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HYDROGEOLOGICAL AND HYDROLOGICAL CHARACTERISTICS OF THE METALLIFEROUS REGION NORTH OF OLOVO

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ABSTRACT

This paperwork included the complex process of collecting and processing data for observed area. Very complex geological relations in this area have caused complex hydrological conditions which in combination with the hydrological and climatic characteristics represent a complex hydrogeological system. Further research in this area would contribute to confidence defining this area in the hydrological sense.

Keywords: *hydrological conditions, geological relations, hydrogeological characteristics*

INTRODUCTION

The area north of the town of Olovo - mining area "Olovo", which is localized in the reef limestone of Upper Triassic. As a major holder of lead is mineral ore Cerussite in mineral wires that are formed along tectonic fractures in Triassic limestone. Limestone floor seams are usually more compact in contrast to the roof limestones, which are quite cracked and easily decompose in the finer fractions. The floor of roofing always shared a sharp fault along which usually is more or less clay material (fillings). These faults at the same time represent a sharp underlying stratum to contact ore, while the overlying boundary in many cases is difficult to determine without chemical analysis. Accordingly, the ore is located in the hanging wall of the cracked limestone.

Hydrographic network in the broad and narrow of lead ore zone is highly developed and reflects the characteristic hydrological and hydrogeological relations in the studied karst area. Lines and spatial distribution of water streams are intimately linked to geological and tectonic structure of the terrain. The water flows are mainly in the deep and steep valleys, often canyon type and typically represent deep drainage base for karst aquifers in the left and right hinterland river Bioštica.

HYDROLOGICAL CHARACTERISTICS AND THE HYDROGRAPHIC NETWORK

In the area of Olovo mining region, main waterways are rivers Bioštica and Stupčanica, which are at town of Olovo, approximately at the level of 530 m.n.m, merge and form the river Krivaja. Krivaja is the right tributary of river Bosnia. Krivaja merge with river Bosnia in town of Zavidovici.

When considering the narrow area, the main recipient of the water is the river Bioštica. Bioštica rises about 6-7 km northwest of Sokolac. The source consists of a strong karst springs Dubljani, whose minimum yield is estimated at about 0.3 m³/s, and the average flow of about 0.9 m³/s and a few occasional springs, which occur during rain and snow melt. The source area is located at about 760 m.a.s, and partially capped for water supply Sokolac. The general direction of the flow is to the northwest, and the sink is largely canyon type with places that are deep several hundred meters (1). The total length of the stream is 24 km and basin area 411 km².

One of the major tributaries of Biostica river is the left tributary Kaljina, which drains the northern slopes of Romanija and eastern slopes of Ozren, and it is positioned approximately 5 km upstream of the studied area of lead mineralization. Downstream from the confluence of the rivers Bioštica have no longer any left tributary mainly because of the karst nature of the terrain, Figure 1.



Figure 1. River Canyon Biostica in the upper reaches

At the right waterside of Bioštica the catchment area is very limited, however, it appear with few short permanent or temporary watercourses. Significant stream Bugojevac, which after a very short flow, sinks into the abyss Kruščanje, on the border districts "Očkalj" and „Prgoševo“ where it have underground connection to the source of Zeleni vir.

Hydrographic network and spring network in the wider area of the reservoirs are characterized by substantial fluctuations in flow rate or yield, during the year - for the most part of the year are extremely low, and it only grow with rapid snowmelt in the upper parts of the river basins Bioštica and Stupčanica. The caves are for the most time practically dry, with small isolated puddles, a more water occurs during heavy rains or rapid melting of snow.

Measurements and observations of water levels in watercourses and water flow on specific sections were established in 1984 as part of the Study (Studije površinskih i podzemnih voda za investicioni program izgradnje rudnika olova „Olovo“ (Zavod za vodoprivredu Sarajevo, 1985), which provided a

set of data of the daily levels and flow rates in several hydrological stations: Bioštica Olovo, Bioštica spring, Bioštica mine, Bioštica Zeleni vir and profundity Bugojevac,

During the war devastation in these stations are not in functional state. But on the basis of available data we can provide an average flows as the mean value of the measured data for the period of observation. In 1984, the average specific swelling are in range from 10 to 25 l/s / km², while the multi-string is in range from 10 to 20 l/s / km². Coefficients are ranging from 0.33 to 0.73 and average about 0.50. These values are in the range expected for areas that have climatic and geological characteristics similar to the study area.

On the examined area have been developed karstic processes, therefore it is necessary to point out the need for constant study of karst aquifers, especially in the area of mining operations. It is necessary to achieve their full security, because the entrance of water to the zone of a larger water channel, could have tragic consequences for miners and mine. Therefore, in the construction phase of the mine, should be carried out new research, as well as when the mine is in operation.

