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Triassic Pelagic Limestones in Pillow Lavas in the Orešje Quarry near Gornja Bistra, Medvednica Mt. (Northwest Croatia)

Josip **HALAMIĆ**[1], Damir **SLOVENEC**[1] and Tea **KOLAR-JURKOVŠEK**[2]

Key words: Peperites, Basaltic pillow lavas, Triassic conodonts, Medvednica Mt., Croatia.

Abstract

Investigated outcrops in the Orešje quarry near Gornja Bistra on Medvednica Mt. contain pillow lavas and massive metabasalts with fragments of carbonate rocks between them. The effusive rocks were determined as high-Ti tholeiitic metabasalts, corresponding to those which originated in the MOR area, which today represent obducted, allochthonous parts of Triassic oceanic crust. Carbonate rock fragments are characterised by micrite, biomicrosparite, fossiliferous microsparite, biosparite and sparite types, all of which are more or less recrystallised. From their appearance between pillows, together with hyaloclasts they were determined as peperites. Micropalaeontological analysis of conodonts from the limestone samples indicated a Middle Triassic age, which is also the age of the effusive rocks discovered in the quarry.

1. INTRODUCTION

For the last 20-30 years it has been possible to determine the age of magmatic rocks rather precisely by physico-chemical methods. However, different processes can have an important influence on the result of such investigations, such as spilitization, hydrothermal metamorphism and very low to low grade metamorphism. Therefore, the best results are those which could be justified by palaeontological data gained from sedimentary rocks genetically connected with the effusives, although such cases are relatively infrequent. During the geological investigations for the Geological Map of the Republic of Croatia (1:50.000 scale) in the abandoned Orešje quarry of basic effusive rocks near Gornja Bistra on Medvednica Mt., fragments of limestones containing Triassic conodonts were found between pillow lavas.

The abandoned quarry is located on the NW flanks of Medvednica Mt., 10 km NE of Zagreb, approximately 1 km SE of Gornja Bistra village, and only 100 m SE of Orešje village (Fig. 1). The local road connecting Gornja Bistra with the main road towards Sljeme passes through the quarry.

There have been no detailed geological and petrological data on the basic effusive rocks of this quarry, since they were treated as a part of a complete magmatic body of NW part of the Medvednica Mt. (GORJANOVIĆ-KRAMBERGER, 1908; CRNKOVIĆ, 1963; ŠIKIĆ et al., 1979). Recently, after measuring of the sequence in the quarry for the Geological Map these rocks were shortly described in the Geological Guidebook of Medvednica Mt. (HALAMIĆ & SLOVENEC, 1995).

The main purpose of this paper is to present a detailed geological, petrographical and geochemical description of the eruptive rocks from the quarry and its immediate vicinity, as well as a palaeontological and stratigraphical description of the carbonate rocks, which are genetically connected with them on the SW margin of the magmatic-sedimentary complex of the NW part of Medvednica Mt. Palaeontological data would enable determination of the age of the carbonate fragments, and in this way also the age of the volcanic activity which resulted with pillow lavas in the Gornja Bistra quarry. These data are very important for the reconstruction of the palaeogeographic relationships in this part of Tethys during the period of effusion of these basic volcanics.

2. BASIC GEOLOGICAL DATA

Medvednica Mt. is located in the SW part of the Pannonian Basin, and represents part of the Supradinaricum geodynamic unit (HERAK, 1986) or Inner Dinarides (HERAK et al., 1990).

Effusive rocks of the Gornja Bistra quarry are located on the SW margin of a several kilometre long basalt body, which belongs to the magmatic-sedimentary complex of the NW part of Medvednica Mt. (Fig. 1). Extension, or parts of this complex can be found further towards the north on Kalnik Mt., as well as on SE flanks of Ivanščica Mt. (ŠIMUNIĆ et al., 1981; HALAMIĆ, 1998).

Magmatic rocks with accompanying sedimentary rocks are towards the SE in reverse contact with the low-grade metamorphic rocks, while towards the NE they are in normal tectonic contact with the correspond-

[1] Institute of Geology, Sachsova 2, P.O.Box 268, HR-10000 Zagreb, Croatia.

[2] Institute of Geology, Geotechnics and Geophysics, Dimičeva 14, SLO-1000 Ljubljana, Slovenia.

