTIĆ-PODGORSKA, V. (1955): Oberkarbonische Korallen von Trgovska Gora (Croatien) [*Upper Carboniferous corals from Trgovska Gora (Croatia)* – in German].– Geol. vjesnik, 8–9 (1954–55), 115–121.

KRAINER, K. (1993): Late- and Post- Variscan Sediments of the Eastern and Southern Alps.– In: Von RAUMER, J.F. & NEUBAUER, F. (eds.): Premesozoic Geology in the Alps. Springer-Verlag, Berlin–Heidelberg, 537–564.

MARJANAC, T. & SREMAC, J. (2000): Middle Permian calcispongal cement reef on the Velebit Mt.– In: PAMIĆ, J. & TOMLJENOVIĆ, B. (eds.): PANCARDI 2000. Dubrovnik, Croatia, 1–3.10.2000. Fieldtrip Guidebook. Vijesti Hrv. geol. društva, 37/2, 135–138, Zagreb.

MILANOVIĆ, M. (1965): *Salopekiella*, novi rod familije Dasycladaceae iz permskih sedimenata Velebita (*Salopekiella*, a new genus of the Dasycladaceae family from the Permian sediments of the Velebit Range).– Acta geol., 5, 373–382, Zagreb.

MILANOVIĆ, M. (1966a): *Likanella* – a new Permian genus of the family Dasycladaceae (*Likanella* – novi permski rod familije Dasycladaceae).– Geol. vjesnik, 19 (1965), 9–13.

MILANOVIĆ, M. (1966b): *Goniolinopsis* – a new Permian genus of the family Dasycladaceae (*Goniolinopsis* – novi permski rod familije Dasycladaceae).– Geol. vjesnik, 19 (1965), 115–121.

MILANOVIĆ, M. (1968): *Salopekiella*? *kochanskae* n.sp. (Dasycladaceae) from the Permian of the Velebit mountain (*Salopekiella*? *kochanskae* n.sp. (Dasycladaceae) iz perma Velebita).– Geol. vjesnik, 21 (1967), 157–160.

MILANOVIĆ, M. (1974): *Kochanskyella* (Chlorophyta, Dasycladaceae), a new Permian genus of the Mount Velebit, Croatia (*Kochanskyella* (Chlorophyta, Dasycladaceae) iz perma Velebita).– Geol. vjesnik, 27, 127–132.

MILANOVIĆ, M. (1975): *Salopekiella*? *breziki* n.sp. (Calcareous algae, Dasycladaceae) from the Permian of Mt. Velebit (Croatia) (*Salopekiella*? *breziki* n.sp. (vapnenačke alge, Dasycladaceae) iz perma Velebita).– Geol. vjesnik, 28, 81–86.

MILANOVIĆ, M. (1981): Carboniferous microfossil associations from Gorski kotar, Hrvatsko Zagorje and Banija.– Palaeont. jugosl., 28, 1–34, Zagreb.

PEŠIĆ, L., RAMOVŠ, A., SREMAC, J., PANTIĆ-PRODANOVIĆ, S., FILIPOVIĆ, I., KOVACS, S. & PELIKAN, P. (1988): Upper Permian deposits of the Jadar region and their position within the Western Palaeotethys.– Mem. Soc. Geol. Ital., 34 (1986), 211–219.

RAFFAELLI, P. & ŠĆAVNIČAR, B. (1968): Naslage gornjeg paleozoika Like i Gorskog kotara [*Upper Palaeozoic deposits of Lika and Gorski kotar* – in Croatian].– I. kol. geol. Dinar., Ljubljana, 21–27.

RAMOVŠ, A. (1958): Razvoj zgornjega perma v Loških in Polhograjskih hribih [*Development of the Upper Permian in the Loški and Polhograjski hribi* – in Slovenian].– Razprave SAZU, 1, 451–622, Ljubljana.

RAMOVŠ, A. (1968): Razvoj paleozoika v slovenskem delu zunanjih Dinaridov (Die Entwicklung des Paläozoikums im Slowenischen Teil des Aussendinariden) [*Development of Palaeozoic in the Slovenian part of the Outer Dinarides* – in Slovenian and German].– I. kol. geol. Dinaridov, 1, 7–19, Ljubljana.

