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Contribution to Knowledge of Contains on Peridotite Rocks of the Krivaja-Konjuh Ophiolitic Complex (Massif)

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Abstract: Krivaja-Konjuh ultramafic complex is mainly constructed of ultramafic rocks associated with different varieties of igneous rocks (gabbro, dolerite, diabase, spilite, keratophyres, granitoids) and metamorphic rocks (amphibolites, amphibolite schists and eclogites). This paper presents results of mineralogical and chemical analysis of ultramafite rocks (peridotite-lherzolites) samples in the southern part of Krivaja-Konjuh massif. The samples were examined optically, by using method of X-ray fluorescence spectroscopy and electron microprobe method. Optical results showed that lherzolites have uniform textural characteristics and mineral composition. Results of chemical studies on these rocks demonstrated modal composition with high content of MgO, low content of CaO and high content of MgO:FeO (about 5 and up). Based on CIPW normative system, their composition is uniform with a very small variation in the content of diopside, with a slightly larger variation in the content of olivine. The rhombic pyroxene in composition correspond to enstatite and monoclinic pyroxenes are diopside by the composition. Spinel in peridotites are Al spinels and Al chromium spinels.

INTRODUCTION

Ophiolite zone of Internal Dinarides is a separate tectonic unit and it stretches from Banija in Croatia through Bosnia and western Serbia, to Kosovo on southeast and continues to Hellenides. Within ophiolite zones in Bosnia, there are 6 ophiolite complexes (Krivaja-Konjuh, Ozren, Kozara, Varde and Višegrad area, complex Ljubić, Čavke and Vrbanje, and complex Borje and Mahnjače) mainly of identical composition, although each carries some specific characteristics that makes it different from other complexes. Krivaja-Konjuh complex is located in the central parts of the ophiolite zone of the Dinarides and is elongated in the northwestsoutheast direction. The dominant role in Krivaja-Konjuh massif have ultramafic rocks occupying an area of over 500 km2 and they are associated with different varienties of ingeous rocks and metamorphic rocks. A few ten of samples pf peridotides were microscopic processed, and selected representative samples were examined in detail which will significantly extend our knowledge of peridotite in Krivaja-Konjuh (massif). Based on all acquired field and laboratory data, the mineral and chemical composition of samples have been determined. Determination of the content of macro elements and normative CIPW composition and determination of micro elements is the basis for rock classification and complete definition of the chemical composition of these rocks.

Geological characteristics of the dinaride ophiolite zone

Ophiolite complex rocksare is related to the internal Dinarides and they represent very complex association of rocks among which ultramafites are the most characteristic ones which are associated with different varieties of gabbros, dolerite, diabases, spilite and amphibolites and united in the so-called diabase-chert formation or Jurassic-igneous-sedimentary formation (Katzer, 1906.; Ćirić, 1954.; Pamić, 1964.). Various types of gabbros, dolerites, diabases and spilites constitute about 5-10% ophiolite complex (Pamić, 1964).

Ophiolite zone of the Dinarides has been camouflaged in some parts, with drawn Mesozoic, mainly calcareous and Paleozoic semimetamorphic rocks. In ophiolite complexes of the Dinarides ophiolite zones, prevail ultramafites (lherzolites, harzburgites) and serpentinite. Very rarely one encounters complete preserved ophiolite profiles (Pamić&Desmons, 1989), but more often than chaotic relationships, i.e. ophiolite mélange (Dimitrijević, 1973) is present.

Ophiolite mélange is built of shale-silt matrix in which they are usually fragments of greywackes, radiolarites and exotic limestones of Middle Triassic to Jurassic - Lower-Cretaceous age. In the mélange, there are also fragments and blocks of ophiolites centimeter - decimeter - hectometer - the kilometer in size.

As the most dominant rocks in the ophiolite mélange appear fragments and blocks of peridotites represented by faulted plates, thickness from a few hundred meters to 2000 meters, drawn on ophiolite mélange (Pamić&Desmons, 1989).

So far, in the ophiolite mélange, e.g. in its matrix, typical fossil remains have not been found. Based on uncharacteristic fossils, Jurassic age is assumed, which is consistent with available data on isotopic age 189-136 Mav(Lanphere et al., 1975; Meyer et al., 1979; Lugović et al., 1991).

Over the ophiolite mélange of the Dinarides ophiolite zone lie transgressive Lower Cretaceous formations of Pogarska formation.

