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MAIN GEOCHEMICAL ASSOCIATION OF THE SULFIDES OF LEAD-ZINC MINERALIZATION IN TREPÇA MINERAL BELT- BADOVC MINE, KOSOVO

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ABSTRACT

This paper presented the distribution of major metals (Pb, Zn, and Ag) and accompanying metals (Bi, Cd, Cu, Sb, As) in Badovc mineral deposit. The main elements of economic importance are zinc (Zn), lead (Pb), and silver (Ag), for which are calculated the industrial reserves of the mineral deposit of Badovc. Besides, the main metals during the technological process extradited other associated components such as gold (Au), cadmium (Cd), bismuth (Bi), etc. With special emphasis, we studied the main geochemical association of lead (Pb) and zinc (Zn) sulfides mineralization. According to the factorial analysis, the result of these geochemical associations is as follows: Pb-Ag-(Bi-Sb); Cd-Cu. In 1% of the content of lead (Pb) has 14.51g/t silver (Ag). Variation coefficient for lead is K_v^{Pb} = 80.57% and for zinc is K_v^{Zn} = 81.02%.

Keywords: badovc mine, geochemical association, lead-zinc mineralization, Trepça mineral belt, Kosovo.

INTRODUCTION

The Badovc mine is 10 km away from Prishtina, just off the road to Gjilan, on a paved road from the main highway. The mine side is located near of the like Badovc dam and reservoir. Is part of the "Hajvali-Badovc-Kizhnica" ore field, and as a whole is located within tectonic Vardar zone (Kossmat F., *et al*., 1924), the metallogenic region of Kopaonik (Jankovič S., 1955), the Trepça mineral Belt (Hyseni S., *et al*., 2003), in Figure-1 and Figure-3. The metalogenesis of which are genetically and timely is related to the andesitic magmatism of tertiary (Cissarc A., 1951, Jankovič S., 1977, Jankovič S., (1995).

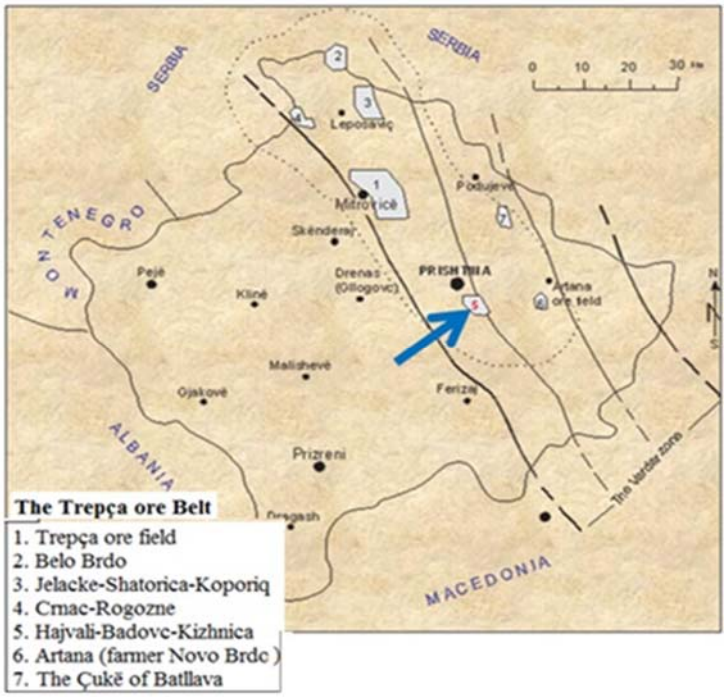

Figure-1. The lead and zinc sulfide mineralization in the region of Kosovo, geographical position of the "Hajvali-Badovc-Kizhnica" ore field (no.5).

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The general state of geological reserves in the Badovc mineral deposit was evaluated around 8 Mt ore reserves with average content of the main metals of 5.21% Pb, 3.13% Zn, and 71g/t Ag, (Radoslav P., *et al*. 1989, Klisič M. 1995). The main accompanying of metals in this deposit are: lead (Pb), zinc (Zn), and silver (Ag), while other elements such as: Cd, Bi, Au, etc., can be found in smaller quantities. The study is based on the data of Badovc mineral deposit taken during the years of exploitation. The contents of main metals of lead (Pb) and zinc (Zn) were analyzed in separate samples, whereas the content of Zn, Pb, Ag, Au, Cd, Bi etc., were analyzed only as composite samples (Kizhnica - chemical laboratory).

