

PRESENT STATE OF ORE MINING IN SLOVAK REPUBLIC

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SÚČASNÝ STAV DOBYVANIA RUDNÝCH LOŽÍSK NA SLOVENSKU

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Abstrakt

Článok stručne popisuje súčasný stav v dobývaní rudných ložísk na Slovensku ako aj niektoré technologické aspekty dobývania a ťažby dvoch ložísk. Prvým je ložisko Au a Ag Banská Hodruša na strednom Slovensku (historicky veľmi dôležitý región dobývania zlata) a druhým je Fe-sideritové ložisko Nižná Slaná-Kobeliarovo na východnom Slovensku. V súčasnosti obe uvedené ložiská predstavujú rozhodujúcu ťažobnú kapacitu slovenského banského priemyslu. Zlatonosné ložisko Svätozár v Banskej Hodruši patrí do BANSKO-HODRUŠSKÉHO rudného rajóna a Mano-Gabriela železo-sideritové ložisko do SPIŠSKO-GEMERSKÉHO rudného rajóna. V práci sú tiež popísané niektoré technické aspekty dobývania zlatej a sideritovej rudy v Želba, a.s. Spišská Nová Ves (závod Siderit) a Slovenská banská, a.s. v Hodruši. Práca tiež pojednáva o bankých metódach a technológii na oboch bankých závodoch. Spolu s tým sú poskytnuté výsledky dobývania a ťažby v blokoch. Stručne je tiež popísaný tzv. "Zlatý program", ktorý sa v súčasnosti na Slovensku realizuje s cieľom transformácie rudného baníctva na ťažbu vzácnych kovov.

Abstract

The article briefly describes the present state of ore mining in Slovakia and describes some technological aspects of mining and exploitation of two selected deposits. The first is the gold and silver deposit in Banská Hodruša (located in the central part of Slovakia - the historically very important region of gold mining) and second is the iron (siderite) deposit in Nižná Slaná-Kobeliarovo (located in eastern part of the country). At the present time, the deposits belong to the key mining facilities of the Slovak mining industry. The Svätozár gold deposit at Banská Hodruša is in the BANSKO-HODRUŠSKÝ ore district and the Mano-Gabriela iron deposit is in the SPIŠSKO-GEMERSKÝ ore district. The area of perspective extraction of gold and silver is also the deposit of tetrahedrite ore of the Silver vein (Mária Baňa mine) in Rožňava. In the paper, some technical aspects of the gold and iron mining at the mining works - ŽB Spišská Nová Ves, enterprise SIDERIT and the SLOVENSKA BANSKA Ltd. Mines in Hodruša are further described. One part of the paper deals with the mining method and the technology at both mining enterprises. The results of mining and exploitation of the deposits by block-caving are presented. The so-called "Gold programme", which is presently realized in Slovakia, supposing a transformation of the ore mining to the mining of precious metals, is shortly described.

Key words: mining, gold ore, deposit, marketing

1. Introduction

Ore mining and capacities of ore deposits in Slovakia, formerly very important, is presently in quite difficult situation. It is a result of the economic transformation and structural changes in the economy of the Slovak Republic during last ten years. The economical changes need new views on the mining industry and the problematic use of minerals from own deposits. Ore mining has entered the market in which the economical profit of underground mines is decisive. Several deposits of metallic and polymetallic ores were gradually classified to the category of uneconomical and non-perspective small deposits. An attenuation programme for the ore mining has been proposed by the government, according to which non-effective exploitation sites should be liquidated. The main rule was to abandon and, according to the mining law, to liquidate or conserve the mining sites, whose quality of the mineral deposit, technical and geological conditions do not guarantee a prosperity. Simultaneously, it was decided to change the state financial support of the economically nonrentable mining enterprises. Moreover, a conception of utilizing selected metals from mineral deposits has been worked out. Technical-economical variants had to be also evaluated for the transition of non-effective deposits to prove their economical benefit for the mining industry. Two metallic deposits, namely in Hodruša-Hámre (gold deposit) and Nižná Slaná-Kobeliarovo (iron deposit) are presently exploited by prosperous mining enterprises [1].

