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ANALYSIS THE POSSIBILITY OF INCREASING CAPACITY OF COPPER ORE MINING AT THE OPEN PIT SOUTH MINING DISTRICT MAJDANPEK AT 11×10^6 TONS ANNUALLY**

Abstract

The paper analyzes the possibility of increasing capacity at the Open Pit South Mining District in terms of achieving maximum net present value. The analysis is based on the movement of discounted cash flow during exploitation period of 18 years. The modern approach of designing the open pits was used for this consideration using the software Whittle and Gemcom Gems.

The analysis showed a positive trend of discounted cash flow from the third year until the end of analyzed period in achieving the net present value in the amount of 596 252 546 \$.

Keywords: *Open Pit South mining District Majdanpek, optimization of boundary of open pit, open pit development phase, net present value, software Whittle, Gemcom*

INTRODUCTION

Mining works at the open pit South Mining District, which were suspended in May 2009, continued in 2012 by stripping the deposit on location Andesite finger, on the basis of designed technical solutions by the experts from the Mining and Metallurgy Institute Bor from Bor [1], [2].

In accordance with the new strategic plan of development of copper production in RTB with the annual production capacity of 80-85 000 t of ore, it is necessary to increase the capacity of ore mining and processing at the open pit South Mining District from the existing capacity of 8.5 million tons to 11 million tons annually. Among others, this is one of the prerequisites for achieving the

profitable mining and processing of copper ore.

The long-term designing of the open pit and solution to the problem of optimization was achieved by modeling the problems using software. Software, which were used, Whittle and Gems, their work based on an algorithm that is applied to a three-dimensional block model of the ore body South Mining District

Technical and economic analysis were carried out in software Whittle, while the deposit modeling and design of optimal contour of the open pit and development phase of the open pit development were carried out in software Gemcom Gems.

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PROBLEMS OF THE PRODUCTION SYSTEM AT THE OPEN PIT

The basic problem of the production system at the open pit South Mining District is:

- Deviation from designed calendar plan of excavation.
- Implementation of works out of designed boundaries of the open pit.
- Delay in revitalization and rehabilitation of mining machines and infrastructure facilities (transport system for overburden TS-1 crushing plant for ore).
- Pumping of mine water, which is of crucial importance for ore mining at the open pit, has not yet commenced. Also a problem is in defining an optimal technology for treatment of such waters, as well as the treatment plant.

Also, in the coming period it is necessary to carry out the relocation of capital infrastructural facilities in the coming period, as follows:

- A route of the state road M22 I B order.
- A part of the route of the existing power line 35 kV.
- The riverbed of the river Mali Pek.
- The town collector of waste water.

METHODOLOGY

Analysis of the possibility of increasing the capacity of mining was carried out on the basis of long-term planning of copper ore exploitation at the open pit South Mining District.

The conducted analysis in this paper, with the aim of maximizing the net present value is achieved by application the method of geostatistical modeling, method of long-term planning and optimization method for open pits.

The procedure is carried out through the following steps:

- 1) The first step presents a development of block model using the statistical methods for analysis and assessment. Deposit modeling was performed in the software Gemcom Gems.
- 2) The second step is optimization the final contours of the open pit. The basis for optimization is the block model. In this paper, optimization of the open pit of copper ore was carried out in the software Whittle that applied a modified Lerchs-Grossmann algorithm. Software for generating the nested pits and defining the pushbacks uses a technique of parameterization (Revenue Factors), and calculation is based on undiscounted cash values.
- 3) The third step is to define the development phases of the open pit. The main reason for planning the development phase of the open pit is of economic nature, i.e. maximization the net present value.

In defining the development phases of the open pit, the following requirements are satisfied [3]:

- There is a minimum allowable distance between the phase boundaries.
- There is a minimum working width of each phase bottom.
- NPV of each phase is positive.
- NPV for defined phases is maximum.