GEOLOGY OF BADOVC MINERAL DEPOSIT

The Badovc mineral deposit is composed of rocks of various stratigraphies from Paleozoic to Tertiary in age and of various lithological types. The oldest and most widespread rocks in the vicinity of the Badovc mineral deposit belong to the "Veles series" of probably Paleozoic age (Kossmat F., 1924; Smejkal S., 1955), although the upper part has been proven to be Triassic in age. This so-called "metamorphic series" represents the host rocks for the mineralization and consists of phyllite and sericite schist`s with a central unit containing subordinated carbonate and calc silicate layers. The metamorphic series is overlain by serpentinites, gabro and diabases-hornfels of Jurassic age, which together with flysch sediments of Upper Cretaceous age cover large parts of the ore field (Figure-2). Tertiary sediments occur as breccias, sandstone, clay and marl. Volcanic rocks mainly andezite occur to the south of the mine (Radoslav P., *et al*. 1989, Klisič M. 1995).

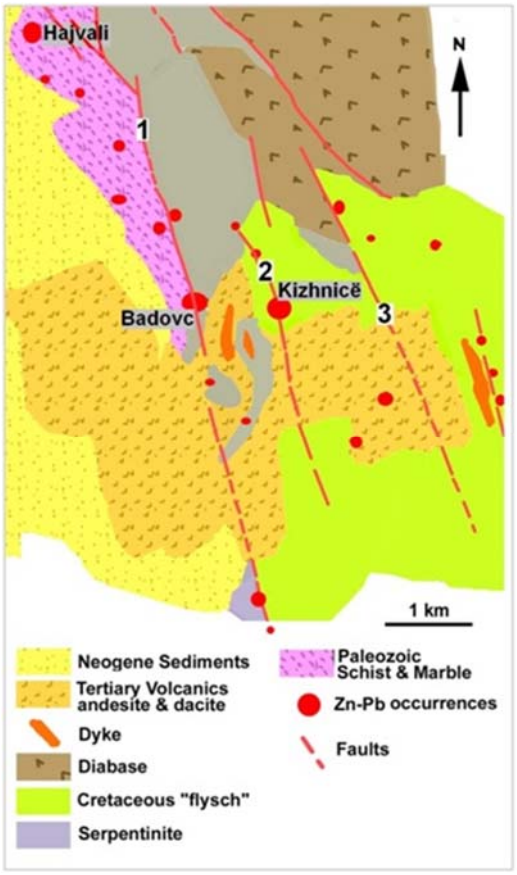

Figure-2. Geological map of "Hajvalia-Badovc-Kizhnica" ore field, simplified geology.

The mineralization of economical importance in the mineral deposit of Badovc are formed in limestone, then in the serpentinite, and the space between andesite-serpentinite contacts. Structurally, the setting of the Hajvali-Badovc-Kizhnica ore field is an integral part of eastern zone of deep fracture of Kapaonik. In this view, the "Hajvali-Badovc-Kizhnica" ore field composes most of the Southeast Trepça ore Belt, and as a whole belongs to the Vardar zone (Figure-3). This fracture in the region of the "Hajvali-Badovc-Kizhnica" ore field is divided into three smaller structural-tectonic units (Figure-2), which are: 1. Structure zone in Hajvali-Badovc; 2. Structure zone in Kizhnica and 3. Structure zone in Okosnica.

