INNOVATIONS IN THE MINING METHODS IN THE "VARBA – BATANTZI" UNDERGROUND MINE

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ABSTRACT. The paper reviews the innovations in the mining methods applied in the "Varba - Batantzi" underground deposit. The mining method applied at the moment in the mine, "sublevel caving", is analysed and attention is paid to the need of creating and designing new mining methods for the "Varba – Batantzi" underground mine. Innovations in the new mining methods are described – "sublevel caving" and "cut and fill" for the specific conditions in the mine. The technological parameters of the new mining methods are presented. Some conclusions are given.

Keywords: mine, innovation, technological parameters

ИНОВАЦИИ ПРИ СИСТЕМИТЕ НА РАЗРАБОТВАНЕ ЗА НАХОДИЩЕ „ВЪРБА – БАТАНЦИ"

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РЕЗЮМЕ. Статията разглежда иновациите при системите на разработване прилагани в находище "Върба - Батанци". В статията е направен анализ на сега прилаганата система на разработване с подетажнио обрушаване в находището и е обърнато сериозно внимание на необходимостта от разработване и конструиране на нови системи на разработване за рудник "Върба - Батанци". Също така са разгледани и иновациите при новите системи на разработване – с подетажно обрушаване и крепене и запълване с прилагане на мобилна механизация. Представени са технологични показатели при системите на разработване и са дадени изводи и заключения.

Ключови думи: рудник, иновация, технологични параметри

Need for changes in the applied mining methods

The development of mining works in the "Varba - Batantzi" underground mine necessitates its modernisation both with the introduction of new machinery and with the introduction of new technology − the introduction of new and innovative mining methods.

It is necessary to apply different mining methods for the different mining areas for the complete mining of the reserves in the deposit. There are no restrictions for protection of objects and facilities in and outside the mine on the flanks of the two sections of Varba and Batants deposits. The project deals with a much more productive and less mine process engaged mining method (sublevel caving mining method). However, a heavy, energy-intensive and resource-intensive mining method with a single-layer of cut and fill mining method is required in the central area of the deposit to guarantee the stability of the existing infrastructure and to ensure the mining of the reserves in the vertical shaft pillar.

The aim of the project is to find optimal parameters of the proposed new mining methods in order to increase the production and to achieve the optimal effect.

Applied mining method in the "Varba - Batantsi" deposit (Anastasov, Eftimov, 2013)

The preparation of the block in the applied mining method, sublevel caving, is characterised by rock drifts. The block rise is running out of the influence area of rock movement, and it is made with an inclination of 72° according to the ore body. The main level gallery is drifted in the rock mass with cross-section of 7.0 m^2. Its length is 50 m and it is attached with ¾ wooden frames through 0.75 m, which defines a light cross section of 6.2 - 6.4 m^2. The rise starts at the 25th meter (in the middle of the ore block) and it is with cross section of 6 m^2 (3 m x 2 m). The rise is with two compartments − one is a walk-in ventilator and the other is an ore pass.

From the block rise the cross cuts are drifted to the sub level gallery. The cross section is 7.0 m^2 and is secured with ¾ wooden frames and siding. Their light section is 6.2-6.4 m^2 and is connected with the mechanisation used or mining.

At the mail level gallery, a 10-meter-long cross cut is made with a 7.0 m^2 cross section, which is again secured with ¾ wooden frames. It makes a connection with the first sub level, and the same is used for ventilation and second exit for the next block.

At the bottom of each intersection, a scraper area is formed (5 pieces), with a length of 2.5 m, a section of 7.0 m^2, in which a scraper is mounted.

At both ends of each of the sub level galleries, it is planned to run initial compensatory spaces with a height of 7.5 m and sections of 6.0 m^2 (3 m x 2 m). They are classically made by sectional blasting of boreholes with a diameter of 51 mm (special passport) and use of the ANFO explosive.

The required time for all mine workings for the preparation of one ore block is 8.01 months.

