Economic Concepts on Mineral Resources and Mining Planning

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Abstract

In recent decades, the demand for minerals has always been growing and selling price of minerals has been an upward trend sustainable. However, difficulties in the development of existing mining activities, or the opening of a new mining activity, are always increasing. The difficulties in the development of a mining activity comes mainly, in addition to the impact of increased costs for the extraction of minerals from depths increasingly larger, and the additional costs of environmental protection, from the selection of the mining method, planning of mining, development rates of mining operations and industrial policies of the cut-off grade. In this paper we will bring the impact of each of these mining elements, the interaction between them and solve the optimal model for a given mineral deposit. Addressing the problems will be accompanied by examples taken from our own mines.

KEYWORDS: Method of mining, Mine plans, Scale of mining operations, Cut-off grade policy

1. Introduction

Extraction and processing of mineral raw materials is distinguish for an upward trend of mining production, marking in recent years a production of mineral row materials over 30 billion tons per year. Besides intensive method of extracting the minerals from existing mines, we noted in recent years and an expansion of mining activities in mineral deposits that were once considered as uneconomic, or returning to the mines abandoned years ago.

Intensification of production at existing mines, which are the main source of production of minerals, requires the resolution of the contradiction between the growing difficulties with the performance of mining at great depths and increases the scientific level of performance in various mining processes, to improving economic indicators in a mining activity.

Minerals market has seen a steady rise in prices, mainly due to increasing demand for minerals from their manufacturing industry, but also because of increases in production costs. Mining operations are going always deeper, extracted from underground the lasted quantities of resources rated as profitable so far. Also in our country nowadays we are talking about the evidently decrease of mineral reserves in general, and chromium and copper minerals in particular, as the two main mineral in our country, although the extraction of minerals in recent years in our country is distinguished for lower production rates.

Nowadays the copper reserves in our country, according to the latest data (Grup autoresh 1), fluctuate around 22 million tons of reserves, with an average content of about 1.8% copper metal. These mineral deposits are scattered in 21 deposits. Most of reserves, about 9 million tones, are located in deposits Munellë, Paluca and Rehovë.

Currently we have a mining activity only in Munella deposits. Two other mines are under mining, geological, and economic evaluation.The rest of the reserves are distributed in 18 other deposits. Some of these deposits were partially exploited and mining works have been abandoned some years ago.Restarting the work in abandoned mines will be accompanied by some technical and economic problems.A not optimistic situation is also in chrome mines, where the privatization of this sector has led to serious problems in the management of chrome ore reserves as a national repeatedly asset.

To face this situation as best as possible, the global industry of extraction and processing of minerals, is asking for new development road mainly in:

1. Reducing the consumption of minerals, using alternative materials to replace them.
2. Recycling of waste arising from enrichment mining and processing in metallurgy.
3. Improvement of mining technologies to increase the indicators of mineral extraction and to minimize qualitative and quantitative waste during mining.

.Quantitative and qualitative management of mineral reserves in the process of mining is the main direction where we have to work to increase economic efficiency in the exploitation of ore deposits. The main factors affecting the quantitative and qualitative management of mineral reserves of a ore deposits should be divided into three main groups.

The first group is geological factors influencing the formation of quality and quantity of the minerals in the rock mass. Geological information is the bases on which decisions are made for managing of quality and quantity of the ore in subsequent the exploration mining activities.

The second group is factors influencing the formation of quality and quantity of the ore in the phase of mining, let say technological and organizational factors. These factors determine the opportunities for quality and quantity of ore production in mining stage.

The last group of factors, but more important, is requirements of the processing plant to the quality of extracted ore.

2. Some concepts on mining activities

Before we explain the importance of the above factors in the success of a mining activity, we are giving some concepts of mining economy, which are often confused during the drafting of reports on geological modeling of deposits and mining projects for extraction of mineral resources.

A mining project adapted for a particular ore deposits. Since every ore deposits is unique, then mining projects vary from one deposit to another. However the main structure of a mining activity is stable for similar type of ore deposits. This allows us to prepare economic models which can be adapted to the specifics of each mineral deposit. In the base of an economic modelremain facilities where they are based facilities and the product they produce. Let’s clarify some basic concepts such as mineralized rocks, ore and mineral.

