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The Palaeozoic of Velebit Mt.

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The succession on Velebit Mt. provides evidence of shallow-marine deposition with several periods of emergence from the Late Carboniferous (Moscovian) to the Oligocene, when the dominant uplift phase took place. Quaternary deposits in highlands and valleys tell the story of the more recent geological history, including the Pleistocene glaciation.

Late Palaeozoic rocks (Fig. 1), ranging from the Moscovian to the Uppermost Permian, exposed in cores of anticlines, can be observed at several localities in the Central and Southern Velebit Mt. (IVANOVIC et al., 1976; MAJCEN et al, 1973; SOKAC et al, 1976a, b). Although outcropping in restricted belts, these rocks represent the most completely developed, and the best known Palaeozoic area of Croatia (SREMAC, 2003).

CARBONIFEROUS

During the Carboniferous, clastic and carbonate deposition took place in shelf environments of the Western Palaeotethys. Dominant rock types are dark grey organic-rich limestones, dolomites and finely-layered argillaceous slates and graywackes.

Moscovian

The oldest determined fossils are of Moscovian age (KOCHANSKY-DEVIDE, 1955, 1970). Three horizons can be clearly recognized within these deposits:

1) The lowermost horizon comprises cyanobacteria *(Girvanelld)* and calcareous algae *(Eugonophyllum, Anchicodium, Gyroporella, Connexia, Herakella),* together with foraminifera (genera *Pseudoendothyra, Schubertella, Fusulinella, Eofusulina, Novella, Pseudostaffella, Aljutovella, Tuberitina, Tetrataxis, Globivalvulina, Glomospira, Palaeotextularia, Spiroplectammina, Ammodiscus, Plectogyra).*
2) The middle horizon comprises a slightly different foraminiferal community *(Pseudoendothyra, Ozawainella, Pseudostaffella, Beedina, Hemifusulina, Schubertella),* while the algae were almost nonexistent only *Dvinella* being observed.
3) The Upper Moscovian is again characterized by abundant species of calcareous algae, including: *Anthracoporella, Beresella, Dvinella, Eugonophyllum* and *Anchicodium.* Foraminifera are also present in significant amounts, particularly the genera *Eostaffella, Pseudoendothyra, Fusiella, Schubertella, Fusulinella, Beedina, Fusulina, Tuberitina, Tetrataxis, Globivalvulina, Cribrostomum, Palaeotextularia, Endothyra* and *Bradyiina.* In this horizon macrofossils (gastropods, trilobites and numerous brachiopods) are also common.

Kasimovian

The Kasimovian age of the overlying deposits has been determined on the basis of the first fusulinids with keriothecal tests *(Protriticites).* Two horizons can be clearly recognized.

The lower horizon contains rich algal assemblages: the genera Eugonophyllum, Anchicodium, Anthracoporella and Velebitella can be found together with foraminifera Pseudoendothyra, Eostaffella, Schubertella and Protriticites. An encrusting genus Tubiphytes is also common in this horizon. The Late Kasimovian horizon is exposed in the wider area (SIMIC, 1935; KOCHANSKY-DEVIDE, 1955; BALAZ, 1981), and can be closely compared to the Auernig beds of the Carnic Alps. These deposits are highly fossiliferous. The best preserved microfossils can be observed in limestones, while a rich macrofauna has been collected from argillaceous deposits. Yellowish-coloured 'Triticites-sandstones' with washed-out fusulinid moulds are very common rock types. These deposits are predominantly marine, but remnants of a continental macroflora, including for example, pteridosperms, lepidophytes, spenopsids and cordaitids (NEMEJC, 1938) indicate the close vicinity of land. Marine macrofossils have been determined by numerous authors (SIMIC, 1935; SALOPEK, 1939, 1948; RUKAVINA, 1973; BALAZ, 1981). Bivalves, gastropods, bryozoans, echinoderms and brachiopods, are particularly frequent while trilobite remnants are very scarce and poorly preserved.

