Geol. vjesnik	Vol. 38	str. 191—213	Zagreb 1985.

UDC 553.492.1(497.13) *Izvorni znanstveni rad*

Bauxite Occurrances in the Region of Zavojane and northwardly of Imotski

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In the region of Zavojane, ther has been discovered, up to now unknown, Late Paleogene karst bauxite occurrences and several Early and Late Paleogene occurrences in the Imotski bauxite region. The bauxites differ mutually in chemical and mineralogical composition as well. Geochemical investigation determined variation in chemical composition among the Early Paleogene bauxites themselves, as well as major trace element bearer among clay minerals and iron (hydroxy) oxides.

INTRODUCTION

Purpose of this paper is to point out possibility of finding new bauxite bodies in the Dinaric karst terrains, as well as necessity of detailed geological mapping of sedimentary deposits (f. e. of Upper Cretaceous — Paleogene age). Namely, the bauxite occurrences might be not observable between two distant profiles on the topographic maps (M 1 : 25.000). Therefor, it is necessary to investigate the bauxites by detailed geological mapping on the maps with larger scale (for example M 1 : 1.000).

The discovered bauxite occurrences are small in size and often considered as having no economic significance (M a g a š et al. 1979). On the other hand, this is the first quality bauxite (Š e b e č i ć et al. 1977), confirmed also by this paper, which could be exploited in situation of shortage of bigger deposits in some future time.

The authors propose detail investigation of the contact Upper Cretaceous — Paleogene and registration of all bauxite occurrences. There has been, up to now, registered only one bauxite outcrop at the border between the Cretaceous and Promina layers in wider surrounding of Vrgorac. At seven nappes, where a route of the contact between the Upper Cretaceous and Paleogene layers is delineated, however, no bauxite outcrop was evidenced. The seven nappes, like seven »potential zones«, give a solid base for beginning of detailed geological mapping on the Ploče map and others, and evaluation of the real bauxite potential in the second nappe at Plana, nearby Vrgorac (Šebečić et al. 1977). A supposition of further extension of the bauxite zone was confirmed, and further on substantiated with discoveries of new outcrops in the Vrgorac region (Šebečić et al. 1980/81) and then in Zavojane.

DESCRIPTION OF BAUXITE OCCURRENCES

The bauxite occurrences in Zavojane are placed at the very contact between the Upper Cretaceous (Senonian) and the Paleogene limestones, and on the Senonian limestones. Their position is linked with the second nappe, and with limbs of a faulted anticline extending NW—SE (fig. 1). Bauxite outcrops were discovered at slopes of the Matokit mountain, at several places in Zekulići and Ajduci villages (northeastern limb of the anticline, p. 1—3) and at several sites in Majići village (southeastern limb of the anticline, p. 4—5). An interrupted bauxite contact line (»bauxite zone«) was investigated at a length of 1700 m, but its extension, however, is even longer. The bauxite in the ore bearing zone occurs as isolated outcrops or is mixed intimately with »terra rossa«. The bauxite zone is thick approximately 4—6 m. The occurrences are particularly frequent in Zekulići, where is a site of the first bauxite discovering called Pirovište, p. 1 (fig. 1 and 2). The name Pirovište came after red soil, consisting of bauxite and terra rossa. New bauxite occurrences were being followed toward Matokit, southeastwardly (fig. 3) and toward Ajduci on the northwest.

Footwall rocks of the bauxite ore body in Pirovište (fig. 2) are built up of the Senonian limestone (sampl. 2), that is a fossiliferous micrite (M) texturally, with 5—7 % of microfossils. There are in the limestone desiccation cracks, filled up by (micro)sparry calcite. A white weathering crust on the limestone, thick 1—2 mm, contains 0.92% SiO_2, 4.15% Fe_2O_3, 0.16 % Al_2O_3, while TiO_2 has not been determined.

Redbrown oolitic bauxite with terra rossa (40—60%), thick in the measured profile 5.7 m, overlays the limestones. The bauxite specimens (3—5) are slightly ferruginous. Discoidal oolites constitute only two thin hematitic-limonitic shells. Degree of grading of oolites is poor, except in the sample 5. The redbrown bauxites are proceeded by greenish-gray oolitic bauxite (sample 5a and 6) with terra rossa, thick 2.5 m. Pyrite in the bauxite turned into limonite, occurring in crack fillings or tiny spotty masses. Agglomerates of oolitic bauxites, big 1—3 mm, with predominantly 1 husk are registered in the sample 6.

Bigger oolites are also discoidal, containing two thin husks, sporadically limonitized. At the some places in the bauxite fossiliferous (micrite) limestones crop out.

Further on the profile (fig. 2), the Senonian limestones are sporadically covered by regolith and the primary limestone bedrocks were deciphered only by wheathering material and rare outcrops. There have been registered outcrops of biogenic limestones — biomicrites (w) with about 15 % of microfossils (sample 7). Stromatolitic (3) laminas are visible (sample 9 and 10) by a microscope. There were observed also alternation of algae laminas with recrystallized-pseudo-(micro)-sparitic laminas (sam-

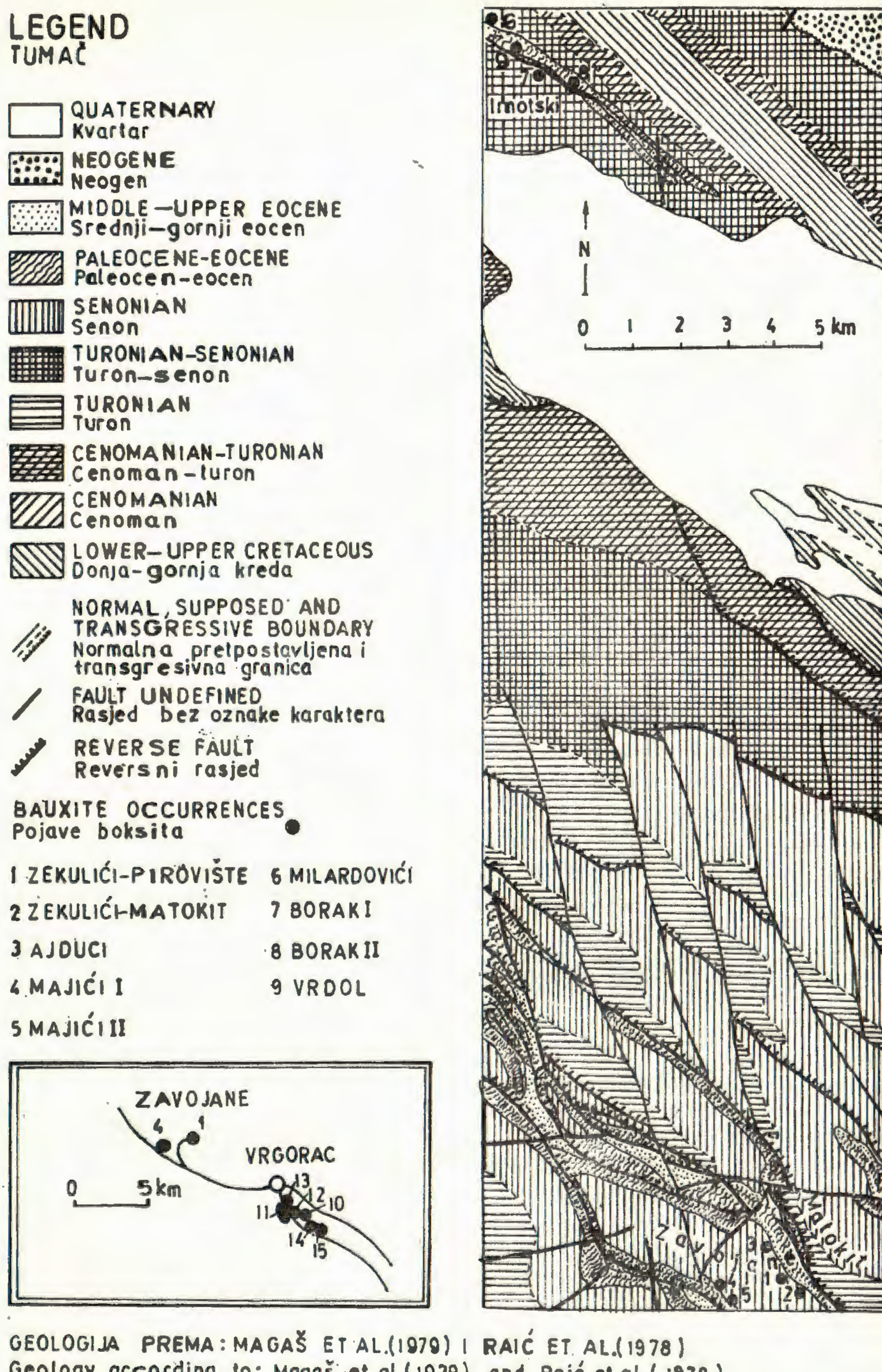


Fig. 1. Geological map of the investigated region according to Magaš et al. (1979) and Raić et al. (1978)