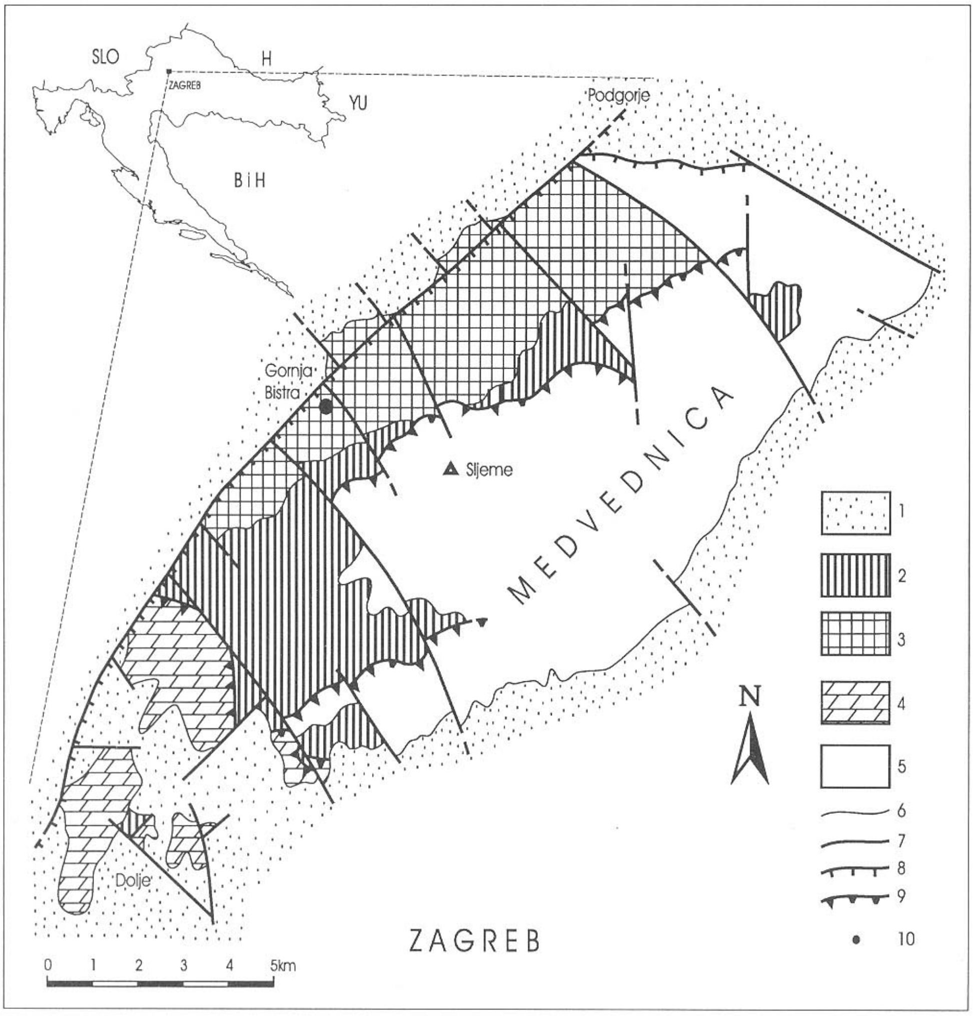

Fig. 1 Location map and schematic geological map of Mt. Medvednica (after ŠIKIĆ et al., 1977, BASCH, 1981 and our data - simplified). Legend: 1) Tertiary sedimentary rocks; 2) Cretaceous-Palaeogene sedimentary rocks; 3) magmatic and sedimentary rocks; 4) Triassic clastic and carbonate rocks of Zakičnica nappe; 5) metamorphic rocks; 6) boundary; 7) fault; 8) reverse fault; 9) thrust fault; 10) investigated locality.

ing rocks. Towards the SW they are divided from the Upper Cretaceous - Palaeogene sedimentary rocks by a fault system. On their NW side magmatic rocks are discordantly covered by Neogene deposits. Sedimentary rocks of Neogene age were also sporadically found in the reversed position beneath the effusive rocks (Fig. 1).

In the vicinity of the quarry the geological situation is very complex. This is the consequence of tangential tectonic movements, which were subsequently masked by radial tectonics. From the quarry towards the N and NE effusive rocks border the main magmatic complex. Towards the east, metabasalts are covered by coarse-grained clastic rocks composed of pebbles, cobbles and blocks of sandstone, siltstone and effusive rocks. The matrix of these rocks is composed of siltite and shale, and their structure is schistose. Towards the south and southwest, basalts of the quarry are in contact with silicified siltose shales, dark red and greenish in colour, which are interbedded with radiolarian cherts of the same colour, and metre-thick beds of breccio-conglomerates with chert fragments. Radiolarian cherts found 300 m SW of the quarry are of Upper Triassic age. Middle to Upper Triassic radiolarites were also found in the area of the Poljanica creek, south of the quarry (HALAMIĆ & GORIČAN, 1995).

The age of the magmatic-sedimentary complex of the NW part of Medvednica Mt. was defined as Lower Cretaceous (ŠIKIĆ & BASCH, 1975; ŠIKIĆ et al., 1979; BASCH, 1983). According to CRNKOVIĆ (1963) magmatic rocks are of Upper Cretaceous age. These conclusions on the age of the magmatic rocks were based on the micropalaeontological data from the carbonate clastic rocks (GUŠIĆ, 1971, 1974), which are mostly found above the main part of the magmatic rocks of the Medvednica Mt. (HALAMIĆ, 1998).

3. PETROLOGICAL AND GEOCHEMICAL DATA

3.1. MAGMATIC ROCKS

3.1.1. Petrography

Analysed magmatic rocks represent basic effusive rocks, determined as metabasalts. These rocks are green and dark red, sporadically are somewhat jointed and weathered, and along fault zones intensely cataclastyzed. The major part of the rock mass is composed of pillow lavas (30-50 cm in diameter) and a lesser component of massive metabasalts (Fig. 2). The matrix bet-

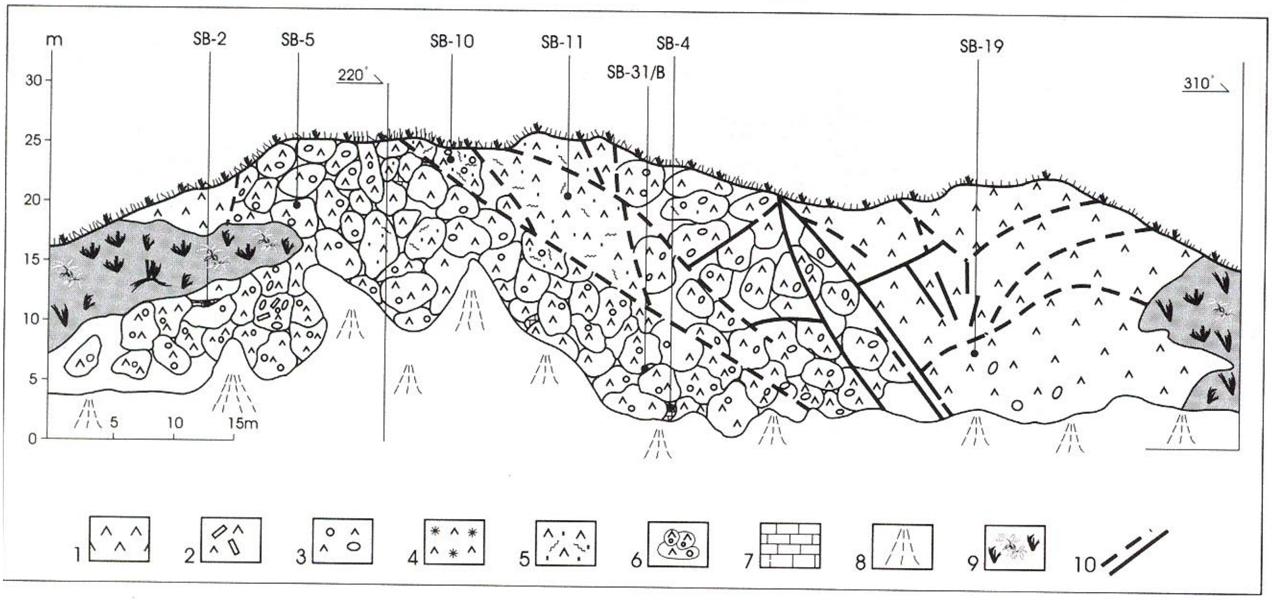

Fig. 2 Sketched cross-section through the Orešje quarry. Legend: 1) ophitic metabasalt; 2) porphiritic-ophitic metabasalt; 3) metabasalt with amygdaloidal structure; 4) metabasalt with divergent-radial structure; 5) cataclastyzed metabasalt; 6) pillow lava; 7) carbonate rock; 8) scree; 9) grown part; 10) fault.

ween the pillows is composed of red-violet and green mineral agglomerates and calcite (Fig. 3). Calcite was removed from the green agglomerates, and Rtg analysis indicated a composition characterised by chlorite, vermiculite and seladonite, with subordinate quartz (approximately 12%), haematite (approximately 5%) and a very low portion of plagioclase.

The marginal as well as inner parts of the pillows (sample SB5) are composed of metabasalts that have a mostly divergent-radial and intersertal texture, whereas the marginal parts of the pillows have explicitly variolitic structure, which suggests rapid cooling of the entire pillow and not just of its marginal part, partly caused by pillow size.