In addition to the economic, the practical importance of the phase open pit development is also considered, and it is applied to the problems caused by the excessive number of phases which can lead to [3]:

- increase in costs for maintenance of many sites,

Modeling of deposit

- increase in costs due to the redevelopment of transport routes,
 - insufficient width of the working platforms for operation of mechanization,
 - increased number of the primary and auxiliary equipment, etc.
- 4) The fourth step defining the mining dynamics. The analysis is based on the Milawa algorithm, which is supported by the software Whittle, and it is specifically designed for defining the mining dynamics in long-term planning strategies of exploitation.

Geological reserves of the copper deposit South Mining District Majdanpek were calculated by the method of mini blocks, whereby the dimensions of the blocks are $15 \times 15 \times 15$ m. The basis for calculation the geological reserves is a digital block model of deposit which was formed in the software Gemcom using the geostatistical methods of analysis and assessment [4], [5].

Figure 1 shows a three dimensional view of the block model Cu in the deposit South Mining District.

Figure 1 Three dimensional view of the block model Cu in the deposit South Mining District

Optimization of the open pit boundary

Optimization process was carried out on the basis of defining the selling price of metals, discount rate and costs and efficiency of excavation, flotation and metallurgical treatment.

Table 1 presents the starting parameters used to define the optimal contour of the open pit and defining the excavation phases.

Table 1 Starting parameters for optimization the open pit boundary and defining the excavation phases

Parameter	Unit	Value
Base metal prices		
– Copper	USD/t	6 000.00
– Gold	USD/kg	35 000.00
– Silver	USD/kg	650.00
Costs of ore mining	USD/t	1.50
Costs of overburden mining	USD/t	2.50
Costs of flotation ore processing	USD/t	3.20
Costs of metallurgical treatment of concentrate		
– Costs of copper production from concentrates	USD/t Cu cathode	600.00
– Costs of gold refining	USD/kg	150.00
– Costs of silver refining	USD/kg	15.00
Flotation copper recovery from ore	%	86.0
Metallurgical copper recovery from ore	%	98.5
Total recovery on gold	%	50.0
Total recovery on silver	%	50.0
Discount rate	%	10

Ore mining capacities are limited by years, based on assessment the possibility of increasing the capacity of flotation processing.

The planned value of ore mining capacity at annual level is as follows:

1. In the 1st and 2nd year
6 000 000 t of ore
- In the 3rd year
8 500 000 t of ore

- in the 4th year to the end of the exploitation period
11 000 000 t of ore

Overburden mining is limited by the capacity of the transport system for waste TS-1 (27 million tons per year) and capacity of the external waste dumps (Table 2 and Figure 2). Due to this reason, maximum designed capacity of waste is 32 million tons per year.

Table 2 View the capacities of the external waste dumps

Capacities of the outer waste dumps				Total
Kovej	Andesite finger	Bugarski potok	Dump	
1 995 000	8 000 000	13 000 000	23 500 000	46 495 000

Figure 2 View of the truck dumps

The optimum boundary of excavation the open pit was obtained using the software for optimization and strategic planning of the open pits Whittle [6], [7].

Figure 3 graphically shows the results of optimization for the base copper price of 6000 USD/t, on the basis of which the optimal contour of the open pit and development phases of the open pit are selected.

Figure 3 Graphical presentation of optimization results (Pit by pit graph)

It can be seen from graph that, for the adopted technical-economic parameters the open pit No. 25 was chosen as the optimal one. The selected open pit has total of 549,837,135 t excavation, out of which 175,536,668 t of ore and 374,300,467 t of overburden. Overburden coefficient is 2.13 t/t.

Defining the development phases of the open pit (Pushbacks)

After determining the final borders of mining, the next step in the process of designing the open pits is to define the excavation phases.

Simulations and DCF analysis are carried out in this step to obtain the most favorable variant, or determine the number of

phases that affect the maximization of net present value for long-term planning of open pits.