Sl. 1. Geološka karta proučavanog područja prema Magaš et al. (1979) i Raić et al. (1978)

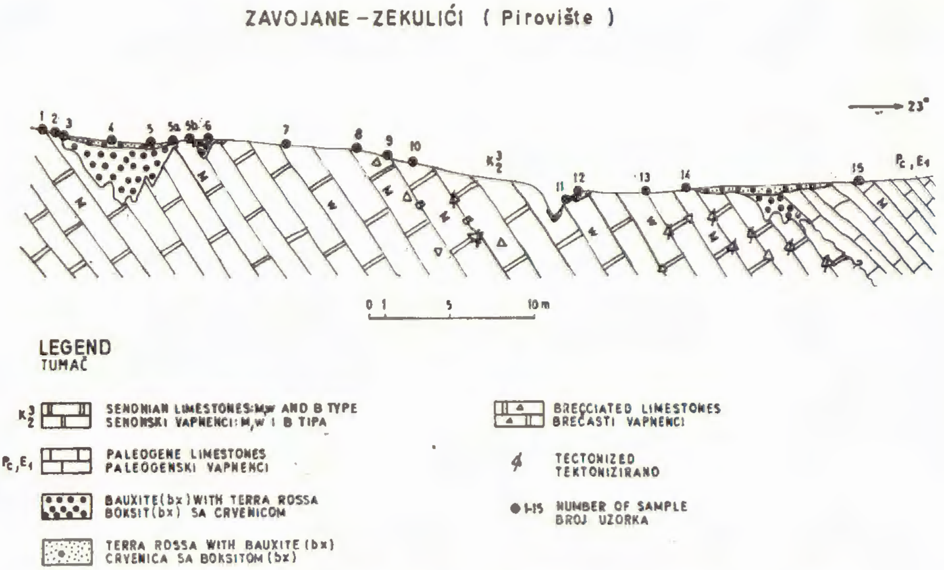


Fig. 2. Bauxite occurrence at the Zavojane-Zekulići (Pirovište) locality

Sl. 2. Boksitna pojava na lokalitetu Zavojane-Zekulići (Pirovište)

ple 9) and trimming of cavities with isometric microsparry calcite (sample 10) as well as internal sedimentation with intrasparites onto the bottom of the cavity, intraclastic micrite, and sparite (fillings of cavities). Terra rossa with bauxite fragments is situated close to the contact between the Senonian and the Paleogene limestones, probably younger than the Kozina limestones (sample 12). The contact is assumed to be bauxite bearing, and it is covered by terra rossa and bauxite now. The limestones are partly limonitized, fractured and tectonized (samples 10 and 13). Outcrops of bauxites with terra rossa can be found nortwest from Pirovište in Zekulići and Ajduci, p. 3. Their stratigraphic position marks contact between the white Senonian limestones and brown Paleogene limestones. Width of the outcrops is 0.7—7 m, on an average 4—5 m. Outcrops of bauxites may also be found on the Upper Cretaceous-Senonian paleorelief, which is developed not far from the contact of Upper Cretaceous and Paleogene limestones.

Southeastwardly from Pirovište, on the southwestern slopes of the Matokit, p. 2, there was registered a bauxite bearing zone with bauxite and terra rossa outcrops (fig. 3). The bauxite ore bodies are on the Upper Cretaceous-Senonian paleorelief built up of fossiliferous micrite (sample 1) and sporadically of rudist biomicrudites in the vicinite of the contact with the brown fossiliferous Kozina limestones. The bauxites are predominantly oolitic (samples 4, 6, 7) and partly made of bauxite fragments (between samples 1 and 2, and sample 5). They are more or less ferruginous.

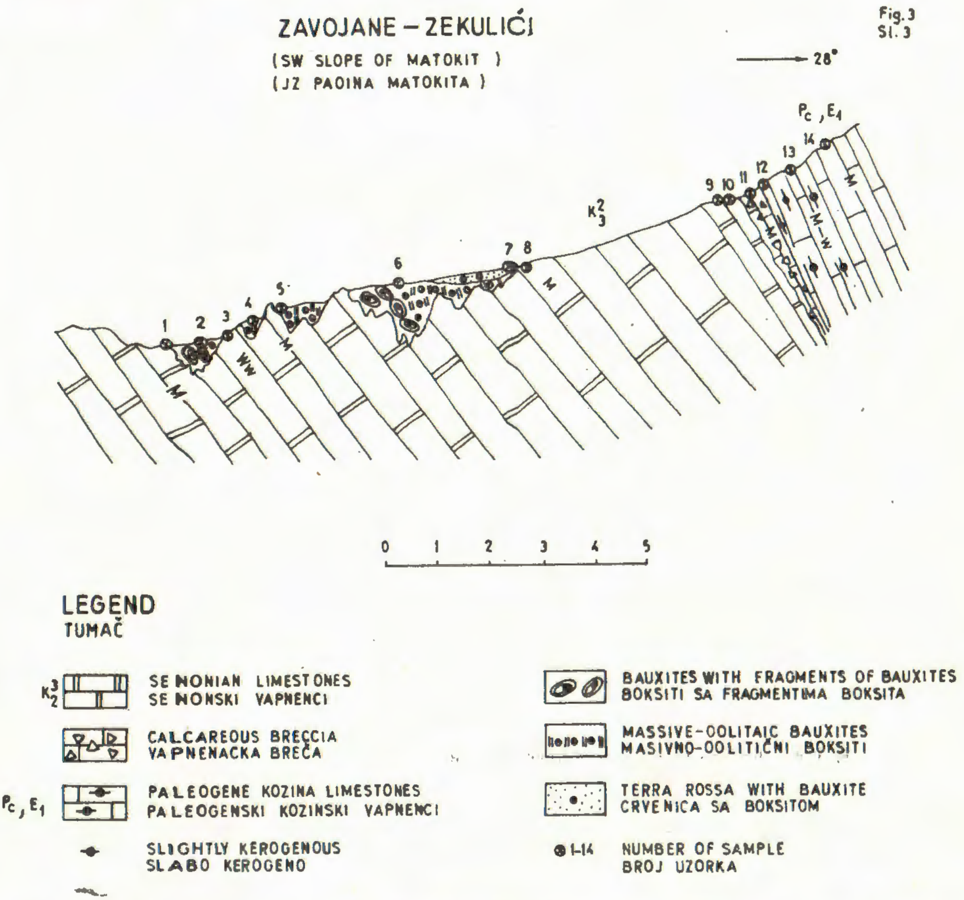


Fig. 3. Bauxite occurrence at the Zavojane-Zekulići locality (SW slope of the Matokit mountain)

Sl. 3. Boksitna pojava na lokalitetu Zavojane-Zekulići (jugozapadna padina Matokita)

In transition polarized light their colour is brown-yellowish. They contain 15—40 % of oolites. Oolites with 1 husk predominate. Oolites with two or more husks may be found very seldom.

Bauxite fragments in redeposited bauxites are built up of finegrained oolites and composite oolites. Ooolitic size varies between 1.5—6—15 mm.

Outcrops of intraclastic-biomicruditic limestone (Ww) with 5 % intraclasts and 30—40 % fossils and fossil detritus protrude through the bauxite. Fossiliferous micrites (M) with biolithic lamina relics, which were kerogenized, overlays the bauxite. They are followed by biogenic limestones: biopseudomicrosparite — biomicrite (w) with biolithic relics (B) and dismicritization of matrix (sample 10).

