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TREPÇA ORE BELT AND LEAD AND ZINC DISTRIBUTION IN BADOVC MINERAL DEPOSIT, KOSOVO (SE EUROPE)

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ABSTRACT

The Trepça Belt of Pb-Zn-Ag mineralization is located in the NNW-SSE trending Vardar zone. The Belt extends for ever 80 km, and supported five mines during period 1930-2010, and contains a number of the other Pb-Zn occurrences. The replacement and vein type mineralization is hosted primarily by Mesozoic carbonates, but also occasionally by amphibolites, and it display a clear structural control. Mineralization is spatially and genetically related to Neogene andesite-dacite extrusive and sub volcanic intrusive. We use for this paper only Badovc mine. In this paper we featured lateral distribution and inside ore bodies of Pb and Zn how two main components and Ag association with economic importance in the mineral deposit Badovc. Pb and Zn distribution within the contoured ore body in Badovc is heterogeneous. Lateral Pb, Zn and Zn/Pb ratio distributions are studied for the ore bodies 6, 7 etc. of Badovc ore deposit. Mineral deposit of Badovc, consisting of Pb-Zn-Ag mineralization, does not close genetically towards its deepest exploitation level.

Keywords: Badovc mines, minerals, lead, zinc, distribution, Trepça ore belt, Kosovo.

INTRODUCTION

The history of silver, lead and zinc mining in Kosovo is intertwined with the history of Kosovo itself. In the modern era, the production of silver, lead and zinc has been synonymous with Trepça. This briefing note describes the current situation at Trepça and examines its future outlook.

Mining activities and smelting of the silver-bearing lead-zinc ore in Kosovo has a long history and can be dated back to even pre-Roman times as relics of tools and diggings show. From the Roman period to the middle Ages, the area between Serbia and Greece - and especially the southern part of Kosovo - was intensively exploited for its lead-zinc and silver ores and at that time was one of most important sources of its kind. The Roman and Ottoman Empires fought to take control of silver mines in Kosovo and at a later stage the Serbian Middle Kingdom produced much of its coinage from silver mined at Arana/Novo Berdo.

The British company Seltrust founded at one stage, in Trepça operated nine mines as shown on the map (Figure-1). Currently, only five of these have significant remaining resources although all have the potential for extensions to the known mineralization. The mining and processing infrastructure following the conflict was in very poor condition; however, after major efforts and significant investment, four of the mines have restarted limited production.

The successful industry of the 60s and the historic mines were founded on the quality of the lead-zinc deposits that occur in the Trepça Mineral Belt running in a NW-SE direction from Kapaonik (Beloberdo) in the North to Kizhnicë in the South. Whilst the 80's and 90's were characterized, at least partly, by a lack of exploration, the known deposits are not exhausted and mine able reserves and measured resources (Adam Wheeler study) at the five key mines totaling at 7.068 million tones at 5.46 wt% lead, 5.64 wt% zinc and 116 g/tone silver. All deposits are open at depth or extend on strike. Recent geological work strongly indicates that the deposits within the Trepça Mineral Belt are considered highly prospective regarding additional reserves and resources as the mineralization is structurally and/or fault controlled. Consequently, the Trepça Mineral Belts (Hyseni and Large, 2003) holds a high potential, not only for lead, zinc and silver but also for copper and gold.

REGIONAL GEOLOGY

The linear Trepça "Belt" of lead-zinc mineralization extends for over 80 km in northern Kosovo, and includes numerous mines and occurrences (Figure-1). Although evidence of mining dates back to the Romans, who were primarily interested in the small gold occurrences, modern mining started in 1930 at the Stan Tërg lead-zinc mine, which is located on the Trepça stream.

The Trepça Belt, which comprises part of what has been previously described as the Kapaonik District (Forgan 1948; Jankovic *et al.*, 1997), includes numerous lead-zinc deposits. On a regional scale, the Trepça Belt belongs to the Kosovo sector of the Serbo- Kosovo-Macedonian-Rhodope Metallogenic belt of Oligocene-Miocene age, which includes the base and precious-metal districts in Kosovo, southern and western Serbia, variscan structures marginal to the Serbo-Kosovo-Macedonia, northern Greece and southern Bulgaria (Heinrich and Neubauer, 2002).

