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PROCEEDINGS

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Prof. dr Ivica Ristovic

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WASTE MANAGEMENT PLAN GENERATED FROM MINING ACTIVITIES IN THE MINE FOR PRODUCTION OF LEAD AND ZINC "TORANICA" - KRIVA PALANKA

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Abstract: *Before it starts the production and mining activities, the new concessionaire of the mine "Toranica" - Kriva Palanka, had a legal obligation to the Ministry of economy of the Government in R. Macedonia, to prepare plan for waste management that will be generated from production and processing of lead and zinc ore for the period from 2016 to 2019. In this paper will be presented the planned activities and measures for waste management and reduction of harmful impacts of mining activities on the environment.*

Keywords: *Lead and zinc mine, Waste, Hydro tailings*

1. INTRODUCTION

The mine for production of lead and zinc "Toranica" is located in the northeastern part of Macedonia, 120 km from Skopje, and 24 km from Kriva Palanka, close to the Serbian-Bulgarian border. Located in the area between the mountain peaks: Ruen-2.252 m, Carev Vrv, Sultan Tepe-2.085 m and Sokol-2.038 m, which make up the Osogovski mountain range ridge in length of 3 to 4 km.
Mine "Toranica" started with active production in 1987 with an initial annual production of 41.232 tons of ore, and is the youngest underground mine in R. Macedonia. Over the years its production grew steadily so that in 1990 it reached 314.210 tons of ore.
Mine "Toranica" operated continuously over 14 years, followed by a period with a break of 5 years because of transformation of ownership. In its chemical composition, the ore in mine "Toranica" is polymetallic with a high concentration of minerals of lead and zinc together with minerals of copper, silver, cadmium and other minerals and elements that are economically viable for exploitation with existing technology.
Flotation plant is build for the process of separation of these metals in form of concentrate and the end product of this processing are lead and zinc concentrates.
In 2006 the mine for lead and zinc "Toranica" was privatized by the company "Binani industry" and they registered company with name "Indo minerals and metals Probishtip-Toranica Mine".
The company "Indo minerals and metals Probishtip" from 24.09.2015 ceased the production, and from 19.11.2015 went bankrupt.
Government of Macedonia assign existing concession to company "BULMAK 2016"- Probishtip and was signed concession for exploitation of minerals in the area of Toranica, Sokol, Bacilo, Sredno brdo and Municipality of Kriva Palanka.
The company "BULMAK 2016"-Probishtip based on the available raw materials, mining and geological conditions, the available mechanization and techno-economic factors prepare a 4-year plan for production and processing of lead and zinc ore, which is shown in Table 1.

Table 1. *Planned production of ores and concentrates for the period 2016-2019.*

Year	Ore production	Waste rock		Pb Concentrate	Zn Concentrate	Flotation waste	
	(t)	(t)	m^3	(t)	(t)	t	m^3
2016	42.400	11.104	4.113	1.349	1.516	37.415	20.786
2017	215.550	55.354	20.501	6.865	7.664	205.572	114.207
2018	227.800	59.846	22.165	7.252	7.888	217.046	120.581
2019	268.000	27.365	10.135	8.600	8.949	237.051	131.695
TOTAL	**753.750**	**153.669**	**56.914**	**24.066**	**26.017**	**697.084**	**387.269**

Production of lead and zinc concentrates is accompanied by generating certain types of mining waste like waste rock and flotation waste. Their expected values are shown in Table 1.

2. STRUCTURE OF THE WASTE MANAGEMENT PLAN

The waste management plan should contain sufficient information for the obligations of Mine "Toranica" for dealing with mining waste according the Directive on Waste Management and the Law on Mineral Resources. According to the low and the Guidelines for Waste Management [3], it has been determined the structure of the waste management plan:

1.	Classification of installation	Review the criteria for classification of the installation for waste from mineral resources
2.	Categorization of waste	Geological characteristics of the mine
		Basic (background) information about the mine
		Nature of waste and the way of dealing with it
		Geomechanical characteristics of the waste
		Geochemical characteristics of waste
		Auscultation of the drainage system
3.	Building and managing the installation of mining waste	Description of the facilities within the hydro tailings
4.	Assessment of risks to the environment and human health	Destabilization of hydro tailings
		Pollution of surface and underground water
		Air pollution
		Pollution of land
5.	Measures to prevent environmental risks	Measures for water protection
		Measures for air protection
		Measures to protect the land
		Measures to ensure stability of the hydro tailings
		Measures to protect the environment in case of accidents
		Administrative measures
6.	Control and monitoring of procedures	Monitoring during the construction and exploitation of hydro tailings
		Monitoring during remediation
		Monitoring after closure
7.	Plan in case of emergencies	Purpose of the emergency plan
		Scope of the emergency plan
		Objectives of the emergency plan
		Alert in case of an incident from the installation of waste from mineral resources
		Level of alert and activities at the location of the tailings
8.	Draft plan for closure, after-care and monitoring	Selection of acceptable methods for closure remediation
		Plan for remediation of the installation for waste from mineral resources