Krivaja-Konjuh Ophiolite Complex

There is a large number of works related to certain small areas (Pamić, et al., 1977., Pamić, 1978: Operta et al., 2003., Trubelja et al., 1995., Šegvin, B., 2010., Faul et al., 2014) about Krivaja-Konjuh ophiolite complex,

Krivaja-Konjuh complex extends from the Bosna river valley in the west to the road Sarajevo-Tuzla in the east.

In the north, i.e., the northwest, boundary is not visible, while to the south it extends to Vareš. Through the central part of the ophiolite complex the river Krivaja flows dividing it into two equally sized blocks, after which, together with neighboring mountain Konjuh the complex got its name.

The dominant role in the Krivaja-Konjuh massif have ultramafite rocks occupying an area of over 500 km^2 and they are associated with different varieties of igneous

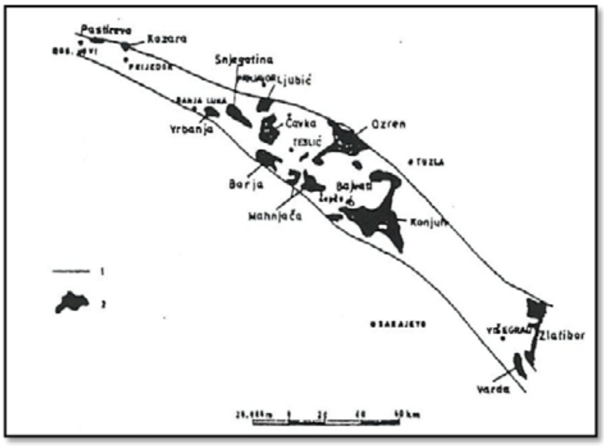

Figure 1. Schematic map of northwestern and middle parts of the Dinaride Ophiolite zone (Pamić et al., 1977). 1. boundary of the Ophiolite zone. 2. larger ultramafic massifs.

rocks and metamorphic rocks (amphibolites, amphibolite schists and eclogites). (Pamić, 1978).

Amphibolites form narrower or wider zones around ultramafite massif and in some areas they exceed ultramafic in size. All these rocks are members of the Jurassic ophiolite mélange with a dominant share of greywacke sandstones and slates. Krivaja-Konjuh ophiolite complex together with ophiolite mélange covers an area of approximately 1000 km^2 (Pamić, 1978).

Over the ophiolite mélange, synclinally lies Pogari Formation of Tithonian-Cretaceous age and over the Krivaja-Konjuh ultramafic massif in the area Sokoline, transgressivelly lie the Upper Jurassic limestones. This suggests that age of ophiolite mèlange falls between the Jurassic and Tithonian.

Phyllite and quartz-sericite schists were spotted in the central part of the southern perimeter of Duboštica and on the east end at Konjuh to Miljevice, similar in appearance to match the Paleozoic formations. It is concluded that they represent the transformed greywacke sandstones and slates of Jurassic ophiolite mélange.

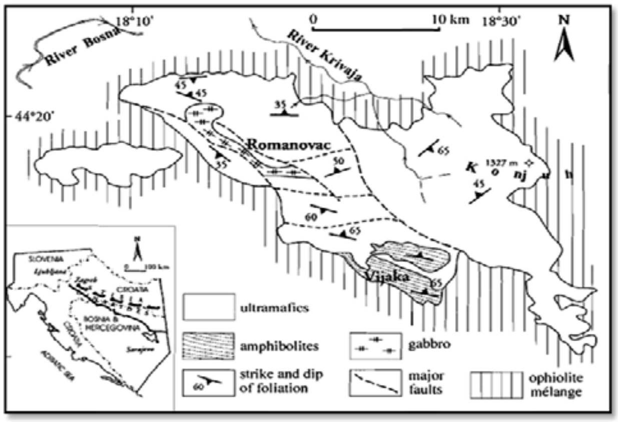

Figure 2. Schematic structural map of Krivaja-Konjuh massif (Pamić et al., 1977).

Ophiolite complexes of various geographical areas mainly have identical composition. Mafic rocks are much subordinated; they occur frequently but in smaller masses. The relationship between ultramafic and mafitc, including amphibolites, is 9 to 1 (Pamić, 1978).

Rarely one can encounter a fully preserved ophiolite profiles. Usually the complete ophiolite profiles in ophiolite situating are broken, tectonised, and, as smaller or larger fragments, they are included in ophiolite mélange.