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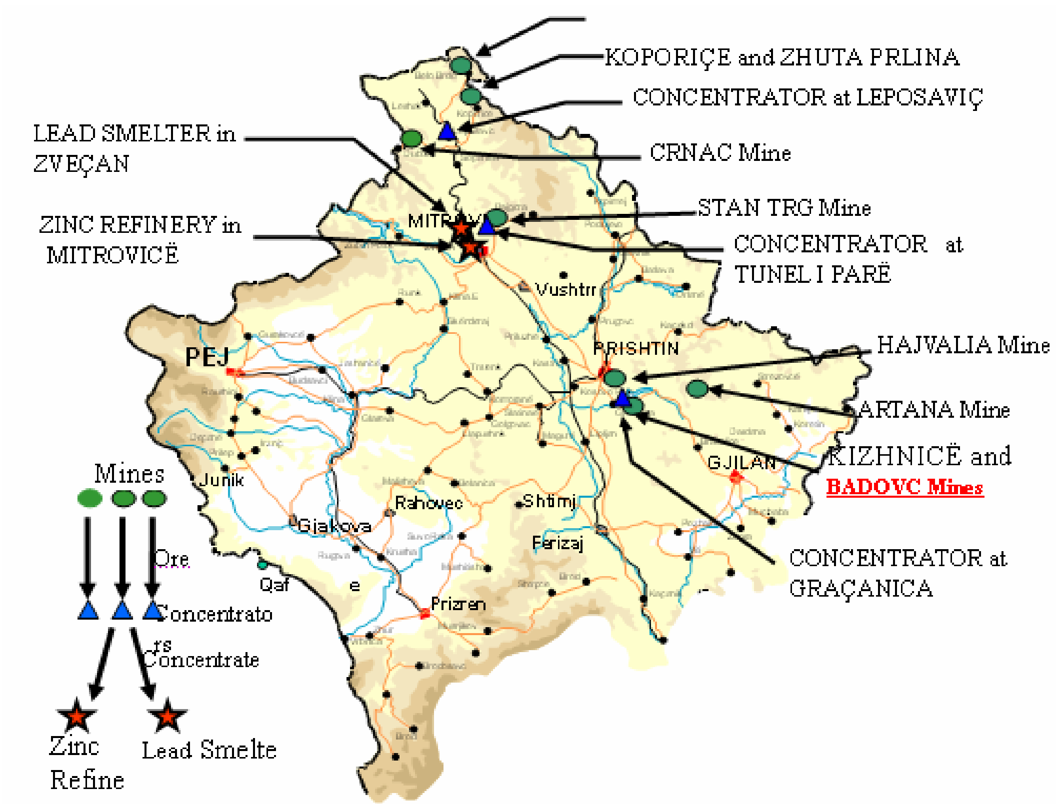

Figure-1. Map of Kosovo showing TREPÇA mines concentrators and final processing facilities.

The Trepça Belt lies within the NNW-SSE trending Vardar tectonic zone (Figure-2).

Figure-2. Vardar zone.

This regional structure marks the fundamental structure between the Serbo-Kosovë-Macedonian Massif, which is underlain by late Proterozoic metamorphic, and the Dina rides, which are comprised of Mesozoic successions with typical Alpine deformation. The Vardar zone contains fragments of Paleozoic crystalline schist and phyllite, with unconformable overlying Triassic clastics, phyllites, volcanoclastic rocks and Upper Triassic carbonates. Serpentinized ultrabazik rocks, gabbros, diabases and sediments of the ophiolite association characterize the Jurassic.

The Cretaceous sequence consists of a complex series (sometimes described as mélange) of clastics, serpentinite, mafic volcanics and volcanoclastic rocks, and carbonates. The Tertiary (Oligocene-Miocene) andesite, trachyte and latite sub volcanic intrusives volcanics and pyroclastic rocks occur at several centers within the Trepça Belt, and cover large areas and is particularly well developed in the eastern sector (so-called Inner Vardar sub-zone) of the Vardar zone. Miocene and Pliocene shallow water sediments fill the Kosovo Basin, which borders the central and southern sectors of the Trepça Belt to the west.

The structure of the Trepça Belt is dominated by NNW-SSE trending structures. Overthrusts with SE vergence are dominant, some of which are demonstrably post-Oligo-Miocene in age while others are clearly older. Congruent WSW-ENE structures link the dominant NNW-SSE trending structures. It is considered that many of the Vardar structures may be reactivated Variscan structures marginal to the Serbo-Kosovo-Macedonian Massif. The

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possible influence of the NW-SE structures in the Drina-Ivanjica (Drenica) structural block, which is an external unit of the Dinarides and forms the western margin of the Vardar zone, are overprinted on the dominant NNW-SSE trend.

Trepça geologists recognized three regional (NNW-SSE) trending zones of mineralization within the Belt (Figure-3).