RAMOVŠ, A. & KOCHANSKY-DEVIDÉ, V. (1981): Permian–Triassic boundary in Brušane village (Velebit Mt., Croatia).– Geologija, 24/2, 327–330, Ljubljana.

RAMOVŠ, A. & SREMAC, J. (1986): Permian reefs in Yugoslavia.– IGCP Project No. 5: Proceedings. Final Meeting, Sardinia 1986, Cagliari, 69–76.

RAMOVŠ, A., SREMAC, J. & KULENOVIĆ, E. (1987): Results of biostratigraphical investigations in Western Yugoslav Paleozoic realized in IGCP Project No. 5.– In: FLÜGEL, H.W., SASSI, F.P. & GRECULA, P. (eds.): Pre-Variscan and Variscan Events in the Alpine–Mediterranean mountain belts. Alfa Publ., 397–406, Bratislava.

RAMOVŠ, A., HINTERLECHNER-RAVNIK, A., KALENIĆ, M., KARAMATA, S., KOCHANSKY-DEVIDÉ, V., MIRKOVIĆ, M., PETKOVSKI, P., SREMAC, J., KRSTIĆ, B., KULENOVIĆ, E. & TEMKOVA, V. (1990): Stratigraphic correlation forms of the Yugoslav Paleozoic.– Rend. Soc. Geol. Ital., 12 (1989), 359–383.

ROSS, C.A. & ROSS, J.R.P. (1995a): Foraminiferal zonation of late Paleozoic depositional sequences.– Marine Micropal., 26, 469–478.

ROSS, C.A. & ROSS, J.R.P. (1995b): Permian sequence stratigraphy.– In: SCHOLLE, P.A., PERYT, T.M. & ULMER-SCHOLLE, D.S. (eds.): The Permian of Northern Pangea. Vol. 1. Paleogeography, Paleoclimates, Stratigraphy. Springer-Verlag, Berlin–Heidelberg, 98–123.

RUKAVINA, D. (1973): Prilog poznavanju gornjopaleozojskih školjkaša Like i sjeveroistočnog podnožja Velebita (A contribution to the knowledge on the Upper Paleozoic bivalves of Lika and the northeast foot of Velebit Mt. (Central Croatia)).– Geol. vjesnik, 26, 319–323.

SALOPEK, M. (1942): O gornjem paleozoiku Velebita u okolici Brušana i Baških Oštarija [*On the Upper Palaeozoic of the Velebit Mt. in the vicinity of Brušane and Baške Oštarije* – in Croatian].– Rad Jugosl. akad. znan. umjetn., 274, 218–272, Zagreb.

SALOPEK, M. (1948): O gornjem paleozoiku sjeveroistočnog podnožja Velebita i Like [*On the Upper Palaeozoic of the northeastern slope of the Velebit Mt. and Lika region* – in Croatian].– Prir. istraž. Jugosl. akad. znan. umjetn., 24, 1–75, Zagreb.

SALOPEK, M. (1952): O gornjem permu Velike Paklenice u Velebitu [*On the Upper Permian of Velika Paklenica in the Velebit Mt.* – in Croatian].– Rad Jugosl. akad. znan. umjetn., 289, 5–26, Zagreb.

SALOPEK, M. (1960): O gornjem paleozoiku u okolini Mrzle Vodice i Crnoga Luga u Gorskom kotaru [*On the Upper Palaeozoic in the vicinity of Mrzle Vodice and Crni Lug in Gorski Kotar* – in Croatian].– Acta geol., 2, 121–132, Zagreb.

SALOPEK, M. (1961): Geološki odnosi paleozojskog prodora okoline Smrečja, Tršća i Čabra u Gorskom kotaru [*Geologic settings of the Palaeozoic tectonic belt in the vicinity of Smrečje, Tršće and Čabar in Gorski Kotar* – in Croatian].– Acta geol., 3, 243–249, Zagreb.

SAVIĆ, D. & DOZET, D. (1985): Osnovna geološka karta SFRJ 1:100000. Tumač za list Delnice L33–90 (Basic Geological Map of SFRJ 1:100000. Geology of sheet Delnice).– Geol. zav. Zagreb & Geol. zav. Ljubljana (1983), Sav. geol. zav., Beograd, 66 p.