When considering the rainfall in the area of Olovo, it's oscillating in a wide range. In 1963 amounted to 2,561 l/m², and in 1982 only 691 l/m². Average annual precipitation ranges are from 1000 - 1250 mm. Of course an extreme case represent heavy rains that occurred in Bosnia and Herzegovina, including the area of the municipality Olovo in May 2014, with big scale of the disaster. It was noted that during this period over three days in Bosnia and Herzegovina fell from 200 to 250 liters of rain per square meter, as much as an average fall in three months. As a result, there has been flooding rivers in Olovo and activation of a large number of landslides, which are deposited huge damage to its inhabitants.

HYDROGEOLOGICAL CHARACTERISTICS

Ore mineralisation area is positioned in the lower course of the river basin Biostica. The narrow field of ore and the whole basin Biostica was geologically located in the southwestern part of tectonic units called "inner Dinarides", or in an area dominated by Triassic and Jurassic sediments with high degree of tectonic disturbance and brokenness of faults and handles.

From the aspect of hydro-geological characteristics of rocks in the structure of the field, stand out as hydrogeological collectors in limestone karst rock fracture porosity and Triassic complex hydrogeological isolators and impermeable sediments (Werfenian sandstones, conglomerates, shales and aleurolites), who along with Jurassic sediments presented ophiolitic rocks liquid egg (marl, shales and cherts) form a hydrogeological barrier (hydro insulators).

In such structural and geological conditions of karstification process was dominant diagenetic process so that this area is characterized by very pronounced fracture karst massif structure and morphology of the terrain, and is considered the area of mineralization and wider, formed a typical karst aquifer. The general characteristic of karst aquifers is a close connection hydrogeological, hydrological characteristics and manifestations, as is the case in the area under consideration.

Fracture-karst aquifer is the only significant intersections returned to date for the region can be clearly limited in area, defined by mutual spatial relations karstified collectors of middle tertiary limestone and impermeable to isolators of Lower Triassic clastic rocks and diabase floral formations (volcanogenic sedimentary series), Figure 2.

In the propagation of aquifers is a larger number of hydro-geological phenomenon of typical karst character. In addition to the typical karst surface morphology (sinkholes) appear to be numerous types of hydro-geological karst objects: sinkholes, springs, caves and estavelles.

As a result of intensive underground drainage, in the lower parts of the basin, mainly along riverbeds Biostica, there is a greater number of permanent and temporary sources. Some have very high maximum capacity and the most important among them are the Zeleni Vir (> 10 m³ / s), Kruševačka springs (~ 6 m³ / s) and boiling Boljaci. In addition to the springs that occur along Biostica, part of the water in the area of karst aquifers left hinterland drains to the north, toward the riverbed downstream

of Krivaja near Olovo. In this area, the most important is the well Orlje (~ 2 m³ / s), as well as the source in the village Križevići in the trough Orlje, which flows into the paternal and this wrong. In addition to hot forming Orlja occur and springs in the bed of Krivaje, Tisovac (~ 9 m³ / s) and Studenac between Boganović and Krizevici (2).

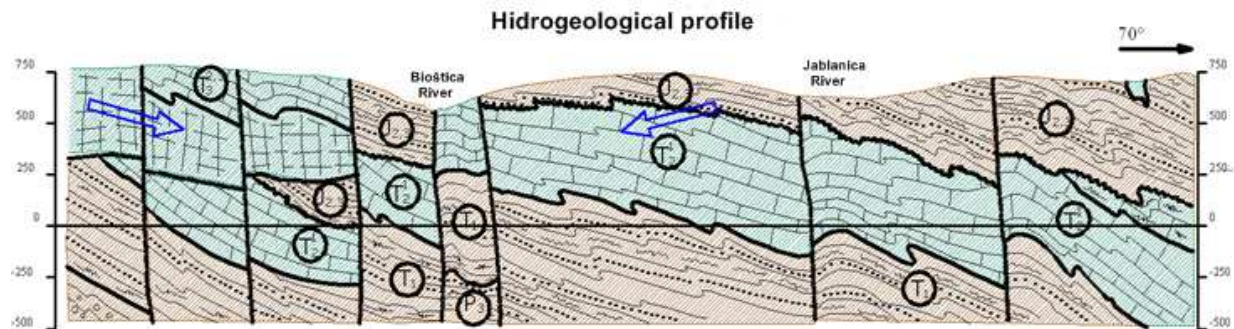


Figure 2. Longitudinal hydrogeological profile of area

The source of the Zeleni Vir for the area under consideration ore of lead especially important because its underground and surface basin encompasses the area of spreading mineral wire solder. The source consists of two branches, whose total yield is the minimum estimated at ~ 0.11 m³ / s, and the average is around 0.54 m³ / s. The surface of the sub-basin of the Zeleni Vir is about 40 km², although the border difficult to uniquely determine its dominant karst morphology.