EXPERIMENTAL

A few dozen samples of peridotites were selected in the southern part of the Krivaja-Konjuh ultramafic massif, which were optically tested and based on the results of optical tests, seven samples were selected. The samples were labeled and prepared for analysis of macroelements and microelements, by X-ray fluorescence spectroscopy method, and for chemical analysis of mineral phases by electron microprobe. The paper presents in detail the results of those tests.

Optical Methods

To determine mineral composition and structural, textural characteristics of rocks as well as relationships among minerals, microscopic preparates were made with standard thickness from 0.02 to 0.03 mm. As a binding agent and at the same time as an internal standard for refractive index, Canada balsam from the "Semikem"Company was used.

When making microscopic preparates,slides were used, with various sizes, depending on whether they are used for testing the structure and textures, mineral composition, or for determining on universal table.

In microscopic determination, a polarizing Reichart microscope was used with a range of increasing 25-630x at the Faculty of Science in Zagreb, and polarizing Olympus microscope brand PX 40 at the Institute of Mineralogy of Innsbruck.

Samples were microscoped in transmitted light in orthoscopic conditions, without and with the included analyzer, and in conoscopic illumination observations conditions. Standard microscope equipmentwas used.

A polarizing microscope was also used, with the Carl Zeiss Jena universal table (4 + 1 axis) with increases 125-500x. Hemispheres were used, with refractive indexes n-1,516 and n-1,648 depending on the refractive index of the measured minerals. As a light source, "white" light microscope bulb was used.

Chemical Analyzes of Rocks

Analysis of macro elements

The rocks have been chemically analyzed by the method of X-ray fluorescence spectroscopy using wave-dispersive instrument SRS 3000 (TYROLIT Schleifmittelwerk, SWAROVSKI GROUP-SCHWARZ Tyrol) at the Institute of Mineralogy and Petrology in Innsbruck.

Analysis of macroelements was also performed by the method of X-ray fluorescence spectroscopy according to the procedure recommended by Johnson & Matthey.

Proportion of bivalent iron in the sample was determined according to the volumetric method, according to WILSON (1955).

Water in the sample was determined gravimetrically, drying at 110 °C (H_2O^-) and the subsequent sample annealing at 1025 °C to determine H_2O^+.

Analysis of micro elements

Analysis of trace elements was also performed by the method of X-ray fluorescence spectroscopy. For the analysis of trace elements, 35 mm diameter tablets were made by compressing 4 g of finely ground sample. Before pressing, the sample was admixed 1 g binder (Hoechst Wachs C). The sample was pressed in a hydraulic press for ten minutes with pressure to 20 kN and dried at 110°C.

Chemical analyzes of mineral phases

Chemical analyzes of mineral phases were carried out using electron microprobe ARL -SEMQ at the Institute of Mineralogy and Petrology in Innsbruck. This instrument has four WDS spectrometers and Noran-Voayager EDS (energy dispersive system). All analyzes were done at a voltage of 15 kV and current of 20 nA with a nominal diameter of the beam of 1-2 microns. Next standards were used: labradorite (Si, Al, Ca) rutile (Ti), chromite (Cr), diopside (Mg), rodonite (Mn), fayalite (Fe), albite (Na), sanidine (K), V metal (V), metal (V), pyrope (Si analysis with garnets).

Bivalent and trivalent iron in ilmenite, garnet, clinopyroxenes and orthopyroxenes, is calculated based on the stoichiometry.

Method for calculation of chemical analysis to the standard formula

Analysis results were calculated to a number of oxygen and cations.

Analyses of clinopyroxene and orthopyroxene werecalculated according to the Norm recommendations (Wood, 1988) at 6 O.

Analyses of spinel and olivine were calculated according to the recommendations of HYPER - FORM (S.Bjerg et al. 1991). Analyses of spinel were calculated at 32 O, and olivine at 4 O.

RESULTS AND DISCUSSION

In the southern part of Krivaja-Konjuh ultramafic massif, peridotite samples were taken and optically tested,and samples were selected for analysis of macro and micro elements by X-ray fluorescence spectroscopy method as well as for chemical analysis of mineral phases by electron microprobe.

The results of optical tests showed that lherzolites have uniform structural-textural characteristics and mineral composition. They were made of olivine, enstatite and diopside, with a clear domination of olivine. Accessory ingredient is spinel.

The structures of ultramafic rocks are granular and porphyroide. The grain size of the primary constituents of the granular representatives ranges from 0, 5 to 2 mm, and in ultramafic with porphyroblastic structure, phenocrystic size (typically lamellar enstatite) goes up to 20 mm.Very rarely are fresh, usually are serpentinised. Serpentised ultramafite are fine-ground. Ultramafic textures are massive (rarely) and various parallel (pseudostratification and foliation).