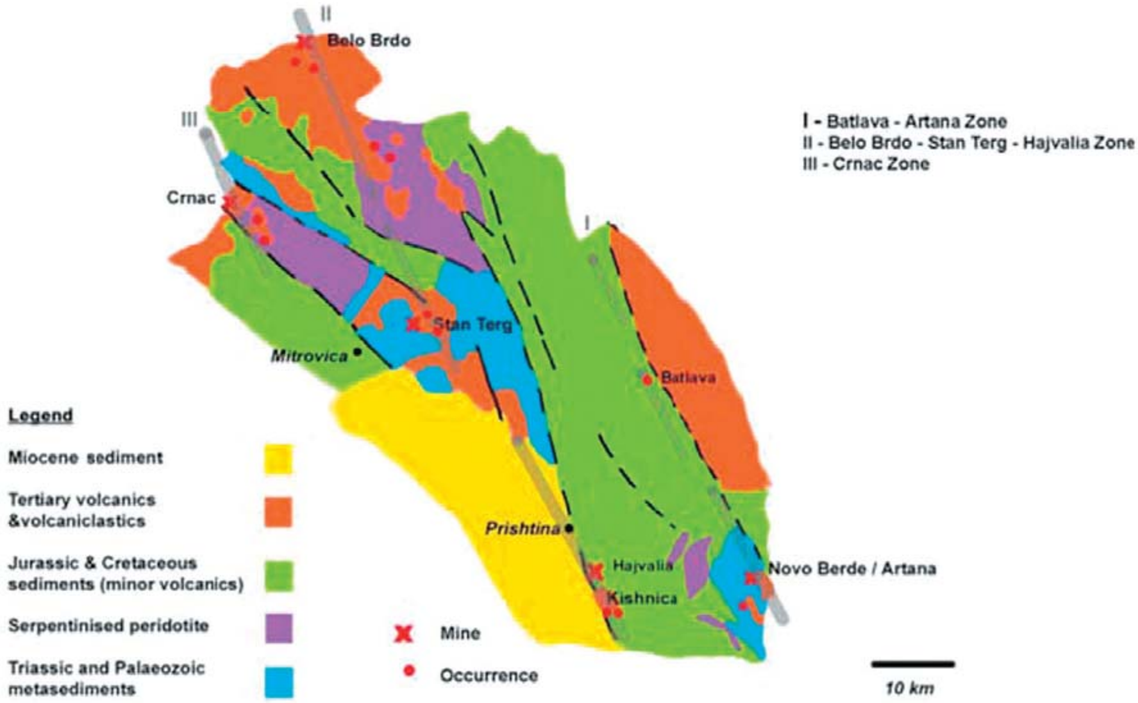

Figure-3. Trepça mineral belt

Zone-I: Includes Artana (Novoberdo)- Batllavë. Zone I follows the boundary between the Kosovo sector of the Serbo-Kosovaro-Macedonian Massif, which is marked here by extensive Neogene calc-alkaline volcanics and intrusive, with the Vardar Zone.

Zone-II: Extends from the Hajvalia- Kizhnica district in the south to Belo Berdo in the north, and includes the Stan Tërg mine and numerous other occurrences. Zone II follows the major fault that marks the eastern margin of the Miocene Prishtina basin, and its extension to the NNW and the intrusive and volcanic complexes (Figure-3) in northern Kosovo.

Zone-III: Includes the Crnac mine, and extends along a number of lead-zinc occurrences on the western border of the Vardar Zone, where it is in contract with the Dinaride-Drina-Ivanjica (Drenica) structural block

GEOLOGICAL SETTING MINERAL DEPOSIT BADOVC

The Badovc mine is 10 km from Prishtina, just off the road to Gjilan, on a paved road from the main highway. The mine site is located near of the Lake Badovc Dam and reservoir. The Badovc concentrator is 1 km far from the mine. The Badovcit Pb-Zn-Ag deposit is located at the southern end of the so-called Zone II of the NNW-SSE - trending Vardar zone (Figures 3 and 4). The oldest and most widespread rocks in the vicinity of the Badovcit deposit belong to the Velesit Series of probably Paleozoic age 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 serpentinite, gabbros and diabase-hornfels of Jurassic age, which together with flysch sediments of Upper Cretaceous age cover large parts of the area (Figure-4). Tertiary sediments occur as breccias, sandstone, clay and marl. Volcanic rocks mainly andesite occur to the South of the mine (Klisič, 1995 *et al*).