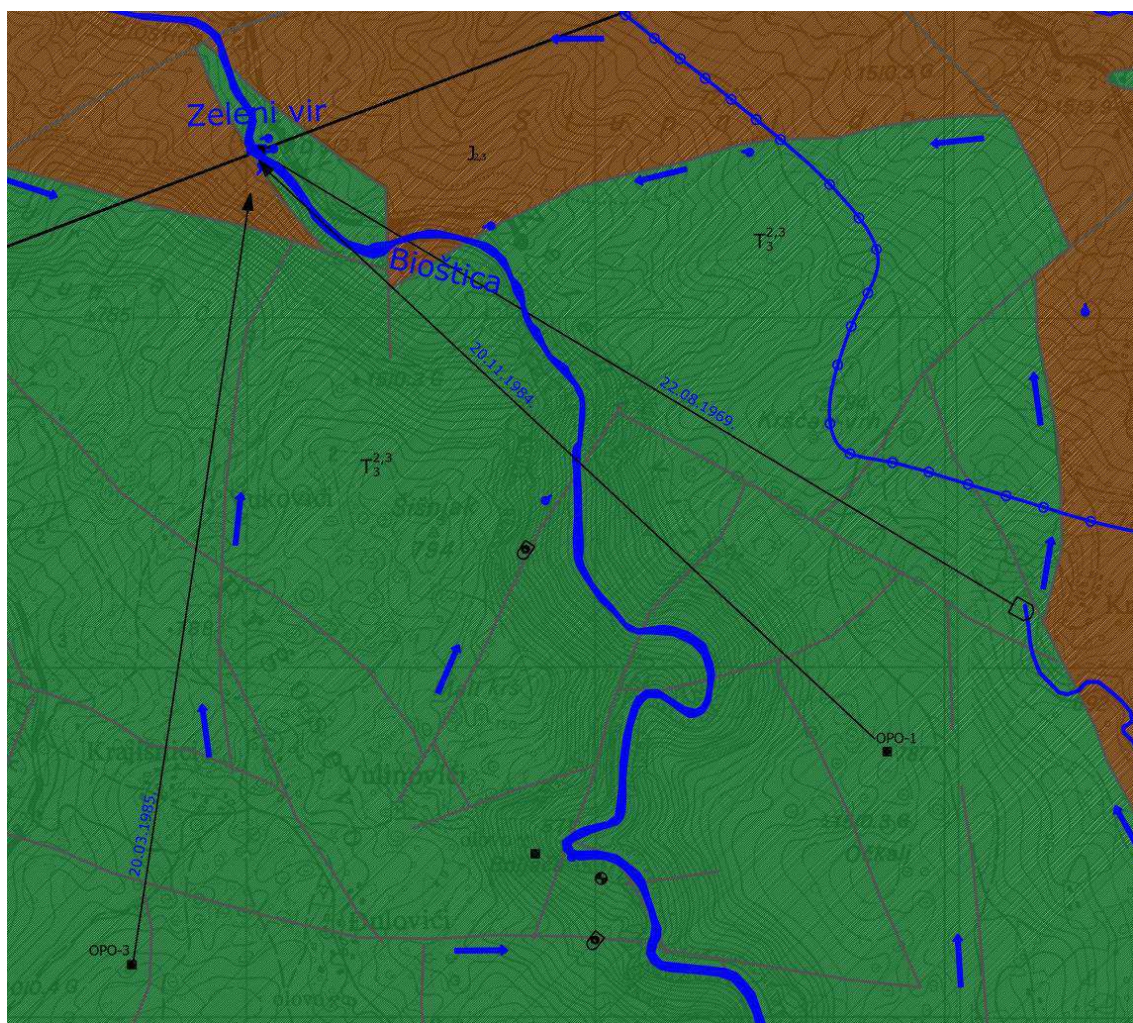


Figure 2: Extract from hydrogeological map of the ore regions in Olovo

At the right hinterland Biostica the karst hydrogeological phenomena less common due to the nature of rocks in the structure, less karstification and close to the basin watersheds Stupčanica. In this area, the more pronounced surface runoff and the formation of surface flows, than in the west. Very interesting and significant for the area districts Očkalj is the flow stream Bugojevac, which after surface flow length of about 5 km in the whole ends plunging into the abyss Bugojevac, whose direct underground connection with the Zeleni Vir has been demonstrated staining experiments. Maximum capacity of descent is estimated at $\sim 0.6 \text{ m}^3/\text{s}$.