However, in the sample SB10 from the inner part of a pillow, crossed twig-like albite with interstices filled by feather-like to prismatic clinopyroxene (augite) were observed (Fig. 4). The ophitic texture of metabasalts indicates slower cooling of the inner pillow part, with simultaneous crystallization of the primary mineral element of plagioclase and clinopyroxene.

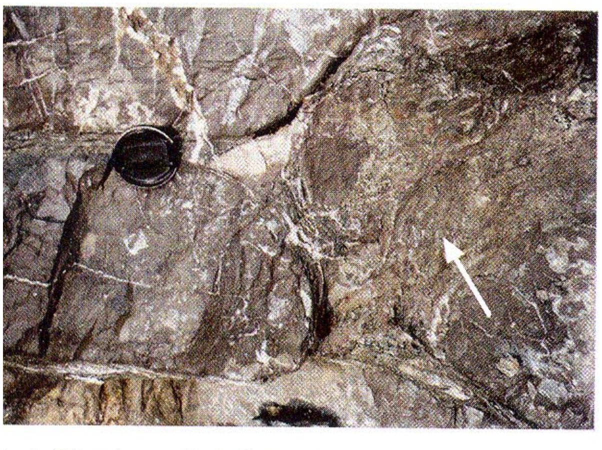

Fig. 3 Pillow lavas with decimetre-sized pillows. To the right of the objective cover a large (5 cm in diameter) enclave of pale gray micrite is visible. The matrix between the pillows is composed of red-violet and green mineral agglomerates and calcite (arrow).

Textures of masssive metabasalts (samples SB11 and SB19) are mostly microcrystalline, ophitic to relict ophitic (in cataclastic varieties) and divergent-radial, only sporadically porphyritic-ophitic. Their structure is massive and rarely amygdaloidal. On the basis of textural and structural characteristics ophitic, relict ophitic, porphyritic-ophitic, divergent-radial, amygdaloidal variolitic and cataclastic varieties were distinguished. These aforementioned types comprise the mineral association of albite + altered augite + secondary minerals. A sample of porphyritic-ophitic basalt from a dark red pillow was analysed by Rtg diffraction, and it was determined that it is composed predominantly of albite, and subordinate calcite (approximately 15%), 7% of finely dispersed haematite and a very low content of seladonite, identical to that found in the matrix between the pillows. Albite is twig-like, ranging in size from 0.2-0.9 mm, only sporadically as phenocrysts up to 3 mm in porphyritic-ophitic metabasalt, and practically has no relief. It is mostly blurred, inhomogenuous, weathered, weakly sericitized, and contains numerous enclaves of chlorite, clinozoisite, epidote, and calcite. Albite originated by albitization during the postmagmatic phase under the influence of hydrotherms, and it was formed from the basic plagioclases, of which relic forms are sporadically preserved.

Augite is only partially preserved as articulated and feather-like forms (Fig. 4), it is granular and characterised by intense positive relief. It is mostly completely weathered, and postmagmatically hydrothermally altered into chlorite and a blurred cryptocrystalline mass of

Fig. 4 Relics of articulated and feather-like augite (scale bar = 0.1 mm; N+).

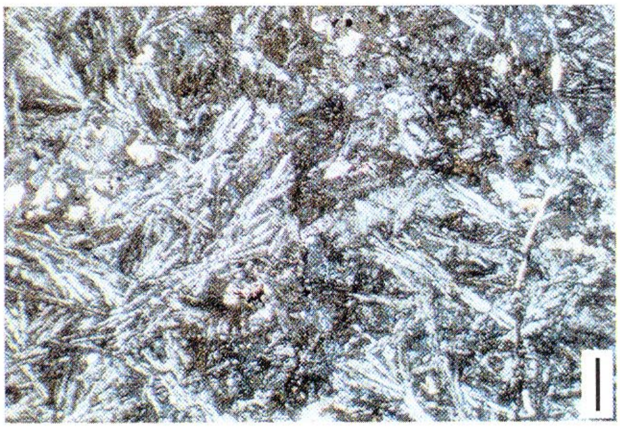

Fig. 5 Augite which is weathered and completely altered into chlorite and blurred cryptocrystalline mass of the clinozoisite-epidote(?) (scale bar = 0.1 mm; N+).

clinozoisite-epidote(?) (Fig. 5). The interstitial space is filled with agglomerates of chlorite, blurred epidote, pumpellyite(?), cryptocrystalline products of devitrified volcanic glass, haematite, clinozoisite and calcite, which, together with chlorite, zeolite, neoalbite and quartz also fills secondary fractures. Monomineralic vesicles of chlorite, calcite, chalcedony and subordinately zeolite are common, while zonal vesicles of chlorite with a calcite margin are infrequent. Opâque minerals are accessories.

3.1.2. Geochemistry

Four samples of the magmatic rocks from the Orešje quarry were geochemically analysed. Major elements and some trace elements (Rb, Sr, Y, Zr, Nb and Ba) were analysed by XRF in XRAL Laboratories (Canada), while other trace elements were analysed by ICP in ACME Analytical Laboratories (Canada). Results of these analyses are presented in Table 1, while CIPW norms and petrochemical indices are presented in Table 2.

In comparison with the modal composition, normative plagioclases in some of the analysed samples indicate a more basic character (Table 2). This may be caused by calcium, which is a constituent of the minerals from the zoisite-epidote group and augite (samples SB10 & SB19). According to the normative CIPW composition samples SB5 & SB10 contain normative hypersthene, and samples SB11 & SB19 normative nepheline, and they correspond to the alkaline basalts.

On the TAS diagram (Le BAS et al., 1986) three analysed samples belong to the area of basic rocks, while one belongs to the neutral type (Fig. 6). Since analysed rocks are metabasalts, which are postmagmatically enriched in Na and K, it is not unusual that they belong not only to the basalt field but also to that of the phonotephrite (basic member) and basalt andesite (intermediate member). In the latter, postconsolidational alterations were strongest, with the presence of quartz vesicles, which resulted in an increased silica content and decreased CaO value. Furthermore, the Al_2O_3 content in sample SB5 is somewhat decreased, as well as the MgO content in samples SB10 & SB11, while the K_2O content in sample SB11 is considerably increased, with an increased content of P_2O_5 in sample SB10, as well as TiO_2 content in samples SB10, SB11 & SB19 in regard to the average major elements contents of the oceanic tholeiites of middle-oceanic ridges (MORB) (WEDEPOHL, 1988). Values of other major elements are within the ranges of average values for the MORB.

A particularly high Na_2O content in samples SB5 & SB11 is the result of the albitisation, where mafic plagioclase is completely altered to albite, with a raised content of silica and decreased content of MgO. Partial alteration of mafic plagioclase to albite, with abundant clinopyroxene (augite) in samples SB10 & SB19, caused an increase of CaO and simultaneous decrease of Na_2O content.

