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ANALYSIS THE POSIBILITY OF IMPROVING THE ECONOMIC INDICATORS OF EXPLOITATION THE DEPOSIT CEMENTACIJA KRAKU BUGARESKU - ORE FIELD CEROVO***

Abstract

Cementacija - Kraku Bugaresku is a complex of ore bodies in the southeastern part of the deposit Cerovo. It contains a substantial portion of ore with high content of oxides regarding to the total copper in the ore, and with the existing processing technology in the current period, the modest results in metal recovery were achieved. This work, through an analysis, gives a discussion of possible combination of processing using the conventional flotation processing with pyrometallurgical treatment and heap leaching with the hydrometallurgical extraction of metal by SX -EW, in terms of the economic viability of such method. This work firstly made a comparison of optimization results of potential open pits in the ore deposit (Whittle Fx), in both cases for the same input techno-economic data. The obtained potential open pits in the optimization process (pit shells) for Revenue Factor 1 (i.e. the selling price of Cu cathode ton of 5,000 $) are differ from each other by about 8 million tons of ore in favor of the combined processing method and the amount of Cu in the ore to 16,502.44 t, while had grade in the case of method combination is higher for 3.27 %. Discounted cash flow is higher by as much as 61.94 %, which expressed in monetary units is 47,905,712 $.
Keywords: *heap leaching, SX -EW , optimization of open pits, discounted cash flow*

INTRODUCTION

The ore field Kraku Bugaresku (KB) - Cementacija is part of a complex of ore deposits at the site Cerovo Mali Krivelj, which is different from the rest of the deposit by the way of origin and type of mineralization. It is a cementation zone of secondary enrichment, and a portion of mineralization belongs to the oxide mineralization (about 40% of total geological reserves). It consists of the ore bodies Cementacija 1, 2, 3 and 4, out of which Cementacija 3 and 4 are distinguished by content of oxide ore to total reserves. According to the copper content, the complex belongs to the low-grade deposits whose economics of exploitation is very sensitive to some parameters such metal recovery in the process of enrichment, exploitation costs in technological chain from mining to metallurgical treatment, and even the sequence of mining the ore bodies (Push backs) within the cementation zone.

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Figure 1 shows the analysis of "Grade tonnage" for different cut-off grades, which is the characteristic of the deposit, where the ratio of amount RSULF and ROXD, i.e. amounts of both types of ore deposit.

The most common copper minerals in the upper part of the deposit, the oxidation zone, are cuprite, malachite and azurite, while in the zone of secondary sulphide enrichment, the most common are covellite and chalcocite.

CU Cut-off	ORSU tonne	OROX tonne	CUOX Ave grade	CUSU Ave grade
0.1	118000050	61458241	0.0186	0.1841
0.15	77644440	35989082	0.0217	0.2273
0.2	49637929	20080618	0.0249	0.2721
0.25	30505437	10594773	0.0282	0.3209
0.3	19244147	5625561	0.0312	0.3682
0.35	11857650	3321796	0.0351	0.4136
0.4	7065534	1939478	0.0402	0.4609
0.45	4448241	1231875	0.0443	0.5024
0.5	2869062	700313	0.0472	0.5425
0.55	1847175	371250	0.0501	0.5792
0.6	1168264	151875	0.0502	0.6191
0.65	645079	42188	0.052	0.6597
0.7	287078	25313	0.0605	0.7032
0.75	134847	8438	0.0599	0.7521
0.8	75938	8438	0.068	0.7663

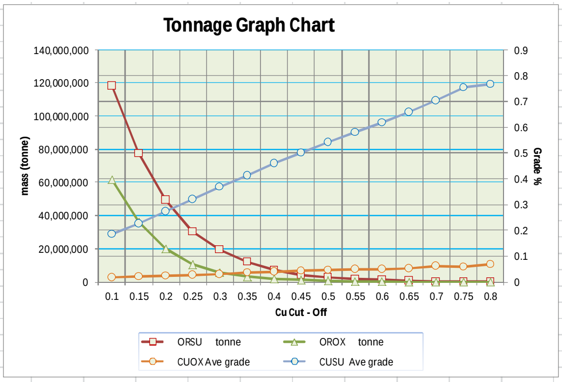

Figure 1 *"Grade tonnage"analysis for the copper ore deposit KB - Cementacija for different cut-off grades – Table and Graph*

The previous work applied to the mining of deposits Cementacija 1, which consisted of flotation processing of the entire amount of ore above the cut-off grade, without separation of oxide parties of ore from the sulphide, resulted in low copper recovery in the flotation plant, which ranged in the interval between 50 and 70%[1]. This has certainly a negative impact on the achieved economic results.

Due to these facts it is important to review and analyze the possibilities of increasing NPV, ie Cashflow in the exploitation of the complex ore bodies.

At the present level of technological development of exploitation and recovery of metals from oxide and sulphide ores, the importance is recently given to *leaching and solvent extraction of leaching solutions* from oxide ore, and even from sulphide ore (or concentrate).