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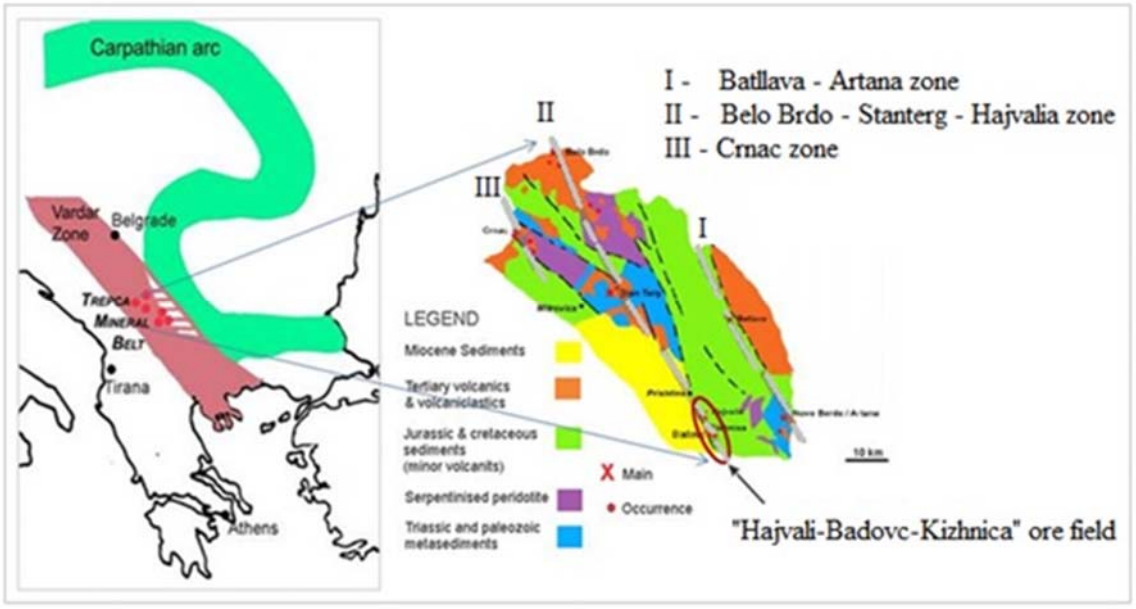

Figure-3. Vardar zone and Trepça mineral Belt-Summary Geology.

CHEMISTRY AND DISTRIBUTION OF EXPLOITED MAIN METALS IN THE BADOVC MINERAL DEPOSIT

Based on the data of chemical analysis of samples of mineralization in the polymetallic deposit of Badovc (Bedri Durmishaj, *et al*., (2006), it results that the polymetallic minerals have high content of useful components such as: lead (Pb), zinc (Zn), and silver (Ag). So, in the Badovc mineral deposit, the chemical composition of mineralization is averagely: 3.48 % Pb; 2.57% Zn; 50g/t Ag; 0.023% Cd; 0.020 % Bi; 0.011 % Sn; 0.03% Cu; 0.017% As; 0.034% Sb; 0.25g/t Au, (flotation samples taking, Kizhnica geological survey, Prishtina). As far as oxide components, results these average contents: 35.92% SiO_2; 2.20 % MgO; 3.02% MnO; .0.38% CaO and 5.10% Al_2O_3.

The distribution of main elements in the deposit is characterized with the following variation coefficient (Hyseni S., et. al. 1989): K_v^{Pb} = 80.57% and K_v^{Zn} = 81.02%. The main elements of economic importance are lead (Pb), zinc (Zn), and silver (Ag), for which are calculated the industrial reserves of the mineral deposit of Badovc. Besides, the main metals during the technological process extradited other associated components such as gold (Au), cadmium (Cd), bismuth (Bi), etc.

The elementary distribution is partly related to sphalerite. According, Jankovič S., 1995, results from the sphalerite analysis are as follows: Fe = 8.12%, Cd = 0.1%, Mn = 0.2 to 1%, Ag = 10 to 20g/t, Sn = 30 to 50 g/t, Ga up to 3g/t. Sphalerite of high temperature (Mudrinič Č., 1974) always contains more manganese, the one of middle temperatures has higher values of indium and cadmium whereas the sphalerite low temperature is rich in gallium and germanium.

According Durmishaj B., 2007, some of the platinum group elements (PGE) are present in the three main minerals: galena, sphalerite, and Pyrite. The average contents are: In mineral galena (104 ppm Os, 245 ppm Pt, 120 ppm Pd); sphalerite (69 ppm Ru, 256 ppm Rh, 49 ppm Pd, and Pyrite (560 ppm Os, 70 ppm Ru, 127 ppm Rh, 215 ppm Pt, 313 ppm Pd).