Some common calcareous algae from the Carboniferous of the Velebit Mt. are presented in PI. I.

PERMIAN

"Rattendorf equivalents"

Permian deposits are always in tectonic contact with Carboniferous rocks. Early Permian, dominantly carbonate rocks, are the equivalents of the Rattendorf Beds of the Alps. Large fusulinids *(Schwagerina, Pseudoschwagerina, Zellia* and *Quasifusulina)* are common in these deposits, together with the encruster *Ramovsia.* Sparry cement and the composition of the fossil communities indicate an open shelf, high energy environment, not very favourable for calcareous algae, but remnants of *Epimastopora* have been found in the upper horizon.

"Kosna deposits"

Carbonate deposition in the area of Velebit and Lika was at this time interrupted by uplift in the wider area, and an approxiamtely 750 m thick complex of clastic Kosna deposits was deposited contemporaneously with the Trogkofel

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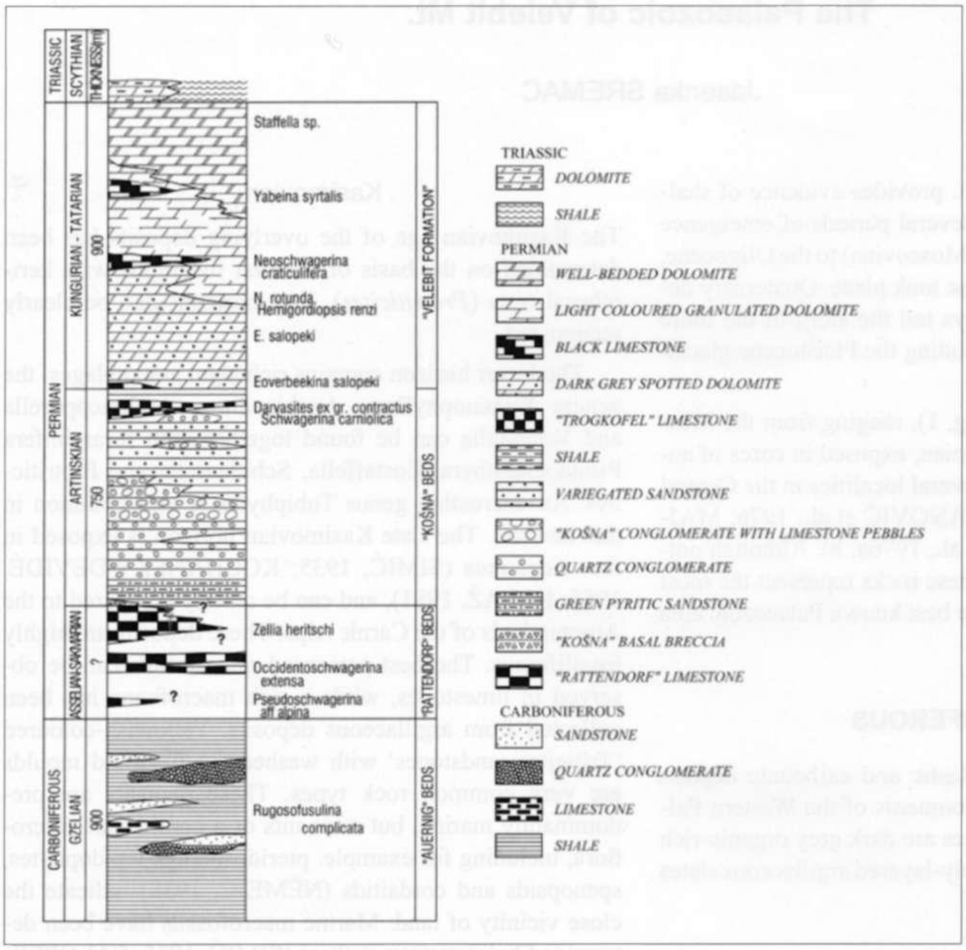