Based on the results of optimization, which is graphically shown in Figure 3, the excavation phases are defined and those are the open pits Nos. 18 and 22. Based on a need of providing the quantities of ore by the mining dynamics, according to the request of the Investor, with minimum quantity of overburden, it is necessary to split the open pit No. 18 into four phases, whereby the northern part is the Phase 1, the eastern phase is the Phases 2 and 3, and the southern and western part are designated as the Phase 4. Pursuant to the adopted rule of labeling the phases, the open pits Nos. 22 and 25 are defined as the Phase 5 and Phase 6, respectively (Figure 4).

Figure 4 View of the final contour (3D view)
a) Phase 1; b) Phase 2; c) Phase 3; d) Phase 4; e) Phase 5; f) Phase 6

Optimization of mining dynamics

Mining dynamics by years of exploitation was obtained in Whittle software. To optimize the mining dynamics, the used software was Milawa algorithm

for balancing regime (Milawa Balanced) [8].

Results of optimization the mining dynamics are shown in Table 3.

Table 3 Mining dynamics by years and periods of exploitation

Year	Ore (t)	Overburden (t)	Excavation (t)	Overburden coefficient (t/t)	Cu	Ag	Au	Cash flow	Cash flow (disc)
					%	g/t	g/t	\$	\$
1	5 999 884	32 000 116	38 000 000	5.33	0.253	1.230	0.159	- 22 398 758	- 20 362 507
2	6 000 000	24 936 051	30 936 051	4.16	0.275	0.910	0.092	- 10 929 178	- 9 032 379
3	8 498 890	31 501 110	40 000 000	3.71	0.332	0.980	0.150	19 931 446	14 974 790
4	10 999 696	29 000 304	40 000 000	2.64	0.371	1.441	0.310	109 734 414	74 950 081
5	11 000 000	25 307 661	36 307 661	2.30	0.340	1.197	0.188	82 744 790	51 378 004
6	10 998 579	32 001 421	43 000 000	2.91	0.372	1.065	0.211	88 765 834	50 105 999
7	10 993 690	32 006 310	43 000 000	2.91	0.396	2.292	0.288	110 481 287	56 694 369
8	10 999 785	32 000 215	43 000 000	2.91	0.393	2.042	0.301	112 074 145	52 283 416
9	10 987 165	32 012 834	42 999 999	2.91	0.404	1.587	0.265	113 338 664	48 066 657
10	10 999 999	27 167 299	38 167 298	2.47	0.430	1.319	0.211	118 184 201	45 565 126
11	10 999 999	21 171 797	32 171 796	1.92	0.412	1.244	0.187	143 817 710	50 407 230
12	10 999 999	24 875 159	35 875 158	2.26	0.404	0.888	0.110	95 904 893	30 558 255
13	11 000 000	25 766 972	36 766 972	2.34	0.344	1.939	0.170	74 240 820	21 504 921
14	11 000 000	8 467 334	19 467 334	0.77	0.334	2.192	0.220	124 017 674	32 657 730
15	11 000 000	3 536 252	14 536 252	0.32	0.337	2.022	0.189	132 320 385	31 676 448
16	10 999 998	9 514	11 009 512	0.00	0.329	1.389	0.165	132 997 165	28 944 058
17	10 999 996	0	10 999 996		0.341	1.303	0.159	137 458 664	27 195 464
18	4 288 324	0	4 288 324		0.320	1.068	0.122	45 559 243	8 684 884
Total	178 766 004	381 760 349	560 526 353	2.14	0.361	1.493	0.201	1 608 243 399	596 252 546

CONCLUSION

The performed analysis the possibilities for increasing the capacity at the open pit South Mining District was carried out using the software for optimization and strategic planning of the open pits Whittle, which is based on an analysis of trends the discounted cash flow during its service period, or the net present value, and that is an indicator of the achieved economic results of exploitation the deposit South Mining District for the given initial conditions. Deposit modeling and design of optimal contour of the open pit and the phases of development the open pit are carried out in the software Gemcom Gems

On the basis of performed analysis, the following is concluded:

- 1) There is a possibility to increase the capacities of copper ore excavation at the open pit South Mining District Majdanpek, which is realized in the 4th year for the analyzed period.