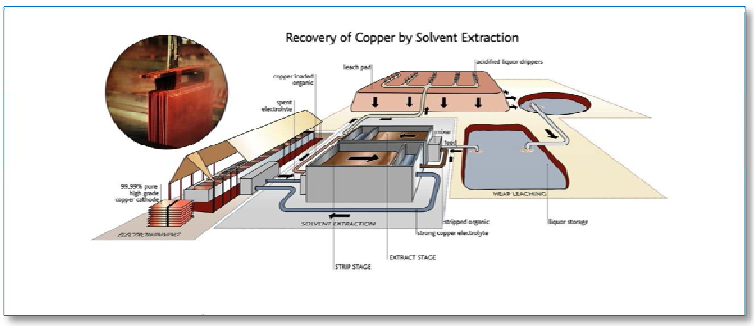

Figure 2 *Process Flow Diagram - heap leaching, solvent extraction and electro wining*

[1] *In the official Documents (Annual Technical Reports on Production of RBB, 1993. -2000.), the Production Results are not Presented Credible*

ANALYSIS IN SOFTWARE FOR STRATEGIC PLANNING WHITTLE FX

The input techno-economic data for carried out analysis in software for strategic planning Whittle Fx, for scenario 1 and 2, i.e. flotation of sulphide and oxide ores together, without selective mining with additional method of enrichment - heap leaching of the ore with more than 10% of oxides, are the following:

Table 1 *Input techno-economic parameters of exploitation for the optimization process (input)*

Parameter	Unit	Values
Capacity of excavation - excavations	t/year	12Mt from 3.year17 Mt
Capacity of flotation processing – Sulphide ore with max. 10% oxide	t/year	2.5Mt from 3. year 5.5 Mt
Capacity of heap leaching – Oxide ore with over 10% oxide content	t/year	2.5 Mt
Copper price	$/t cathode	5,000.00
Gold price	$/kg	40,000.00
Silver price	$/kg	500.00
Excavation costs	$/t	2.3
Flotation processing costs	$/t	4.00
Heap leaching costs	$/t ore	1.00
Metallurgical copper treatment costs	$/t cathode	450.00
Metallurgical gold treatment costs	$/kg	150.00
Metallurgical silver treatment costs	$/kg	15.00
Hydrometallurgical treatment costs (SXEW)	$/t cathode	100.0
Initial capital costs of leaching and SXEW	$	20,000,000
Total copper recovery (flotation and metal.)	%	0.788
Total gold recovery (flotation and metal.)	%	0.50
Silver recovery (flotation and metal.)	%	0.40
Copper recovery from oxide ore with over 10% oxide content	%	0.54
Discount rate	%	10.0

Analysis[2] was carried out for 3 scenarios, as follows:

1. Scenario 1 – processing method marked as "MILL", i.e. flotation ROXD and RSULF, i.e. two types of ore;
2. Scenario 2 – method "MILL" for ore with > 10% oxide, and method "LEAC" for ore with content > 10% oxide, wherein the leaching capacity is not limited;
3. Scenario 3 – same as Scenario 2, but with limited capacity of leaching to 2,500,000 t, and with the use of two types of stockpiles for ore less than 10% oxide ore and over 10% oxide (SP1 and SP2). Stockpiles were used as a "buffer" for addition of design capacity both in the flotation and leaching.

In further analysis for Scenarios 1 and 2, the results of optimization are presented in the tables type *Pit Pit By Garph*, i.e. the open pits from optimization with calculated cash flow and discounted cash flow for each of a set of nested open pit mines. Economic indicators are calculated for three possible cases – the *Best Case*, *Worst Case*, and *Specific Case*, i.e. for the mining bench by bench, and using pushbacks in mining. A key for the evaluation and selection of the optimal pit on the criterion of the optimal profit is *discounted cash flow* best case. This means that the selected pit (*Final pit*) is excavated in stages (Push backs).

In all three cases, a mining schedule is designed and calculated for mine life of selected open pit per the above criteria with the appropriate graphical views. Also, the calculated amounts per type of ore (as *Rock Type*) are presented in tables, with lower and higher oxide contents, or the realized capacities for the method "MILL" and method "LEAC" in Scenario 3 – with additional calculated amounts of ore that go to the stockpiles and from there into the process.

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[2] *Beside the above given input data, the block model of deposit, so called "mod" file, is exported into software Whittle. In designing the mentioned "mod" file in the basic software, in this case Gemcom, the terrain topography is used, i.e. current mining lay out. In the case of this analysis, the mining lay out is at 10.08.2001, before reactivation of open pit, because the analysis was not carried out as a part of the Study or Project, but with the aim to point out the possibilities for increasing the economic effects of production, also initiating the important explorations aimed to extraction of Cu by hydrometallurgical method.*

SCENARIO 1 One Type of Processing MILL (Flotation) of Sulphide and Oxide Ore Together

Table 2 *Tabular presentation of optimization results per Scenario 1 with calculated cash flow*