In mineral composition of the optically surveyed lherzolites, one can find primary and secondary minerals. The primary minerals of lherzolites are olivine, enstatite, diopside and spinel. Secondary minerals were following: serpentine, chlorite, amphibole, talc, magnesite, quartz, opal, magnetite, limonite and hematite.

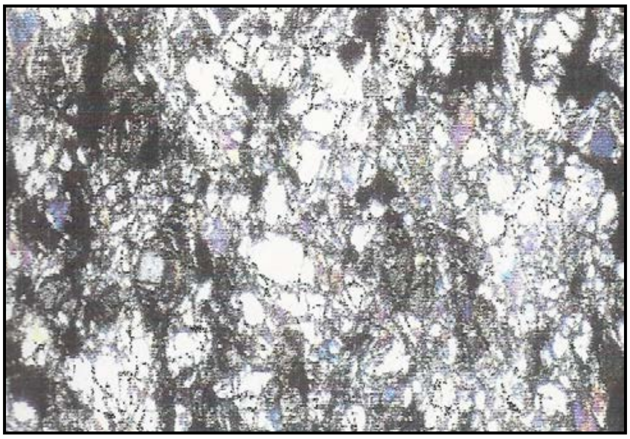

Figure 3: Recrystalization of olivine small grains mixed with pyroxene in lherzolites. N+.

Chemical composition of lherzolites in Vijaka area is very uniform and it stands out with high MgO content (about 40 wt. %), low CaO content about 3% (from 1.96 to 2.86%) and a high ratio of MgO: FeO (about 5 or higher) - table 1.

Table 1. Chemical analysis of macro elements in peridotites-lherzolites (macroelements in wt. %)

Sample	1	2	3	4
SiO_2	41,03	41,75	40,31	39,81
TiO_2	0,15	0,18	0,14	0,12
Al_2O_3	0,92	1,63	1,57	1,08
Fe_2O_3	2,91	2,92	2,96	3,16
FeO	5,83	5,85	5,91	6,33
MnO	0,13	0,12	0,13	0,13
MgO	35,77	38,34	38,89	40,17
CaO	1,96	2,86	2,64	2,42
Na_2O	0,18	0,31	0,22	0,19
K_2O	0,02	0,00	0,00	0,00
P_2O_5	0,02	0,01	0,00	0,01
H_2O^-	0,52	0,59	0,64	0,59
H_2O^+	10,49	6,28	6,88	6,40
total	99,92	100,8	100,2	100,4

1 and 4-lherzolites; 2-serpentinizied lherzolites; 3-porphyroblastic lherzolites.

This, in fact, is in accordance with the contents of the main components which Pamić (1977) got by researching the chemical composition of spinel lherzolites in the Krivaja-Konjuh ultramafic massif.

The whole chemical compositions of the samples analyzed are shown in Table 1. Frey (1984) used calcium for the differentiation of rocks between the Ca rich and Ca poor mantle rocks, since calcium is closely associated with clinopyroxene and this mineral is very often well-preserved in the rocks.

Analyzed samples are affected by serpentinisation, which probably results in changes, of the primary Ca content.

Like Ca, Ti is incompatible element, which is exhausted during melting, in the mantle rocks coming to separation Ti rich phases of the gabrous composition solutions. In contrast to Ca, Ti is an element with low mobility (Pearce & Cann, 1973) and therefore during metamorphism stay in mantle rocks even if Ca is shifted-removed. As trace elements Ni and Co are significantly enriched, both become compatible elements with high distribution relationship between the residue and the partial solution. Usually they are incorporated in olivine crystal lattice replacing Mg. The same route of enrichment must be valid for Cr (2930 ppm) but in research of mantle rocks, this is not fully explored. The content of chromium in the less exhausted and inexhaustible mantle rocks is 2510-3090 ppm (Table 2).

Table 2. Chemical analysis of trace elements in peridotites-lherzolites (trace elements and rare soils in ppm).