All analysed samples belong to the Na-series, which is obvious on the Na_2O vs. K_2O diagram (MIDDLEMOST, 1975) (Fig. 7).

In massive metabasalts (samples SB11 & SB19) the content of P_2O_5 is remarkably decreased in relation to metabasalts from pillows (samples SB5 & SB10) with a very high P_2O_5 content. The values of manganese and aluminium are similar in all analysed samples.

On the SiO_2 vs. (Na_2O+K_2O) diagram (MIYASHIRO, 1974) (Fig. 8b) samples SB11 & SB19 are situated in the field of alkali basalts, and sample SB5 in the field of subalkali rocks. Sample SB10 is located on the boundary between these two fields. Comparison of this diagram and the SiO_2 vs. FeO*/MgO diagram (MIYASHIRO, 1974) (Fig. 8a) indicates differences, since samples SB10, SB11 & SB19 fall within the field of the tholeiitic series, and only sample SB5 within the field of the calk-alkaline series.

On the basis of the Ti vs. V ratio (SHERVAIS, 1982) all samples belong to the high-Ti basalts (Ti/V ratio >20), which originated in the MOR area, i.e. BAB

Sample	1	2	3	4	Recalc. on 100% without volatiles 1	2	3	4
SiO_2	53.90	45.70	47.01	43.05	57.77	48.99	50.53	45.53
TiO_2	1.22	1.50	2.02	1.59	1.31	1.61	2.20	1.68
Al_2O_3	13.10	16.00	15.30	15.71	14.04	17.15	16.45	16.61
Fe_2O_3	2.72	3.00	1.48	3.60	2.92	3.22	1.59	3.27
FeO	8.17	5.34	6.72	6.61	8.75	5.73	7.22	7.48
MnO	0.19	0.13	0.15	0.13	0.20	0.14	0.16	0.14
MgO	5.64	8.07	5.56	9.32	6.05	8.65	5.98	9.86
CaO	3.39	10.00	7.32	11.50	3.63	10.72	7.87	12.16
Na_2O	4.70	3.11	5.41	2.90	5.04	3.33	5.81	3.07
K_2O	0.04	0.12	2.05	0.19	0.04	0.13	2.17	0.20
P_2O_5	0.23	0.31	0.02	0.01	0.25	0.33	0.02	0.01
LOI	4.35	5.15	6.22	5.11				
Total	**98.70**	**99.10**	**99.29**	**99.72**				
Ba	150	210	675	73				
Cr	500	300	203	160				
Nb	22	29	20	20				
Sr	102	119	424	100				
V	265	203	213	252				
Y	23	24	23	25				
Zr	113	124	121	123				

Table 1 Chemical composition of metabasalts (in %), values recalculated to 100% without volatile components, and some trace element contents (in ppm).

(Fig. 9). This is also confirmed by the Cr vs. Y diagram (PEARCE, 1982), on which all analysed rocks fall within the MORB field, although in this diagram this field corresponds to the fields of VAB and WPB (Fig. 10).

Certain differences in the interpretation of the geotectonic regime of origin of the analysed samples are present on Zr : Yx3 : Ti/100 (PEARCE & CANN, 1973), on which samples SB11 & SB19 fall within the MORB field, while samples SB5 & SB10 show a tendency of grouping into the field of basalts formed within plates (WPB) (Fig. 11).

3.2. SEDIMENTARY ROCKS

Fragments of carbonate sediments were found on the SE part of the quarry, between pillows of red and dark red varieties of metabasalts. They range in size

Sample	CIPW norms 1	2	3	4		Petrochemical indices 1	2	3	4
qz	6.97	-	-	-	AI	0.8	3.7	27.2	6.1
c	-	-	-	-	FI	58.3	24.4	50.4	21.2
or	0.25	0.76	12.83	1.88	MI	65.9	50.8	59.6	52.2
ab	42.62	28.21	23.13	14.54	SI	26.9	41.7	26.4	41.9
an	15.57	31.45	12.36	30.98	DI	49.9	28.9	50.1	21.9
ne	-	-	14.12	6.18	VSM	CA	Th	Th	Th
diwo	0.35	8.16	11.08	12.23	VSIB	ThA	B	TB	AIB
dien	0.19	5.91	6.64	8.36					
difs	0.15	1.50	3.84	2.89		CA - calc-alk			
hyen	14.86	4.19	-	-		Th - tholeiite			
hyfs	11.74	1.06	-	-		A - andesite			
olfo	-	8.02	5.77	11.34		B - basalt			
olfa	-	2.24	3.68	4.33		TB - trachybasalt			
mt	4.22	4.66	2.31	4.74		AIB - alkalibasalt			
hm	-	-	-	-					
il	2.48	3.05	4.18	3.19					
ap	0.57	0.77	0.05	0.02					
norm. Pl. (%an)	27	53	21	55					

Table 2 CIPW norms and petrochemical indices.

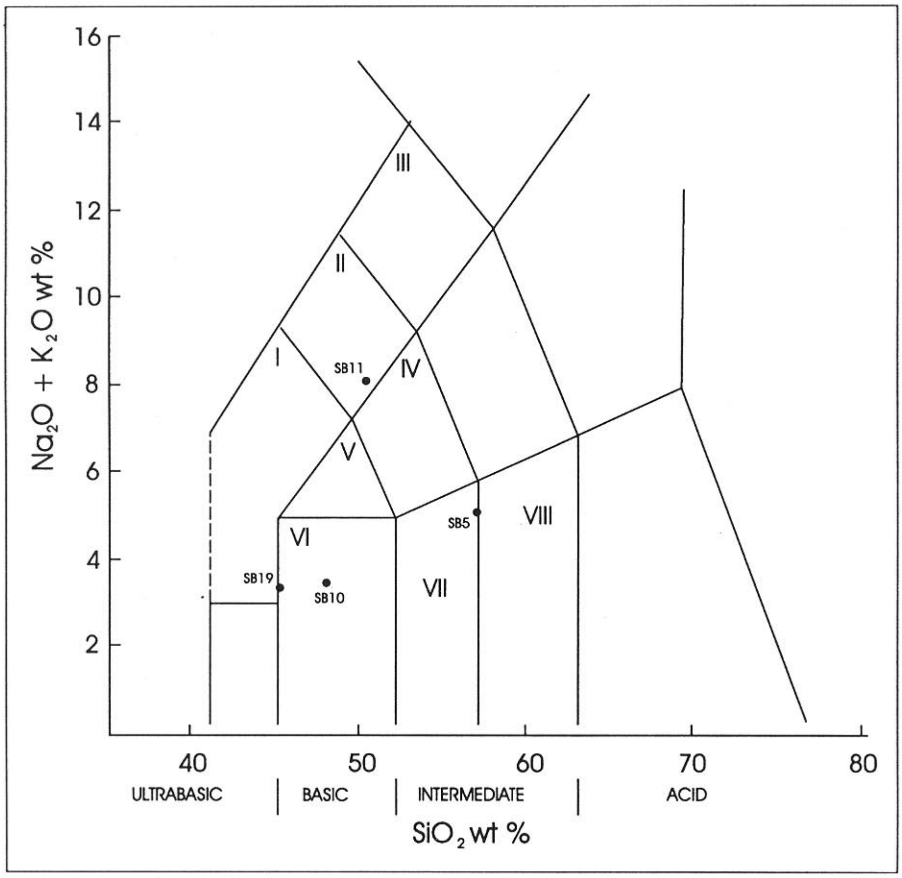

Fig. 6 TAS diagram (Le BAS et al., 1986).