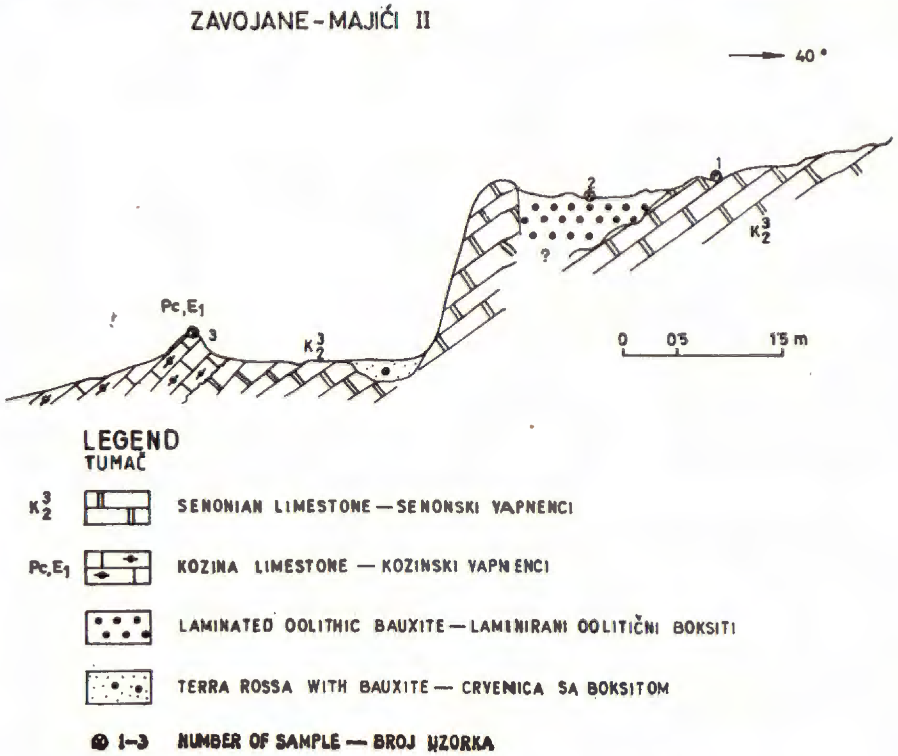


Fig. 4. Bauxite occurrence II at the Zavojane Majići locality
Sl. 4. Boksitna pojava II na lokalitetu Zavojane-Majići

The contact between the Senonian and Paleogene (Kozina) limestones is represented by brecciated limestones and calcareous desiccation breccias with fragments of 4 × 2 cm. The limestone breccia is tectonized. The Kozina limestone (sample 12 and 13) are made of fossiliferous micrites-biomicrites (M-w) with low content of kerogen.

Northwest from Majići (p. 4 and 5), there are several smaller bauxite outcrops of 2 × 1 to 1 × 0.5 m. They are placed on the Upper Cretaceous — Senonian calcareous paleorelief, i.e. on dismicritized fossiliferous micrite (M, M-w), not far from the contact of the Upper Cretaceous and the Paleogene limestones (fig. 4). The bauxite is oolitic with 40—50% of oolites. The oolites possess one husk mostly, made of Al-hydroxides however, some of them have tiny limonitized (pyrite) husk between two light-ones. Parallel lamination of oolites was also observed.

Beside yellow-brown oolitic bauxite, there has been also registered gray homogeneous oolitic bauxite at the Majići locality (p. 4).

Chemical composition of some selected Early Paleogene bauxites from Zavojane, whose position is shown on the geological map (fig. 1) is presented in the table 1. The results of geochemical investigation of all Zavojane bauxites are presented in the next chapters.

Table 1.
Chemical composition of some bauxites from Zavojane and Imotski
Tablica 1.
Kemijski sastav nekih zavojanskih i imotskih boksita

Locality Lokalitet	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	L. o. I. G. ž.	Total Ukupno	Mark on the map Oznaka na geol. karti
ZAVOJANE							
Zekulići							
sample 3. — Pirovište, uz 3.	6,10	3,25	48,69	22,98	15,61	96,63	1
sample 4. — Matokit, uz. 4.	8,66	3,25	36,38	29,77	15,19	93,25	2
sample 7. — Ajduci, uz. 7.	8,54	3,38	43,76	25,46	16,17	97,31	3
Majići occurrence I.,							
sample 3. — pojava I, uz. 3.	4,26	3,45	52,84	20,91	15,82	97,28	4
occurrence II, sample 2. — pojava II, uz 2.	1,88	3,80	52,58	22,02	15,72	96,03	5
IMOTSKI							
Milardovići							
ocurrence I, sample 1 pojava I, uz. 1	1,56	3,25	60,92	21,23	14,86	101,82	6
The late Paleogene Mlađi Paleogen							
Vrdol sample 2 uzorak 2	11,02	2,00	25,39	26,01	27,29	91,71	9

The bauxite bearing region of **I m o t s k i** was described by **M a r u š i ć** (1954). The bauxite occurrences are associated with two horizons, i.e. zones: the first one is between rudist limestones and the Kozina layers (»Cretaceous bauxite«), and the second one is between alveoline limestones and the Late Paleogene deposits (»Tertiary bauxite«). According to M a r u š i ć, several thousands tons of bauxite has been excavated in a village Milardovići (p. 6).

To get an idea about type and quality of the Early Paleogene bauxite, we examined two, mostly exploited bauxite bodies. The shape of the bigger body is modeled by a karst funnel. The contact surface between bauxites and the Cretaceous paleorelief is uneven and karstified, and with the Kozina limestones smooth and even. The bauxite is massive and olive-brownish. It is slightly oolitic (1—2 %), and has a very good quality.

The thickness of the smaller bauxite body is 1,5 m (fig. 5). The outcrop is partly enriched in hematite and limonite. It containes discoidal fragments of bauxites with different degree of grading, but dimensions of 0.2—3.5 mm (sample 2) prevail.

The footwall rocks of the bauxite are built of the Upper Cretaceous massive and poorly inbedded, lightgray and pink limestones.

Rudists, poorly preserved, mostly like remnants, together with microfossils (forams and algae) are constituents of the limestones. The families Radiolitidae and Hippuritidae have been registered, and the Senonian age determined by them (S l i š k o v i ć, 1967, T r u t i n, 1981). Texturally, they are (intraclastic) biomicritic — biomicruditic limestones, f. e w-Ww (sample 1).

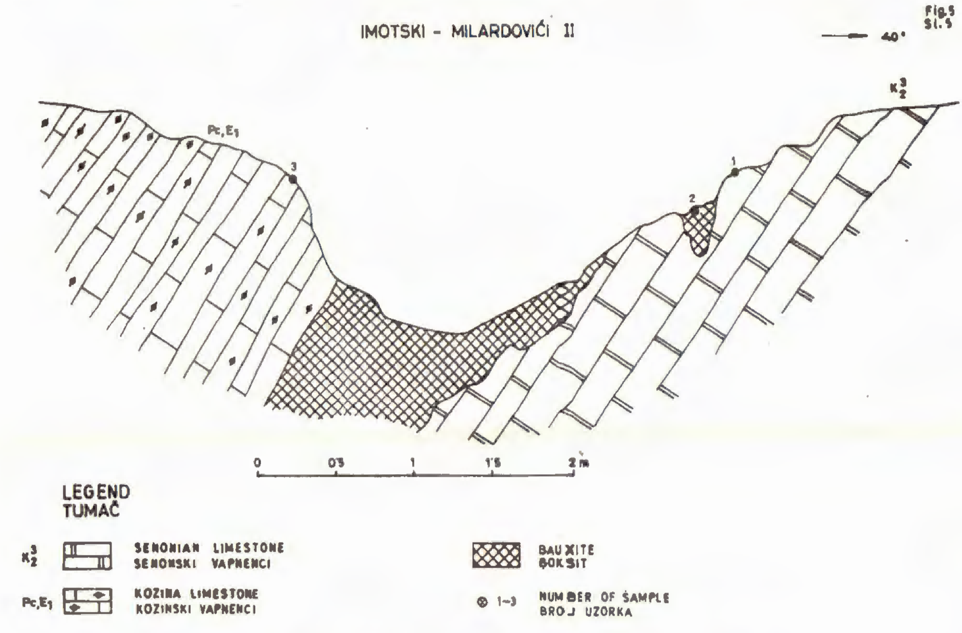


Fig. 5. Bauxite occurrence II of the Milardovići locality

Sl. 5. Boksitna pojava II na lokalitetu Milardovići

The hangingwall of the bauxite are brownish to red-brownish Kozina layers from the Liburnian formation with gastropodes (Stomatopsis and Cosinia), ostracodes and haraceae. The fossils point out influence of fresh water in the sedimentary basin in Late Paleocene and the earliest Eocene time (R a i ć, et al. 1978. and T r u t i n, 1981). The hangingwall limestone is enriched in organic (bituminous-kerogenous) matter and belongs to biomicrudite type (Ww).

Northwardly from Imotski, there were discovered occurrences of the Early Paleogene bauxites Borak I (p. 7) and the Paleogene bauxites, i. e. Al—Fe ores Borak II (p. 8) and Vrdol (p. 9).