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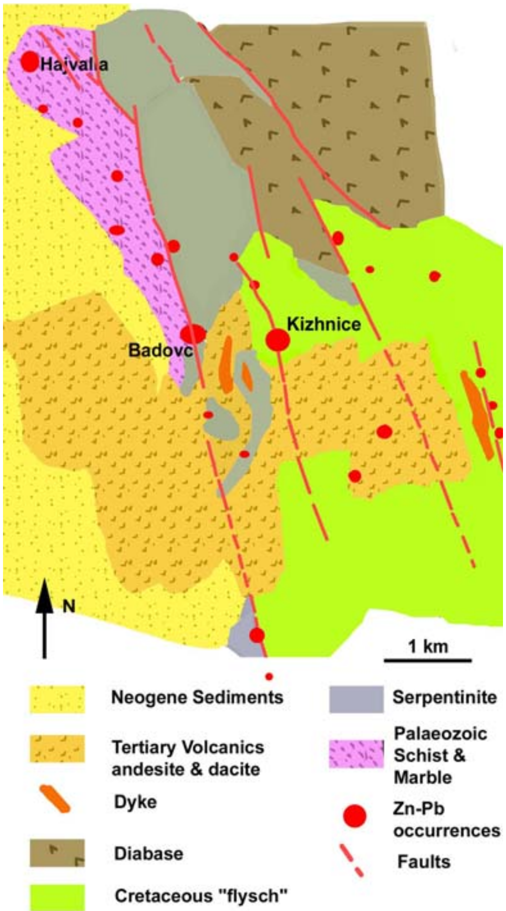

Figure-4. The Hajvalia-Kizhnica District: simplified Geology

LEAD AND ZINC DISTRIBUTION IN BADOVC MINERAL DEPOSIT (MINERALOGY)

The mineralogy of this mineral deposit consists chiefly of metallic minerals: pyrite, pyrrhotite, galena, sfalerite, chalcopyrite, arsenopyrite, cubanite, tetrahedrite, vallerite, bournonite, boulangerite, plumosite, marcasite, and stibinite. Among the nonmetallic minerals, the following ones are present: quartz, siderite, Mn-siderite, calcite, Mn-calcite, rhodochrosite, barite, and chalcedony. From secondary minerals, cerusite, 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. Zn is mainly related to the meso - epithermal phase and Pb with the epithermal one (Smejkal, 1956).

CHEMISTRY AND Pb, Zn DISTRIBUTION IN THE ORE BODIES

The chemical analysis data of the mineralization samples from Badovc ore deposit show that the mineralization contains Pb-3.48%, Zn-2.13%, Ag-50 gr/t, Bi-0.20%, Cu-0.06%, As-0.017%. The average values of non-metallic components are: SiO_2-35.92%, MgO-2.20%, MnO-3.20%, CaO-0.38%, Al_2O_3-5.10%. Major element distribution in exploited deposit is characterized by these variation coefficients for lead and zinc: K_v^{Pb} = 80.57% and K_v^{Zn} = 81.02% Hyseni, 1987).

Lead, zinc and silver are the major elements of economic priority for which the industrial ore reserves have been calculated. Besides these major elements, the processing technology removes also other elements such as gold, cadmium, bismuth etc. The elementary distribution is partly related to sfalerite. Sfalerite from Badovc deposit (Jankovic, 1967) shows this chemistry: Fe-8.12, Cd-0.1%, Mn-0.2 to 1%, Ag-10 to 20 g/t, Sn- 30 to 50 g/t, Ga-until 3g/t. Sfalerite of high temperature (Mudrinić, 1974) always contains more manganese, the one of middle temperatures has higher values of indium and cadmium whereas the sfalerite low temperature is rich in gallium and germanium.

LATERAL Pb AND Zn DISTRUBUTION IN THE ORE BODIES

Lateral Pb, Zn and Zn/Pb ratio distributions are studied for the ore bodies 6 and 7 of Badovc ore deposit. The data show (Figures 5, 6 and 7), variation of these distributions for highly thick ore bodies, so the mineralization is not homogeneous in this ore deposit.

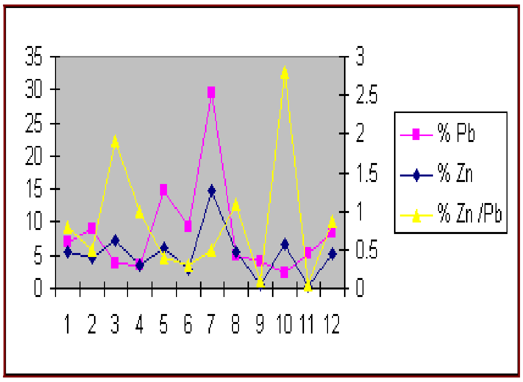

Figure-5. Lateral Pb, Zn and Zn / Pb ratio in the Ore body 7.