Mineralized material (rocks)

In a mining economic model mineralized material is the main object of a mining

activity. In geological terms mineralized material represents that part of the rocky bodies where the content of a practical metal is higher than a "cut-off grade" defined previously.With a detailed geological documentation we provided data on the spatial position of this mineralized material, and data on the tonnage and average contents of metals in separate blocks and for all mineralized bodies. Based on this material and the requirements of a given mining – economic model we defined the contours of the mineralized zone. Based on contours of mineralized zone and the mining methodology defined for the extraction of ore reserve for a practical deposits (surface or underground mine), specified mining work for the opening of the mine until the "contact" with mineralized zone, defined system of exploitation, and all mining processes for the extraction of the mineralized material from the rocky massif to surface. At this stage we calculate the full estimated costs for every ton of mineralized material extracted on the surface (see scheme in Figure 1).

Mining Model			
Stage	**Object - assets**	**Processes**	**Production**
Modelling of ore deposit	Mineralized material Geological cut-off grade	Based on mining cut-off grade modelling of ore deposit	Inventors of ore reserves based on average grade of metal (p_m)
Mining operation	Inventors of ore reserves based on average grade of metal *(p_m)*	Developing, opening mining works. Raising, Cross cutting , blasting Transportation of blasting ore	Extracted ore (x) with average grade of metal (p_m)
Enrich ment operation	Extracted ore (x) with average grade of metal (p_m)	Crushing Grinding, Separating,	Preparation of mineral for sale

Fig. 1 Stages of work in a mining model

Ore

The entire amount of mineralized material extracted from underground to the surface is called ore. The extracted ore is the subject of enrichment processes. The cost of processing is calculated for each ton of processed ore in enrichment plants. So a mining activity means the mine and enrichment plants. It would not be normal that the mining activity to sell extracted product without enriched. This brings negative impacts in economic indicators of a mine, relating mainly by transport problems of all ore from mine to the customer.Relations between extractive capacities of a mine, whether it is surface or underground mines, and the processing capacities of enrichment plants, are very important. It generally requires that more than 70% of all ore extracted from the mine to pass directly in the process of enrichment.

The product to be released from the processing of ore (we call it mineral) is the

main indicator in mining activities. As such, this indicator should be maximized in order to get a mining-profit activity.

Mineral

Mining activity usually ends with the ore enrichment process, having as a final product mineral (concentrate), although this product requires other processing processes (melting) before final use in metal industry. So mining activities has as final product mineral and sell it to metallurgy companies. We should mark that the melting process are standard and there are little change for minerals taken from different mines.So the final product of a mining activity (extraction of ore &enrichment) is the mineral. In this moment we determined the economic indicators realized in a mining activity, as the amount of mineral production, in tonnes or kilogram, the cost of production for one ton mineral (or kilogram), selling price and the net amount earned by mining activities. The amount of mineral extracted depends not only on the quantity of ore processed, but also to the averages content of metal in this ore. The relation between the quantity of ore extracted by mining and metal content in this ore arecarefully defined in ratio with economic indicators of mining activity.

The product extracted from the mine, in the terminology of the mining economy, generally called ore. In some cases, depending on the content of metal useful component in the extracted ore, the product can be called mineral. This occurs when the content of metal in the extracted ore is high and this ore can pass directly in metallurgical processes, without having necessarily the enrichment process.

Evaluation of the work processes for the treatment of three components above, until the production of mineral, must be carried separately in the processes related to the extraction of ore from mines and processes relating to the treatment of ore in enrichment plant (see Figure 1).

3. Modelling of ore deposits and calculation of reserves

Among the main factors taken into account in quantitative and qualitative managing of reserves in a mining activity are and the geological factors that have contributed to the creation of mineral deposits. Modelling of mineral deposits and calculation of reserves is higher stages of geological mining and economic evaluation of an ore deposit. Based on ore reserves given for a deposit, we judged on the investments to be carried out for the exploitation of this deposit.

The geological factors have important meaning and create the basis for the quality and quantity management of the ore in mining and enrichment stages. These natural resources play an important role and their studding is a task of paramount importance because they form the bases data upon which will take all other decisions for the development of mining processes and the management of quantity and quality of the extracted ore. The errors made in the mining processes lead to making a small profit compare to the planning profit, while errors in calculating the ore reserve could bring irreparable damage to the rest of the mining project.

The calculation of reserves should not only determine the quantity values of ore bodies but also have to contain clear evidence that characterize the spatial distribution of reserves, the geological and mining conditions, expansion of rich and poor sectors, the nature and degree of change of the main parameters of reserves (metal content, ore body thickness), and other data needed for preparing the mining project.

In recent years, with the introduction in a large scale of geophysical works in research phase of ore deposits, and a numerous of computer programs, modelling of ore deposits is much improved. Nowadays a geologic report, by descriptive materials and digital graphic prepared for a concrete deposit, gives the full details on the spatial position of mineralized bodies, the presence of tectonic which accompany geological environment, the diversity of metal content until the calculation of tonnage and quality for different size of mining blocks. Thisgeological information is sound basis on which decisions are made for managing a mining activity (see Figure 2).