- 2) Service life of the open pit mining is 18 years.
- 3) Movement in cash flow is positive throughout the whole period of exploitation, except in the first and second year of the analyzed period.
- 4) The net present value is achieved in the amount of **596,252,546 \$**.

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ANALIZA MOGUĆNOSTI POVEĆANJA KAPACITETA OTKOPAVANJA RUDE BAKRA NA POVRŠINSKOM KOPU JUŽNI REVIR MAJDANPEK NA 11x10⁶ TONA GODIŠNJE**

Izvod

U radu je izvršena analiza mogućnosti povećanja kapaciteta na površinskom kopu Južni revir sa aspekta ostvarivanja maksimizacije neto sadašnje vrednosti. Analiza se bazira na kretanju diskontovanog novčanog toka tokom eksploatacionog perioda od 18 godina. Za ovo sagledavanje korišćen je savremeni pristup projektovanju površinskih kopova primenom softvera Whittle i Gemcom Gems.

*Analiza je pokazala pozitivno kretanje diskontovanog novčanog toka od treće godine do kraja analiziranog perioda, pri čemu se ostvaruje neto sadašnja vrednost u iznosu od **596.252.546 \$**.*

***Ključne reči:** površinski kop Južni revir Majdanpek, optimizacija granice kopa, fazni razvoj kopa, neto sadašnja vrednost, softver Whittle, softver Gemcom Gems*

UVOD

Rudarski radovi na površinskom kopu Južni revir, koji su obustavljeni maja 2009. godine, nastavljani su 2012. godine, raskriivanjem ležišta na lokaciji Andezitskog prsta, na osnovu projektovanih tehničkih rešenja od starne stručnjaka iz Instituta za rudarstvo i metalurgiju Bor iz Bora [1], [2].

U skladu sa novim strateškim planom razvoja proizvodnje bakra u RTB-u sa godišnjim kapacitetom proizvodnje od 80-85.000 t rude, neophodno je povećanje i kapaciteta otkopavanja i prerade rude na površinskom kopu Južni revir sa postojećeg kapaciteta od 8,5 miliona tona na 11 miliona tona na godišnjem nivou. Pored

ostalih, ovo je jedan od preduslova za ostvarenje profitabilne eksploatacije i prerade rude bakra.

Dugoročno projektovanje površinskog kopa i rešenje problema optimizacije ostvareno je modeliranjem problema primenom softvera. Softveri koji su korišćeni, Whittle i Gems, svoj rad baziraju na algoritmu koji se primenjuje na trodimenzionalnom blok modelu rudnog tela Južni revir.

Tehničko-ekonomska analiza izvršena je u softveru Whittle, dok je modeliranje ležišta i konstrukcija optimalne konture kopa i faza razvoja kopa izvršena u softveru Gemcom Gems.

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PROBLEMATIKA PROIZVODNOG SISTEMA NA KOPU

Osnovna problematika proizvodnog sistema na površinskom kopu Južni revir jeste:

- Odstupanje od projektovanog kalendarskog plana otkopavanja.
- Izvođenje radova van projektovanih granica kopa.
- Kašnjenje u revitalizaciji i sanaciji rudarskih mašina i infrastrukturnih objekata (transportni sistem za jalovinu TS-1, drobilčno postrojenje za rudu).
- Ispumpavanje rudničkih voda, što je od presudnog značaja za otkopavanje rude na kopu, nije započeto. Problem je i definisanje optimalne tehnologije prečišćavanja tih voda, kao i samog postrojenja za prečišćavanje.

Takođe, u narednom periodu neophodno je da se izvrši izmeštanje kapitalnih infrastrukturnih objekata i to:

- trase državnog puta M22 I B reda,
- dela trase postojećeg dalekovoda 35 kV,
- korita reke Mali Pek,
- gradskog kolektora otpadnih voda.