from a few centimetres up to 0.9 m (Figs. 3 & 12). Most of the fragments are reddish to reddish-brown, while some are pale gray. Their structure is homogeneous, and in some samples horizontal or wavy lamination can be seen. By microscopic analysis several textural varieties of carbonate rocks were distinguished:

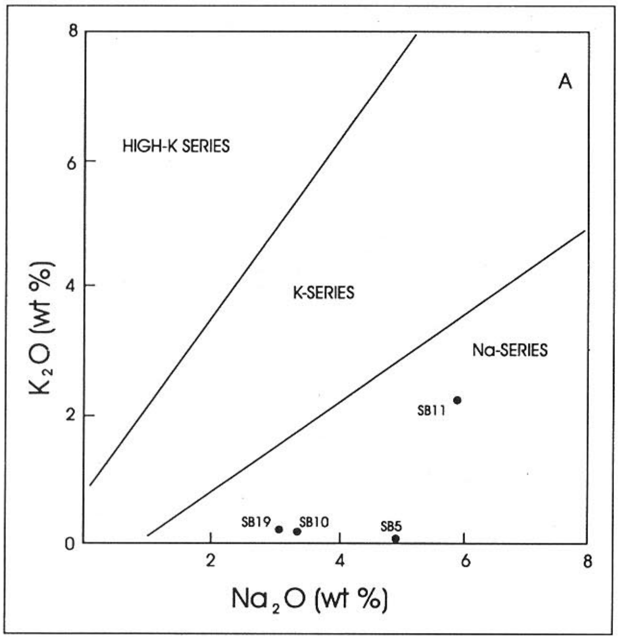

Fig. 7 Variation diagram K_2O vs. Na_2O (MIDDLEMOST, 1975).

microsparite, fossiliferous microsparite, biosparite and sparite, while only in one thin-section was a micrite texture determined. Rocks are intensely recrystallised, and samples contain rare relics of micrite matrix with very infrequent detrital quartz grains up to 0.07 mm in size, which are influenced by the calcitization process. Fossiliferous microsparites and biosparites contain thin shells of bivalves (pelecypods), which are sporadically concentrated in mm-thick laminae. Additionally rare completely calcitized and recrystallised radiolarians were found, which are up to 0.2 mm in diameter.

The thickness of graded lighter coloured laminae in laminated varieties is up to 0.4 mm, and they are composed of completely recrystallised and unrecognizable fossil remains, characterised by circular forms up to 0.06 mm in diameter. These grains probably represent calcitized fragments of radiolarians. Darker laminae are composed of microsparite with rare muscovite, very infrequent fragments and crystals of albite (up to 0.03 mm in size), angular fragments of devitrified volcanic glass, and rare flakes of chlorite. In one thin section grains of intensely weathered and altered basic effusive rock were found. The reddish colour of the limestone originated from finely dispersed ferruginous hydroxides and haematite, which are found between some crystals of sparite or microsparite and along microscopic fissures. The rock is cut by horizontal stylolites with amplitudes of 1 mm, which are mostly filled with a haematite substance. Submillimetre calcite

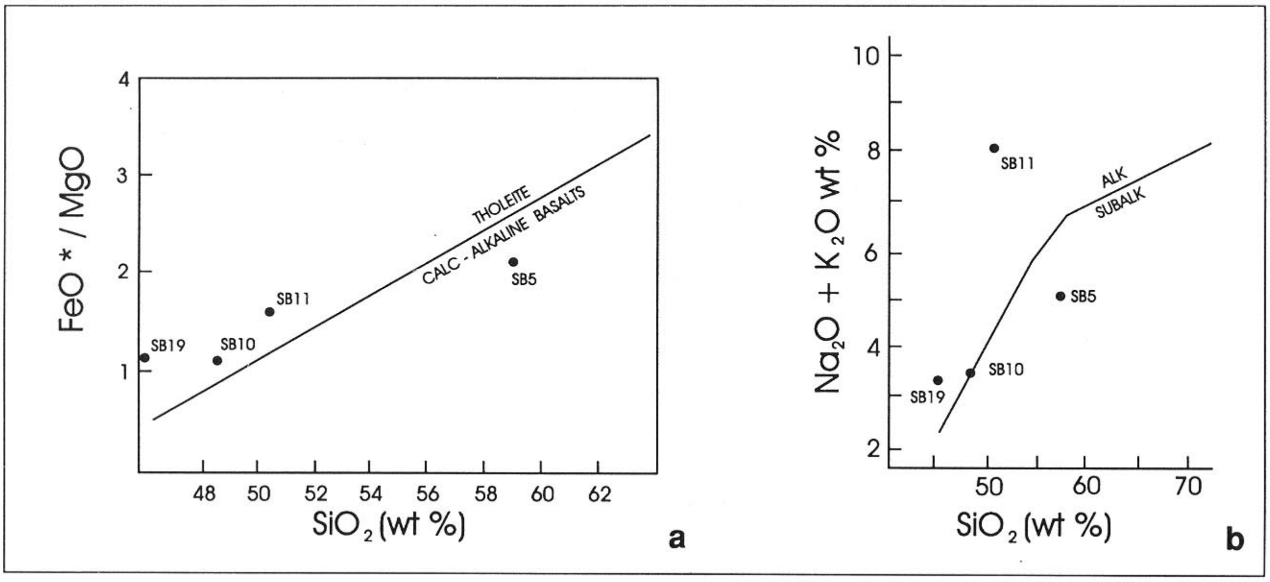

Fig. 8 Variation diagrams: a) FeO*/ MgO vs. SiO_2; b) SiO_2 vs. (Na_2O+K_2O) (MIYASHIRO, 1974).

veins were also observed; weak silicification was found in some fissures, as well as in some parts of the matrix.

Limestone/metabasalt contacts are active and irregular because of the resorption of limestone by lava, and the margins of the limestone were intensely recrystallised and subsequently silicified (Fig. 13). Metabasalts are not characterised by so-called "frozen edges", since the quantity of the incorporated limestone was probably too small in regard to the quantity of the metabasalt. The contact is characterised by the presence of manganese and ferruginous substance.