SCOTESE, C.R. (2002): Plate tectonic maps and continental drift animations.– Paleomap project – www.scotese.com.

SCOTESE, C.R. & LANGFORD, R.P. (1995): Pangea and the paleogeography of the Permian.– In: SCHOLLE, P.A., PERYT, T.M. & ULMER-SCHOLLE, D.S. (eds.):

The Permian of Northern Pangea. Vol. 1. Paleogeography, Paleoclimates, Stratigraphy. Springer-Verlag, Berlin–Heidelberg, 3–19.

SKABERNE, D. & OGORELEC, B. (2003): Žažar Formation, Upper Permian marine transgression over the Val Gardena Formation (Javorjev dol, SW from Cerkno, Western Slovenia).– In: VLAHOVIĆ, I. & TIŠLJAR, J. (eds.): 22nd IAS Meeting of Sedimentology – Opatija 2003, Field trip Guidebook, 59–61, Zagreb.

SOKAČ, B. (1973): Geologija Velebita [*Geology of the Velebit Mt.* – in Croatian].– Unpubl. PhD Thesis, University of Zagreb, 151 p.

SOKAČ, B., ŠĆAVNIČAR, B. & VELIĆ, I. (1976): Osnovna geološka karta SFRJ 1:100000. Tumač za list Gospić K33–127 (Basic Geological Map of SFRJ 1:100000. Geology of sheet Gospić).– Inst. geol. istraž. Zagreb (1967), Sav. geol. zav., Beograd, 64 p.

SREMAC, J. (1986): Middle Permian Brachiopods from the Velebit Mt. (Croatia, Yugoslavia) (Srednjopermski brahiopodi Velebita (Hrvatska, Jugoslavija)).– Palaeont. jugosl., 35, 1–43, Zagreb.

SREMAC, J. (1991): Zona Neoschwagerina craticulifera u Srednjem Velebitu [*Neoschwagerina craticulifera zone in the Middle Velebit Mt. (Croatia, Yugoslavia)* – in Croatian].– Geologija, 34, 7–55, Ljubljana.

SREMAC, J. (2001): Ekvatorijalni šelf permskog superkontinenta – kolijevka Jadranske karbonatne platforme/platformi [*Equatorial shelf of the Permian Supercontinent – craddle of the Adriatic Carbonate Platform/Platforms* – in Croatian].– In: DRAGIČEVIĆ, I. & VELIĆ, I. (eds.): 1. Znanstv. skup “Karbonatna platforma ili karbonatne platforme Dinarida”, Zagreb 1–2. 10. 2001. Knjiga sažetaka, 9–16, Zagreb.

SREMAC, J. & ALJINOVIĆ, D. (1997): Upper Palaeozoic fossils from clastic sedimentary rocks in the Gorski Kotar region.– Geol. Croat., 50/2, 187–199.

SREMAC, J. & KOCHANSKY-DEVIDÉ, V. (1982): Paleozoik Hrvatske (kratki pregled) [*Paleozoic of Croatia – a*