Sample	1	2	3	4
Qtz	0,00	0,00	0,00	0,00
Or	0,10	0,00	0,00	0,00
Ab	1,70	2,80	2,00	1,70
An	1,90	3,30	3,60	2,20
Lct	0,00	0,00	0,00	0,00
Ne	0,00	0,00	0,00	0,00
C	0,00	0,00	0,00	0,00
Di	7,10	9,30	8,30	8,30
Hy	28,50	14,20	10,30	6,40
Ol	57,70	67,50	72,90	78,50
Ac	0,00	0,00	0,00	0,00
Mt	2,70	2,60	2,60	2,50
Ilm	0,30	0,00	0,00	0,00
Ap	0,10	0,00	0,00	0,00

1 and 4-lherzolites; 2-serpentinizied lherzolites; 3-porphyroblastic lherzolites.

Most likely it seems that the Cr is incorporated (plugged-annexed) in spinels which are very unevenly distributed in mantle rocks. This explains the variability of Cr in peridotites.

Table 3. provides a lherzolites modal relationship.

Table 3. Normative composition of the CIPW (wt.%)

	1	2	3	4)
Ba	7	9	6	5
Co	119	109	106	117
Cr	2730	2650	3090	2510
Cu	23	25	25	26
Ga	4	4	3	3
Ni	2380	2050	1930	2180
Sc	11	12	14	11
Sr	< 2	12	< 2	< 2
V	59	68	72	63
Y	2	3	3	2
Zn	53	50	52	51
Zr	3	6	2	2
S	230	180	150	200
Cl	790	890	540	580
F	< 50	< 50	< 50	< 50
Pb	4	2	2	2
Rb	< 2	< 2	< 2	< 2
Cs	< 5	< 5	< 5	< 5
La	< 5	< 5	< 5	< 5
Ce	< 10	< 10	< 10	< 10
Pr	< 5	< 5	< 5	< 5
Nd	< 5	< 8	< 5	< 5
Sm	7	< 5	< 5	< 5
As	< 2	< 2	< 2	< 2
Mo	2	2	2	2
Nb	2	2	2	2
Sn	< 3	< 3	< 3	< 3
Th	< 2	< 2	< 2	< 2
U	< 2	< 2	< 2	< 2

1 and 4-lherzolites; 2-serpentinizied lherzolites; 3-porphyroblastic lherzolites

Unified in this way, modal relations conditioned uniform chemical characteristics of lherzolites. The table 3 (normative composition of the CIPW) shows a balanced composition of the main components of which should be pointed out the following: a small variation in the content of the diopside (7.10 to 9.30 wt. %) and slightly larger variations in the content of hyperstene (6.40-28.50) and the content of olivine (57.70 to 78.50%). Converted Niggli parameters (table 4.) indicate the great ratio of magnesium to iron (Niggli value Mg is usually between 0.80 and 0.90), a low content of aluminum and calcium is conditioned by the presence of small amounts of diopside (transition to harzburgite). Usually there is a higher amount of constitutive water, which shows a high degree of serpentinization of these rocks.

Olivine, clinopyroxene, orthopyroxene and spinels

Olivine is a common phase/mineral. It is developed hypidiomorphic to allotriomorphic, often, however, with rounded, egg-shaped contours. The content of fayalite component in lherzolites of Vijaka area varies from 9-11%. The mean content of fayalite in the analyzed lherzolites of Vijaka area is 10.12%. The average results of fayalite are roughly in line with the values of mean content-received by Pamić (1977) for the Vijaka ultramafic area (8% fayalite). Mean Fo content in the analyzed lherzolite rocks is 89% . The values obtained are consistent with the values of mean content received by Pamić et al (1977) for the Vijaka ultramafic area (89% forsterite).

Table 4. Niggli petrochemical classification for analyzed peridotites.

Sampl e	1	2	3	4
Si	66,05	61,89	59,28	57,06
Al	0,87	1,43	1,33	0,95
Fm	95,45	93,59	94,17	95,09
C	3,38	4,54	4,15	3,70
Alk	0,29	0,45	0,35	0,26
K	0,00	0,00	0,00	0,00
Mg	0,88	0,89	0,89	0,88
Ti	0,19	0,18	0,18	0,17
P	0,00	0,00	0,00	0,00
H	56,29	31,08	33,75	30,55
W	0,31	0,31	0,32	0,31
C/fm	0,04	0,05	0,04	0,04

.

Olivine in lherzolites has high content of MgO and small content of CaO which is unusually low (0.04 to 0.10%). NiO content (from 0.19 to 0.45%) is characteristic of olivines from crust peridotites (Table 5).

Analyzed peridotites-lherzolites in Vijaka area are characterized by quite uniform modal composition, and the main petrogene minerals have uniform chemistry; olivine contains about 89.7% forsterite and orthopyroxene about the same number of percentage enstatite component, which is reflected in very high ratio MgO: (MgO + FeO), which is more than 5 (table 6).