4. BIOSTRATIGRAPHY

4.1. MATERIAL AND METHODS

The material originates from 3 carbonate samples from between pillows in the Orešje quarry. The Gaus-Krieger coordinates of the sample localities are as follows:

SB31/B	X 50 85 775,	Y 55 70 878,	Z 300;
SB2	X 50 85 768,	Y 55 70 915,	Z 290;
SB4	X 50 85 777,	Y 55 70 875,	Z 295.

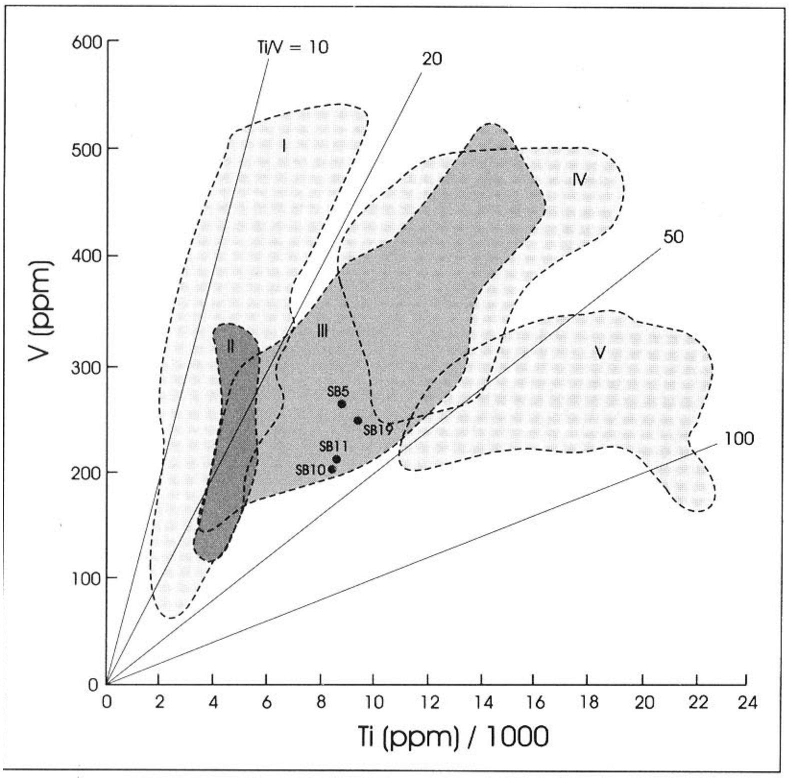

Fig. 9 Ti vs. V discrimination diagram (SHERVAIS, 1982).

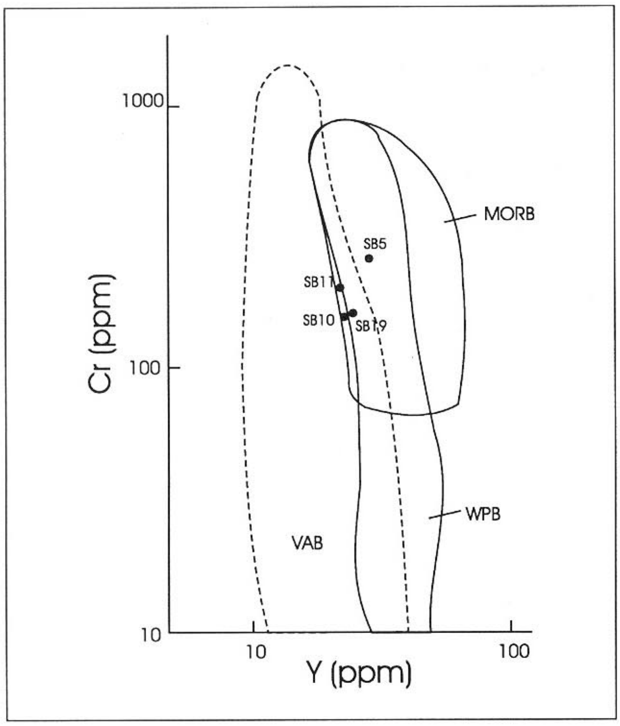

Fig. 10 Cr vs. Y diagram (PEARCE, 1982).

Samples of 0.5-1 kg were prepared according to the standard procedure for conodont analyses with the use of acetic acid. The insoluble residue was subsequently divided by the application of bromoform. A conodont fauna has been found in two samples (SB31/B & SB2), while in sample SB4 infrequent radiolarians occurred. The frequency of conodont elements is low, and their preservation is mostly incomplete.

The fossil material is deposited and catalogued at the Institute of Geology, Geotechnics and Geophysics in Ljubljana (Slovenia), under the designations IGGG 3139 & 3141. Conodont elements were photographed on the EM JEOL electronic microscope at the Department of Biology of the Biotechnical Faculty of the University of Ljubljana.

4.2. SAMPLE SB31/B

The collection yields several ramiform and platform conodont elements. The platform elements display a high, semicircular carina, and even but weakly developed platform (Pl. 1, Figs. 4-5). A juvenile stage of this species is shown on Pl. 1, Figs. 1-3 and has a carina of the *excelsa*-type, and in certain specimens the beginning of a platform is observed. These elements are attributed to *Paragondolella* aff. *excelsa* MOSHER. Similar forms were figured by KOZUR et al. (1994) as *Paragondolella* n.sp. ex gr. *excelsa* MOSHER from samples WWS (Weisse Wand Member of the Loibl Formation, Austria) which is presumably latest Illyrian in age. Specimens determined as *Paragondolella* n. sp. ex gr. *excelsa* MOSHER, sensu KOZUR, KRAINER & MOSTLER were collected in a limestone assignable to the Late Anisian or earliest Ladinian of Šmarna Gora, Slovenia (RAMOVŠ & GORIČAN, 1995).

Age: Illyrian - Fassanian.

4.3. SAMPLE SB 2

The microfauna contains recrystallized ostracods and conodont elements, both ramiform and platform. The later are represented by *Gladigondolella* sp. and

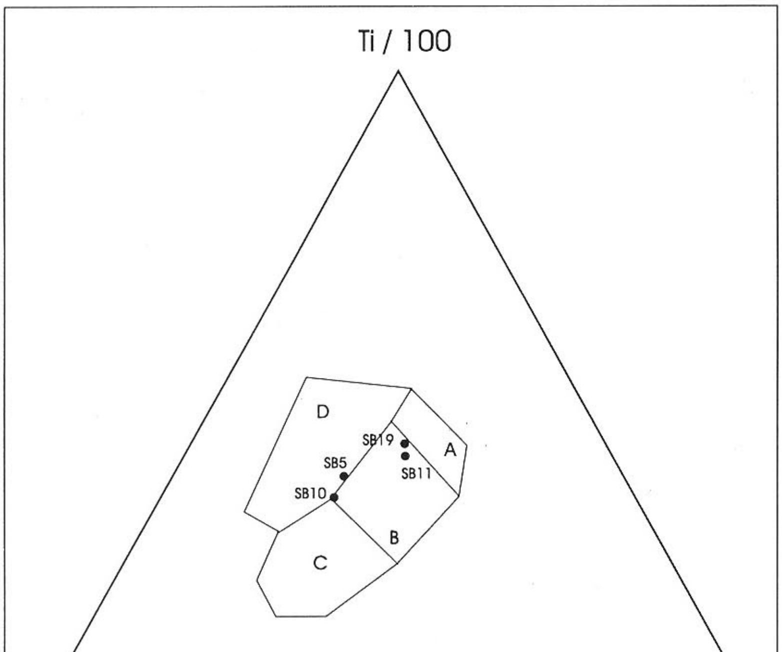

Fig. 11 Zr:Yx3:Ti/100 diagram (PEARCE & CANN, 1973).