PIT BY PIT GRAPH - SCENARIO 1

Final pit	Revenue factor for final pit	Open pit cashflow best $ disc	Open pit cashflow specified $ disc	Open pit cashflow worst $ disc	tonne input best	Waste best tonne	Mine life years best	Mine life years specified	Mine life years worst
1	0.32	1,257,649	1,257,649	1,257,649	64,520	9,407	0.03	0.03	0.03
2	0.34	2,340,019	2,340,019	2,340,019	127,897	9,971	0.05	0.05	0.05
3	0.36	3,265,188	3,265,188	3,265,188	188,088	10,150	0.08	0.08	0.08
4	0.38	4,415,908	4,415,908	4,415,908	272,142	14,544	0.11	0.11	0.11
5	0.4	5,121,194	5,121,194	5,121,194	326,594	28,340	0.13	0.13	0.13
6	0.42	6,782,948	6,782,948	6,782,948	475,371	39,226	0.19	0.19	0.19
7	0.44	8,622,922	8,622,922	8,622,922	654,558	64,086	0.26	0.26	0.26
8	0.46	10,525,070	10,525,070	10,525,070	868,580	85,685	0.35	0.35	0.35
9	0.48	13,053,414	13,053,414	13,053,414	1,188,709	111,857	0.48	0.48	0.48
10	0.5	15,071,636	15,071,636	15,071,636	1,480,565	120,560	0.59	0.59	0.59
11	0.52	15,737,824	15,737,824	15,737,824	1,589,257	128,947	0.64	0.64	0.64
12	0.54	18,383,286	18,383,286	18,383,286	2,040,985	229,016	0.82	0.82	0.82
13	0.56	20,388,697	20,388,697	20,388,697	2,429,329	299,806	0.97	0.97	0.97
14	0.58	21,534,215	21,532,415	21,532,415	2,663,808	335,688	1.07	1.07	1.07
15	0.6	48,788,934	47,538,914	47,538,914	7,875,043	5,582,314	2.52	2.52	2.52
16	0.62	55,146,867	53,508,008	53,508,008	9,599,654	6,485,167	2.84	2.84	2.84
17	0.64	63,570,562	60,902,078	60,902,078	11,991,784	7,986,686	3.27	3.27	3.27
18	0.66	67,546,940	64,308,942	64,308,942	13,194,047	8,727,104	3.49	3.49	3.49
19	0.68	76,251,473	71,761,565	71,761,565	16,394,020	10,505,786	4.07	4.07	4.07
20	0.7	79,816,489	74,837,962	74,837,962	17,911,544	11,034,033	4.35	4.35	4.35
21	0.72	84,775,931	78,120,000	78,120,000	20,275,932	12,509,270	4.78	4.78	4.78
22	0.74	87,297,954	79,729,295	79,729,295	21,721,280	13,173,614	5.04	5.04	5.04
23	0.76	99,408,000	82,884,123	82,884,123	28,647,492	19,642,382	6.30	6.55	6.55
24	0.78	102,648,142	83,151,343	83,151,343	31,079,978	21,409,083	6.74	7.05	7.05
25	0.8	105,911,193	82,932,523	82,932,523	33,864,262	24,482,200	7.25	7.62	7.62
26	0.82	107,796,516	83,166,000	83,166,000	36,026,740	25,479,248	7.64	8.02	8.02
27	0.84	109,864,961	82,857,682	82,857,682	38,690,541	27,906,217	8.13	8.52	8.52
28	0.86	112,055,441	81,155,078	81,155,078	41,754,095	31,007,667	8.68	9.10	9.10
29	0.88	113,121,606	80,039,265	80,039,265	43,695,298	33,065,173	9.04	9.46	9.46
30	0.9	115,083,888	75,541,273	75,541,273	48,341,430	37,235,782	9.88	10.32	10.32
31	0.92	115,955,763	71,519,775	71,519,775	50,942,253	40,014,353	10.35	10.89	10.89
32	0.94	116,329,206	69,437,935	69,437,935	52,691,741	42,144,430	10.67	11.24	11.24
33	0.96	116,577,596	67,166,852	67,166,852	54,558,738	44,257,231	11.01	11.62	11.62
34	0.98	116,812,522	63,546,156	63,546,156	56,940,722	47,520,092	11.44	12.10	12.10
35	1	116,822,322	62,763,271	62,763,271	57,462,570	48,143,878	11.54	12.20	12.20
36	1.02	116,733,132	60,247,593	60,247,593	59,523,326	50,336,326	11.91	12.60	12.60
37	1.04	116,570,305	57,088,898	57,088,898	61,004,701	52,645,714	12.18	12.91	12.91
38	1.06	116,246,697	53,548,340	53,548,340	62,679,665	55,723,640	12.49	13.27	13.27
39	1.08	116,104,201	52,612,974	52,612,974	63,285,683	56,807,448	12.60	13.38	13.38
40	1.1	115,890,094	51,230,325	51,230,325	63,973,933	57,909,775	12.72	13.51	13.51
41	1.12	114,776,583	41,519,881	41,519,881	67,492,199	62,846,779	13.36	14.34	14.34
42	1.14	114,282,584	37,924,212	37,924,212	68,822,070	65,024,645	13.60	14.65	14.65
43	1.16	114,198,024	37,513,600	37,513,600	69,049,326	65,188,415	13.65	14.69	14.69
44	1.18	113,547,212	35,394,348	35,394,348	70,505,451	68,088,287	13.91	14.96	14.96
45	1.2	113,180,094	34,216,439	34,216,439	71,313,473	69,376,637	14.06	15.11	15.11
46	1.22	112,692,740	31,159,282	31,159,282	72,264,584	71,233,186	14.23	15.34	15.34
47	1.24	112,393,820	29,204,421	29,204,421	72,820,099	72,285,894	14.33	15.48	15.48
48	1.26	110,665,910	18,407,558	18,407,558	75,656,596	79,276,775	14.86	16.25	16.25
49	1.28	109,992,003	16,490,497	16,490,497	76,759,211	81,937,428	15.15	16.46	16.46
50	1.3	109,028,005	11,329,090	11,329,090	78,333,172	85,123,865	15.43	16.80	16.80
51	1.32	108,936,513	10,951,659	10,951,659	78,476,259	85,430,456	15.46	16.83	16.83
52	1.34	108,604,954	9,631,895	9,631,895	78,947,606	86,580,421	15.54	16.93	16.93
53	1.36	108,528,079	9,319,586	9,319,586	79,090,693	86,744,802	15.57	16.96	16.96
54	1.38	107,646,094	6,399,243	6,399,243	80,168,057	89,781,653	15.77	17.17	17.17
55	1.4	106,959,546	4,034,446	4,034,446	81,102,333	92,015,091	15.94	17.35	17.35
56	1.42	106,704,144	3,213,701	3,213,701	81,439,009	92,833,624	16.00	17.41	17.41
57	1.44	106,461,667	2,659,448	2,659,448	81,716,767	93,627,441	16.06	17.47	17.47
58	1.46	106,136,964	1,975,632	1,975,632	82,087,111	94,621,529	16.14	17.53	17.53
59	1.48	106,087,512	1,742,133	1,742,133	82,154,446	94,741,304	16.15	17.55	17.55
60	1.5	105,680,501	702,770	702,770	82,533,207	96,158,579	16.25	17.62	17.62