The Early Paleogene bauxite occurrence Borak I. is made of several single outcrops placed at the very contact of the Senonian and Kozina limestones at the border of a big karst funnel. Its size is 30 × 1—1.5 m. The bauxite body is in the Senonian limestones in a pocketlike form, supposingly a remnant of a contact type ore body. The bauxite colour in polarized light is olivebrown. Texture is homogeneous and homogeneous-globular. Globular particules are smaller than 1 mm.

The hangingwall rocks of the bauxite are built of bituminous-kerogenous and limonitized biomicrudite (Ww) with 20—25 % of fossil and fossil fragments. Fossiliferous-foraminiferous limestones of Early and Middle Eocene age overlay continuously the Liburnian layers. Alveolines prevail among fossils, while nummulites are rare, so their name should be alveoline limestone. Lack of nummulitic limestones might be explained by regression of the sea, which started before their deposition or by erosion after intensive movement and lifting up in Middle Eocene time. Alveoline limestones constitute the footwall of the Middle Eocene bauxites at Borak II. and Vrdol localities.

Red Paleogene bauxite in the deposit Borak II. are situated southwardly from the road Imotski-Posušje, not far from a new quarry. Its structure is massive, and texture homogeneous. Lenslike and polygonal fractures of weathering have been determined in it. The size of the bauxite outcrop is 19 × 9 m and content of Al is low.

Redbrown bauxite with homogeneous structure was discovered in Vrdol (fig. 6). It appears in lenses, with dimensions > 41 × 4.5 m, on the Paleogene alveoline limestones. The alveoline limestones (sample 1 and 5) are intraclastic biosparite to biosparrudite (Pp—Gg), containing 10—15 % of micrite intraclasts and changable quantity of fossils (40—70 %).

Younger hangingwall limestones are slightly clayey biomicrites (w) to biomicrudites (Ww). They bear many forams (Nummulites, Discocyclinae, Alveolinae, Textulariidae, Miliolidae, Peneroplidae etc.), Algae (Corallinaceae and Dasycladaceae), Coralla, Echynodermata and fragments of shells and gastropods. S a k a č (1965) determined Middle Eocene and Upper Eocen age by Mollusca. The same age was determined by T r u t i n (1981) on the basis of foram determination.

CHEMICAL COMPOSITION OF THE BAUXITES

The content of oxides is determined by wet silicate analysis. Cu, Ni, Cr, Pb and Zn have been analyzed by atomic absorption, and K, Rb, and Ba by flame photometry.

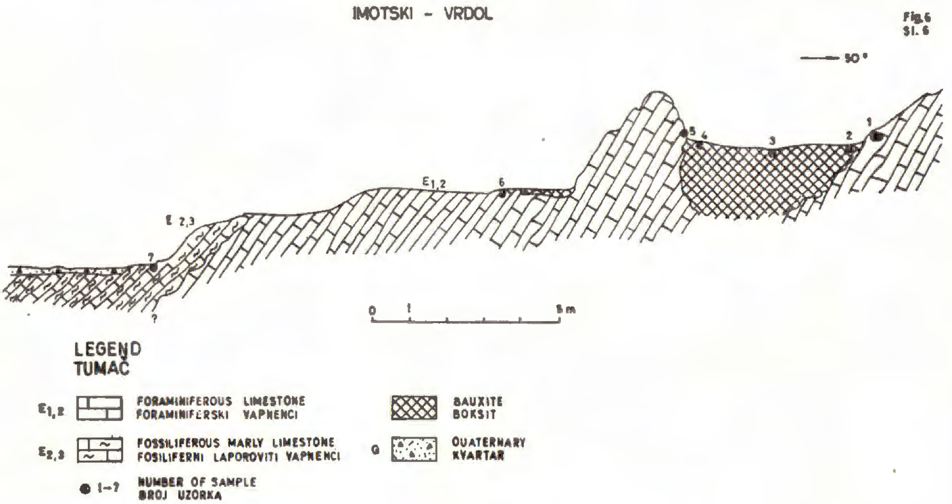


Fig. 6. Bauxite occurrence at the Vrdol locality

Sl. 6. Boksitna pojava na lokalitetu Vrdol

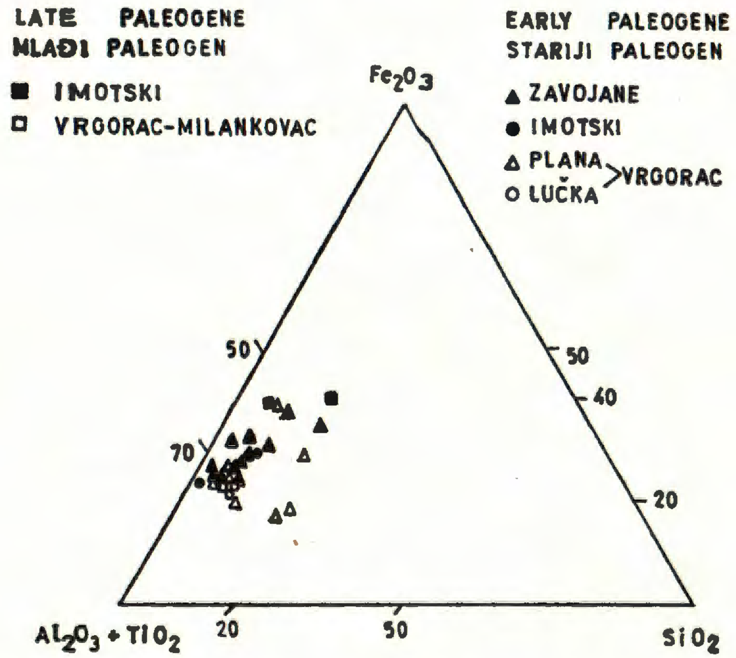
Fig. 7. Major chemical components (SiO_2, Al_2O_3 + TiO_2, Fe_2O_3) of the investigated bauxites. The number of the analyzed Early Paleogene bauxite samples is 24 and of the Late Paleogene ones is 3.

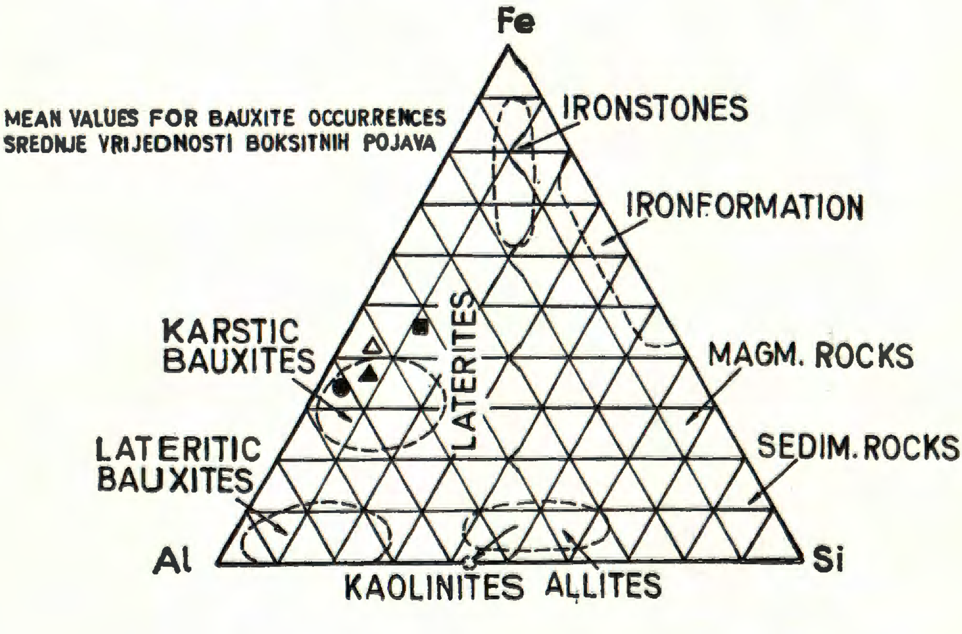
Osnovni kemijski sastav (SiO_2, Al_2O_3 + TiO_2, Fe_2O_3) proučavanih boksita. Analizirano je 24 uzoraka paleogenih boksita i 3 uzorka mlađe paleogenih boksita.