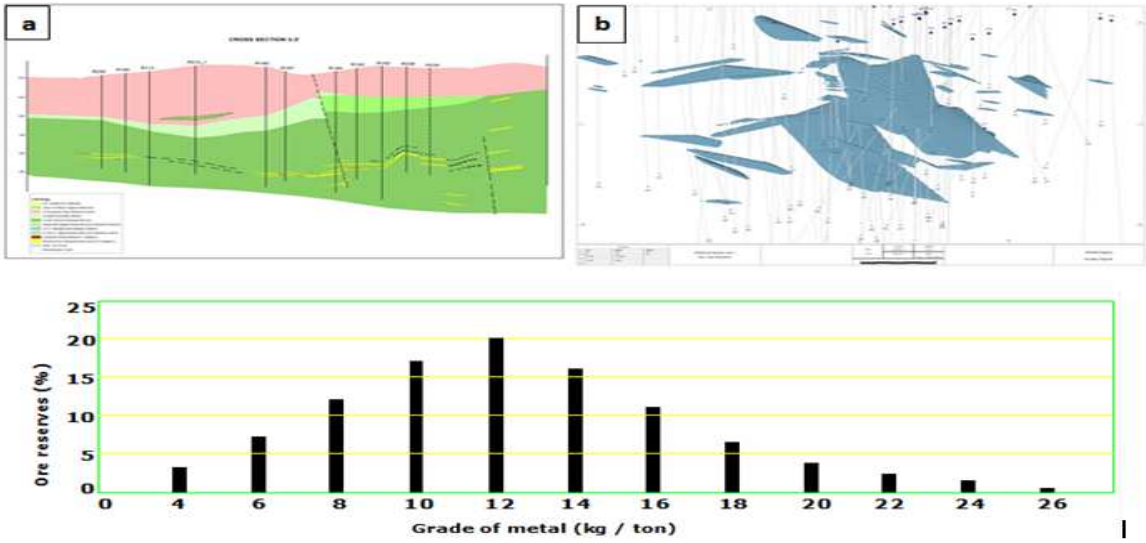

Fig. 2 Graphical documentations from coper mine in Rehova, a) Cross section; b) Presentation of a model for some mining units; c) Information about the distribution of ore reserves in relation with mining cut-off grade.

The calculation of ore reserves based on approved cut-off grade of metal in mineralized material.Based on this cut-off grade of metal the mineralized material reserves divided into industrial reserves the ore mass) and temporary non-industrial reserves. *Minimal cut-off grade in geology* have god relation with *minimal cut-off grade in enrichment*, and usually is a little higher. Based on this cut-off grade, modelling specialists estimate as geological reserves for a given ore deposit only those parts of ore bodies that have grade of metal equal or higher than the minimum cut of grade.

4. Planning a mining activity

Not all ore deposits, although are modelled very carefully, will fulfil all mining and economic criteria to grant a successful mining activity. Mining activities are generally engineering activities with a high economic risk. We marked above that mining activity begins with a performance of opening mining works, preparation and extraction of ore from underground to surface, continues with enrichment process of ore, and ends with the preparation of the ore produced for sale. All these processes must be carried out strictly according to the mining project requirements, with aaim to realise the required product (mineral) and planned costs for each process.The economic assessments of mining activities usually start from indicators of final

product (quantity and quality of mineral)) and the total costs for realization of this product. The formula for the cash flow arising from one unit is:

$$F = (ç - k_m) \cdot x \cdot r \cdot p_m - x \cdot k_p - k_n - k_f \cdot t$$

To calculate the cash flow per unit of output, should know: the price per unit of mineral (ç) and marketing cost per unit (k_m), the amount of mineralized material classified as or (x); index of recovery in enrichment (r) average grade of metal in extracted ore (p_m); treatment cost per unit of mineral (k_p); the cost for ore extraction from the mine (k_n) and time taken to work through one unit (t) with the time cost per year (k_f) (fixed costs for electricity, administration..).

Definition of all terms bringing in this draw, in the stage of preparation of the mining project is difficult to set. All these terms can be roughly estimated, while their true values will be determined at the time that these mining processes are realized. This makes the risk of a mining activity to be very high. Among the factors listed above we will highlight the amount of ore extracted and processed (x) and the content of the average of the metal in the ore (p_m). These two indicators should first carefully assess, as their impact on the success of a mining activity is high. The estimated costs for each process, as well as the selling price of the product (mineral), are sustainable and sure evaluated within certain limits (V. Velev**2**).