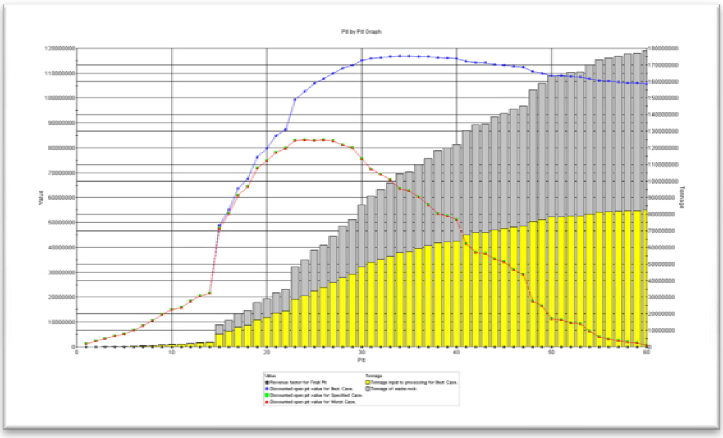

Figure 3 *Pit by Pit graph – Graph of optimization per Scenario 1*

Table 3 *Mining dynamics per Scenario 1*

					SCENARIO 1_ SHEDULE GRAPPH										
	PB: 19, 26,3														
Period	tonne input	Waste tonne	Strip ratio	tonne input RSUL	Units input RSUL CU	Grade input CUS	tonne input ROXD	Units input ROXD CU	Grade input CUOX	Grade input CU	Grade input PRCU	Grade input AU	Grade input AG	Open pit cashflow $	Open pit cashflow $ disc
					x 100			x100							
1	2,497,779	9,502,221	3.8	601,834	241,726	0.2449	1,895,945	462,625	0.0413	0.282	15.4797	0.0753	1.1065	-9,847,862	-8,952,602
2	2,499,693	9,500,307	3.8	917,321	451,536	0.3076	1,582,372	426,201	0.0484	0.3511	15.7806	0.0802	1.0753	-3,387,689	-2,799,743
3	5,495,999	11,504,001	2.09	1,769,556	816,733	0.2808	3,726,443	952,774	0.0458	0.322	16.0559	0.0718	1.0124	6,867,290	5,159,496
4	5,499,999	6,315,358	1.15	1,462,051	427,596	0.2038	4,037,947	887,950	0.0393	0.2392	16.1273	0.0693	1.1278	3,452,064	2,357,806
5	5,500,000	3,586,533	0.65	1,785,345	533,392	0.2303	3,714,655	929,696	0.0397	0.266	14.6026	0.0791	1.1537	15,477,799	9,610,495
6	5,500,000	2,599,697	0.47	2,570,586	823,796	0.2542	2,929,414	753,057	0.0361	0.2867	13.4667	0.0727	1.0313	20,814,587	11,749,292
7	5,500,000	1,403,682	0.26	3,146,090	1,044,249	0.2634	2,353,910	553,530	0.0301	0.2905	11.1239	0.0848	1.0792	28,194,533	14,468,253
8	5,499,999	1,557,531	0.28	4,021,808	1,109,667	0.2397	1,478,191	300,803	0.0186	0.2564	7.6091	0.0862	1.0487	23,064,615	10,759,813
9	5,500,000	1,263,215	0.23	5,082,426	1,282,422	0.2367	417,573	85,504	0.0133	0.2487	5.3879	0.0827	1.031	21,474,074	9,107,104
10	5,500,000	605,505	0.11	4,879,546	1,326,078	0.252	620,454	125,263	0.0133	0.2639	5.2266	0.0996	1.2105	27,995,708	10,793,557
11	5,500,000	271,792	0.05	5,017,944	1,395,811	0.2582	482,056	88,229	0.0129	0.2698	5.0344	0.0848	1.3015	28,542,461	10,003,959
12	2,969,102	34,036	0.01	2,916,661	803,531	0.2654	52,440	12,601	0.0105	0.2749	3.7942	0.0994	1.3529	17,194,580	5,724,357
	57,462,571	48,143,878		34,171,168			23,291,400							179,842,160	77,981,787