Maximum capacity of concentrated highlighting groundwater at listed sites, according to the geological elaborate karst channels can move significant quantities of groundwater. The single pit mining facilities, hydro-geological mapping has recorded a small number of phenomena sources or concentrated highlighting groundwater that does not indicate that the cave exploration activities cut off some of the main directions of groundwater flow.

FILTRATION CHARACTERISTICS AND GROUNDWATER AQUIFERS

While in the middle of Karst filtration coefficient, as the speed parameter of the underground flow in porous media, can be considered representative within the wells of test investigative CA-1, 2 and 3 are experiments conducted permeability tests (VDP), the method of injection of water under pressure, by Lugeon-in. The results of this assay provide a wide range of filtration coefficient $k = 1.0 \times 10^{-5}$ to $k = 8.2 \times 10^{-8} \text{ m/s}$. These values confirm the heterogeneous structure of the porosity, typical of fracture-karst media and the flow of the privileged directions. The profile of the drilling are noticeable individual intervals increased the value of filtration coefficient (izdrobljenosti limestone), but mostly it is a cracked limestone with fissures filled with clay, calcite and siderite binder. Open cavernous channels, as privileged directions of turbulent flow, not drilled, nor are observed complete loss of water during experiments.

In the middle of this distinctive fracture karst structure dominates the underground flow of the elaborate carstified channels and in the turbulent regime, so the method of determining the direction and speed of underground stream customized it. During the previous period were carried out in a number of field experiments tracing staining for determining the direction and rate of groundwater flow, and the most in order to establish the connection spring green source with peripheral sinks. Identified as direct hydraulic connections and lines underground stream between:

- Sink Malinović – Zeleni Vir
- Wells CA-3 (left hinterland, hunt "Prgoševo ") - Zeleni Vir
- Wells CA-1 (right hinterland hunt "Očkalj") - Zeleni Vir
- Sink Kruscanje (Bugojevac) - Zeleni Vir
- Sink Horsehead b. - Spring Tisovac
- Sink Bijambare - Spring Orlja.

Staining experiments have established relatively large apparent velocities underground stream to the source Green source of 1037 m/day (0.012 m/s) to 250 m/day (0.0029 m/s), as well as in other directions towards Tisovac (1123 meters/day) and hot Orlje (1900 m/day). These results confirm that it is a subterranean flow by elaborate karst channels and in the turbulent regime. The spatial orientation directions of groundwater flow and position of sinks and sources is visible on the cut of hydrogeological maps in Figure 2.

In the earlier performed piezometric wells CA-1, 2 and 3 the measurements are made only for a short period in 1985 and can be considered only informational. Table 1 provides an overview of the measured maximum and minimum values of NPV in this period.

Table 1. Overview of the measured maximum and minimum values NPV

Piesometer	Period of observation	The level of ground water (NPV – m.n.m.)		Remark
		Max. NPV	Min. NPV	
OPO-1	II-VI.1985	582,22	571,63	right bank „Očkalj“
OPO-2	II-VI.1985	570,85	568,83	bank of Bioštica
OPO-3	V-VI.1985	707,22	703,40	left bank „Prgoševo“

CONCLUSION

For a more detailed discussion of the dynamics of groundwater in the limestone aquifer deposits of lead ore missing sustained and long-term observation of elements of the underground flow (levels, flow rates, etc.) In the area under consideration. Previous studies and observations have provided sufficient indicators for the qualitative defining hydrodynamic regime in the discussion but not enough to be in quantitative terms defined all elements of the underground flow and balance of groundwater. The groundwater regime in the area under consideration is undoubtedly a typical karst character and basic parameters of the underground flow (levels and flows) are in close functional relationship with hydrological conditions, the infiltration of rainfall and drainage on the primary hydrographic network. At the same factors infiltration of precipitation (primarily karst morphology) caused directly limestone aquifer recharge, and factors structure porosity (the degree of karstification) quickly and directly discharging or draining of aquifers through basic drainage artery, the river Biostica.

When it comes to significant and frequent changes in groundwater levels, depending on the amount of rain and snow melt, and also the capacity of the source and flow in the open channels. Measurements have never been achieved in the continuity and for a longer period of time or can be assumed high amplitude fluctuations NPV especially in deeper hinterland.

With more detailed measurements and tests of this (with an aspect of a complex geological area) can gain a detailed insight into the capacity and drainage conditions of the aquifer, and its potential as a water body.

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