PLATE 1

Carbonate producers in the Carboniferous and the Lower Permian of Croatia

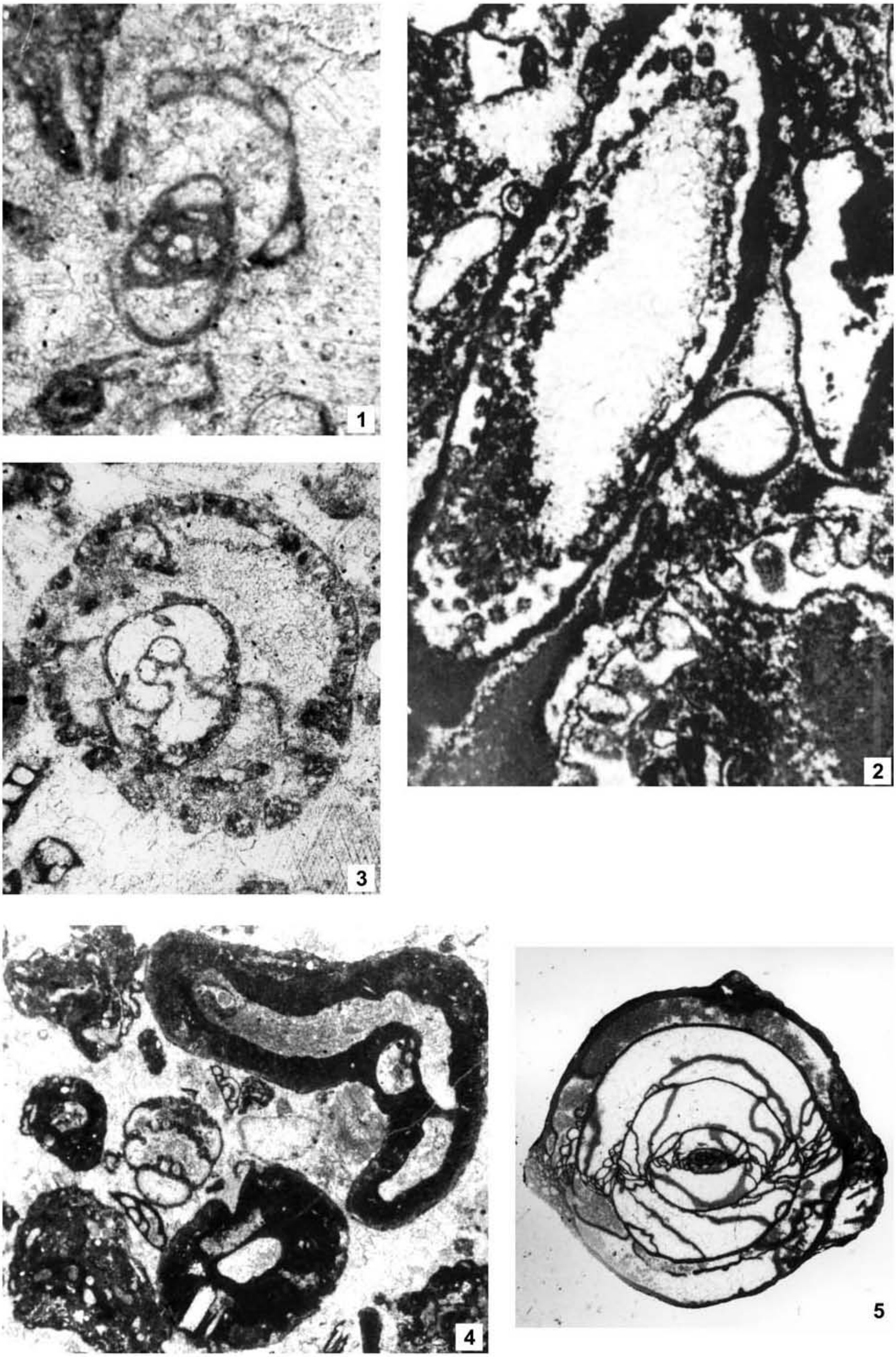
1 Foraminifera *Priscella prisca* (RAUZER-CERNOUSOVA). Lower Carboniferous (Viséan); from younger clastic sediments. Bizek, Medvednica Mt. – 100x.

2 Calcareous algae *Gyroporella likana* KOCHANSKY-DEVIDÉ. Upper Carboniferous (Moscovian). Brnjičevo, Velebit Mt. – 30x.

3 Foraminifera *Bradyina cribrostomata* RAUZER-CERNOUSOVA. Upper Carboniferous (Moscovian); from younger clastic sediments. Bizek, Medvednica Mt. – 100x.

4 Algosponge *Claracrusta calamistriata* VACHARD & MONTENAT; foraminifera *Cribrogenerina sumatrana* (VOLZ); Lower Permian?; from younger clastic sediments. Bizek, Medvednica Mt. – 25x.

5 Foraminifera *Pseudoschwagerina* cf. *moelleri* (RAUZER-CERNOUSOVA). Lower Permian (Rattendorf group). Popov Panj, Velebit Mt. – 10x.


1
2
3
4
5

short review – in Croatian].– In: SREMAC, J. (ed.): Vodič ekskurzije. Terenski sastanak Velebit (1982). IGCP Project br. 5, Jugosl. radna grupa, 3–7 (41–42), Zagreb.

SREMAC, J. & MIHAJLOVIĆ-PAVLOVIĆ, M. (1981): Graptolites of Mt. Medvednica (Zagrebačka Gora).– Rad Jugosl. akad. znan. umjetn., 404, 65–68, Zagreb.