2. Mineral potential and marketing of minerals

Slovakia owns a limited amount of minerals, creating a large scale of small and relatively poor metallic ore deposits as well as polymetallic ore deposits and rare metals deposits. The metallic and polymetallic deposits of several ores are concentrated in two large ore districts in Slovakia - Banská-Hodrušská and Spišsko-Gemerský, with a historically known exploitation and mining of Pb,Zn,Cu,Fe,Hg,Sb,Sn, etc., including gold-silver ores. In the past, approximately 2,5 million ton of metallic and polymetallic ores was exploited by these mining enterprises in the districts yearly and the whole production of Au and Ag was sold to abroad. The domestic industrial need for the metals was therefore covered by the import and partially by the production from own sources of secondary raw materials.

The well-known deteriorating situation in the marketing of raw materials during years of 1991-1992 (a huge increase and then a decrease of costs for the metals) but also the continuing recession of the industrial production caused a decrease of the domestic metal needs. After eliminating the state subsidies and liberalizing the sale prices, a dramatic decrease and gradual attenuation of exploiting the metallic ores deposits originated. In 1993, an economical unbalance appeared between costs for exploitation and the profits from selling of the production. The whole expenses for the exploitation and processing of the extracted ores were higher than the income from the concentrates. Along with the uneconomical exploitation of the ores, the final treatment of the concentrates in order to beneficiate the metals was not made at Slovakian metallurgical plants. Consequently, it was necessary to analyse the exploitation of metallic ores and the deposits were evaluated by technical- economical case study, using a computer modeling [3]. From the results of the technical-economical evaluation of the metallic ores, a further mining of the deposits was characterized as not economical. It was shown that both ore districts are marked with a low level of information concerning the prospecting and state of the stock at the deposits. It was indicated that there is a need to increase the intensity of geological-prospecting work but also of the openings and preparation works. The known reasons connected with reducing the state subsidy to the area of mining and ore processing did not allow these unambiguously results of technical-economical model to be realized [4]. After analyses of all alternative plans of mining, it was confirmed that, due to the hard market conditions, a next exploitation of the metallic ores would not be possible.

Depending on the knowledge about the raw materials potential, technical and technological development of mining, market conditions and utilizing economical criteria, raw materials have been classified into three groups:

Raw materials, which do not have any chance to achieve an economical prosperity and for the attenuation of mining which is necessary

Raw materials whose mining balances on the boundary of prosperity with an assumption of achieving positive results. This group of raw materials can be further more exploited, with application of technological innovations and modernization

Raw materials excavated or prepared for prosperously mining

Table 1 Ore mineral evaluation according to mining in Slovakia

For the deposits classified into group 1, plans for their liquidation have been worked out. The scheduling plan should be prepared to the end of 2003, when the last uneffective ore mine will be flooded. The financial support for the liquidation has been distributed to individual mining enterprises on early basis, according to the schedule plan of attenuation. From 1993, the state completely stopped the financial support for mining and mineral processing. From this point of view, in the market conditions only two deposits exist in which the ore is presently excavated. Another ore deposits in Slovakia are, according to the grade of valuable components, very poor and they will not be exploited neither by the radical decreasing the costs nor by possible increasing the metal prices on the world market. From the qualitative viewpoint, ores can be evaluated as follows from Tab.1.

3. Underground exploitation of gold and iron ores deposits

On the basis of available characterization of the mining potential as well as of the conception of the utility of chosen metallic raw materials in Slovakia, an attenuation programme was accepted with a time schedule of the exploitation and liquidation of mining enterprises. Amongst raw materials and ores deposits currently exploited, two deposits belong, namely in Banská Hodruša-Hámre (gold) and in Nižná Slaná-Kobeliarovo (iron).