The drilling and blasting works foresee the drilling of boreholes with a diameter of 51 mm and a heights of 10 m. The drilling gallery has a cross section of 7.0 m^2.

Borehole loading is mechanised with bulk explosive ANFO and use of AZS-35 or "Kurama" charging machine.

At the same time, one fan is blasted to obtain a 1.8 m thick layer, ensuring normal draining of the ore.

The drain is carried out by a scraper system with a volume of 0.4 m^3 and a scraper with a capacity of 30 kW.

The ore supply under this mining method is done by angular scraping along the undercut work and the intersection to the block rise.

The frames are dismantled before drilling of the boreholes by dismounting 2 frames at the same time spaced 0.75 m apart.

Table 1.

No	Parameter	Dimension	Quantity
1.	Type of block preparation – in the rock mass	-	-
2.	Block parameters		
.	- length	m	50
	- main level height	m	50
	- average thickness of the vein	m	3.0
3.	Angle of inclination of the vein	◦	80
4.	Drill costs	m/m^3	0.84
5.	Blasted ore from 1 m of drill hole	m^3/m'	1.19
6.	Ore density	t/m^3	3.0
7.	Sublevel height	m	10.0
8.	Mining method losses	%	10
9.	Primary sterile mass intake	%	17
10.	Productivity of miner	m^3/person per shift	11.98
		t/ person per shift	35.94
11.	Daily block production	t/day	158.5
12.	Monthly block production	t/month	3486.8
13.	Number of blocks in simultaneously works for 120 000 t/year ore production.	number	3
14.	Number of blocks in preparation	number	5

Innovations in the mining methods in the "Varba - Batantsi" deposit (Anastasov, Eftimov, 2018; Yanev, Anastasova, 2015)

The existing mining method in the underground mine "Varba - Batantsi" is characterised by the use of a large amount of manual labour, using the old equipment which leads to achieving unsatisfactory results. The innovations related to the proposed new mining methods are linked with the use of modern equipment, manual labour reduction and increased production performance. This leads to the design of new mining methods for the deposit and their connecting to the specific conditions in the underground mine.

A sub level caving method for mining the reserves in the flanks of the deposit and a cut and fill method for the reserves in the vertical shaft pillar are introduced.

Sub level caving mining method

- Option I

The preparation of the block with this version of the mining method is done in the rock mass and includes the drifting of a 210-meter-long gallery with a section of 7 m^2, as well as a 61m-high block rise with a 6 m^2 cross section.

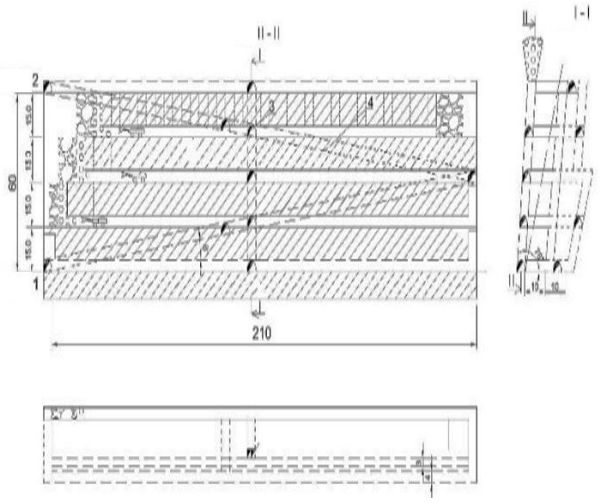

Fig. 1. Sub level caving method

Preparatory mining work includes drifting of cross cuts from the rise with a length of 10 m, a cross section of 12 m^2 and a local inclined ramp 212 m in length and 14 m^2. Four cross cuts are drifted from the local ramp with a single length of 25 m and a cross section of 14 m^2, which provide the access of the mobile mechanisation to the extraction mine faces in each block.