METODOLOGIJA

Analiza mogućnosti povećanja kapaciteta otkopavanja sprovedena je na osnovu dugoročnog planiranja eksploatacije rude bakra na površinskom kopu Južni revir.

Sprovedena analiza u ovom radu sa ciljem postizanja maksimalne neto sadašnje vrednosti, ostvarena je primenom metoda geostatističkog modeliranja, metoda dugoročnog planiranja i metoda optimizacije površinskih kopova.

Procedura je sprovedena je kroz sledeće korake:

- 1) Prvi korak predstavlja izradu blok modela primenom geostatističkih metoda za analizu i procenu. Modeliranje ležišta izvršeno je u softveru Gemcom Gems.
- 2) Drugi korak je optimizacija završne konture površinskog kopa. Osnova za optimizaciju jeste blok model. U ovom radu optimizacija površinskog kopa rude bakra izvršena je u softveru Whittle, koji primenjuje modifikovani Lerchs-Grossmann algoritam. Softver za generisanje ugnježenih kopova i definisanje pushback-ova koristi tehniku parametrizacije (Revenue Factors), a proračun se zasniva na nediskontovanim novčanim vrednostima.
- 3) Treći korak je definisanje faza razvoja površinskog kopa. Osnovni razlog za planiranje faznog razvoja kopa jeste ekonomske prirode, odnosno maksimizacija neto sadašnje vrednosti.

Kod definisanje faza razvoja kopa zadovoljeni su sledeći zahtevi [3]:

- postoji minimalno dozvoljeno rastojanje između granica faza,
- postoji minimalna radna širina dna svake faze,
- NPV svake faze je pozitivna,
- NPV za definisane faze je maksimalna.

Pored ekonomskog, uvažen je i praktičan značaj faznog razvoja kopa, a odnosi se na problematiku uzrokovanu prevelikim brojem faza što može da dovede do [3]:

- povećanja troškova zbog održavanja više radilišta,
- povećanja troškova zbog ponovne izrade transportnih puteva,

Modelovanje ležišta

- nedovoljne širina radnih platoa za rad mehanizacije,
 - povećanog broj osnovne i pomoćne opreme i dr.
- 4) Četvrti korak predstavlja definisanje dinamike otkopavanja. Analiza se bazira na Milawa algoritmu, koji podržava softver Whittle, a specifično je namenjen za definisanje dinamike otkopavanja kod strategije dugoročnog planiranja eksploatacije.

Geološke rezerve ležište bakra Južni revir Majdanpek sračunate su metodom mini blokova, pri čemu su dimenzije blokova $15 \times 15 \times 15$ m. Osnova za proračun geoloških rezervi jeste digitalni blok model ležišta koji je formiran u softveru Gemcom, primenom geostatističkih metoda analize i procene [4], [5].

Na slici 1 prikazan je trodimenzionalni izgled blok modela Cu u ležištu Južni revir.

Sl. 1. Trodimenzionalni izgled blok modela Cu u ležištu Južni revir

Optimizacija granice površinskog kopa

Proces optimizacije sproveden je na osnovu definisane prodajne cene metala, diskontne stope i troškova i iskorišćenja otkopavanja, flotacijske i metalurške prerade.

U tabeli 1 dati polazni parametri koji su poslužili za definisanje optimalne konture kopa i definisanje faza otkopavanja.