The modern history of the underground mining of gold started in 1972 on the Svätózár deposit at Banská Hodruša. The mining of the only auriferous deposit in Slovakia is realized by the mining society (Slovenská banská Ltd.). The polymetallic ore mineralization of the deposit, in the past mined by the Rudné Bane - state company Banská Bystrica, contained copper and polymetallic ores (Pb-Zn-Cu-Au-Ag) but the mining of this deposit was stopped in 1991 due to economic reasons. In the course of the mine damping and the liquidation of stopes, only those openings were kept operating that could be used for accessing the mine field of the Rozália mine with a promising occurrence of auriferous ores. In addition to the above deposit in which the gold is presently exploited, from the standpoint of prospecting other deposits, a possibility of mining the gold ores in the Pezinok deposit is considered. Further prospecting works, made in the frame of various geological surveys, including these of numerous foreign mine companies, did not prove the existence of any other economically important gold-bearing deposits [5]. At present time exist in Slovakia so called "Gold programme of mining" in which it is assumed to secure gold from domestic polymetallic deposits at the amount of approximately 1 ton of gold per year. Hereby, many foreign mining companies were interested about this programme. Since 1990, after the fall of the former economical regime, foreign companies have started the exploitation activities in Slovakia, culminating between 1995 and 1998. So, at the end of 1998, there was a sharp decrease of exploration activities aimed for gold in Slovakia. There are three main reasons of the decreasing of exploration for gold:

ambiguos results of currently realized projects,

the existing fall of the world prices since beginning in 1997,

the so called Busang swindle, revealed on May, 1997.

Because in Slovakia most of the foreign companies are represented by the junior ones, the third reason can be considered as the most important. Under present conditions of depression, the state recommends recommended to pay the greater attention to the gold prognosis [7]. The most promising gold districts with possibilities of discovering new gold deposits, are at the Banská Hodruša mine. The gold mineral deposits are generally in two groups according to the distribution. The first one, classical gold deposits

and occurrences (vein typ Au-Ag ores, usually connected with neovolcanics) and the second one, untraditional types of gold mineralization (Carlin-typ, gold-porphyries mineralized Au). See Tab.2.

Table 2 Gold ores areas and reserves of gold [7]

4. Present state of mining and treating gold in Slovakia

Slovenská banská Ltd. mines the gold ore along with the silver ore from January 1, 1994. The economical parameters of the mining are such that it can be continuously increased. The initial problems connected with the gold extraction can be characterized as follows [6] :

- a) exploiting of the vein, geologically extremely complicated deposit represents the so-called small-scale ore mining,
- b) unsatisfactory production of the gold mining and the utilization of technological and technical capacity,
- c) very low initial quality of the mined gold ore (only 5.3 g Au per ton),
- d) unsatisfactory quality parameters of the concentrate produced,
- e) low concentrate yield and recovery of the cyanide leaching stage at the gold treating in RB Kremnica,
- f) mining was realized basing on a small volume of geological-prospecting works - 1500 m of stope per year but the investment for the development stope was minimal,
- g) the investment for the purchase of new machines and mining engineering.

During 1994-98 years, Slovenská banská Ltd. succeeded to increase the quality of the extracted ore as well as of the produced concentrate and its yield. In this first stage of mining the given production-technical parameters and production-economic results of mining were such that it could be realized for reserves of Au ores in the Z1 to Z3 category, with the total value was 87 kt in volume and 7.71 g of Au per tone in average. The mining of gold as such represents a complicated system of extracting many vein structures with the thickness of utmost a few tens of cms. The lay and pitch of the vein structures vary appreciably and are tectonically fractured. The ore fill is formed by quartz-carbonate gangue with a content of metallic sulphides and microscopic gold. The adjacent rock of the given vein structures is andesite. That this why the regular geometrization of mined blocks is difficult. Owing to a small area of the vein mineralization zone, the keeping of interblock ore pillars is a presupposition of mining the thin veins. Therefore, the mining method applied in the deposit has a highly selective character and the development of the veins can be followed in such a way that only those or their parts with a requested gold content can be extracted. This method was formerly used for the extraction of polymetallic ores in the Rozália mine as well as of gold and silver in the ancient mines of the Banská Štiavnica and Banská Hodruša auriferous ore area. Using this method, 50 to 60 kt of gold ore with the Au content of cca. 8 g per one ton was extracted in the last years. The scheme of the method, named professionally as the "upward compartmenting by short holes without the lining and with the draw by the scraper hoist" is shown in Fig.1.