Fig. 12 A 90 cm long enclave of red micritic limestone in pillow lavas of the Orešje quarry. Along the enclave secondary haematitization and limonitization of metabasalt is visible (objective cap is 5.5 cm in diameter).

Paragondolella excelsa MOSHER. The element of *P. excelsa* is characterised by a high carina and flat platform with a brim behind the posterior nodelike denticle. This species is well known from the Tethyan realm (KOZUR, 1980).

Age: Illyrian - Fassanian.

5. DISCUSSION

A major part of the effusive body of the Orešje quarry and its closer surroundings is composed of basic pillow lavas. The diameter of single pillows ranges in size from a few decimetres to more than 1 m, mostly from 30-50 cm. Their shape is variable, from almost circular to an elongate ellipsoid shape. Margins of adjacent pillows exhibit load casts and structures of accommodation, while the space between them is filled by green hyaloclastite, which is mainly composed of the material scaled from rapidly cooled pillows. Hyaloclastites are pervaded and impregnated by calcite, haematite and epidote. Some pillows are fractured, and are characterised by tortoise-shell structure, with fractures filled by white calcite. The major part of the main body of pillow lavas is dark red to indigo-violet in colour, as a consequence of intense haematitization. The depth of haematitization varies for different pillows, depending on their size and porosity, which is visible on sections of the pillows. Most of the pillow lavas have an amygdaloidal texture, with vesicles filled by calcite, chlorite, chalcedony, and subordinately zeolite. They are concentrated predominantly in the marginal parts of the pillows. Their rounded shape suggests rapid submarine cooling.

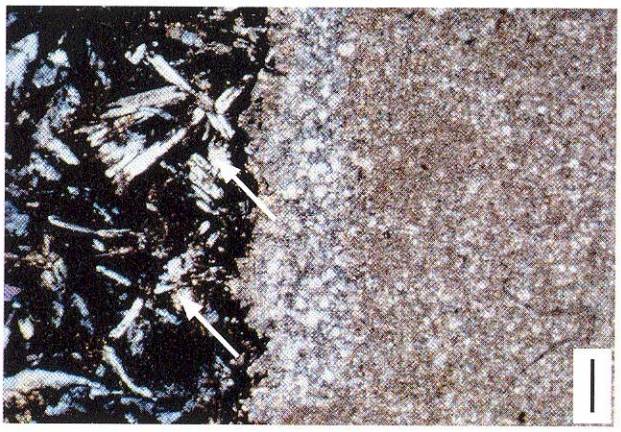

Fig. 13 Metabasalt/micrite contact. The marginal part of metabasalt encompasses fragments of the micrite (arrows). Contact is irregular. Micrite along the contact is recrystallised and silicified due to the thermal changes (scale bar = 0.1 mm; N+).

Pillow-shaped forms of the investigated lavas indicate their submarine effusion and their amygdaloidal texture indicates the expansion of gases from lavas. On the basis of a literature survey, together with their aforementioned characteristics, we suppose that the investigated lavas were probably extruded at depths of more than 1,500 m (JONES, 1969; HIGGINS, 1971; FURNES, 1973; WELLS et al., 1979; McPHIE et al., 1993).

Material scaled from rapidly cooled pillows, and fragments of limestone of different size have been found in the spaces between basic pillow lavas investigated in the Orešje quarry, while in the massive variety of basalts similar fragments have not been observed. On the basis of their occurrence with the pillow lavas, we can conclude that these limestones represent peperites, which are, according to their definition, rocks originated by the mixing of lava with unconsolidated, wet sediments (FISHER, 1960; McPHIE et al., 1993). Furthermore, we assume that the lavas were extruded on diagenetically unconsolidated carbonate mud, which was broken down and incorporated in the space between pillows, where it was mixed with the material scaled from rapidly cooled pillows. Considering the size of fragments and their frequency we suppose that the sedimentary cover on the sea floor during the effusion was relatively thin. It is difficult to obtain more data on the rocks representing the base of the sedimentary cover, since the entire magmatic-sedimentary complex was reduced during the subduction processes, and the investigated rocks represent only a small, obducted part of this complex.

Due to the intense alteration of magmatic rocks by spilitization, hydrothermal metamorphism and very low to low-grade metamorphism, it is very hard to interpret without question their position in the volcanic series. Some differences existed in the chemical content between particular parts of massive metabasalts and between the marginal and inner part of pillows because of the varying intensity of alteration. According to the obtained data, the volcanic body of the quarry belongs to the tholeiitic series, but partially also to the alkali series. Fresh samples belong to the tholeiites, and it is to be supposed that other samples probably also belong to the same series. It may be concluded that the investigated metabasalts could be well correlated with tholeiitic basalts of the recent middle-oceanic rifts (MORB), i.e. with the upper parts of the oceanic crust of recent oceans.

Since carbonate sediments correspond to peperites, it may be concluded that the pillow lavas of the Orešje quarry and its surroundings are of the same age as the limestones (which are proven by their fossil contents to be of a Middle Triassic age) or are slightly younger, and that they probably represent parts of the dismembered ophiolitic sequence of the Triassic ocean floor. Since it has previously been proposed that the magmatic rocks of the Orešje quarry, as well as the entire magmatic-sedimentary complex of the NW Medvednica, are of Lower Cretaceous age, the presented findings of Triassic conodonts in peperites from the investigated quarry raise the question of the age of other parts of the eruptive body of the aforementioned complex.

Comparison of the studied rocks with similar sections in the Pannonian Basin is aggravated by the intense tectonic disintegration, as well as by a thick Tertiary-Quaternary sedimentary cover. Furthermore, the major part of the Triassic ophiolitic sequence has been consumed during the Jurassic - Lower Cretaceous (?) subduction of the oceanic crust, and recently in the zone of the subduction suture only obducted (allochthonous) parts of the floor can be found (HALAMIĆ & GORIČAN, 1995; HALAMIĆ, 1998).