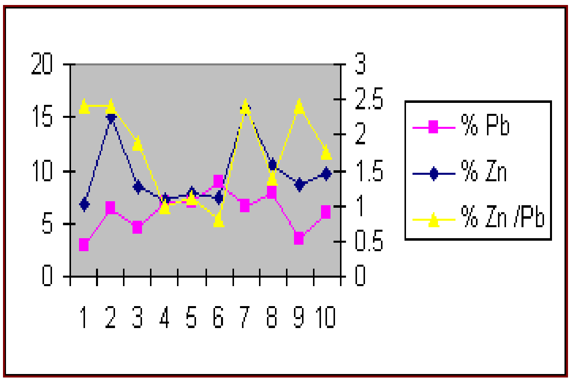

Figure-6. Distributions of Pb, Zn and relation Zn Pb in thickness ore body 7.

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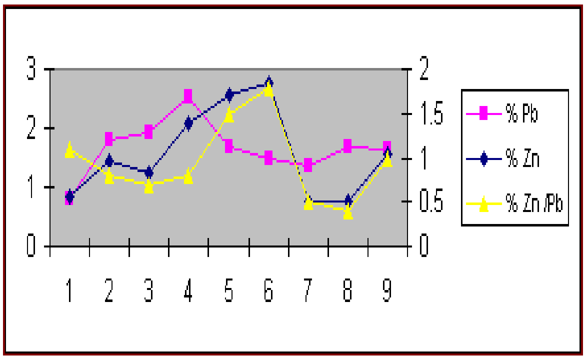

Figure-7. Lateral Pb, Zn and Zn/Pb ratio in the Ore body 6.

In most mining drifts, the lateral non-homogeneous Pb and Zn distribution is typical. This shows that there is not a regular distribution of the main ore forming elements, Pb and Zn, going from the centre towards the lateral parts of the ore body.

Frequently, the data show an increase of their values in the contact of ore body with the host rocks and a decrease inside the ore body. The geochemical data and the geological mapping of the mining drifts show that this distribution is controlled by the lithological factors.

The data on Zn/Pb ratio show that it varies from 0.9 to 1.8, but in isolated cases it changes from 0.05 to 2.8. If we consider the Zn/Pb ratio of values 0.9 to 1.8 as typical ones for Badovc ore deposit, the values lower and higher of the typical ones should be related to specific local ore-forming conditions.

Pb AND Zn DISTURBUTION INSIDE THE CONTOURED ORE BODIES

In Figures 8 and 9 show Pb and Zn distributions inside the contoured ore bodies 7 and 13 which are processed by surfer methods. The total section of ore body 7 is 554 m^2 and mineralization is of lode-lens type. The section of the ore body 13 is 1250 m^2 and the mineralization is also lode- lens type. The statistical data on the distributions of major element values and their ratios in the ore body 7 and 13 is shown in Tables 1 and 2.