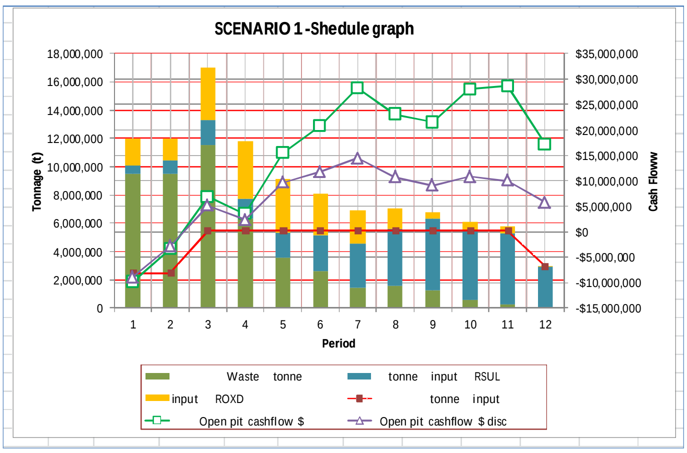

Figure 4 *Graphical view of mining dynamics per Scenario 1, with one processing method– MILL; total ore amounts without selective mining go to the flotation processing and concentrate to the pyrometallurgical method*

SCENARIO 2 Two Types of Processing
MILL (Flotation) and HEAP LEACHING

Table 4 *Tabular presentation of optimization results per Scenario with calculated cash flow*