Mean chemical composition (Si, Al, Fe) of the Early Paleogene and Late Paleogene bauxits drawn in the Schroll's diagram (1979)

Srednji kemijski sastav (Si, Al, Fe) starije paleogenih i mlađe paleogenih boksita unesen u Schrollov dijagram (1979)

The Early Paleogene bauxites Starije paleogeni boksiti	— Zavojane	9 analyses 9 analiza
	— Imotski	2 analyses 2 analize
	— Vrgorac	2 analyses 2 analize
The Late Paleogene bauxites Mlađe paleogeni boksiti	— Imotski	2 analyses 2 analize


LATE PALEOGENE
MLAĐI PALEOGEN
IMOTSKI
VRGORAC-MILANKOVAC
EARLY PALEOGENE
STARIJI PALEOGEN
ZAVOJANE
IMOTSKI
PLANA
LUČKA
VRGORAC
Fe2O3
50
70
50
40
20
Al2O3 + TiO2
20
50
SiO2


Fe
MEAN VALUES FOR BAUXITE OCCURRENCES
SREDNJE VRIJEDNOSTI BOKSITNIH POJAVA
IRONSTONES
IRONFORMATION
KARSTIC
BAUXITES
LATERITES
MAGM. ROCKS
LATERITIC
BAUXITES
SEDIM. ROCKS
Al
Si
KAOLINITES
ALLITES

Relations among major oxides, i.e.: $Al_2O_3 + TiO_2$. Fe_2O_3 and SiO_2 in all analyzed bauxites from the Zavojane, Imotski and nearby Vrgorac region (fig. 1: No. 10 Milankovac, 11—13 Plana and 14—15 Lučka) are presented in a ternary diagram (fig. 7). The major elements also show similar relation, what is visible in the Schroll diagram (S c h r o l l, 1979).

In the diagram, mean values for particular groups were used (fig. 7 down) Correlation between trace elements and macroelements Ni-Fe (fig. 13) Cr-Ti, Cr-Ni, point out karst origin of the bauxites.

Comparing content of elements in the analyzed bauxites with the clarke in the equivalent bauxites (B u š i n s k i j, 1975) it may be concluded that concentration of Si, Ti, Fe, Cr and Pb in investigated bauxites is higher than the clarke, while Cu, Zn and Ba is lower. The Zavojane Early Paleogene bauxites have significantly higher Cr concentration (1160—4205 ppm) than eqvivalent bauxites from Hercegovina (Š č a v n i č a r et al. 1968). Content of Pb is similar, while Zn (15—40 ppm) is lower. Generally, their content resembles to the bauxite of the same horizons in Istria and Dalmatia (Š i n k o v e c, 1977). The quality of investigated bauxite is determined by module Al_2O_3/SiO_2 (B u š i n s k i j, 1975). The module varies in a wide span in the majority of deposits (Zavojane 2.38—27.97, Imotski 6.21—39.09, Vrgorac 2.64—14.33) i. e. their quality varies, from high siliceous to high aluminium ones.

The Late Paleogene bauxites are siliceous (Imotski 2.80—6.73, and Vrgorac 7.20—9.49). With regards to iron a part of analyzed samples are ferroginous. According to technological standards most of the Early Paleogene bauxites might be used in aluminium production. Technological process would not accept the Early Paleogene bauxite from Zavojane, i. e. Matokit and Ajduci, as well as the Late Paleogene bauxite from Imotski.

All analyzed limestones from the footwall and roofwall are inside the span of trace element content of equivalent limestones related to similar bauxite occurrences in Croatia (Š i n k o v e c et al. 1982).

Fig. 8. X-ray diffraction paterns

Sl. 8. Rendgenske difrakcijske slike

Symbols of the minerals: B boehmite, K kaolinite, H hematite G goethite, A anatase, Hy hydrargillite

Simboli minerala: B bemit, K kaolinit, H hematit, G getit, A anatas, Hy hidrargilit

Mark 1. Bauxite with fragments of bauxites, bauxite Matokit
(See Fig 3, sample 2)

Oznaka 1. Boksit s fragmentima boksita Matokit
(vidi sl. 3, uz. 2)

Mark 2. Massive-oolithic bauxite of Matokit
(See Fig 3, sample 4)

Oznaka 2. Masivno-oolitični boksit Matokita
(vidi sl. 3, uz. 4)

Mark 3. Massive bauxite of Vrdol
(See Fig 6, sample 3)

Oznaka 3. Masivni boksit Vrdola
(vidi sl. 6, uz. 3)

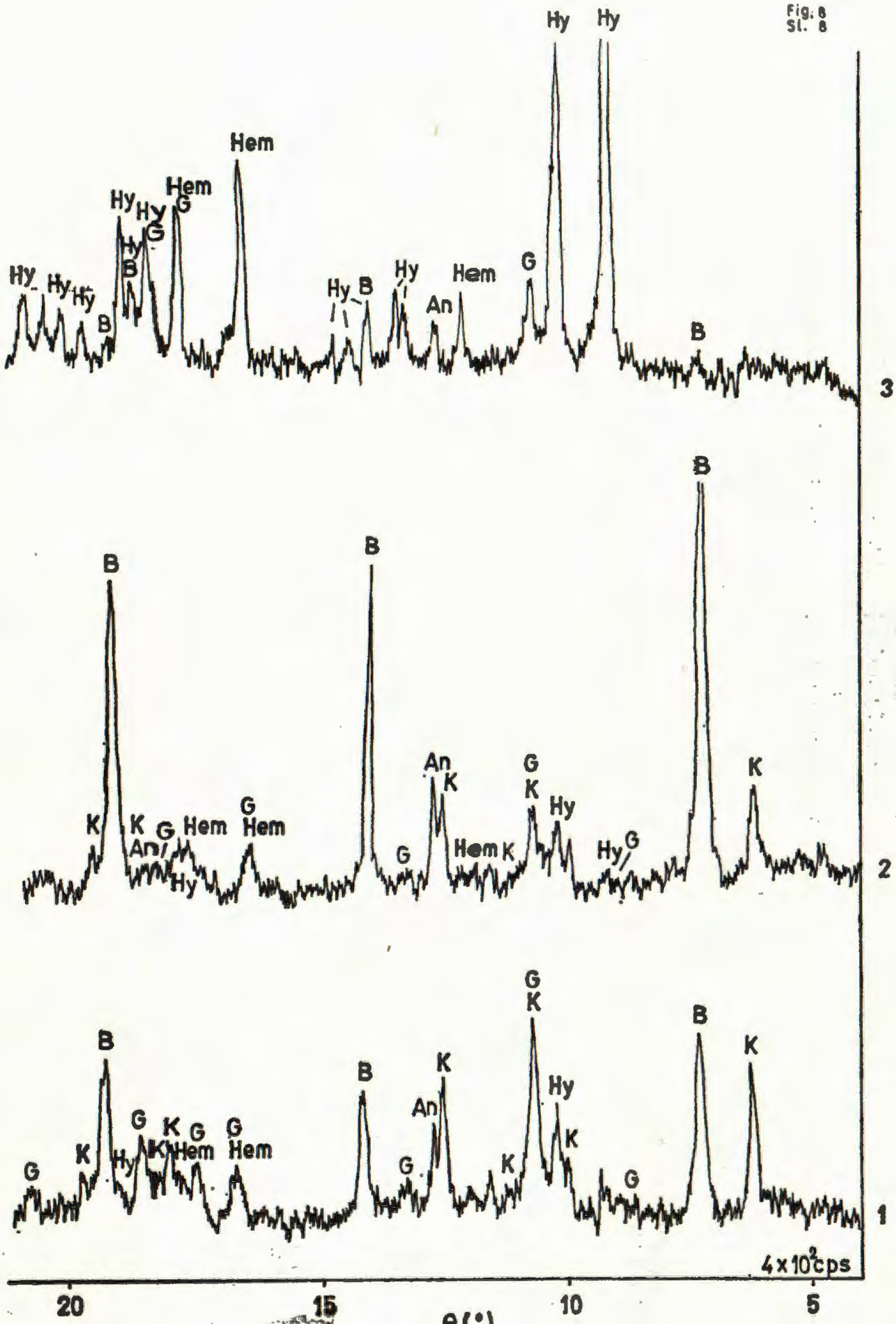


Fig. 8
Sl. 8
Hy
Hem
G
B
K
An
3
2
1
4x10² cps
20
15
10
5
θ (°)

Table 2.
Mean chemical composition of bauxite ($\bar{x}$) with standard deviations (s)

Tablica 2.
Srednje vrijednosti kemijskog sastava boksita ($\bar{x}$) sa standardnim devijacijama (s)

	%						ppm						
	SiO_2	Fe_2O_3	Al_2O_3	TiO_2	L. o. I. G. ž.	K	Rb	Ba	Pb	Cr	Cu	Ni	Zn
THE EARLY PALEOGENE													
Stariji paleogen													
Zavojane													
$\bar{x}$	6,65	24,77	47,31	3,29	15,53	0,1066	30,75	64,63	74,89	2409,44	30,89	191,67	17,22
s	3,55	3,22	7,85	0,325	0,35	0,017	5,47	6,61	28,53	785,35	14,73	55,74	3,23
Imotski													
$\bar{x}$	5,10	24,58	57,28	3,34	14,89	0,086	24	57,5	62	835,5	45	581	106
s	5,01	4,74	5,15	0,127	0,245	0,016	4,24	10,61	7,07	197,28	15,56	557,20	43,84
THE LATE PALEOGENE													
Mlađi Paleogen													
Imotski													
$\bar{x}$	7,96	25,70	29,17	1,94	25,84	0,093	25	54,5	138,5	921	230	804	397
s	4,33	0,44	5,35	0,092	2,05	0,027	5,66	3,54	101,12	236,17	56,57	299,81	89,10

Remark — Zavojane: Number of samples N = 9, except for K, Rb and Ba N = 8
— Imotski: The Early Paleogene N = 2 and the Late Paleogene N = 2

Napomena: — Zavojane: Broj uzoraka N = 9, osim za K, Rb i Ba N = 8
— Imotski: stariji paleogen N = 2 i mlađi paleogen N = 2

MINERALOGICAL COMPOSITION OF THE BAUXITES

The major bauxite minerals are cryptocrystalline, intimately mixed in a uniform mass, at some places slightly more ferroginous.