Fig.1 Mining method - Upward compartmenting by short holes without the lining

and with the draw by the scraper hoist

The process of the mining is limited by the basic mining-geological conditions and the geometrization of the mined blocks. The interblock preparatory works are the upward drifts, raises, and airways mined with the appropriate profile. The advance of mining is given by the mining of stope face in the whole thickness of veins. As a result of the variability of vein structures the width is also variable. The firing is made with the use of DAP explosive. In order to render the ore chambers, the interblock pillars are used in mined blocks so that the openings in the blocks are not lined. The given mining method enables a flexible adjustment of the mining technology to changed conditions in the development of particular vein structures. The worked-out space in the block is finally selfcaved or the filling material can be used [6].

The applied method of mineral processing is limited by the economic and following technical possibilities. In the flotation separation is attained an appropriate recovery. The research of the flotation process is still open and there are some possibilities of increasing the content of valuable components and their recovery. Aside from the limitations of the physico-chemical character there certainly is a factor of the available flotation machines and the connected investments.

4.1. Environmental aspects of winning and treating gold-bearing ores

In the underground mining of gold using the above mentioned mining method, associated environmental impacts manifested directly in the working area of stopes should be considered. From the standpoint of working environment it is very important to render a hygienic and safe mining of auriferous ores. The removal of dust or choke damp is rendered by the intensive ventilation of the stopes, wet drilling and regular spraying of broken ore before its drawing. From the standpoint of influences of the mining to the surfacial situation, i.e. a possible occurrence of rock and water bursts, the given method is advantageous. The argument is that the structure of the gold deposit and the physico-chemical properties of its rocks (andesite and dacite) are such that an origination of the above rock and water bursts nor consequent deformational surfacial changes can be expected. Moreover, an abrupt water burst is not expected also basing on the hydrogeological situation in the deposit. Therefore, considering the environmental procedures it seems that the deposit can be mined safely. Concerning the underground mechanization used for the mining (scraper hoists, shovel loaders and the preparation of DAP explosive), it does not seem to pollute mine and underground water with petroleum substances, e.g. oils or fuels etc. Furthermore, the pollution of underground water by the radon emanation in the stopes is not probable to occur too. In the case of using methods with the open space during the mining, i.e. when the worked-out space will not be filled with the material, there is no risk of the surface deformation due to the sinking subsidence. When summarizing the above facts, the mining can be characterized as acceptable for the environment since even in the process of liquidation of the worked-out space and stope no ecosystems and their components on the surface would be disturbed thank to a suitable hydrogeological regime. Moreover, agricultural, forestial or any other ecosystems will not be influenced after all appearances.

During last years the gold mining in Slovakia has been complicated due to objective economic conditions resulting from changes at the world metal exchange. Especially, it was the extensive variation of the price and sudden decline of the demands for the production of gold that caused the difficulties with the mining of gold by Slovenská banská Ltd. Hodruša-Hámre. This company uses only own financial resources and its products sells for the market price. That is why it faces a dilemma of how to take care of reality, represented by the presently low price of gold. Possibilities of further economically effective mining of gold ores in the deposit are sought, e.g. lowering the operating expenses, connected with restricting the drive of development and preparation stopes in the mine but also the prospecting on the surface. Simultaneously, the investment to the mining enterprise at the deposit was limited radically. The possibilities of higher recovery and total quality of produced concentrates, and of lower consumption of electric energy and material costs based on the increasing of

work productivity are economical tools of improving the production-economic results of the winning and processing.

Environmental risks of winning gold by the cyanization process are well known. In the case of a disaster the consequences can be very serious. This is confirmed by the event in Europe. This is however not an urgent problem in Slovakia. However, for the possible winning and processing of gold in the future, methods (physical and physico-chemical) with a minimal effect on the environment should be chosen in the first stage, excluding the percolation leaching of the Au ore using cyanides. The cyanide leaching of concentrates (from the gravity or flotation concentration) is not so dangerous since such a method can be well controlled and is verified in the practice. When following the technological discipline, safety measures and procedures of liquidating cyanide residues, environmental hazards can be even entirely minimized. In the flotation of Au ores it is possible to rise the recovery by optimizing the reagents used, especially the collecting surfactants [5]. The flotation process itself is presently safe enough and connected environmental problems are possible only in the consequence of a serious trespassing the safety measures. Therefore it can be concluded that in the present situation in Slovakia there are satisfactory research, professional and technical hinterland needed for solving the environmental problems connected with the winning and processing gold [7].