Fig. 1 Geological column of the Velebit Mt. Upper Palaeozoic deposits (after RAMOVS etal., 1990).

stage in the Alps. Multicoloured conglomerates, quartz conglomerates, sandstones and siltstones are the most common rocks of this phase. In scarce limestone lenses, microfossil communities were found, including the calcareous algae *Epimastopora, Pseudogyroporella* and *Neoanchicodium.*

"Velebit formation"

Shallow marine conditions, suitable for carbonate deposition, were again established during the Middle Permian, and they lasted up to the earliest Triassic. A typical subequatorial platform environment enabled the production of an almost 900 m thick sequence of carbonate deposits. Such a long-lasting platform environment was not common in Western Palaeotethys, and FLUGEL (1977) suggested the name "Velebit formation" for these beds.

During a very long period of time, cycles of shallow subtidal, tidal and supratidal origin were deposited, partly due to the global eustatic curve, and partly due to the local equilibrium between subsidence of the basin and the local deposition rate (SREMAC, 2005; FIO et al, 2006b). Dolomites are predominant, but fossils are best preserved in three horizons of organic-rich dark limestones. Calcareous algae were the most important source of the carbonate detritus.

The first limestone horizon - the Eoverbeekina salopeki Zone, was directly deposited over the red Kosna sandstones. It is overlain by about. 300 m of dolomitic rocks, with the very common recrystallized dasyclad algae *Mizzia* accompanied by large benthic fusulinids. Macrofossils - corals, gastropods, cephalopods and bivalves - have also been found within these rocks.

The second limestone horizon - the Neoschwagerina craticulifera Zone, is characterized by particularly rich fossil assemblages. Besides *Neoschwagerina craticulifera* several genera of foraminifera are very common: *Dunbarula, Nankinella, Chusenella, Dunbarinella, Kahlerina, Schubertella, Glomospira, Globivalvulina, Agathammina* and *Hemigordius* (KOCHANSKY-DEVIDE, 1965).

Algal assemblages were dominant in contemporaneous lagoonal and similar sheltered environments. The most common genera were dasyclad Mizzia and gymnocodiacean genera *Gymnocodium* and *Permocalculus* (SCHUBERT, 1907, 1909; HERAK & KOCHANSKY-DEVIDE, 1960; KOCHANSKY-DEVIDE & HERAK, 1960). Gymnocodiaceans sporadically occur in separate communities, but it is also possible to find them in mixed communities, together with *Mizzia* (SREMAC, 1991). The genera *Vermiporella, Velebitella, Goniolinopsis* and *Salopekiella* also occur in this horizon (KOCHANSKY-DEVIDE, 1964; MILANOVIC, 1965, 1966a, b, 1968, 1974, 1975). Within the algal communities, mounds and bioherms were built by bryozoans *(Fenestella),* cyanobacteria and other incrustants *(Tubiphytes)* in some places (MARJANAC & SREMAC, 2000; see Stop 5 for details). Calcareous sponges, such as *Colospongia, Waagenella, Sinocoelia* and *Guadalu-*

pia were very important in the formation of patch-reefs (SREMAC, 1991). The brachiopod genera *Martinia* and *Enteletes* lived within the reef cavities. Some brachiopod taxa produced biostromes *{Leptodus, Keyserlingind)* and some lived anchored by spines or some other shell adaptations on the muddy bottom (small productids, *Ramovsia;* SREMAC, 1986).

Overlying deposits are in most cases light-grey late-diagenetic dolomites, 'Schwagerina dolomites' sensu SALOPEK (1942), in which algal and other remnants are poorly recognizable. A very shallow, tidal to supratidal environment is presumed.

The uppermost, third limestone horizon has a very similar fossil content to the second zone. The Yabeina syrtalis Zone was proposed on the basis of the common presence of this benthic species. Among the calcareous algae *Mizzia* and gymnocodiaceans are still common.