STAMPFLI, G.M., BOREL, G., CAVAZZA, W., MOSAR, J. & ZIEGLER, P.A. (eds.) (2001): The Paleotectonic Atlas of the Peritethyan Domain.– CD-ROM, European Geophysical Society.

ŠĆAVNIČAR, B. & ŠUŠNJARA, A. (1967): Geološka i petrografska istraživanja trijaskih naslaga u Gorskom kotaru (područje Lokve–Gerovo) [*Geologic and petrographic investigations of the Triassic sediments in Gorski kotar (Lokve–Gerovo area)* – in Croatian].– Geol. vjesnik, 20, 87–106.

ŠIKIĆ, K. (1995): Prikaz geološke građe Medvednice [*Geology of Mt. Medvednica* – in Croatian].– In: ŠIKIĆ, K. (ed.): Geološki vodič Medvednice. Institut za geološka istraživanja & INA d.d. – Naftaplin, 7–40, Zagreb.

ŠUŠNJARA, A., SAKAČ, K., JELEN, B. & GABRIĆ, A. (1992): Upper Permian evaporites and associated rocks of Dalmatia and borderline area of Lika and Bosnia.– Geol. Croat., 45, 95–115.

TIŠLJAR, J. (1992): Origin and depositional environments of the evaporite and carbonate complex (Upper Permian) from the Central Part of the Dinarides (Southern Croatia and Western Bosnia).– Geol. Croat., 45, 115–127.

TIŠLJAR, J., VLAHOVIĆ, I., SREMAC, J., VELIĆ, I., VESELI, V. & STANKOVIĆ, D. (1991): Excursion A – Velebit Mt. Permian–Jurassic.– In: VLAHOVIĆ, I. & VELIĆ, I. (eds.): Excursion Guide-book, Sec. Int. Symp. Adriatic Carbonate Platform, Zadar, Croatia, Yugoslavia, May 12–18, 1991, 3–49, Zagreb.

VELIĆ, I., VLAHOVIĆ, I. & MATIČEC, D. (2002): Depositional sequences and palaeogeography of the Adriatic Carbonate Platform.– Mem. Soc. Geol. It., 57, 141–151.

WIGNALL, P.B. & TWITCHETT, R.J. (2002): Extent and duration of the Permian/Triassic superanoxic event.– In: KOEBERL, C. & MacLEOD, K.G. (eds.): Catastrophic Event and Mass Extinctions. Impact and Beyond. Geol. Soc. Am., Spec. Paper, 395–413.

ZIEGLER, A.M., ESHEL, G., McALLISTER REES, P., ROTHFUS, T.A., ROWLEY, D.B. & SUNDERLIN, D. (2003): Tracing the tropics across land and sea: Permian to present.– Lethaia, 36, 227–254.

Manuscript received March 30, 2004.

Revised manuscript accepted January 19, 2005.

PLATE 2

Carbonate producers in the Middle Permian of Croatia

1 Calcareous algae *Mizzia velebitana* SCHUBERT and *Permocalculus tenellus* (PIA), microproblematica *Tubiphytes obscurus* MASLOV and gastropods. Middle Permian. Milašnovac, Velebit Mt. – 25x.

2 Calcareous algae *Mizzia velebitana* SCHUBERT and *M. cornuta* KOCHANSKY & HERAK, foraminifera *Dunbarula nana* KOCHANSKY & RAMOVŠ and Palaeotextulariidae, Brachiopoda, radiolae. Middle Permian. Crne Grede, Velebit Mt. – 25x.

3 Cortoid grainstone with fragments of calcareous algae and foraminifera. Middle Permian, Road Gospić–Karlobag, Velebit Mt. – 25x.