Average compositions in lherzolites are as follows: enstatite is $Fs_{16}En_{83}Wo_1$ and clinopyroxene Fs_6 En_{48} Wo_{46}.

Enstatite is also characteristic one, although much more subordinated ultramafic ingredient. It occurs in discrete grains and sometimes we find in it clinopyroxene lamelle, which cause lamelliform. According to teodolite-microscopic determination (Pamic et al., 1977), the content of ferrosilite component in the Krivaja-Konjuh-ultramafic massif varies from 7 to 16% and the mean content based on the measurements performed 34 granules is 11%. This geochemical tests on lherzolites composition by electron microprobe, have confirmed that the chemical composition of enstatite is uniform: content of ferrosilite component varies from 15 to 18%, and the mean content is 16%.

Diopsides are more subordinated than enstatite. It usually occurs as hypidiomorphic and flattened grains. Often it occurs in lamelli form, which is due to secretion by direction of other pinacoides. Optical tests on 23 grains Pamic et al., 1977, noted the presence of irondiopside in ultramafic. Our tests have shown that in lherzolites, chromium content in diopside varies from 0.21-0.99 wt.%, with the mean content of 0.60% Cr_2O_3, and it represents the emerald green chrome diopside (table 7).

Table 5. Selected chemical analyzes of olivine in peridotite-lherzolites (wt. % and formula calculation based on 4 O).

	1	3-3	3-5	4-3
SiO_2	40,97	40,79	40,79	40,89
Si	1,001	1,002	1,000	1,002
TiO_2	0,00	0,00	0,24	0,00
Al_2O_3	0,00	0,00	0,00	0,00
Cr_2O_3	0,27	0,00	0,00	0,07
FeO	9,77	10,07	10,05	9,55
MnO	0,19	0,20	0,00	0,26
MgO	49,04	48,71	48,72	48,97
CaO	0,00	0,04	0,00	0,00
Na_2O	0,00	0,00	0,00	0,00
K_2O	0,00	0,00	0,00	0,00
ZnO	0,00	0,17	0,00	0,11
NiO	0,00	0,36	0,34	0,19
total	**100,2**	**100,3**	**100,1**	**100,0**
Si	1,001	1,002	1,000	1,002
Ti	0,000	0,000	0,004	0,000
Al	0,000	0,000	0,000	0,000
Cr	0,005	0,000	0,000	0,001
Fe^{+2}	0,200	0,207	0,206	0,196
Mn	0,004	0,004	0,000	0,005
Mg	1,786	1,771	1,779	1,788
Ca	0,000	0,001	0,000	0,000
Na	0,000	0,000	0,000	0,000
K	0,000	0,00	0,000	0,000
Zn	0,000	0,003	0,000	0,002
Ni	0,000	0,011	0,010	0,004
total	**2,996**	**2,998**	**2,999**	**2,996**

1 olivine in peridotites (lherzolites); 3-3 contact with orthopyroxene; 3-5 contact with clinopyroxene; 4-3 contact with spinel.

The rhombic pyroxene have narrow variation of composition: Fs_{15-18} En_{81-84} $Wo_{0.8-1.5}$ and contain aluminum Al_2O_3 2.41 to 3.64% and a low content of titanium (0.01 to 0.18% TiO_2). They correspond to the composition of enstatite.

Monoclinic pyroxenes in ultramafites have a composition with a relatively narrow variation: Fs_{5-7} En_{47-49} Wo_{45-46} and they are classified as diopsides. The content of aluminum in the monoclinic pyroxene is 2.52 to 5.87% Al_2O_3 and concentration of titanium and chromium are as follows: from 0.14 to 0.49% TiO_2, Cr_2O_3 0.21 to 0.59% (table 7). High values are determined for the loss on ignition in Vijaka area (6.28 to 10.49%), confirms the impression of a strong alteration that affected the original chemistry of ultramafic rocks (Morimoto, 1988).

Spinels are typical accessory minerals of lherzolites. They were developed starting from hypidiomorphic to allotriomorphic. The chemical composition of spinels varies greatly. The most common of them is Al-spinel, which is spotted in over 45% of analyzed peridotite rocks. Something subordinated is Al chromium spinel (over 35%) while the chromium hercinite is subordinate (18%). Their distribution with respect to the different varieties is as follows: Al-spinels and Al chromium spinels in particular often come in lherzolites (table 8).