Based on 8 chemical analysis representative of the mineral deposit of Badovc (ITT, 2000), the result dates suggest a very strong correlation of Ag with Pb (Figure-4), which could be related to the associated of pyrargyrite with galena as well as with isomorphic enrichment of galena with Ag. In 1% of the content of lead (Pb) has 14.51g/t silver (Ag).

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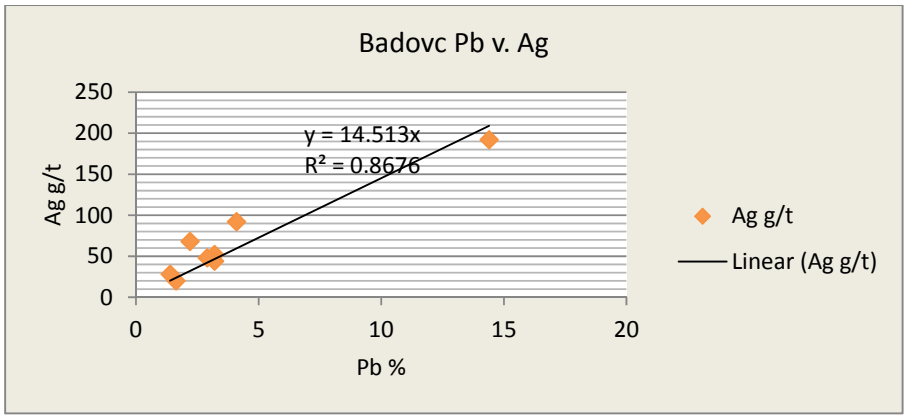

Figure-4. Contents and correlation between Pb v. Ag.

MINERALOGY OF THE BADOVC MINERAL DEPOSIT

The mineralogy of this mineral deposit consists chiefly of metallic minerals: pyrite, pyrrhotite, galena, sphalerite, chalcopyrite, arsenopyrite, cubanite, tetrahedrite, vallerite, bournonite, boulangerite, plumosite, marcasite, and stibnite. Among the nonmetallic minerals, the following ones are present: quartz, siderite, Mn-siderite, calcite, Mn-calcite, rhodochrosite, barite, and chalcedony. From secondary minerals are: cerussite, anglesite, epsomite, grossularite, melanterite, gypsum, limonite, malachite, and Mn-oxide occur. Chromite, magnetite, ilmenite, and graphite, are the relict minerals. So far, three major generations of mineralization are distinguished: katathermal, mesothermal, and epithermal zones. The zinc (Zn) is mainly related to the meso-epithermal phase and lead (Pb) by later phases (epithermal) (Smejkal S., 1956 and 1960, Rakič S, 1956).

ANALYSIS OF MINERALIZATION AND METHODS FOR DETERMINING THE GEOCHEMICAL ASSOCIATION

Study of ore mineral was made by representative samples of deposit during the evidence phase of exploitation. The results of chemical analysis were taken from Kizhnica chemical laboratory. For this study, we have exploited the chemical analysis result for united samples (composite), analyzed a total of 20 samples (Durmishaj B., (2007). Distribution of major chemical elements contents and the associated elements in the Badovc mineral deposit presented through the statistical parameters in Table-1.

Table-1. Statistical parameters of the distribution of metals contents in the Badovc mineral deposit, "Hajvali-Badovc-Kizhnica" ore field near Prishtina.

Parameters/ Elements	Pb %	Zn %	Ag gr/t	Bi %	Cd %	Cu %	As %	Sb %
Average	5,51	2,57	83,15	0,03	0,03	0,07	0,09	0,07
Median	5,00	2,44	64,50	0,02	0,02	0,05	0,05	0,04
St.Dev.	3,24	1,73	64,33	0,02	0,02	0,06	0,08	0,06
Min	1,45	0,37	25,00	0,01	0,01	0,02	0,01	0,02
Max	14,06	6,13	265,00	0,06	0,09	0,19	0,26	0,18
No. of samples	20	20	20	20	20	20	20	20

Based on the correlation analysis for the Badovc mineral deposit, Table-2, indicating these geochemical associations:
1. Pb-Ag-Bi, and
2. Cu-Cd

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Table-2. Correlation matrix for the Badovc mineral deposit "Hajvali-Badovc-Kizhnica" ore field. The correlation coefficients are significant for p <0.05, when have a value greater than 0.41. No. of samples = 20.