PLATE 2

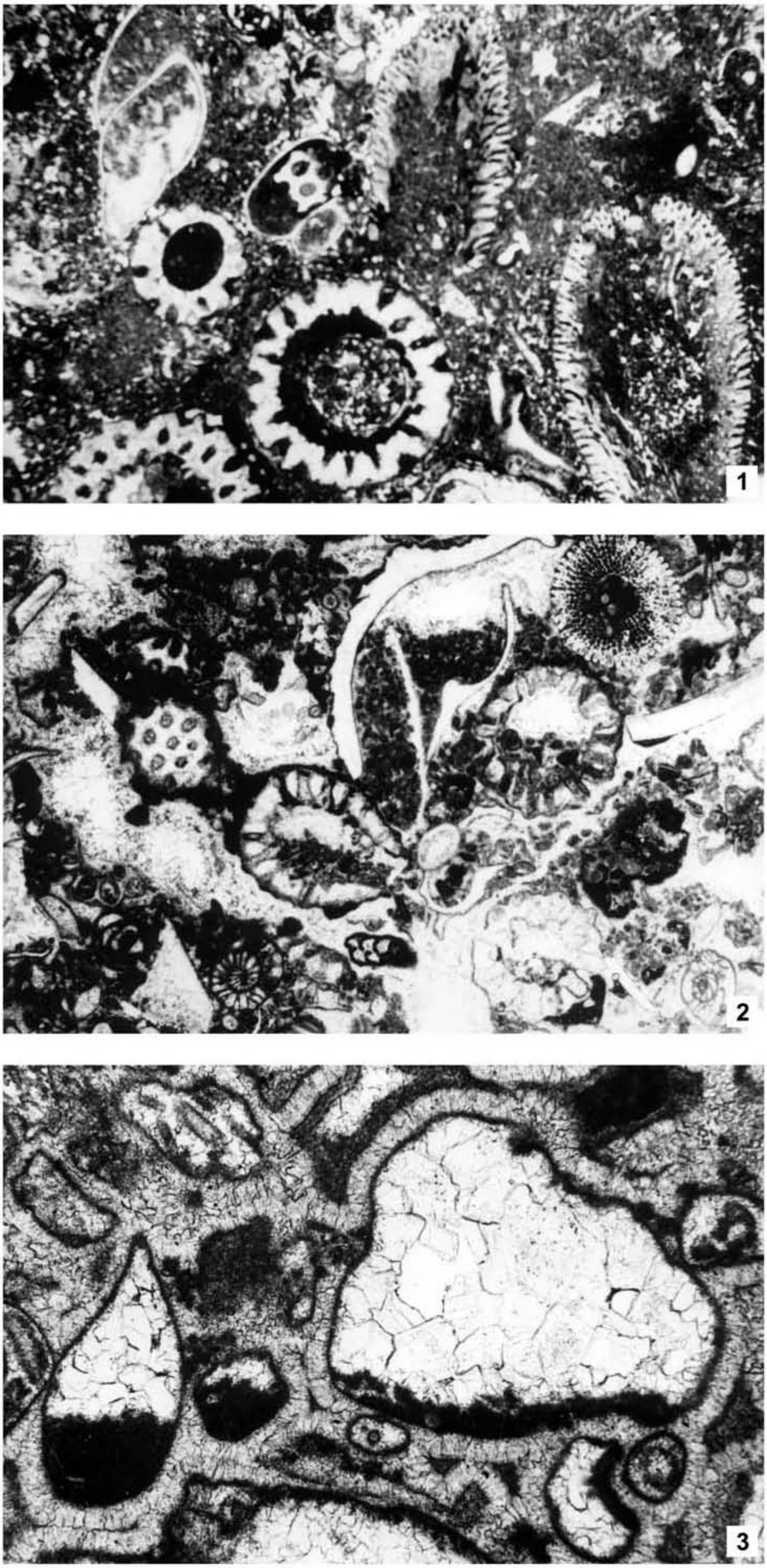


PLATE 3

Reef building biota in the Middle Permian of Croatia

1 Framestone with calcisponges: Inozoa gen.div. and *Sinocoelia lepida* ZHANG & FAN. Acetate peel – negative. Road Gospić–Karlobag, Velebit Mt. – 4x.

2 Floatstone (tempestite) with unsorted reef particles – calcisponges, bryozoans, foraminifera, calcareous algae. Acetate peel – negative. Road Gospić–Karlobag, Velebit Mt. – 4x.