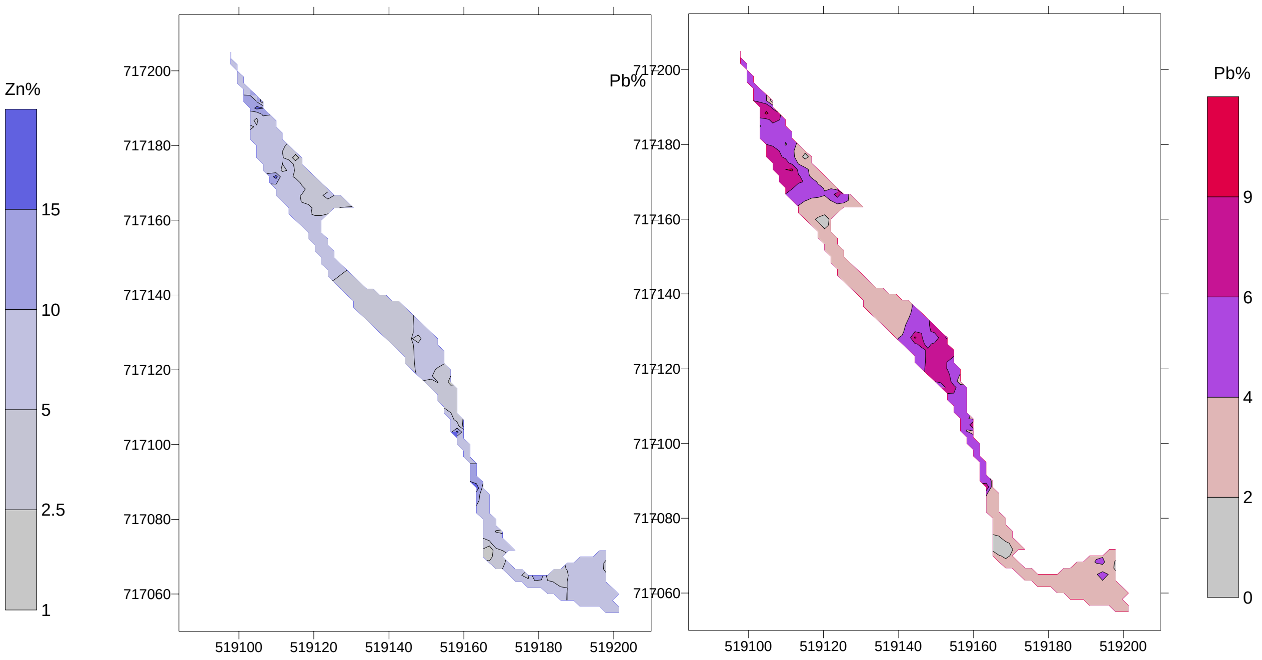

Figure-8. Interpolation value of Pb and Zn in ore body 13 in the lower exploitation level H- Va-505 m.

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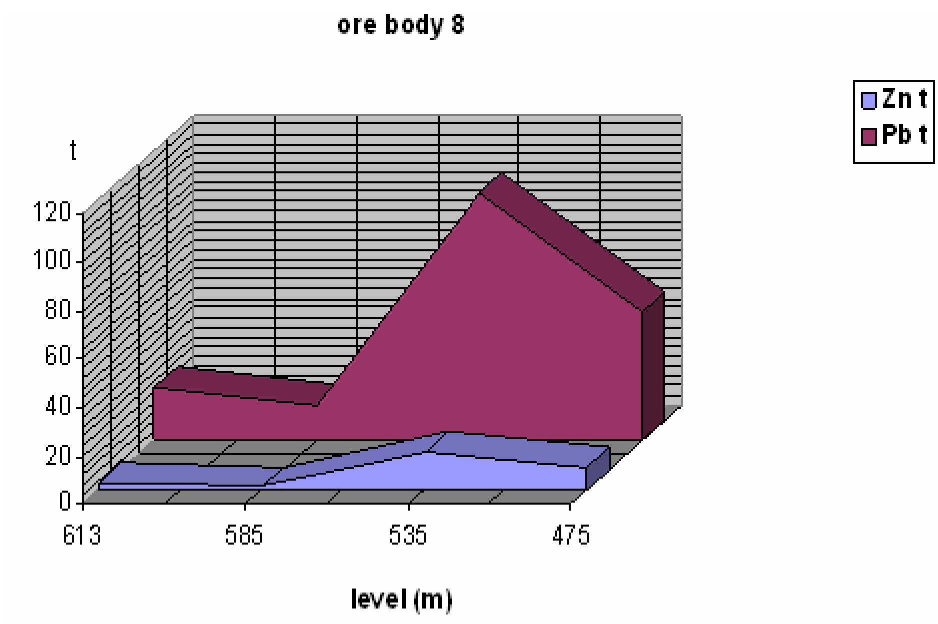

Figure-9. Interpolation value of Pb and Zn in ore body 7 in the lower exploitation level (H- V-475 m).

Table-1. Statistic data and distribution lead and zinc in ore body 7, wt %.

Samp...Σ.32	Pb	Zn	Pb+Zn	Pb/Zn
Average	7.97	3.48	11.45	0.44
Standard dev.	4.38	2.26	6.64	0.52
Minimum	0.78	0.25	1.03	0.32
Maximum	31.47	14.72	46.19	0.47

Table-2. Statistic data and distribution lead And zinc in ore body 13, wt %.

Samp. Σ 98	% Pb	% Zn	Pb+Zn	Zn/Pb
Average	4.01	6.04	10.05	1.5
Standard dev.	2.92	5.17	8.09	1.8
Minimum	0.61	0.24	0.85	0.4
Maximum	15.17	22.68	37.85	1.5

In the obtained maps (Figures 8 and 9), there are non-homogeneous distributions on content Pb inside the two ore bodies (Durmishaj, *et al*, 2007). For that, the entire epicenter with higher value of Pb on 7% (ore body 13), and on 10 % (ore body 7), occur in the periphery of the ore bodies. Similarly, Zn has heterogeneous distributions, but with somewhat a trend of homogeneous distribution within the ore body. Sometimes, this epicenter has direct contacts with host Rocks, and sometimes it seems to decrease gradually distancing from these epicenters. However, the epicenter with Pb values higher than 7 % is the same as the one for Zn in the ore body 13, and this shows for a small correlation between these two elements Contents his, while in the ore body 7 there is no correlation between these two elements, so sites with the highest Pb values are not the same with those for Zn.