Al chromium spinels are of low TiO_2 (0.06 to 0.09 wt.%) with concentrations NiO (0.45 to 0.57) and a narrow range of magnesistion 77.30 to 77.96 and chromium content from 10.92 to 15, 62. In Al spinel, magnesium is in the range of magnesium (Mg # = 100 * / (Mg + Fe^{2+}) = 53.69 to 71.51) with little share variation (Cr # = 100 * / (Cr + Al) = 6,17- 9.32). The concentration of nickel has been increased and is 0.18 to 0.90% and the content of titanium is small 0.0 to 0.02% TiO_2.

In areas of normal contact between ultramafites and amphibolite, appears subordinated colorless edenite hornblende with less chromium and magnesiohornblende. The concentrations of aluminum and calcium depend on the modal content of pyroxene and amphibole. The content of TiO_2 is low.

Calcium content in the olivine, is typical for olivines of high-pressure layered peridotite. This is not the primary feature but is the result of the redistribution of calcium between olivine and interkumulus minerals on subsolidus temperatures.

The distinction between the mantle rocks and ultramafite cumulate rocks was given by Irvine & Findlay (1972), who used the NiO vs Cr_2O_3 diagram for discrimination. Most mantle peridotites with spinel are have NiO value 0.2% .

Table 6. Selected chemical analyzes in orthopyroxene peridotites-lherzolites (wt. % and formula calculation based on 6 O).

	3-4	2-8	2--12	3-2
SiO_2	55,29	56,16	55,72	55,81
TiO_2	0,00	0,00	0,00	0,00
Al_2O_3	3,64	2,72	3,20	2,41
Cr_2O_3	0,17	0,24	0,00	0,06
Fe_2O_3	0,00	0,00	6,97	0,00
FeO	6,75	6,78	0,00	7,30
MnO	0,18	0,20	0,21	0,00
MgO	32,84	33,26	33,59	33,89
CaO	0,49	0,42	0,28	0,46
Na_2O	0,01	0,00	0,06	0,00
K_2O	0,05	0,01	0,00	0,00
NiO	0,39	0,10	0,19	0,29
total	**99,81**	**99,92**	**100,22**	**100,22**
Si	1,919	1,943	1,931	1,932
Ti	0,000	0,000	0,000	0,000
Al	0,148	0,110	0,130	0,098
Cr	0,004	0,006	0,000	0,001
Fe^{+3}	0,000	0,000	0,181	0,000
Fe^{+2}	0,196	0,196	0,000	0,211
Mn	0,005	0,005	0,006	0,000
Mg	1,699	1,715	1,735	1,748
Ca	0,018	0,015	0,010	0,017
Na	0,000	0,000	0,004	0,000
K	0,002	0,00	0,000	0,000
Ni	0,010	0,002	0,005	0,008
total	**4,001**	**3,992**	**4,002**	**4,015**

3-4 orthopyroxene contact with olivine; 2-8 contact with serpentine; 2-12 and 3-2 contact with clinopyroxenes.

Table 7. Selected chemical analyzes of clinopyroxene in peridotites-lherzolites (wt. % and formula calculation based on 6 O).

	3-7	**4-7**
SiO_2	51,87	53,37
TiO_2	0,49	0,14
Al_2O_3	4,70	2,52
Cr_2O_3	0,59	0,21
Fe_2O_3	1,29	1,48
FeO	1,63	1,24
MnO	0,11	0,17
MgO	15,72	16,91
CaO	22,30	23,30
Na_2O	1,12	0,77
K_2O	0,00	0,00
NiO	0,16	0,00
total	99,98	100,11
Si	1,892	1,942
Ti	0,013	0,003
Al	0,202	0,108
Cr	0,017	0,006
Fe^{+3}	0,035	0,040
Fe^{+2}	0,049	0,037
Mn	0,003	0,005
Mg	0,854	0,917
Ca	0,871	0,908
Na	0,079	0,054
K	0,00	0,00
Ni	0,004	0,00
Ni	0,004	0,00
total	4,019	4,020

3-7 and 4-7 contact with olivine.

Table 8. Selected chemical analyzes of spinel in peridotites-lherzolites (wt. % and formula calculation based on 32 O).