5. Present state of siderite mining in Slovakia

The important exploitation localities for mining iron ore in Slovakia are two metasomatic-siderite deposits Mano-Gabriela and Kobeliarovo. Both deposits have been exploited by the ZB Spisska Nova Ves, mine enterprise SIDERIT - Nizna Slana. At the deposits have been applied several variants of the caving-stoping methods on the block. Mostly the sub-level caving with the short drilling and with fell haulage by means of scraping drills or by transport loaders. The second most widely used alternative is the sub-level caving stoping with the aid of medium length bores and with the romboid arrangement, without an accumulation space (Fig.2).

Fig.2 Sub-level caving method with the romboid arrangement of production openings

This mining method uses in full range high performance by the mining on the block-stoping up to 35-40 $t \cdot man^{-1} \cdot bed^{-1}$. For all caving stoping methods on a deposit the methodological basis is "The theory of Flow of Loose and Granulated materials and Substances in ore containers", from which all suggested parameters of mining in a stope block are derived. The mining in stope-block uses the system LHD. The all mining activities by the caving stoping technology are realized with helpfull LHD-Mechanization System. The technology of the sub-level caving is appropriate for heterogeneous ores with particular mining-geological exploitation conditions and space qualitative, quantitative and geo-mechanical characteristics of ore filling and surrounding rock background. A geometrical arrangement of exploitation haulage corridors in the stope block and on the sub-level is linked to the system of extra-block ramp opening and preparation. For the suggested geometrical parameters their mutual conditioning and dependance in the stope block space are typical. In the analysis of fell flow parameters from the haulage ellipsoid the effect of qualitative characteristics of ore and thrust is shown.

Table 3 Overview of mining output

Operational parameters can be controlled in a way while maintaining operational discipline within the basis technological operation of boring and haulage. The objective of the suggested optimum parameters in sub-level caving is to achieve a maximum geometrical and technological block stoping, as well as permissible pollution values. The operational-technological stoping parameters in a stope block present controllable variables, by which the resultant indicators of stoping in a ore block, or eventually on a sub-level, can be effected (stopping rationality indicators, such as stoping, pollution a preparatory work ratio and working performance). For achieving stoping optimum parameters at Sub-level caving method (SLCM), it is necessary in the stoping system to optimize all parameters in the specified groups. For the system of LHD-mechanization and for a fell haulage model on a sub-level was prepared and used method of a computer simulation model [4]. For the shuttle-like character of activity of transport loaders between the place of the disintegrated ore and haulage system could be defined and modeled by the computer. For the fell haulage on a sub-level of the stope block a particular situation, including basis variables for a simulation program, could be described mathematically. The basic variables of a computer simulation program in its end-user version include: a number of localities of primary blast spots, a number of chemical components, a number of transport loaders, maximum progress of transport loaders in the process of haulage, a discharge time interval statistically screened according to a scale and a class interval, a stimulus threshold of a transport loader return to the blast spot.

In solving the problem of the activity optimizing of the transport loaders on the sub-level the above mentioned variables were to be characterized in a detailed way and the whole problem had to be formulated by a computer program. The results of mining technology on the block-stoping for both mining methods are shown in Tab.3.

5. Conclusion

From the standpoint of structure of the Slovak mining industry, both the presented deposits and their mining methods and technologies play a very important role in the exploitation of minerals from own resources. It should be noticed that another ore deposits in the Slovak Republic have no chance to be exploited. Presently, all ore deposits are closed and in the period of flooding. If the big metallurgical plant in Košice will further produce steel, the siderite mining in Nižná Slaná will be perspective as well. Otherwise, the mining enterprises will be abandoned. The gold mining will depend exclusively on the gold market price.

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