The uppermost Permian deposits, "Boundary Dolomites" sensu SALOPEK (1942) indicate slightly different environmental conditions: due to the uplift in the wider area, the input of clastic material (sand containing mica) gradually increased. Fossil communities became less rich and diverse. Dasyclad algae disappeared, while gymnocodiaceans remained for a short period, but decreased in size. The Late Permian assemblages were dominated by tolerant small foraminifera (e.g. *Globivalvulina, Glomospird)* and taxa typical for stressed environments *(Earlandia).* Sea-level oscillations were very common in this period, and periods of emergence can be documented on the basis of sedimentary features, and geochemical and isotope analyses (FIO et al, 2006a, b, 2007). SALOPEK (1942) presumed a continuous transition into the Lower Triassic, which was later confirmed by FIO et al, (2006a, b, 2007), since the P-Tr boundary (PTB) is located approximately 10 m above the lithological boundary marked by emergence. Near the PTB, which was documented by geochemical and isotopic analyses, dolomites are completely sterile, with no evidence of life, but deposition of similar rocks continued into the Early Triassic (FIO et al, 2006a, b, 2007).

Some common calcareous algae from the Permian of the Velebit Mt. are presented in PI. II.

GENERAL REFERENCES

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

FIO, K, SPANGENBERG, J.E, SREMAC, J, VLAHOVIC, I, VELIC, I. & MRINJEK, E. (2006a): Geochemical evidence for environmental changes at the Permian-Triassic transition, Mt. Velebit, Croatia - Geochimica et Cosmochimica Acta, 70/18, Suplement 1,A174.

FIO, K., SPANGENBERG, J.E, SREMAC, J, VLAHOVIC, I, VELIC, I, MRINJEK, E. (2006b): Causes of Permian/Triassic mass extinction at the Velebit Mt, Croatia: geochemical and isotopical insights - Abstract book, 2nd Slovenian Geological Congress, Idrija, Slovenia.

FIO, K, SPANGENBERG, J.E, SREMAC, J, VLAHOVIC, I, VELIC, 1, MRINJEK, E. (2007): Molecular and isotopic records of the Permian-Triassic transition at the Velebit Mt, Croatia.- Studia UBB, Geologia, ESIRIX, Cluj-Napoca, Ro-

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

IVANOVIĆ, A, SAKAČ, K, SOKAČ, B, VRSALOVIĆ-CAREVIĆ, I. &ZUPANIČ, J. (1976): Osnovna geološka karta SFRJ 1:100000. Tumač za list Obrovac, L33-140.- Inst, geol. istraž. Zagreb (1967), Sav. geol. zavod Beograd, 61 p, Beograd.

KOCHANSKY-DEVIDÉ, V. (1955): Karbonske ipermske fuzulinidne foraminifere Velebita i Like 1. Opći dio i karbon - Rad Jugosl. akad. znan. umjet, 305, 5-62, Zagreb.

KOCHANSKY-DEVIDÉ, V. (1965): Karbonske i permske fuzulinidne foraminifere Velebita i Like. Srednji i gornji perm (Die fusuliniden Foraminiferen aus Karbon und Perm im Velebit und in der Lika, Kroatien. Mittleres und oberes Perm).- Acta geol. 5 (Prir. istraž. JAZU, 35), 101-137, Zagreb.

MAJCEN, Ž, KOROLIJA, B, SOKAČ, B. & NIKLER, L. (1973): Osnovna geološka karta SFRJ 1:100000. Tumač za list Zadar, L33-139.- Inst. geol. istraž Zagreb (1967), Sav. geol. zavod Beograd, 44 p, Beograd.

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.

NËMEJC, F. (1936): Contribution to the knowledge of the Carboniferous flora of the coal measures at the North-eastern foot of the Velebit mountains (Yougoslavia).- Bull. int. Acad. Sci. Boheme, 1-16.