3. NATURE OF WASTE (WASTE-ROCK) AND THE WAY OF DEALING WITH IT

For the categorization of waste we should have enough information about the nature of the waste as a result of the activities of exploatation and processing, especially for:

- Origin of waste that occurs as a result of exploitation and processing of mineral resources
- Amount of waste
- Description of the system for transportation of waste
- Description of chemical substances used in the treatment
- Classification of waste in accordance with Commission Decision 2000/532/E0, taking into account the hazardous characteristics
- Type of installation for waste handling, disposal of waste in the installation

Characteristic of all processes of excavation and processing of metallic mineral resources in order to obtain useful minerals in this case of Mine "Toranica" it is Pb and Zn concentrate, they produced two types of waste:

- Waste rock
- Flotation waste

The rocky waste material in itself has no economic content of lead and zinc and is classified as waste material generated in the process of exploitation of the mineral ore body.

With the operation work of mine “Toranica” on the tailings dam is deposited approximately 1.994.000 m^3 of flotation waste. These data were gather as a result of software obtained permanent bases for the land of the hydro tailings.
Location of the tailings dam is 4 km downstream in the valley of Kriva River, between the space from profile "Varosani" and the profile "Cepen Kapen", located close to the inflow of Toranichka River in Kriva River.
The transport of the slag flotation in form of pulp to the hydro tailings is done by gravity trough abrasive resistant PVC pipes with a diameter of 315 mm. The flotation pulp line is 4 km long, partially laid underground and part on surface depending on the terrain.

The composition of hydro tailings includes the following facilities:

- Pulp line with sumps for reducing pressure
- Water-retention dam
- Drain diversion tunnel
- Drain (overflow) collector
- Downstream sand dam

The main purpose of the water-retention dam is diversion of water from Kriva River through a drainage tunnel in order the water not to go through the hydro tailings, also other purpose is the mitigation of flood wave and protection of the hydro tailings from heavy rains.

The water-retention dam consist of supporting body from gravel and water resistant part from clay material.

Downstream sand dam is build for establishing a sand accumulation intended for an acceptance of the flotation waste material. The inside slope of the downstream sand dam is projected to be 1:3, while upstream of the the sediment lake the slope can be 1:2.

The flotation waste pulp come trough PVC pipes in the waste area where it sediment itself, and the clarified water through the collector goes into sedimentation tanks from where it is discharged into Kriva River.

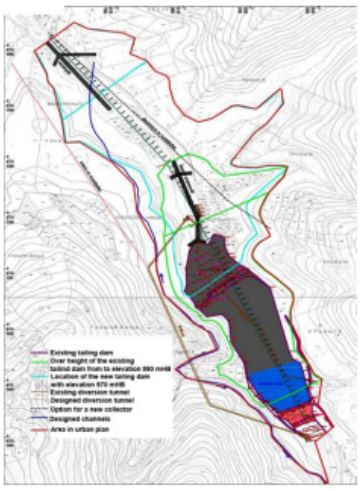

Figure 1. *Hydro tailing "Toranica"*

4. PREVENTION OF RISKS AND MEASURES OF PROTECTION

The environment is a complex system whose components are interconnected and dependent on each other, so that changes in one part can cause changes in other parts. Therefore, the issue of protecting the environment from harmful influences, can be resolved with an integral systematic approach.
In order to ensure maximum effectiveness of the proposed measures and to ensure their successful implementation, it is necessary to integrate them into a comprehensive plan for control and environmental management (ETS) in the zone of influence. The system of environmental management (ETS) is a comprehensive tool that enables the management of the mine to meet the current and future problems in the field of environment. Proper implementation of the ETS system results in many benefits.
Based on the results obtained by assessing risks in the construction phase of the tailings dam, there are proposed measures for its reduction of negative environmental potential, [2].