Tabela 1. Polazni parametri za optimizaciju granice kopa i definisanje faza otkopavanja

Parametar	Jedinica	Vrednost
Bazne cene metala		
– Bakra	USD/t	6 000,00
– Zlata	USD/kg	35 000,00
– Srebra	USD/kg	650,00
Troškovi otkopavanja rude	USD/t	1,50
Troškovi otkopavanja jalovine	USD/t	2,50
Troškovi flotacijske prerade rude	USD/t	3,20
Troškovi metalurške prerade koncentrata		
– Troškovi proizvodnje bakra iz koncentrata	USD/t Cu katode	600,00
– Troškovi rafinacije zlata	USD/kg	150,00
– Troškovi rafinacije srebra	USD/kg	15,00
Flotacijsko iskorišćenje bakra iz rude	%	86,0
Metalurško iskorišćenje bakra iz rude	%	98,5
Ukupno iskorišćenje na zlatu	%	50,0
Ukupno iskorišćenje na srebru	%	50,0
Diskontna stopa	%	10

Kapaciteti otkopavanja rude limitirani su po godinama, na osnovu procene mogućnosti povećanja kapaciteta flotacijske prerade.

Planirana vrednost kapaciteta otkopavanja rude na godišnjem nivou sledeća:

- u 1. i 2. godini 6.000.000 t rude
- u 3. godini 8.500.000 t rude

- u 4. godini do kraja eksploatacionog perioda

11.000.000 t rude

Otkopavanje jalovine ograničena je kapacitetom transportnog sistema za jalovinu TS-1 (27 miliona tona godišnje) i kapacitetom spoljašnjih odlagališta jalovine (tabela 2 i slika 2). Iz tog razloga maksimalni projektovani kapacitet jalovine iznosi 32 miliona tona godišnje.

Tabela 2. Prikaz kapaciteta spoljašnjih odlagališta jalovine

Kapaciteti spoljašnjih odlagališta jalovine				Ukupno
Kovej	Andezitski prst	Bugarski potok	Deponija	
1 995 000	8 000 000	13 000 000	23 500 000	46 495 000

Sl. 2. Prikaz lokacija kamionskih odlagališta

Optimalna granica otkopavanja površinskog kopa dobijena je korišćenjem softvera za optimizaciju i strateško planiranje površinskih kopova Whittle [6], [7].

Na slici 3 grafički su prikazani rezultati optimizacije za baznu cenu bakra od 6.000 USD/t, na osnovu čega se vrši izbor optimalne konture kopa i faze razvoja kopa.

Sl. 3. Grafički prikaz rezultata optimizacije (Pit by pit graf)

Sa grafika može se videti da je, za usvojene tehnno-ekonomske parametre kao optimalan izabran kop broj 25. Izabrani kop ima ukupno 549.837.135 t iskopina, od čega 175.536.668 t rude i 374.300.467 t otkrivke. Koeficijent otkrivke iznosi 2,13 t/t.

Definisanje faza razvoja kopa (pushbacks)

Nakon određivanja konačne granice otkopavanja, sledeći korak u procesu dizajniranja površinskih kopava jeste definisanje faza otkopavanja.

U ovom koraku sprovodi se simulacija i DCF analiza da bi se dobila najpovoljnija varijanta, odnosno odredio broj faza koji

utiče na maksimizaciju neto sadašnje vrednosti kod dugoročnog planiranja kopova.

Na osnovu rezultata optimizacije koja je grafički prikazana na slici 3, definisane su i faze otkopavanja i to su kopovi 18 i 22. Na osnovu potrebe da se dinamikom otkopavanja obezbede potrebne količine rude shodno zahtevu Investitora, uz minimalne količine otkrivke neophodno je da se i kop broj 18 podeli na četiri faze, pri čemu njegov severni deo predstavlja Fazu 1, istočni Fazu 2 i 3, a južni i zapadni deo su označeni kao Faza 4. Shodno usvojenom pravilu označavanja faza, kopovi 22 i 25 definisani su kao Faza 5 i Faza 6, respektivno (slika 4).

Sl. 4. Izgled završne konture (3D prikaz)
a) Faza 1; b) Faza 2; c) Faza 3; d) Faza 4; e) Faza 5; f) Faza 6

Optimizacija dinamike otkopavanja

Dinamika otkopavanja po godinama eksploatacije dobijena je u softveru Whittle. Za optimizaciju dinamike otkopavanja softver korišćen je Milava algo-

ritam, za režim balansiranja (Milawa Balanced) [8].