Pb AND Zn DISTRIBUTIONS FROM SURFACE TO DEPTH

In Figure-10, the Pb and Zn values and their geochemical changes by levels are shown. For the ore body 8, a constant deposition of Pb and Zn occurs at the quota 585m, continuing with fast increase of Pb versus Zn that has only slowly increase up to the quota 585m. Then, they have again gradually decreased up to the lowermost exploitation level. The high quantity of Pb deposition compare to the one of Zn is typical for this ore body in entire the ore deposit.

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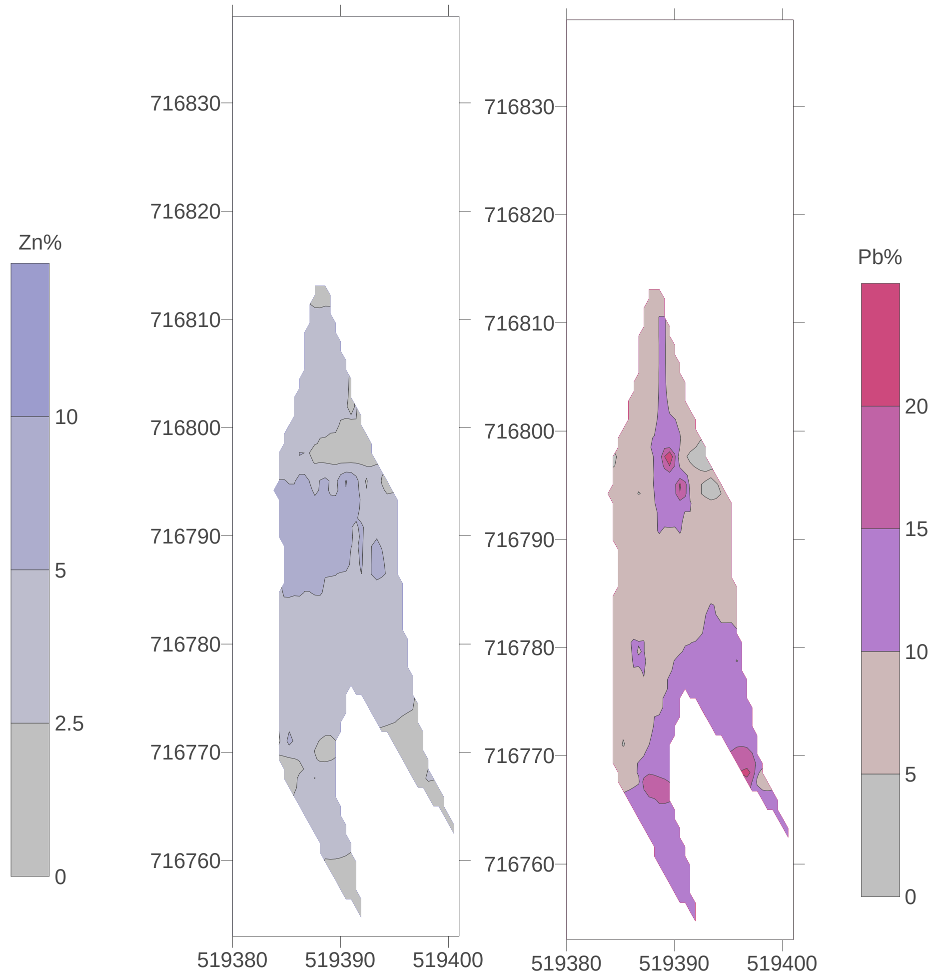

Figure-10. Quantity of the Pb and Zn hydrothermal depositing from surface to depth in Badovc mineral deposit.

Figure-11 shows the ratio Zn/Pb in ore body 8 from surface to depth. There is not the same distributional over the plunge of the ore body. On the contrary, this ratio has the lower values in the level 585m, and towards the depth it remains unchanged. This suggests that the ore body 8 continues genetically below the lowermost exploitation level.

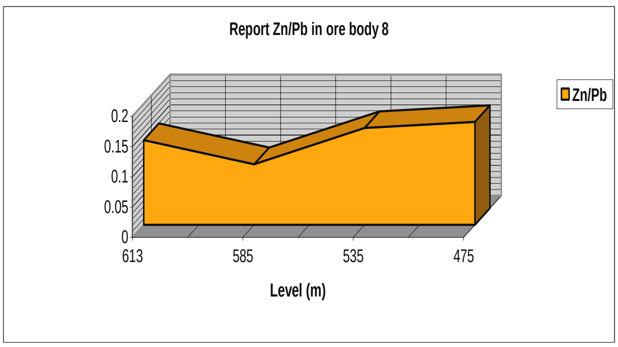

Figure-11. Zn/Pb ratio in ore from surface to depth in Badovc mineral deposit.