X-ray analysis (fig. 8) determined boehmite, kaolinite, geothite, hematite, hydrargillite and anatase.

Boehmite prevails in the Early Paleogene bauxites with more or less kaolinite (mark 1 and 2 in fig. 8) and hydrargillite with hematite in the Late Paleogene ones (mark 3).

STATISTICS

Statistical procedure was done in order to evaluate with greater certainty chemical composition of the bauxites ores, geochemical relationship between trace and macro elements, and on the basis of obtained relations to decipher some genetical characteristics.

Chemical composition ($\bar{x}$) of the Early Paleogene bauxites from the Zavojane and Imotski region as well as the Late Paleogene ones from the vicinity of Imotski with stand. deviations (s) are presented in the table 2.

On the basis of these simple statistical parameters, it is possible to notice certain characteristics of the groups. For example, the Zavojane Early Paleogene bauxites show especially high enrichment in Cr, relatively high concentration of Ni and lower values for Cu, Pb and Zn. The bauxites from the same horizons, nearby Imotski, are poorer in Cr and richer in Ni and Zn. The Late Paleogene bauxites from Imotski, especially in comparison to the ones in Zavojane belonging to the older horizon, are poorer in Cr but possess much higher concentration of other trace elements.

Regression analysis was directed exclusively to 9 samples of the Early Paleogene bauxites from Zavojane, since limited number of investigated specimens from the other regions. In turn, the values for slope and intercept for linear correlation equations as well as correlation coefficients were calculated. More successful linear connections between Pb/SiO_2, SiO_2/K, Ba, Rb/K are presented in diagrams (fig. 10, 11 and 12) with an appropriate linear equation.

The correlation coefficients among trace and macro elements are presented in a correlation matrix (tab. 3). All correlation coefficients were testified by t-values according to the Kendall's formula, $t = r \times \sqrt{N - 2} / \sqrt{1 - r^2}$.

The significant links in the table 3 are underlined, with remark that all coefficients were calculated with $N - 2 = 7$ degrees of freedom, and values for K, Rb and Ba with $N - 2 = 6$ degrees of freedom. Appropriate r values are 0.61 and 0.63 respectively.

Cluster analysis, done after foregoing statistical procedure, points out significant statistical link between trace elements, clay minerals and iron (hydroxy) oxides.

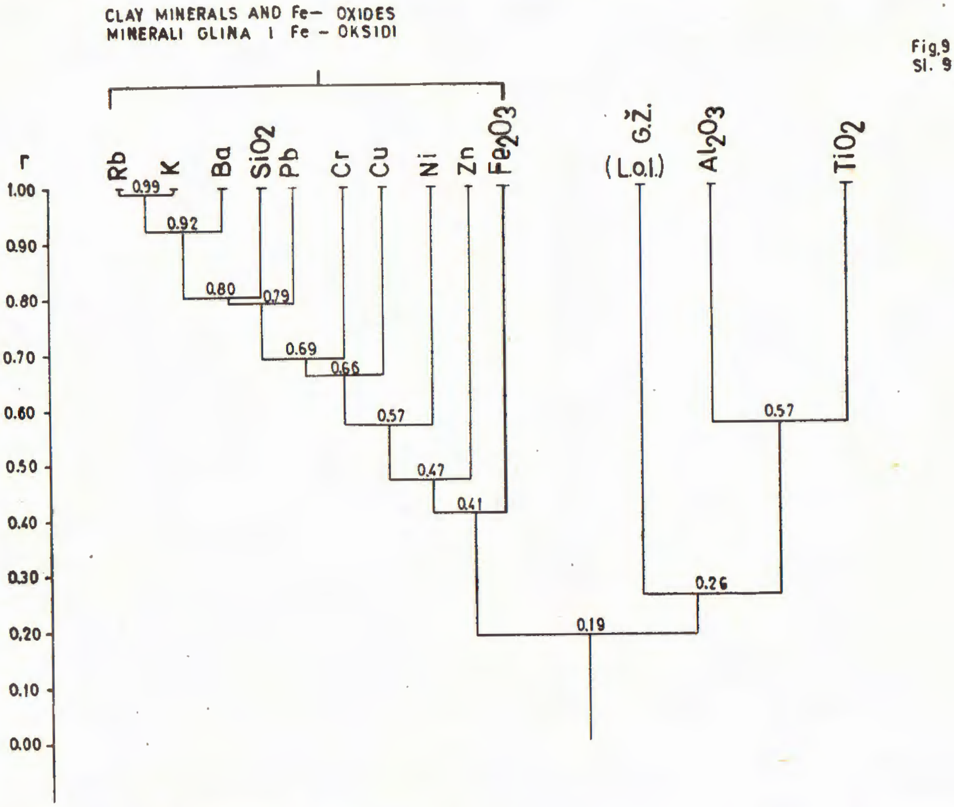


Fig. 9. The dendrogram of geochemical relationship among major and trace elements in the bauxite

Sl. 9. Dendrogram geokemijske povezanosti makroelemenata i elemenata u tragovima u boksitima

REMARKS ON GENESIS

With regards to the fact, that the Early Paleogene and the Late Paleogene bauxites of Dalmatia are relatively well investigated in view of geological, mineralogical and geochemical characteristics, we shall try only to accomplish, otherwise, fairly clear genetic picture.

The Early Paleogene bauxites are placed on the karstified carbonate footwall rocks of Upper Cretaceous age, which were the only country rocks on the newly formed dry land with undeveloped relief. Laramian orogenic phase, that caused uplifting and formation of a new dry land territory, did not cause significant deformations of carbonate sediments. At such circumstances paleokarstification with intensive bauxitization took place under influence of convenient climate on a vast territory. Transport of the material was negligable mostly washing out into nearby