In order to enter the block and start with the mining of the ore four sub level galleries are to be done with a cross section of 12 m^2 (4 x 3 m), a total length of 840 m and a compensatory space of 8 pieces with a cross section of 9 m^2 and a total length of 80 m for ensuring the mining activities. The compensatory spaces are driven at the bottom of each sub level gallery.

Fig. 2. Drilling and blasting design applied to the sub level caving mining method

- *Option II*

The mining method design (the block design) applying the sub level mining method Option II includes drifting of sub level galleries through the ore body and in the local inclined ramps, intersections and rises of the rock mass.

The dimensions of the designed blocks in this version of the mining method are different for each block and are limited by the specific dimensions of the ore body in the area. The design of the parameters takes into account the optimal distances for the new mobile equipment which is used. The block sizes of this sub level caving mining method Option II are approximately 200x105x2.5 m.

For the preparation for mining of the reserves at "Varba-North" all of the mine workings include sub level galleries, local ramp N1, cross cuts and rise with a total length of 4165 m, the costs for this task is BGN 5709700. The reserves prepared for mining are 668749 t with relative costs 8.54 BGN/t.

The mining drifts for preparing the reserves of the “Batantzi” mine include sub level galleries, local ramp N 2 and 3, cross cuts and rises with a total length of 4335 m, costs of BGN 4966259. Thus, the total running costs are BGN 6629420 with relative production costs of 7.94 BGN/t.

Cut and fill mining method

- *Option I*

For mining the reserves in the "Varba - Batantsi" underground mine a new innovative cut and fill mining method designed for use of a mobile equipment is offered.

The parameters of the exploitation ore block are: 210 m length; height 60 m; ore body width - 3 m with an angle of 80°.

In order to optimise the mining processes, it is considered to simultaneously work in faces in 3 different dimensions both from bottom to top and from top to bottom.

14m^2 cross cuts are made to provide the drill rig and the front end loader approach. After the cross cut, the first layer is done and the lower part of the inclined local ramp is placed.

The drifting of the main level gallery and the block rises (the movement of each mine face) are combined in order to prepare the reserves in block for mining for not more than 5.6 months.

- *Option II*

For mining of the reserves in the Varba Central section of the mine a cut and fill mining method with local ramps and usage of new mobile equipment are offered.

The dimensions of the exploitation ore block according to Version II of the cut and fill mining method are different for each block and are limited by the specific size of the ore body in the area. The design of the parameters takes into account the optimal distances for mobile equipment as well as the necessary distance from the ore vein to ensure that mining operations do not enter a zone of motion. The block unit dimensions are approximately 160x105x2.5 m.

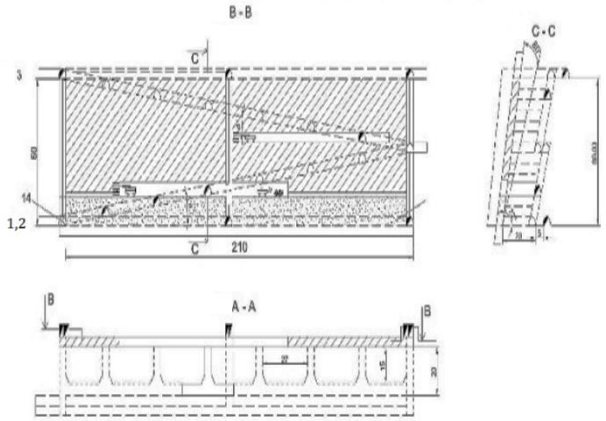

Fig. 3. Cut and fill mining method

The mine workings for this mining method for preparation of the ore body for development are made in the rock mass and include a local ramp, a block rise and triple cross cuts as follows:

• Spiral No 4, triple cross cuts and rise with a total length of 4590 m with a total value of BGN 5434250. The prepared reserves are 693452 t. The relative costs for mining are BGN 7.84 per ton.

• Spiral No 5, cross cuts and rise with a total length of 3437 m and a value of 4776980 BGN. Prepared ore reserves are 372910 t. The relative costs are BGN 12.81 per ton.