The nearest outcrops of radiolarites of Upper Ladinian to Upper Carnian age are located approximately 300 m S of the quarry, and in the valley of the Poljanica creek 2 km towards the south (HALAMIĆ & GORIČAN, 1995). At the locality immediately northwards of the Poljanica creek these radiolarites are in a direct contact with weathered, red-violet amygdaloidal pillow lavas (HALAMIĆ, 1998).

Pillow lavas with the fragments of limestones from the Orešje quarry and radiolarites with pillow lavas found towards the south could be, on the basis of palaeontological and petrological data, stratigraphically positively correlated with the sequences in the Meliata zone (CHANNELL & KOZUR, 1997).

6. CONCLUSIONS

On the basis of the investigation of the rocks of the Orešje quarry near Gornja Bistra on the NW part of Medvednica Mt. and its surroundings it is possible to conclude the following:

1. The structure of the basic lavas (pillow shape and vesicles) indicates their submarine extrusion. The rounded shape of varioles suggests their rapid cooling.
2. The ophitic texture and massive structure of some parts of massive metabasalts indicate slower cooling with simultaneous crystallization of primary mineral ingredients, probably in deeper parts of the magmatic effusion.
3. Among the textural varieties of limestones found between lava pillows, the most frequent are recrystallized micrites, while biomicrosparites, fossiliferous microsparite and biosparite are less abundant; sparites are rare. On the basis of determined textural varieties and fossil assemblages (radiolarians and pelecypods) it may be concluded that these carbonates were deposited in deeper marine environments, above the CCD, which is supposed to be placed much shallower than today (WINTERER & BOSELLINI, 1981).
4. On the basis of the presence of carbonate fragments between pillow lavas, together with hyaloclasts (the material scaled from rapidly cooled pillows), it may be concluded that these rocks represent peperites, and that extruded lavas were of the same age or only slightly younger than the analysed carbonate rocks.
5. Magmatic rocks of the Orešje quarry are determined as high-Ti tholeiitic metabasalts, which geochemically correspond to those formed in the area of the middle oceanic ridge (MORB) and represent obducted (allochthonous) parts of the highest levels of the Triassic oceanic crust.
6. The analysed fossil assemblage of conodonts from the carbonate rocks indicate a Late Anisian to Early Ladinian age, which is penecontemporaneous with the extrusion of the mafic lavas. This fact raises the question of the age of the remaining part of the basic eruptive rocks of the magmatic-sedimentary complex of the NW Medvednica Mt.
7. The described magmatic rocks containing fragments of pelagic limestones could be stratigraphically positively correlated with similar sequences from the Meliata Zone.

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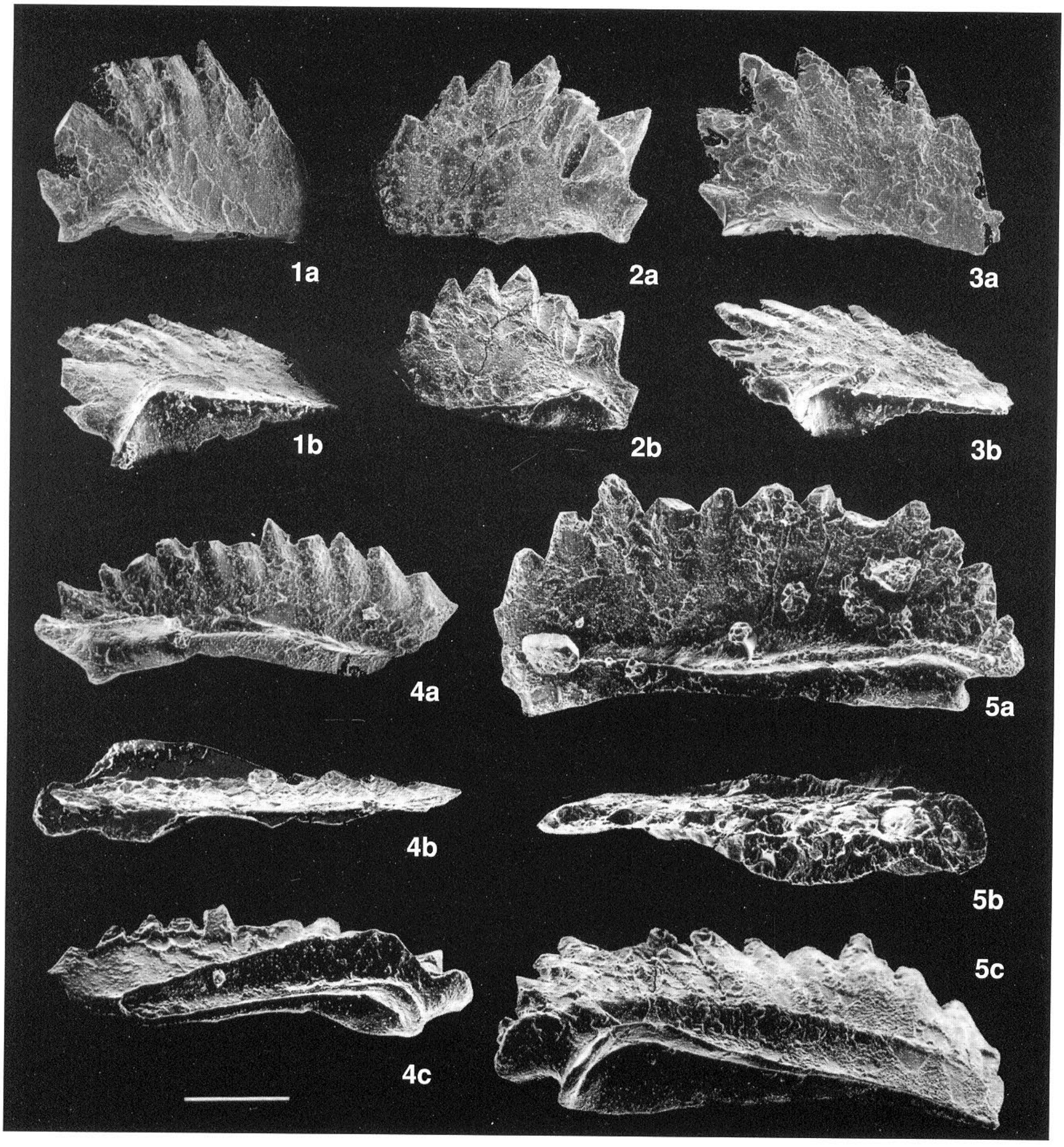
PLATE I

1 - 5 *Paragondolella* aff. *excelsa* MOSHER, sample SB 31/B (3141), 1-3 juvenile ontogenetic stage; 4-5 adult ontogenetic stage; 1a, 2a, 3a, 4a, 5a: lateral views; 1b, 2b, 3b, 4c, 5c: oblique lower views, 4b, 5b: upper views. Scale = 100 μm.


1a
2a
3a
1b
2b
3b
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5a
4b
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5c
4c