PIT BY PIT GRAPH - SCENARIO 2

Final pit	Revenue factor for final pit	Open pit cashflow best $ disc	Open pit cashflow specified $ disc	Open pit cashflow worst $ disc	tonne input best	Waste best tonne	Mine life years best	Mine life years specified	Mine life years worst	Internal rate of return best %	Internal rate of return worst %
1	0.3	-19,672,238	-19,672,238	-19,672,238	26,916	67	0.00	0.00	0.00	0	0
2	0.32	-18,172,452	-18,172,452	-18,172,452	117,064	11,192	0.03	0.03	0.03	0	0
3	0.34	-16,598,225	-16,598,225	-16,598,225	236,298	14,400	0.05	0.05	0.05	0	0
4	0.36	-15,206,239	-15,206,239	-15,206,239	356,166	17,900	0.08	0.08	0.08	0	0
5	0.38	-13,815,237	-13,815,237	-13,815,237	471,549	24,595	0.11	0.11	0.11	0	0
6	0.4	-12,477,700	-12,477,700	-12,477,700	623,194	47,353	0.13	0.13	0.13	0	0
7	0.42	-10,006,388	-10,006,388	-10,006,388	879,677	89,393	0.20	0.20	0.20	0	0
8	0.44	244,677	244,677	244,677	2,221,015	757,403	0.29	0.29	0.29	4.03	4.03
9	0.46	2,673,733	2,673,733	2,673,733	2,552,183	830,394	0.36	0.36	0.36	17.29	17.29
10	0.48	8,658,819	8,658,819	8,658,819	3,431,323	1,262,659	0.48	0.48	0.48	50.03	50.03
11	0.5	17,861,713	17,861,713	17,861,713	5,020,490	2,005,231	0.69	0.69	0.69	102.2	102.2
12	0.52	56,166,769	54,806,665	54,806,665	11,373,660	7,933,596	2.07	2.19	2.19	174.16	136.69
13	0.54	72,345,544	68,906,902	68,906,902	14,459,921	10,464,136	2.36	2.49	2.49	183.73	116.43
14	0.56	78,651,502	74,683,218	74,683,218	15,955,469	11,180,073	2.49	2.64	2.64	187.33	116.22
15	0.58	89,657,379	83,964,252	83,964,252	18,628,312	12,656,334	2.74	2.97	2.97	193.51	112.76
16	0.6	94,177,326	88,262,713	88,262,713	19,906,020	13,491,902	2.86	3.11	3.11	196.05	110.79
17	0.62	102,041,906	94,967,147	94,967,147	22,306,910	14,818,353	3.20	3.44	3.44	198.55	103.31
18	0.64	107,825,197	99,135,151	99,135,151	24,190,047	15,786,074	3.44	3.72	3.72	199.57	98.3
19	0.66	115,263,766	104,855,424	104,855,424	26,963,760	17,384,509	3.78	4.11	4.11	200.93	92.92
20	0.68	119,827,401	109,467,857	108,368,981	28,858,724	18,643,233	4.03	4.36	4.39	201.72	87.95
21	0.7	131,018,438	119,070,774	114,123,936	33,311,000	23,050,589	4.59	4.92	5.07	202.39	74.82
22	0.72	133,849,985	121,691,295	115,646,776	34,870,282	24,119,422	4.77	5.10	5.35	202.58	71.9
23	0.74	146,289,750	134,152,102	117,198,533	42,640,316	31,908,409	5.74	5.84	6.58	202.61	54.6
24	0.76	151,869,938	139,491,522	117,668,350	46,568,407	35,916,783	6.18	6.24	7.17	202.7	49.49
25	0.78	153,176,720	140,648,407	117,997,340	47,586,853	36,658,979	6.32	6.38	7.36	202.71	48.83
26	0.8	155,346,218	141,567,411	116,920,205	49,572,609	38,908,109	6.48	6.75	7.70	202.73	46.22
27	0.82	157,052,532	143,038,162	116,146,307	51,466,413	40,623,250	6.70	6.96	8.01	202.75	44.61
28	0.84	158,467,534	144,384,440	115,089,056	53,107,709	42,556,953	6.92	7.18	8.32	202.76	42.8
29	0.86	159,647,264	145,337,729	114,353,244	54,648,002	44,289,647	7.13	7.40	8.59	202.76	41.68
30	0.88	160,916,422	146,339,541	112,147,672	56,769,062	46,725,984	7.39	7.65	8.95	202.76	39.53
31	0.9	161,913,154	146,964,713	109,851,681	58,780,703	49,642,105	7.63	7.89	9.28	202.77	37.45
32	0.92	162,816,991	147,314,004	104,105,169	61,768,704	53,527,893	8.03	8.11	9.82	202.77	33.85
33	0.94	163,095,472	147,660,882	103,368,020	62,694,563	54,471,675	8.16	8.24	9.98	202.77	33.5
34	0.96	163,321,340	147,887,443	101,824,917	63,822,428	56,193,108	8.31	8.39	10.19	202.77	32.62
35	0.98	163,417,237	147,538,011	98,291,386	65,463,725	58,731,018	8.53	8.61	10.49	202.77	30.92
36	**1.00**	163,413,866	147,208,895	95,534,405	66,860,931	61,005,204	8.75	8.81	10.74	202.77	29.78
37	1.02	163,350,325	146,984,292	93,855,435	67,618,452	62,402,200	8.88	8.92	10.90	202.77	29.17
38	1.04	162,990,167	146,391,624	88,142,664	69,621,676	66,530,279	9.24	9.10	11.32	202.77	26.95
39	1.06	162,687,631	146,011,943	84,136,112	70,825,293	69,012,059	9.45	9.22	11.61	202.77	25.54
40	1.08	162,418,596	145,687,328	81,941,941	71,675,400	70,757,066	9.61	9.32	11.78	202.77	24.91
41	1.1	161,958,663	145,239,954	77,022,384	73,114,691	73,794,528	9.87	9.43	12.01	202.77	23.38
42	1.12	161,715,486	144,974,952	76,337,965	73,754,376	74,761,151	9.97	9.54	12.12	202.77	23.23
43	1.14	161,282,789	144,524,440	74,139,095	74,713,903	76,282,487	10.12	9.66	12.28	202.77	22.64
44	1.16	160,393,985	143,478,731	70,610,743	76,271,030	79,628,190	10.40	9.93	12.63	202.77	21.87
45	1.18	160,009,540	143,005,599	68,802,935	76,927,549	80,809,058	10.51	10.05	12.77	202.77	21.46
46	1.2	159,750,944	142,701,727	67,614,646	77,306,309	81,529,923	10.57	10.12	12.87	202.77	21.21
47	1.22	159,499,447	142,341,707	66,256,070	77,676,653	82,319,161	10.64	10.17	12.96	202.77	20.91
48	1.24	159,295,897	142,113,953	65,799,438	77,945,994	82,837,707	10.69	10.22	13.02	202.77	20.84
49	1.26	158,015,015	139,922,517	62,328,616	79,410,535	86,639,495	11.00	10.79	13.35	202.77	20.18
50	1.28	157,863,368	139,693,840	61,865,282	79,595,707	86,985,252	11.03	10.85	13.39	202.77	20.09
51	1.3	157,367,328	139,021,808	60,337,557	80,134,389	88,212,094	11.13	11.01	13.52	202.77	19.79
52	1.32	157,072,032	138,672,839	59,388,993	80,428,981	88,960,379	11.19	11.11	13.59	202.77	19.61
53	1.34	156,925,269	138,858,175	58,867,463	80,580,485	89,306,146	11.22	11.15	13.63	202.77	19.51
54	1.36	155,676,400	136,824,618	55,643,325	81,582,097	92,525,863	11.47	11.45	13.85	202.77	18.95
55	1.38	155,395,291	136,336,916	54,535,636	81,851,438	93,245,125	11.53	11.51	13.91	202.77	18.73
56	1.4	154,835,151	135,675,444	53,218,993	82,339,618	94,564,453	11.64	11.64	14.02	202.77	18.52
57	1.42	154,365,417	135,440,033	51,467,525	82,785,714	95,738,141	11.73	11.70	14.11	202.77	18.15
58	1.44	154,006,200	134,626,269	50,782,641	83,063,472	96,541,596	11.79	11.76	14.17	202.77	18.05
59	1.46	153,778,993	134,710,293	50,099,768	83,248,644	97,114,026	11.84	11.79	14.22	202.77	17.92
60	1.48	153,362,897	133,681,893	48,817,500	83,534,819	98,184,577	11.92	11.84	14.30	202.77	17.69
61	1.5	152,867,204	133,127,020	47,673,571	83,863,078	99,432,262	12.03	11.90	14.39	202.77	17.49