Rezultati optimizacije dinamike otkopavanja prikazani su u tabeli 3.

Tabela 3. *Dinamika otkopavanja po godinama i periodima eksploatacije*

Godina	Ruda (t)	Otkrivka (t)	Iskopine (t)	Koeficijent otkrivke (t/t)	Cu	Ag	Au	Novčani tok	Novčani tok (disc)
					%	g/t	g/t	\$	\$
1	5 999 884	32 000 116	38 000 000	5.33	0.253	1.230	0.159	- 22 398 758	- 20 362 507
2	6 000 000	24 936 051	30 936 051	4.16	0.275	0.910	0.092	- 10 929 178	- 9 032 379
3	8 498 890	31 501 110	40 000 000	3.71	0.332	0.980	0.150	19 931 446	14 974 790
4	10 999 696	29 000 304	40 000 000	2.64	0.371	1.441	0.310	109 734 414	74 950 081
5	11 000 000	25 307 661	36 307 661	2.30	0.340	1.197	0.188	82 744 790	51 378 004
6	10 998 579	32 001 421	43 000 000	2.91	0.372	1.065	0.211	88 765 834	50 105 999
7	10 993 690	32 006 310	43 000 000	2.91	0.396	2.292	0.288	110 481 287	56 694 369
8	10 999 785	32 000 215	43 000 000	2.91	0.393	2.042	0.301	112 074 145	52 283 416
9	10 987 165	32 012 834	42 999 999	2.91	0.404	1.587	0.265	113 338 664	48 066 657
10	10 999 999	27 167 299	38 167 298	2.47	0.430	1.319	0.211	118 184 201	45 565 126
11	10 999 999	21 171 797	32 171 796	1.92	0.412	1.244	0.187	143 817 710	50 407 230
12	10 999 999	24 875 159	35 875 158	2.26	0.404	0.888	0.110	95 904 893	30 558 255
13	11 000 000	25 766 972	36 766 972	2.34	0.344	1.939	0.170	74 240 820	21 504 921
14	11 000 000	8 467 334	19 467 334	0.77	0.334	2.192	0.220	124 017 674	32 657 730
15	11 000 000	3 536 252	14 536 252	0.32	0.337	2.022	0.189	132 320 385	31 676 448
16	10 999 998	9 514	11 009 512	0.00	0.329	1.389	0.165	132 997 165	28 944 058
17	10 999 996	0	10 999 996		0.341	1.303	0.159	137 458 664	27 195 464
18	4 288 324	0	4 288 324		0.320	1.068	0.122	45 559 243	8 684 884
Ukupno	178 766 004	381 760 349	560 526 353	2.14	0.361	1.493	0.201	1 608 243 399	596 252 546

ZAKLJUČAK

Sprovedena analiza mogućnosti povećanja kapaciteta na kopu Južni revir obavljena je korišćenjem softvera za optimizaciju i strateško planiranje površinskih kopova Whittle, a koja se zasniva na analizi kretanja diskontovanog novčanog toka tokom eksploatacionog perioda, odnosno ostvarene neto sadašnje vrednosti, i koja je pokazatelj postignutih ekonomskih rezultata eksploatacije ležišta Južni revir za zadate početne uslove. Modeliranje ležišta i konstrukcija optimalne konture kopa i faza razvoja kopa izvršena u softveru Gemcom Gems

Na osnovu sprovede analize zaključuje se sledeće:

- 1) Postoji mogućnost povećanja kapaciteta na otkopavanju rude bakra na površinskom kopu Južni revir Majdanpek, koji se ostvaruje u 4. godini za analizirani period

- 2) Vek eksploatacije kopa iznosi 18 godina.
- 3) Kretanje novčanog toka je pozitivno tokom celog perioda eksploatacije, sem u prvoj i drugoj godini analiziranog perioda.
- 4) Ostvaruje se neto sadašnja vrednost u iznosu od **596.252.546 \$**.

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