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

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 (Central Croatia)).- Geol.vjesnik 26, 319-323, Zagreb.

SALOPEK, M. (1939): Karbon i perm u okolini Brušana i Sv. Roka - Ljetopis Jugosl. akad. znan. umjet, 51, 135-139, Zagreb.

SALOPEK, M. (1942): O gornjem paleozoiku Velebita u okolici Brušana i Baških Oštarija - Rad Hrv. akad. znan. umjet, 274, 218-272, Zagreb.

SALOPEK, M. (1948): O gornjem paleozoiku sjeveroistočnog podnožja Velebita i Like (Sur le Paléozoique Supérieur du pied de la Montagne de Velebit et de la Lika).- Prir. istzraž. Jugosl. akad. znan. umjet, 24, 161-169, Zagreb.

SIMIĆ, V. (1935): Gornjokarbonski fosili iz Like u Hrvatskoj (Oberkarbonische Versteinerungen von Lika in Kroatien).- Vesnik Geol. inst. Kralj. Jugosl, 1/1 (4/1), 141-145, Beograd.

SOKAČ, B, ŠUŠNJAR, M, BUKOVAC, J. & BAHUN, S. (1976a): Osnovna geološka karta SFRJ 1:100000. Tumač za list Udbina L33-128- Inst. geol. istraž. Zagreb (1965), Sav. geol. zavod Beograd, 62 p.

SOKAČ, B., ŠĆAVNIČAR, B. & VELIĆ, I. (1976b): Osnovna geološka karta SFRJ 1:100000. Tumač za list Gospić L33-127.- Inst. geol. istraž. Zagreb (1967), Sav. geol. zavod 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 (Zone Neoschwagerina craticulifera in the Middle Velebit Mt. (Croatia, Yugoslavia)).- Geologija, 34, 7-55, Ljubljana.

SREMAC, J. (2003): Inventarizacija geoloških osobitosti Parka prirode Velebit - Park prirode Velebit (internal report), 71 p.

SREMAC, J. (2005): Equatorial shelf of the Palaeozoic supercontinent - Craddle of the Adriatic Carbonate Platform - Geol. Croat. 58/1, 1-19, Zagreb.

References on calcareous algae

HERAK, M. & KOCHANSKY-DEVIDE, V. (1960): Gymnocodiacean calcareous algae in the Permian of Yugoslavia (Gimnokodijacejske vapnenačke alge u permu Jugoslavije).- Geol. vjesnik, 13 (1959), 185-196, Zagreb.

KOCHANSKY-DEVIDE, V. (1964): *Velebitella,* eine neue jungpaläozoische Diploporeengattung und ihre phylogenetischen Verhältnisse *(Velebitella,* novi gornjopaleozojski rod diploporea i njeni filogenetski odnosi).- Geol. vjesnik, 17 (1963), 135-142, Zagreb.

KOCHANSKY-DEVIDE, V. (1970): Die Kalkalgen des Karbons vom Velebit-Gebirge (Moskovien und Kassimovien) (Vapnenačke alge karbona Velebita (moskovijen i kasimovijen)).- Palaeont. jugosl, 10, 1-32, Zagreb.

KOCHANSKY-DEVIDE, V. & HERAK, M. (1960): On the Carboniferous and Permian Dasycladaceae of Yugoslavia (O karbonskim i pennskim dasikladacejama Jugoslavije).- Geol. vjesnik, 13 (1959), 65-94, 9 pi, 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 (Prir. istraž, Jugosl. akad. znan. umjet, 35), 373-382, Zagreb.

MILANOVIĆ, M. (1966a): *Likanella* - a new Permian genus of the family Dasycladaceae *(Likanella* - novi pennski rod familije Dasycladaceae).- Geol. vjesnik, 19 (1965), 9-14, Zagreb.