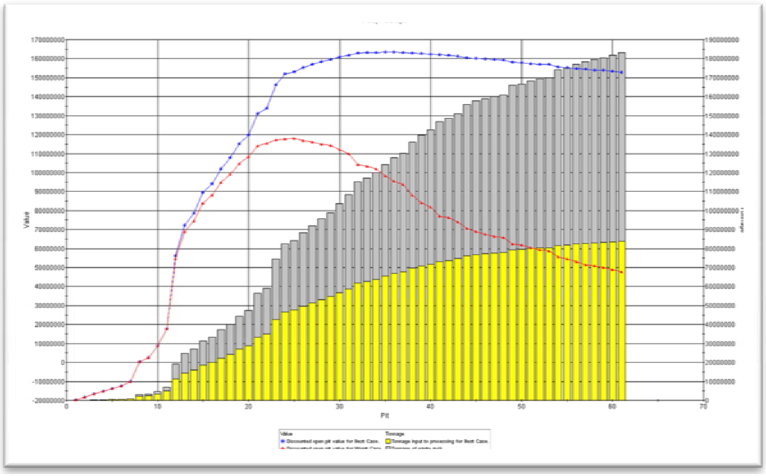

Figure 5 *Pit by Pit Graph optimization per Scenario 2 – output Whittle Fx*

Table 5 *Mining dynamics per Scenario 2*

SCENARIO 2

Shedule Graph

PB: 19,25,35; Methods: MILL, LEAC,

Period	Ore input tonne	Waste tonne	Strip ratio	input **MILL** **RSUL** tonne	Grade input CUS %	RSUL Units t	input **LECH** **ROXD** tonne	Grade input CUOX %	ROXD Units t	Grade input CU %	Grade input AU gram/t	Grade input AG gram/t	Open pit cashflow $	Open pit cashflow $ disc
1	1,483,848	10,516,152	7.09	95,351	0.1952	186	1,388,497	0.0364	505.4129	0.228	0.0641	1.0903	-16,257,162	-14,779,238
2	7,256,451	4,743,549	0.65	2,031,516	0.2616	5,314	5,224,935	0.0544	2842.365	0.3105	0.0678	1.0799	45,641,783	37,720,482
3	11,130,003	5,869,998	0.53	5,498,265	0.3002	16,506	5,631,737	0.0413	2325.907	0.3374	0.0851	1.0354	82,715,224	62,145,172
4	7,496,487	9,503,513	1.27	5,491,447	0.2717	14,920	2,005,040	0.0198	396.9979	0.2895	0.0896	1.2142	28,267,692	19,307,214
5	10,270,649	6,729,351	0.66	4,397,961	0.2189	9,627	5,872,689	0.0273	1603.244	0.2435	0.0814	1.1178	41,111,614	25,527,078
6	7,517,886	1,213,627	0.16	5,500,000	0.2387	13,129	2,017,886	0.0194	391.4699	0.2561	0.0751	1.0332	36,047,092	20,347,644
7	5,577,058	11,422,942	2.05	4,277,886	0.2268	9,702	1,299,172	0.0157	203.9700	0.2409	0.0944	1.2623	1,530,874	785,581
8	9,084,645	7,915,355	0.87	4,530,802	0.1891	8,568	4,553,843	0.0226	1029.169	0.2094	0.0663	1.1096	16,972,872	7,917,970
9	5,646,698	816,532	0.14	5,403,277	0.2183		243,421	0.0101	24.58552	0.2275	0.0884	1.1575	20,451,716	8,688,074
	65,463,725	58,731,019		**37,226,505**	0.2094	77,952	**28,237,220**	0.0330	9323.121				**256,481,705**	**167,659,977**

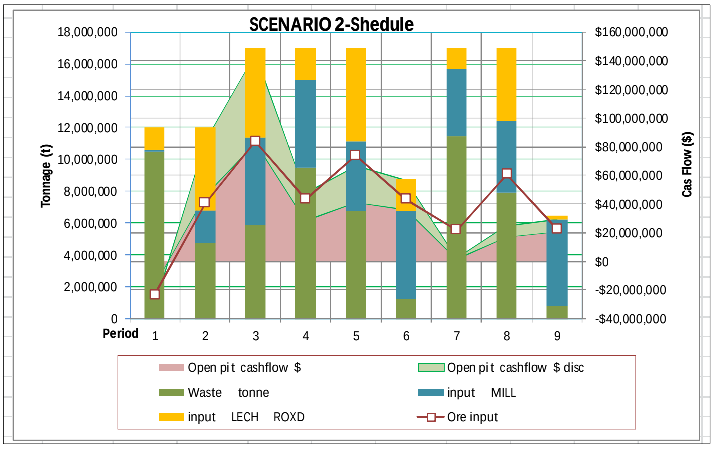

Figure 6 *Graphical view of mining dynamics per Scenariio 2, two processing methods MILL and LEAC; selective ore mining at the open pit*

SCENARIO 3 Two Types of Processing MILL (Flotation) and LEAC (Heap leaching) - Using Stock Pile