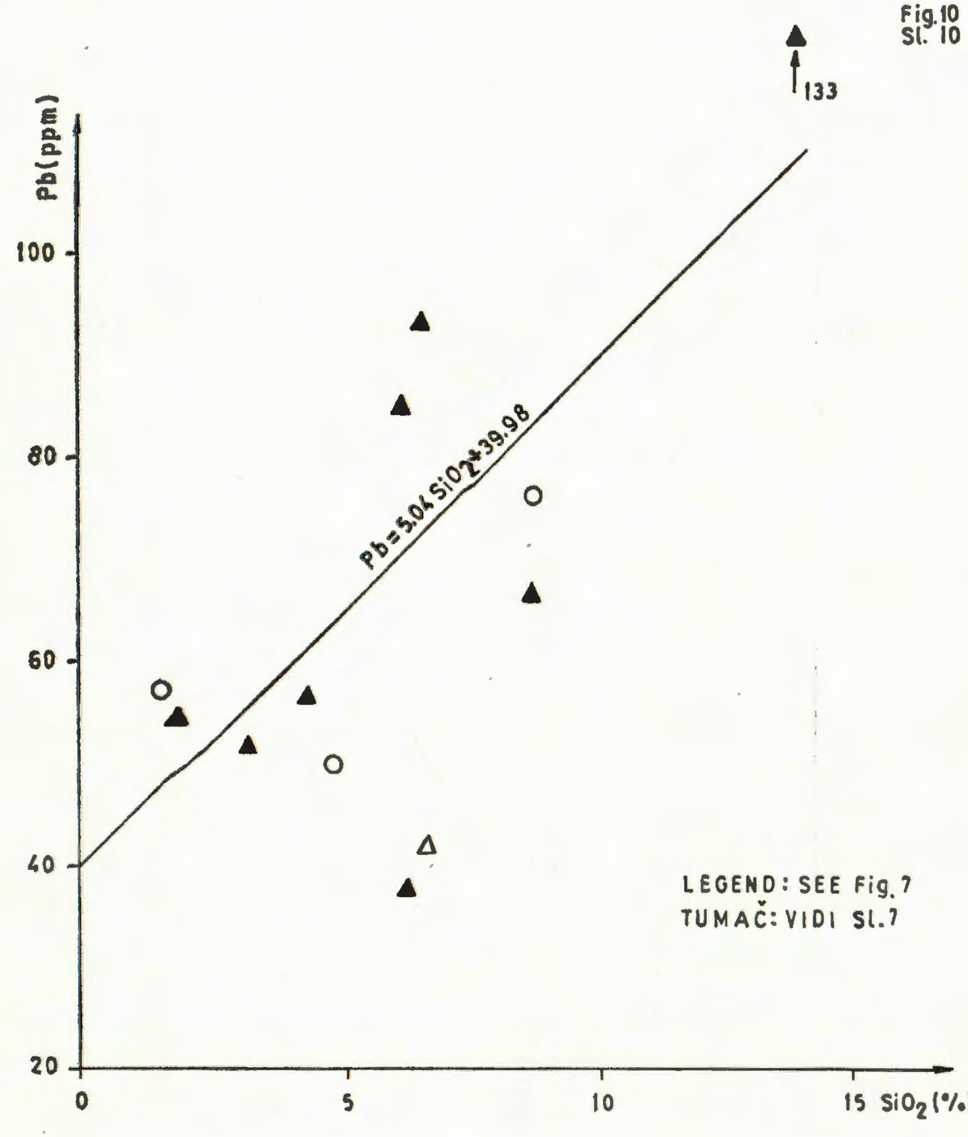


Fig. 10. Linear correlation betwen SiO_2 and Pb

Sl. 10. Linearna korelacija između SiO_2 i Pb

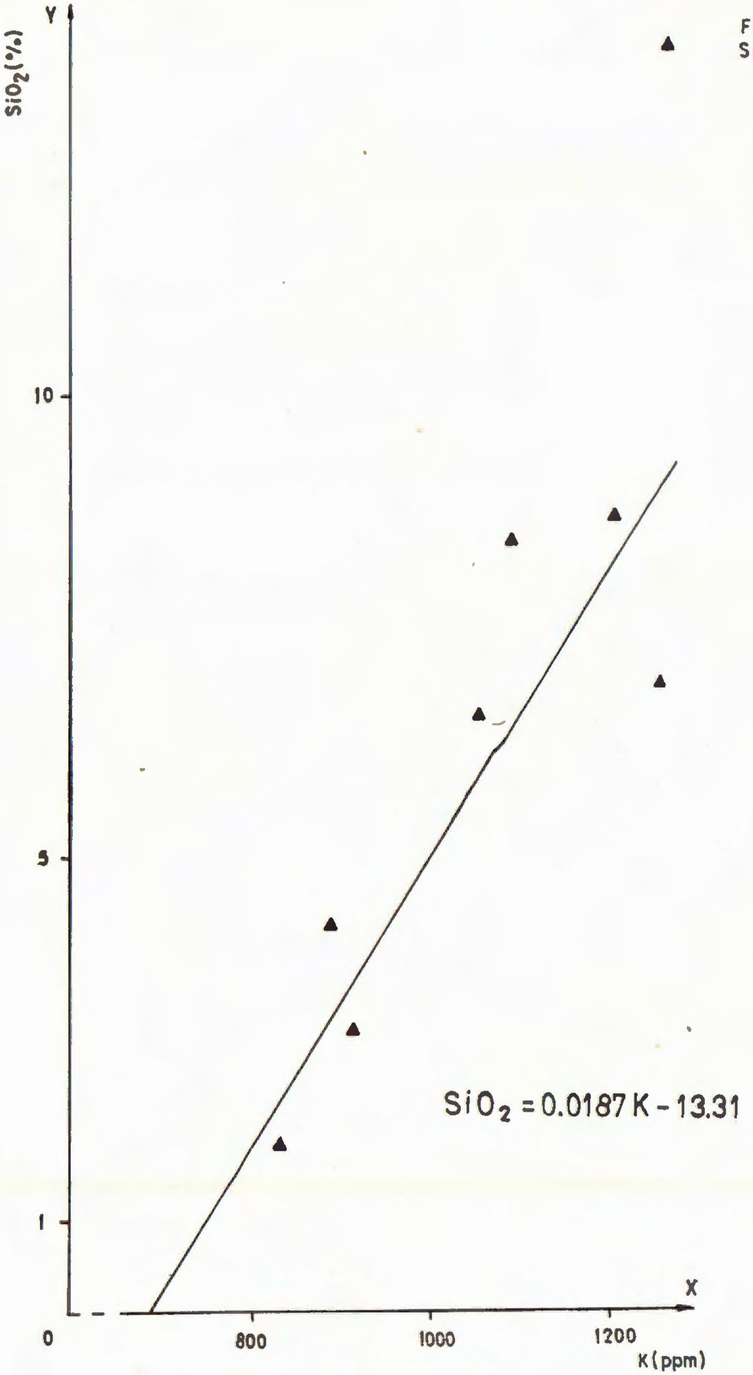


Fig. 11. Linear correlation betwen K and SiO_2
Sl. 11. Linearna korelacija između K i SiO_2

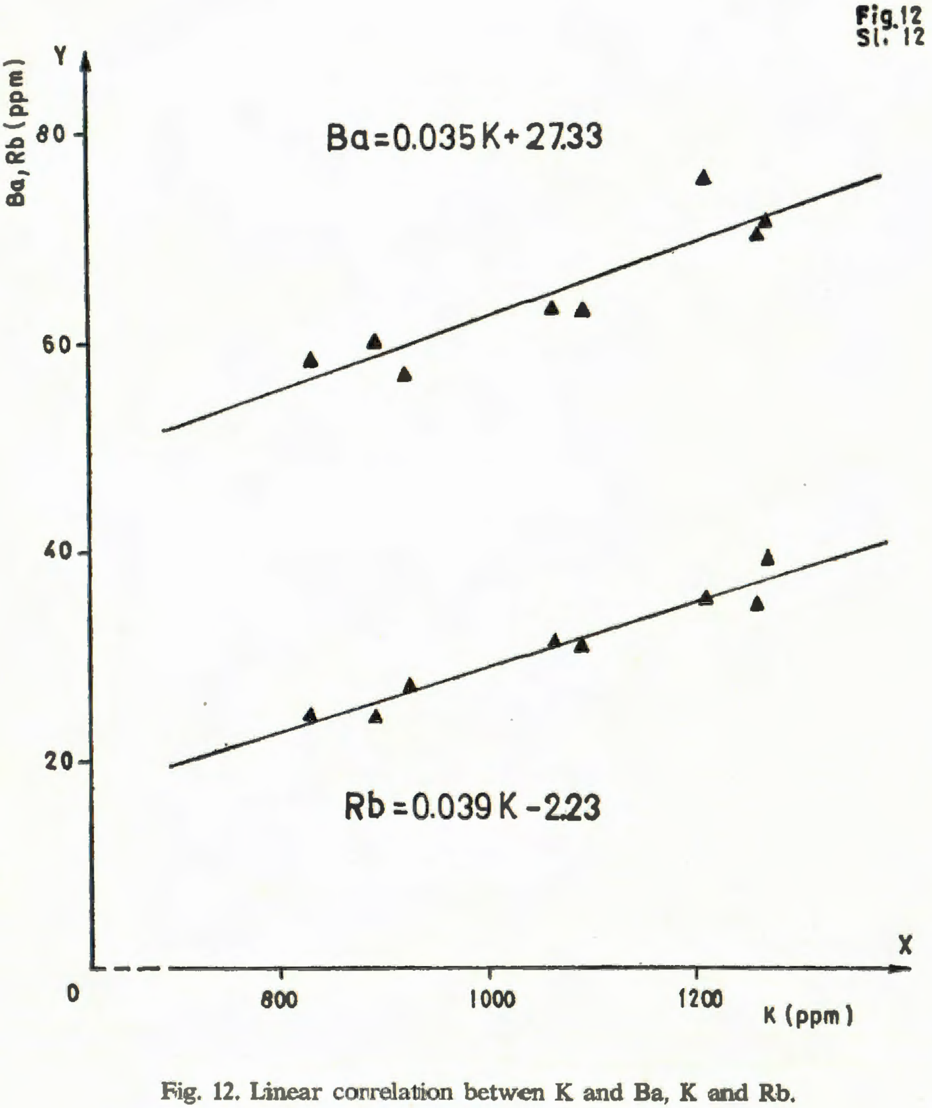


Fig. 12. Linear correlation betwen K and Ba, K and Rb.
Sl. 12. Linearna korelacija između K i B, K i Rb.