• Spiral No 6, cross cuts and rise with a total length of 3401 m, amounting to BGN 4755940 is required, with the prepared reserves being 308251 t. The relative costs are 15.43 BGN/t.

• Spirals No 7, cross cuts and rise with a total length of 3534 m with a value of BGN 4954940. The prepared reserves are 323919 t at a relative cost of 15.30 BGN/t.

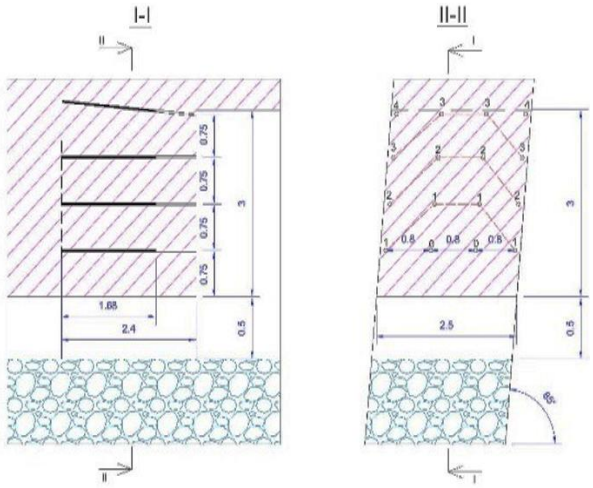

Fig. 4. Drilling and blasting design applied to the cut and fill mining method

Technical and economic indicators in the new mining methods

Table 2.

Parameters	Measure	MINING METHODS		
		Sub level mining method applied at the moment	Cut and fill mining method Option II	Sub level caving mining method Option II
Length of the ore block	m	50	160	200
Height of the main levels	m	50	105	105
Width of the ore body	m	3.0	2.50	2.50
Inclination of the ore body	°	85°	85°	85°
Extracted ore from 1 m of drill hole	m^3/m	0.6	0.47	1.02
Height of the layer/sub level	m	7.0	3.0	15.0
Average production of a mine operator	m^3/miner per shift	5.45	9.04	22.21
Number of the miners up to August 2018	number	229	164	164
Annual mined volumes based on the mining activities	t/year	101 000	130 000	106 524
Average monthly mine production	t/month	8 486	10 805	8 877
Beneficiation costs	BGN/t	25.94	25.94	25.94
Production cost for 1 ton of ore for mining and beneficiation	BGN/t	106.24	84.36	90.13

The economic efficiency of the combined implementation of the sub level caving and cut and fill mining methods Option II shows the following (Anastasova, Yanev, 2017; Siderova, 2018):

- Applying the current mining method, with annual output of 101000 tons of ore and a cost of 106.24 BGN/t an annual loss of approximately BGN 650000 is generated.

- When combining and implementing the new mining methods, sub level caving and cut and fill Option II, the annual output is increased to 236000 tons from both mining methods (130000 tons and 106000 tons, respectively) and an average mine production cost of BGN 87.30 per ton. An annual profit of approximately BGN 3,000,000 before tax and concession fee is realized.

Conclusions

The proposed new mining methods, sub level caving and cut and fill Option II are uniquely designed and developed for each extraction ore block from the deposit. Optimal results are obtained when the two methods are applied together in the underground mine.

The proposed new mining methods, sub level caving and cut and fill Option II, allow the annual production of the mine to increase from 101000 t/y up to 236000 t/y or 2.3 times.

The average productivity of a mine worker is increased from 5.45 m^3/miner per shift up to 15.63 m^3/miner per shift or about 3 times.

The introduction of new mining methods with the usage of mobile equipment allows for the optimisation of the number of workers assigned from 229 to 164, mainly due to the reduction of the staff in extraction, fritters, as well as workers in the field of transport and electric machines.

The implementation of the new mining methods, sub level caving and cut and fill Option II, generates an annual profit of approximately BGN 3000000 before taxes and a concession fee.

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