Figure-12 shows the Ag values in ore body 8 by the hydrothermal levels. From data, the higher quantity of Ag in this ore body belongs to the lower exploitation level, compare to the upper level where Ag is evidently lower.

Figure-12. Ag values from surface direction to depth.

Similarly, the Figure-13 shows the Pb and Zn values and their geochemical changes to different levels. In the ore body 7, these data show that the upper level has

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a low deposition of metals Pb and Zn and there is a tendency of increase towards the bigger depths of exploitation, with exception of Zn that decreases with depth.

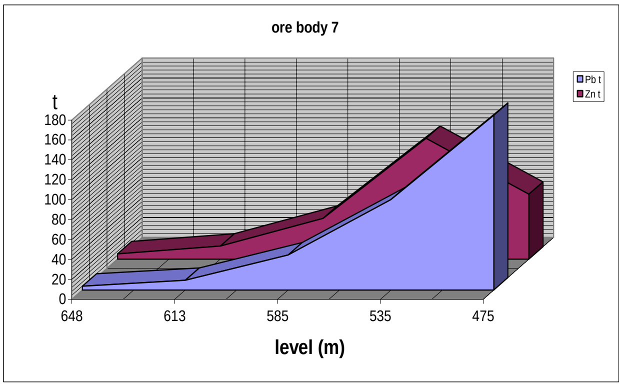

Figure-13. Quantity of Pb and Zn from surface direction to depth.

The Zn/Pb ratio in the ore body 7 is higher than 1.3 and unchanged along all plunge of this body up to the level 535m, except the level 585m where this report is above 1. By data from level 535m to 475m, an abrupt decrease of this ratio can e evidenced. However, it can be suggested that the deep parts of the ore body have the tendency of decreasing of this ratio, but with increased value of Pb and gradually decrease of Zn.

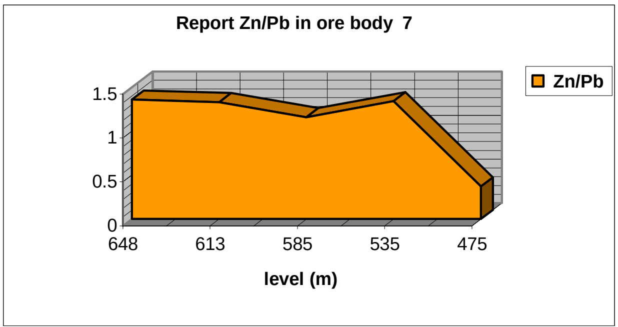

Figure-14. Ratio Zn/Pb in ores from surface to depth deposit.

The data in Figure-15 show the quantity of Ag in the ore body 7 by level. It seems a constant increase of Ag values in all deposit. It is important to mention that for ore body 7 of this deposit, the highest Ag quantity belong to the deepest levels of exploitation.

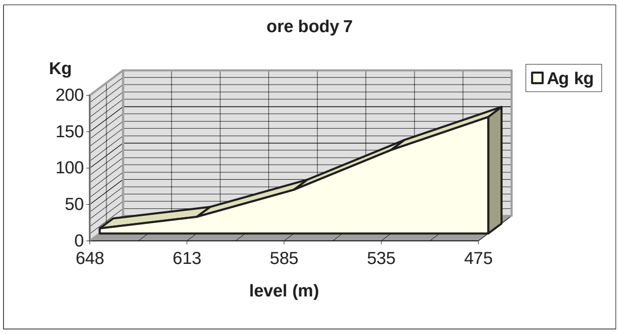

Figure-15. Quantity of Ag deposition from surface to depth.

CONCLUSIONS

Mineral ore deposit of Badovc, consisting of Pb-Zn- Ag mineralization, does not close genetically towards its deepest exploitation level. On the contrary, from the geochemical aspect, it should be expected a further extension of higher intensity mineralization towards the depth in comparison to the uppermost levels of this ore deposit. The Zn/Pb ratio changes, being lower at the level +585m and higher at the lowermost exploitation level (ore body 8). The Ag values are also higher at the deep levels.

For the ore body 7, this ratio is unchanged along its plunge, except in its exploited deep part where it is lower than the one of the uppermost level and it presents a decrease tendency. Ag values increase towards the depth.

Distributions of Pb and Zn inside the ore body seem to be conditioned by litho logical factors (more serpentinite and less carbonate). There are not any Pb - Zn spatial correlation depending on favorable conditions or not intense development of hydrothermal - epithermal phases.

Pb and Zn distribution within the contoured ore body in Badovc ore deposit is heterogeneous. The highest Pb values do not coincide with the highest Zn ones, showing so the lack of e laterals Pb - Zn correlation inside the ore body.

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