MILANOVIĆ, M. (1966b): *Goniolinopsis,* a new Permian genus of the family Dasycladaceae *(Goniolinopsis,* novi pennski rod familije Dasycladaceae).-Geol. vjesnik, 19 (1965), 115-122, Zagreb.

MILANOVIĆ, M. (1968): *Salopekiella Ikochanskae* n.sp. (Dasycladaceae) from the Permian of the Velebit Mountain *(Salopekiella Ikochanskae* n.sp. (Dasycladaceae) iz perma Velebita).-Geol. vjesnik, 21 (1967), 157-160, Zagreb.

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

MILANOVIĆ, M. (1975): *Salopekiella Ibreziki* n.sp. (calcareous algae, Dasycladaceae) from the Permian of Mt. Velebit (Croatia) *(Salopekiella Ibreziki* n.sp. (vapnenačke alge, Dasycladaceae) iz perma Velebita).- Geol. vjesnik, 28, 81-86, Zagreb.

SCHUBERT, R.J. (1907): Vorläufige Mitteilung über Foraminifera und Kalkalgen aus dem dalmatinischen Karbon - Verhandlungen der kaiserlich-königlichen geologischen Reichsanstalt, 8, 211-214, Wien.

SCHUBERT, R.J. (1909): Zur Geologie der österreichischen Velebit- Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt, 58/2 (1908), 345-386, Wien.

PLATE I

Some common dasyclad algae from the Carboniferous of the Velebit Mt.

1 *Gyroporella prisca* KOCHANSKY-DEVIDE

2 *Gyroporella likana* KOCHANSKY-DEVIDE

3 *Gyroporella intraseptata* KOCHANSKY-DEVIDE

4 *Gyroporella constricta* KOCHANSKY-DEVIDE

5 *Herakella paradoxa* KOCHANSKY-DEVIDE

6 *Connexiafragilis* KOCHANSKY-DEVIDE

7 *Anthracoporella vicina* KOCHANSKY & HERAK

Magnification x20.

1-6 Brnjićevo near Ričice (after KOCHANSKY-DEVIDE, 1970)