Measures to protect the environment are classified into several groups:

1. Measures of water protection
2. Measures for the protection of air
3. Measures to protect the land
4. Measures to ensure stability of the tailings dam
5. Measures to protect the environment in case of accidents
6. Administrative measures

1. Measures of water protection

In the process of environmental protection, the greatest attention should be focused in reducing the pollution of watercourses in which is discharged the water from the hydro tailings. The contemporary practice, usually is carried out by recycling the large amount of water, where the input of fresh water is reduced to a minimum and not more than 5%. So, it is best if the water circulates in a closed loop. Bearing in mind the toxic reagents used in the flotation process, in particular NaCN, in order to protect waters from harmful effects of cyanide is necessary for proper processes (measures) to control the concentration of cyanide in surface and underground water.

Measures to protect underground water:

- Coating the bottom of the tailings with an impermeable material such as clay
- Setting up geomembranes for protection of underground water

Measures to prevent the formation of ponds are:

- Tailings dam to be isolated from the surrounding terrain
- In the surroundings of the tailings dam to be build reception channels
- If the reception channels are not sufficient protection, then it is necessary to build drainage channels

2. Measures for the protection of air:

- Spraying water on the crown and slope of the dam
- Control the water level in the accumulation
- Spraying with certain suppressants

Technology to control fugitive dust that occurs as a result of aeolian erosion, can be grouped into three basic groups:

- Technology for reduction the speed of airflow
- Technology for isolation of potential sources of fugitive dust
- Technology for surface stabilization

Technology for reduction the speed of airflow can be:

- Setting up a system of wind fences
- Raising protective vegetation belt (high vegetation)
- Reclamation of inactive surfaces

Technology for isolation of potential sources of fugitive dust:

- Covering with earth materials
- Covering with synthetic membranes (geo-membranes)
- Cover with asphalt, asphalt-concrete, lean concrete
- Covering with plastic sheeting

Technology for surface stabilization:

- Spraying with water (pure or with the chemical additives)
- Use of binders to create a surface crust
- Thermoplastic stabilization
- Cryogenic encapsulation
- In-situ vitrification
- Surface fixation

From the chemical additives to create temporary cover the most commonly used are:

- Polyacrylamide
- Polybutadiene
- Physical stabilizers of soil - geosynthetic
- Polyvinyl acetate co-politer

3. Measures to protect the land:

- Implementation of measures for water and air protection to prevent an indirect contamination of land
- Measures to prevent spillage of flotation waste from the tailings dam
- Technical and biological reclamation of land

4. Measures to ensure stability of the tailings dam:

- Attention of the projected parameters for the tailings dam
- Proper dimensioning and attention of the geometry of the tailings dam
- Construction of the tailings dam with the proposed projected material
- Maintaining the level of clarified water in the sedimentary lake
- Greater beach length (the distance from the dam to the sedimentary lake)
- Providing permanent and professional supervision during the construction of the tailings dam

5. Measures to protect the environment in case of accidents:

- Acting according the emergency instructions

- Opportunity to build temporary levees to protect some endangered settlements
- Examining the quality and long-term monitoring of surface and underground water

6. Administrative measures:

- Keeping accurate records
- Selecting the appropriate personnel and providing training for the personnel
- Documentation of all emergency cases

5. CONCLUSION AND RECOMMENDATIONS

Based on the above stated data on the manner of disposal of waste material from exploatation and processing of mineral resources in the mine "Toranica", we can conclude the following:

1. The method of exploitation, preparation and concentration of the ore as well as the disposal of waste from excavation and processing of mineral resources in the mine "Toranica" do not contribute to the generation of excessive air emissions, pollution of surface and underground water and land that can have a negative impact on the environment and human health.
2. Joint disposal of excavated waste rock and flotation waste of the unique location meets the requirements of VAT, the best available technology, and is beneficial in terms of reducing the surface for disposal and storage of mining waste, ie not occupy a new surface for the disposal of waste. This prevents degradation of the new areas, thereby reducing the negative environmental impact. The waste rock which is deposited in hydro tailings provides improved physical and technical characteristics, that enhance the stability of the hydro tailing.
3. The water level in the sediment lake and the downstream slope of the dam and also the installed piezometric system indicate that there is no indications of any anomalous phenomena that could threaten its stability.
4. Air pollution and contamination of surface and underground water is probable, but will not have a significant impact if applying all provided measures of protection.
5. The length of the dry beach, distance from dam to the water of the sediment lake is big which directly affect the stability of hydro tailing.

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