Tablica 3.
Matrica koeficijenata korelacija između makro i mikroelemenata u boksitu

Table 3.
Matrix of correlation coefficients among major and trace elements in the bauxite

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	G. ž. L. o. I.	Cu	Ni	Cr	Pb	Zn	K	Rb	Ba
SiO_2		—0,83	—0,86	0,40	0,03	0,16	0,32	0,52	0,79	0,22	0,76	0,80	0,68
TiO_2	—0,83		0,57	—0,19	0,26	0,18	—0,47	—0,36	—0,50	—0,25	—0,79	—0,79	—0,66
Al_2O_2	—0,86	0,57		—0,62	—0,07	—0,40	—0,14	—0,47	—0,76	—0,15	—0,56	—0,64	—0,63
Fe_2O_3	0,40	—0,19	—0,62		—0,38	0,17	0,31	0,24	0,41	0,01	0,28	0,38	0,30
G. ž. L. o. I.	0,03	0,26	—0,07	—0,38		0,17	—0,75	0,08	0,19	0,12	—0,25	—0,27	—0,28
Cu	0,16	0,18	—0,40	0,17	0,17		0,14	0,66	0,54	—0,04	—0,18	—0,03	—0,02
Ni	0,32	—0,47	—0,14	0,31	—0,75	0,14		0,35	0,38	0,22	0,48	0,57	0,42
Cr	0,52	—0,36	—0,47	0,24	0,08	0,66	0,35		0,69	—0,05	0,16	0,33	0,067
Pb	0,79	—0,50	—0,76	0,41	0,19	0,54	0,38	0,69		0,47	0,50	0,66	0,38
Zu	0,22	—0,25	—0,15	0,01	0,12	—0,04	0,22	—0,05	0,47		0,15	0,23	0,03
K	0,76	—0,79	—0,56	0,28	—0,25	—0,18	0,48	0,16	0,50	0,15		0,99	0,92
Rb	0,80	—0,79	—0,64	0,38	—0,27	—0,03	0,57	0,33	0,66	0,23	0,99		0,88
Ba	0,68	—0,66	—0,63	0,30	—0,28	—0,02	0,42	0,067	0,38	0,03	0,92	0,88	

depressions. Particularly high pH, characteristic for karst bauxite formation because of buffer effect of carbonate substratum, enabled concentration of Cr and Ni (tab. 2).

Schroll's diagrams Fe%—Ni (fig. 13), and Cr—Ni, Cr—Ti (Schroll, 1979), as well as ternary diagram Fe-Al-Si (fig. 7) point out conspicuously to karst origin of the Early Paleogene bauxites.

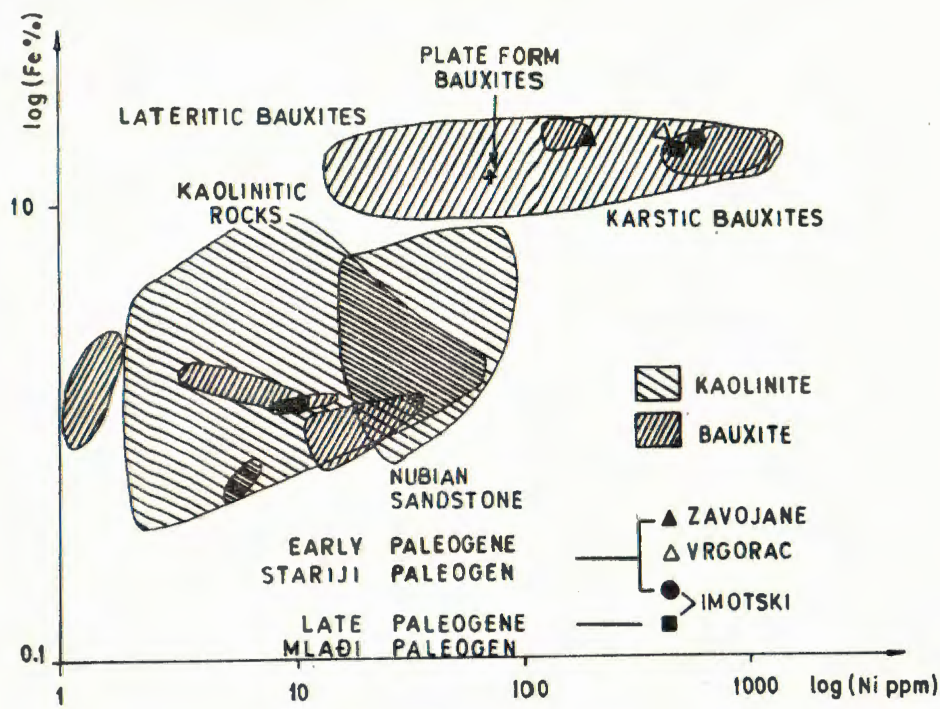


Fig. 13. Schroll's diagram Fe(%)-Ni
Sl. 13. Schrollov dijagram Fe(%)-Ni

Exceptionaly high concentration of Cr in the basal part of the Zavojane-Zekulići (Matokit) ore occurrence might be explained by prolonged bauxitization »in situ« in the ore body itself.

The Late Paleogene bauxites were formed at sightly different conditions, what influenced their mineralogical and chemical composition. Illyrian orogenic phase brought about formation of more expressive tectonic structures. Newly formed relief with pronounced hypsometric forms enabled gathering of bauxite material into big ore bodies but with higher content of SiO_2, i. e. of lower quality. It is a consequence of more intensive mechanical erosion, which prevented complete bauxitization of regolith, originating from different sources (Šinkovec et al. 1982).

Faster and incomplete weathering of different kinds of rocks, which were exposed on the newly formed dry land, effected content of bauxite trace elements, lowering concentration of Cr and arising Cu, Pb and Zn respectively.

Cluster analysis put together analyzed trace elements, clay minerals and iron(hydroxy) oxides, what is in good agreement with proposed supposition (fig. 9, 10, 11 and 12).

Received on 20th December 1984.

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Boksitne pojave u Zavojanima i sjeverno od Imotskog

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U području Zavojana i sjeverno od Imotskog utvrđene su do sada uglavnom nepoznate pojave krških boksita starije paleogenske pripadnosti, a kod Imotskog i mlađe paleogenske pojave. Boksiti pripadaju dvama dobro poznatim boksitnim zonama (stratigrafskim horizontima) u Dinaridima. Češće pojave boksita s manjim izdancima sugeriraju njihovo detaljno geološko kartiranje. Isprekidano boksitno orudnjenje registrirano je u Zavojanima više od 1700 m.
U radu je dan opis geološke situacije (sl. 1), način pojavljivanja rudnih tijela (sl. 2—6), teksture i strukture ruda, mineralni sastav (sl. 8), te njihova kemijska i geokemijska svojstva (sl. 7, 9—13 i tablice 1—3). Debljina boksita varira od 0,7—7 m. Starije paleogeni zavojanski boksiti odlikuju se oolitičnom teksturom i strukturom (ima boksita i s fragmentima boksita), dok se starije i mlađe paleogeni boksiti sjeverno od Imotskog odlikuju homogenom teksturom i strukturom.

Mlađe paleogeni boksiti bitno se razlikuju od starije paleogenskih boksita. Sadrže manje Al i Ti, ali im je veći gubitak žarenjem (odnosno H_2O). U mineralnom sastavu također postoje razlike: starije paleogenski boksiti su pretežno bemitski dok su mlađe paleogeni boksiti hidrargilitski. — Većina analiziranih starije paleogenskih boksita zadovoljila bi zahtjev tehnološkog procesa prerade boksita.

Statistička obrada geokemijskih podataka je uključila regresivnu analizu, određivanje koeficijenata korelacije, t — test signifikantnosti koeficijenta korelacije i klaster analizu. Statistička analiza ukazuje na značajniju ulogu minerala glina i željezovitih (hidro) oksida prilikom vezanja mikroelemenata. Po svojim karakteristikama, to su tipični krški boksiti sa visokim koncentracijama Cr i Ni. Starije paleogeni boksiti su bogatiji na Cr što je vjerojatno posljedica dugotrajnije i potpunije boksitizacije »in situ« na nerazvijenom reljefu. Viši sadržaj Pb, Zn i Cu u mlađe paleogenim boksitima je uzrokovan nešto intenzivnijim mehaničkim trošenjem paleogenog kopna s razvijenim reljefom.