7 Vinac (after KOCHANSKY & HERAK, 1960).

PLATE I

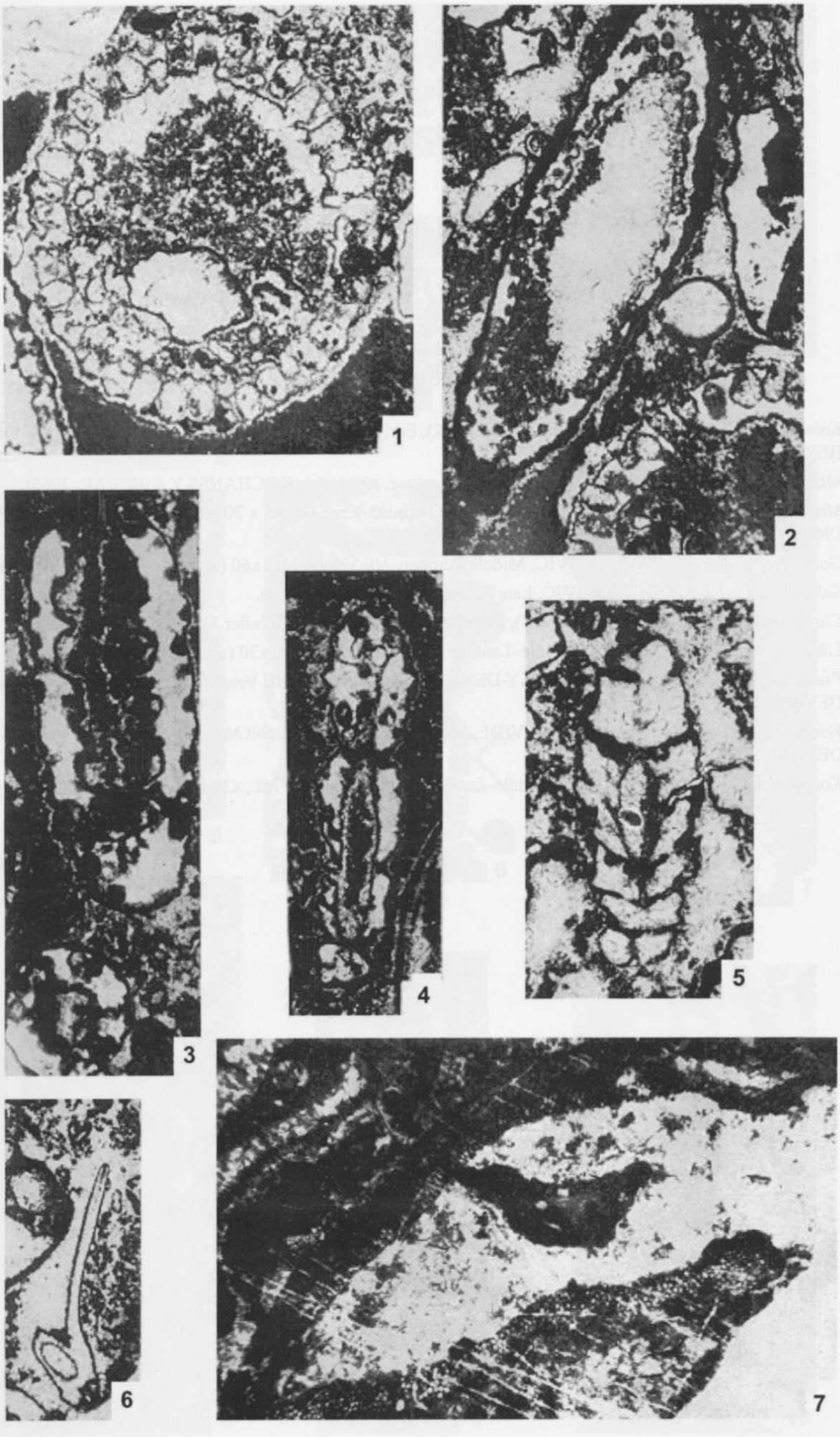

PLATE II

Some common calcareous algae from the Permian of the Velebit Mt.

1 *Epimastoporella likana* (KOCHANSKY & HERAK), Early Permian, Robijača, x40 (after KOCHANSKY & HERAK, 1960).

2 ***Mizzia** velebitana* SCHUBERT, Middle Permian, Brasane, x20 (after KOCHANSKY & HERAK, 1960).

3 *Mizzia cornuta* KOCHANSKY & HERAK, Middle Permian, Crne Grede, x 20 (after KOCHANSKY & HERAK, 1960).

4 *Goniolinopsis hexagona* MILANOVIĆ, Middle Permian. NE Velebit Mt., x60 (after MILANOVIĆ, 1966 b).

5 *Salopekiella velebitana* MILANOVIĆ, Late Permian. NE Velebit Mt., x40.

6 *Clavaporella kochanskae* (MILANOVIĆ), Permian. NE Velebit Mt., x30 (after MILANOVIĆ, 1965).

7 *Likanella spinosa* MILANOVIĆ, Middle-Late Permian. NE Velebit Mt., x30 (after MILANOVIĆ, 1966 a).

8 *Pseudovelebitella simplex* (KOCHANSKY-DEVIDÉ), Early Permian. NE Velebit Mt., x75 (after KOCHANSKY-DEVIDÉ, 1964).

9 *Velebitella triplicata* KOCHANSKY-DEVIDÉ, Middle Permian. NE Velebit Mt., x40 (after KOCHANSKY-DEVIDÉ, 1964).

10 *Kochanskyella tulipa* MILANOVIĆ, Middle-Late Permian. NE Velebit Mt, x30 (after MILANOVIĆ, 1974).