Elements	Pb %	Zn %	Ag gr/t	Bi %	Cd %	Cu %	As %	Sb %
Pb %	1, 000							
Zn %	0, 183	1,000						
Ag gr/t	0, 649	0,242	1,000					
Bi %	0, 419	-0,093	0,317	1,000				
Cd %	0, 228	-0,272	-0,234	0,118	1, 000			
Cu %	0, 257	-0,320	0,080	0,079	0, 734	1,000		
As %	0, 363	-0,115	0,225	0,091	-0,030	-0,091	1,000	
Sb %	0, 246	0,191	0,311	0,224	-0,161	-0,099	0,275	1,000

From Table-3 as follows, result of these geochemical associations are:
1. Pb-Ag-(Bi-Sb), and
2. Cd-Cu

Table-3. The weights of the factors (Vary max normalized). The method of main components. Bold values are about the 0.7 and biggest that so.

Elements	Factors		
	F1	F2	F3
Pb %	0.870245	0.236144	0.004436
Zn %	0.317157	-0.425097	-0.685874
Ag gr/t	0.832436	-0.114704	-0.132544
Bi %	0.563094	0.177981	0.156768
Cd %	0.006821	0.897576	0.069218
Cu %	0.138699	0.895070	-0.010600
As %	0.391624	-0.187423	0.746405
Sb %	0.532278	-0.315838	0.213648
Expl.Var	2.323913	2.022979	1.120257

However, exact data on geochemical association except correlation analysis taken by factorial analysis presented in Table-3 and then in the Figure-4.

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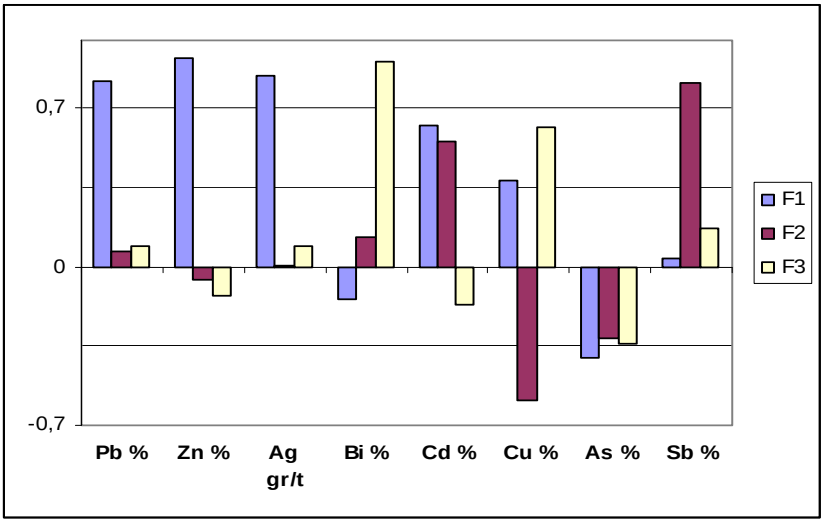

Figure-5. Graphic factors weights, the Badovc mineral deposit, "Hajvali-Badovc-Kizhnica" ore field.

CONCLUSIONS

The mineral deposit of Badovc belongs to "Hajvali-Badovc-Kizhnica" ore field, and extends in the central part of it`s together with Kizhnica mine. Lead (Pb), zinc (Zn), and silver (Ag) are the major metals of economic priority for which the industrial ore reserves have been calculated. In this mineral deposit estimated at about 8 Mt geological reserves with average content of the main metals of 5.21% Pb, 3.13% Zn, and 71g/t Ag. From our results based on factorial analysis it results the geochemical association showing the strongest link lead (Pb) with silver (Ag) and less with bismuth (Bi) and antimony (Sb). Also, this results in an geochemical association of cadmium (Cd) with copper (Cu), while zinc (Zn) and arsenic (As) does not indicate the geochemical association.

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