1

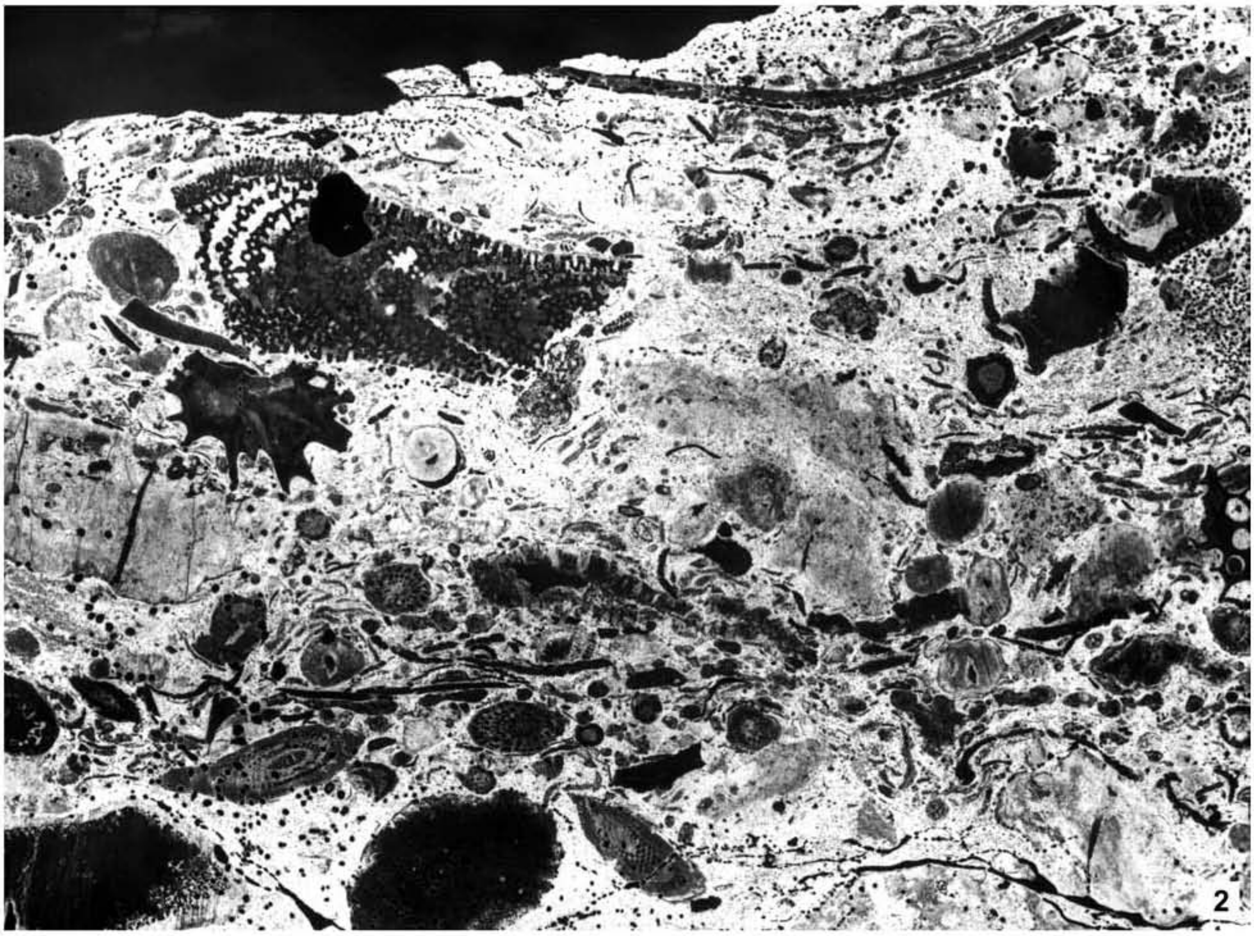

2

PLATE 4

Middle Permian sediments from the basinal slopes

1 Graded bioclastic wackestone–packstone with foraminifera (*Neoschwagerina*) and calcareous algae. Acetate peel – negative. Kalvarija, Velebit Mt. – 3x.