	1	**2-2**	**3-1**	**3-2**	**4-2**
SiO_2	0,11	0,16	0,15	0,05	0,09
TiO_2	0,00	0,21	0,09	0,06	0,00
Al_2O_3	58,98	23,93	55,80	56,97	56,98
Cr_2O_3	7,83	36,33	11,00	10,41	9,70
Fe_2O_3	2,84	8,91	2,15	2,20	2,67
FeO	9,88	14,96	10,00	10,37	9.69
MnO	0,13	0,91	0,31	0,00	0,29
MgO	19,73	12,96	19,11	19,34	19,32
CaO	0,17	0,03	0,06	0,00	0,09
Na_2O	0,18	0,00	0,13	0,00	0,18
K_2O	0,04	0,22	0,00	0,23	0,00
ZnO	0,02	0,55	0,43	0,00	0,07
NiO	0,24	0,13	0,45	0,57	0,49
total	**100,12**	**99,30**	**99,70**	**100,20**	**99,60**
Si	0,023	0,040	0,032	0,010	0,019
Ti	0,000	0,040	0,014	0,009	0,000
Al	14,32	7,055	13,79	13,96	14,03
Cr	1,275	7,156	1,824	1,712	1,608
Fe+3	0,440	1,685	0,340	0,345	0,390
Fe+2	1,701	3,12	1,75	1,80	1,69
Mn	0,023	0,194	0,055	0,00	0,052
Mg	6,058	4,516	5,976	5,997	6,009
Ca	0,038	0,009	0,013	0,00	0,020
Na	0,072	0,00	0,053	0,00	0,073
K	0,010	0,055	0,00	0,062	0,00
Zn	0,00	0,102	0,067	0,00	0,011
Ni	0,040	0,026	0,076	0,095	0,082
total	**24,001**	**24,000**	**24,000**	**23,999**	**23,999**

CONCLUSION

Selected samples of peridotites in the Krivaja-Konjuh massif southern edge were used to conducted optical researches by polarization microscopy, chemical analysis of macro elements, trace elements and rare earth by X-ray fluorescence spectroscopy, and chemical analysis of minerals by electron microprobe.

Vijaka amphibolites are related to the Krivaja-Konjuh ultramafite massif and these amphibolites are frequently layered in their highest parts with ultramafite pointing to their genetic relationships. It is evident that Vijaka amphibolite complex is part of the Dinarides Ophiolite zone in which they are involved with related Krivaja-Konjuh ultramafite massif.

Peridotite-lherzolites are thoroughly investigated by optical, chemical analysis and electron microprobe. The results of chemical research of these peridotites showed quite uniform modal composition of these rocks, which is characterized by a high content of MgO, low CaO and high content of MgO: FeO (about 5 and more), which is in accordance with the contents of the main components of the research results spinel lherzolites in the Krivaja-Konjuh ultramafic massif.

Based on CIPW normative system they have uniform composition with a very small variation in the content of the diopside with a slightly larger variation in the content of olivine. The content of CaO and NiO in olivine indicate olivines from crustal peridotites. The rhombic pyroxenes, according to their composition correspond to enstatites and monoclinic pyroxenes to diopsides. Spinelles in peridotites are Al spinels and Al chromium spinels.

High values determined for losses on ignition peridotite confirm virtual impression of strongly altered the original chemistry of ultramafite rocks.

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Summary/Sažetak

Na odabranim uzorcima ultramafitskih stijena peridotita na južnom obodu krivajsko – konjuškog masiva provedena su detaljna optička istraživanja polarizacionim mikroskopom, hemijske analize makroelemenata, mikroelemenata i rijetkih zemalja rentgenskom fluorescentnom spektroskopijom, te hemijske analize minerala elektronskom mikrosondom. Peridotiti-lerzoliti su detaljno ispitani optičkim, hemijskim analizama i elektronskom mikrosondom. Rezultati hemijskih istraživanja ovih peridotita su pokazali dosta ujednačen modalni sastav ovih stijena, koji se odlikuje visokim sadržajem MgO, niskim sadržajem CaO i visokim sadržajem MgO:FeO (oko 5 i više). Bazirano na CIPW normativnom sistemu ujednačenog su sastava sa vrlo malim variranjem u sadržaju diopsida sa nešto većim variranjem u sadržaju sadržaju olivina. Sadržaj CaO i NiO u olivinu ukazuju na olivine iz krustalnih peridotita. Rompski pirokseni po sastavu odgovaraju enstatitu a monoklinski pirokseni su po sastavu diopsidi. Spineli u peridotitima su Al spineli i Al hromni spineli. Visoke vrijednosti određene za gubitke žarenjem peridotita potvrđuju virtualan dojam o snažno izmjenjenom izvornom hemizmu ultramafitskih stijena.