The average content of metal in the produced ore (p_m) depending on the average content of metal in the mineralized material, and will be less than this content due to dilution of ore in the process of extraction from underground to surface. This is anobjective dependency. On the other hand this content, from an economical concept, is dictated by the *optimal cut-off grade of metal* required by the enrichment process.

Dilution influences the cut-off in coper mine were we use sublevel method, because you intended or unintended mine material with less or no minerals at all. Mining material below the economic cut-off limit can be critical for a marginal project, because treatment cost factor (production stopping and processing) increase by the dilution percentage. The income component is not directly affected by dilution, as the tonnage x increase by the same factor as head-grade decreases. Problem occurs when treatment is limiting, meaning that processplant or mining equipment has a limited capacity. The outcome in this case will be the sameannual production as for no dilution, producing fewer minerals, requiring more years to produce the reserves (A. M. Sletten 3).

Minimum cut of grade of metal in enrichment. This cut-off grade is determined based on the indicators taken for a given enrichment technology.In other words this cut of grade is related to a lower content of metal in the ore which is accepted for processing in enrichment plants. In this grade firstly affects chosen enrich technology, the type of mineralization, the cost of enrichment and processing capabilities of enrichment plant. Besides minimal cut-off grade in enrichment, there is anoptimal cut-off grade, where for a given grade of metal in ore, reached higher recovery higher in enrichment (content of metal in the output from the plant is minimal), and with an optimal cost in processing . For this condition, the enriching process of the ore reaches the highest economic indicators. Just optimalcut-off grade that requires ore processing technology is the basic indicator of a grade that in turn are used in mining and geology, to achieve an optimal profit in mining activities. The higher the value of optimal cut-off grade in enrichment, the higher will be the value of cut-off grade in extraction processes.

The production capacity of the mine, so the amount of ore produced in quantity (x) and quality (p_m) are required to be as high as possible. In economic terms, based on indicators bring in equation (1), the beginning of a mining activity based on a quantity of reserves defined in quantity and quality. If a source of mining has a high content of metal, but a limited quantity reserves, then this source cannot be the subject of a mining activity. This situation we met in the cooper deposit in Rehovë.Ore deposits “Bregu I geshtenjes” has a limited quantity reserves of copper ore, about 1.3 million tonnes and a high average grade of 1.8% Cu. Although the content of the metal is high, compared with optimal enrichment grade (0.9 – 1.1 % Cu), amount of reserves cannot cover the costs for a new successful mining operation (grupautor 4).

In cases where anore deposit have significant amount of ore, but low metal content, it can be temporarily a non-industrial ore deposit. With improving in technologies, mineral extraction and processing of this king of ore deposits may be subject to a mining activity. In these conditions are nowadays some of the iron-nickel deposits in the region Pogradec - Prrenjas.

Based on this grade of metal, we determine the average grade of metal in extracted ore. Extraction of ore in mining activities carried out simultaneously by several mining units with different grade of metal.Quality management of the ore thus should be provided with sufficient information on the quality and quantity indicators of the extracted ore from different mining units and indicators of dilution of ore in the extracted process. To have effective averaging of the quality of ore is needed to optimise the transport process. There should be enough opportunities for homogenizing of the ore extracted from different mining units. Ensuring a good mixing of the ore with various indicators may be effected by transportation in ore passes, or by using intermediate storage for averaging the grade of the ore. Extraction of ore with constant parameters is crucial for the enrichment process, because even the smallest deviation from optimal cut of grade in processing will lead to poor results in the final product.

The average grade of ore withinthe cut-off boundary is that grade, fulfilling a certain profit criteria or the grade in which the ore pays for itself. A cut-off grade is a complex number depending on economic variables, but also on the nature of the mineralisation. It dictates the selection of mining method, by defining the location andtonnage of the ore. A high cut-off grade may require more selective mining method, affecting mining cost and capacity. Change in raw material prices, costs and technology may also affect the cut-off for production in a long term or short term. It is tempting to mine the high grade stopes at once, gaining quick money, but saving them for periods of low raw material prices, may be the crucial step to avoid mine closure.

5. CONCLUSIONS

A mining activity includes accurate documentations of geological modelling of mineral deposits, a successfully adaptation of mining processes related to geological condition and adaptation of ore enrichment processes.

The management of the quality and quantity of the ore in underground mines, yet in the stage of ore extraction, is an important action of the mining processes. With better planning of mining works are achieved successful technical and economical results.

Among Cut-off grade calculated in a mining activity, mining cut-off grade is more difficult to assess. While in the process of ore enrichment, calculation of optimal

cut of grade depending on the mineralogy of ore and technology selected for enrichment, the mining cut-off grade related with a number of mining processes that is difficult to determine accurately on the stage of a mining project preparation.

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