2 Mudstone with bioturbations. Acetate peel – negative. Kalvarija, Velebit Mt. – 2x.

Carbonate producers in the Upper Permian of Croatia

3 Calcareous alga *Atractyliopsis lastensis* ACCORDI. Bregana – 25x.

4 Earlandiaceae. Brušane – Baške Oštarije, Velebit Mt. – 50x.

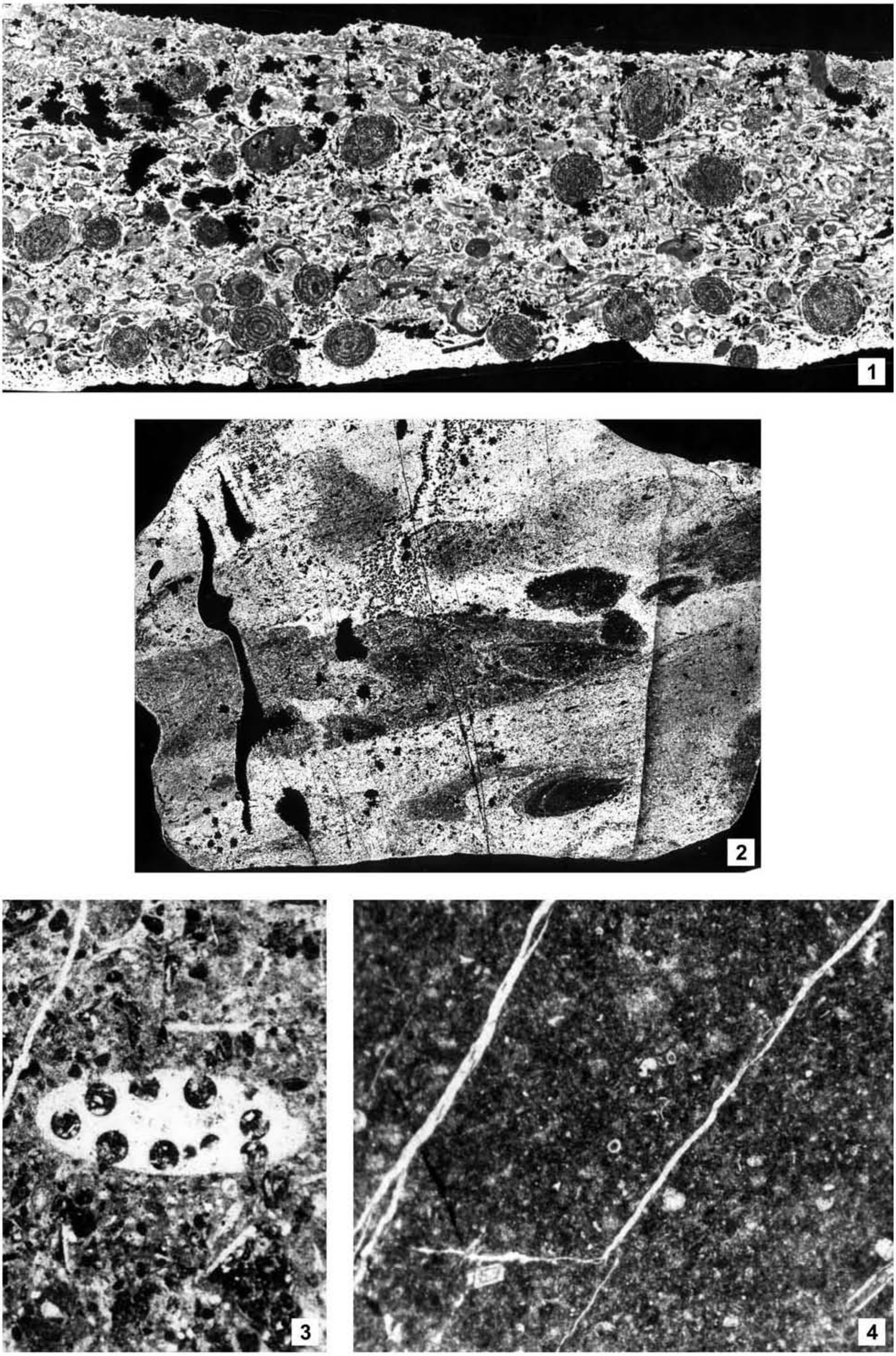


PLATE 5

Low diversity fossil communities of the Lower Triassic

1 Dolomite with stromatolites. Lower Triassic?, Brušane, Velebit Mt.

2 Micaceous sandstone with *Claraia clarai* (EMMERICH). Scythian, Gorski Kotar.

3 Marly dolomite with *Turbo rectecostatus* HAUER. Scythian, Muć.

PLATE 5