Table 6 *Mining dynamics per Scenario 3*

SCENARIO 3
Shedule graph, PB 19,26,35
METHODS: MILLS, LEAC,using STOCK PILE

Period	tonne input tonne	Waste tonne tonne	Grade input CU %	Strip ratio	tonne input MILL tonne	Grade input CUS %	**Total tonne RSUL input MILL Total tonne**	tonne input LECH tonne	**Total tonne ROXD input LEAC** Total tonne	Grade input CUOX %	to stockpile SP1-RSUL tonne	to stockpile SP2-ROXD tonne	from stockpile SP1-RSUL tonne	from stockpile SP2-ROXD tonne	Grade input AU gram/t	Grade input AG gram/t	Open pit cashflow $	Open pit cashflow $disc
1	4007473	12992527	0.248	4.73	466151	0.2103	**466,151**	2500000	**2,500,000**	0.042	285,841	755,480	0	0	0.0627	1.0459	-15,069,161	-13,699,237
2	11090720	5909280	0.3211	3.82	1024734	0.27	**1,310,575**	2500000	**2,500,000**	0.057	2,969,891	4,596,095	285,841	0	0.0697	1.1192	1,348,967	1,114,849
3	5854174	15145826	0.2866	2.59	3483203	0.2619	**5,500,000**	2370971	**2,500,000**	0.030	0	0	2,016,797	129,029	0.0985	1.0567	34,882,993	26,208,109
4	13715438	7284562	0.2878	1.97	4566208	0.2679	**5,500,000**	2500000	**2,500,000**	0.027	3,166,789	3,482,440	933,792	0	0.0919	1.2133	29,060,028	19,848,390
5	12774591	8225409	0.2487	3.36	2314153	0.2233	**5,500,000**	2500000	**2,500,000**	0.026	6,210,311	1,750,127	3,185,847	0	0.0749	1.0548	15,770,587	9,792,294
6	12525343	8474657	0.2297	2.52	3472467	0.2118	**5,500,000**	2500000	**2,500,000**	0.013	4,065,003	2,487,872	2,027,533	0	0.0862	1.3173	9,011,769	5,086,909
7	5442522	752221	0.2274	0.14	5201753	0.2183	**5,500,000**	240769	**2,500,000**	0.012	0	0	298,247	2,259,231	0.0891	1.166	39,699,894	20,372,323
8	0	0	0	999.99	0	0	**5,500,000**	0	**2,500,000**	0	0	0	5,500,000	2,500,000	0	0	55,009,671	25,662,417
9	0	0	0	999.99	0	0	**2,449,779**	0	**2,500,000**	0	0	0	2,449,779	2,500,000	0	0	35,498,778	15,054,947
10	0	0	0	999.99	0	0	**0**	0	**2,500,000**	0	0	0	0	2,500,000	0	0	19,828,642	7,644,800
11	0	0	0	999.99	0	0	**0**	0	**2,500,000**	0	0	0	0	2,500,000	0	0	19,828,642	6,949,818
12	0	0	0	999.99	0	0	**0**	0	**683,755**	0	0	0	0	683,755	0	0	5,423,171	1,851,880
	65,410,261	58,784,482					**37,226,505**		**28,183,755**		16,697,835	13,072,014	16,697,836	13,072,015			250,293,981	125,887,499

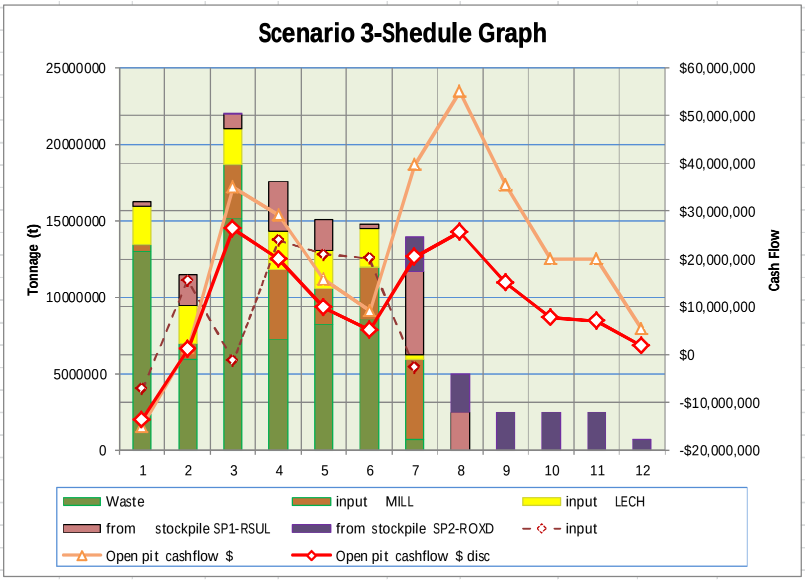

Figure 7 *Graphical view of mining dynamics per Scenario 3 – twp processing methods MILL and LEA, selective ore mining at the open pit*

CONCLUSION

The obtained possible open pits from the pit shells for *Revenu Factor 1*[3] *(*i.e. the selling price of a tone of Cu cathode of 5,000$*)*, are mutually different for about 8 million tons of ore in favor of combined method of processing, and the amounts of

[3] *Revenue Factor is a coefficient for multiplying the basic selling price of metal. In the case of this optimization the basic price is $ 5,000, and RevFtr is in the range 0.3 do 1.5.*

Cu in the ore for 16,502.44 t, while the had grade in the case of combination the processing method is higher for 3.27%. Discounted cash flow is higher for even 61.94%, as expressed in monetary units is 47,905,712 $.

These results of analysis, in addition to being a part of the input data related to leaching, solvent extraction and electrolysis - estimated on the basis of literature and experience in the world, and the degree of their accuracy is decreased, indicating in principle, to a significant improvement of economic results in the case of use the combined processing method. This suggests that it is needed to do more detailed tests (metallurgical test), which will increase the level of accuracy of the results to the level of relevance to business decision-making.

Table 7 *Comparative presentation of the cash flow for three scenarios of processing*

Period	Scenario 1		Scenario 2		Scenario 3	
	Open pit cashflow $	Open pit cashflow $disc	Open pit cashflow $	Open pit cashflow $disc	Open pit cashflow $	Open pit cashflow $disc
1	-9,847,862	-8,952,602	-16,257,162	-14,779,238	-15,069,161	-13,699,237
2	-3,387,689	-2,799,743	45,641,783	37,720,482	1,348,967	1,114,849
3	6,867,290	5,159,496	82,715,224	62,145,172	34,882,993	26,208,109
4	3,452,064	2,357,806	28,267,692	19,307,214	29,060,028	19,848,390
5	15,477,799	9,610,495	41,111,614	25,527,078	15,770,587	9,792,294
6	20,814,587	11,749,292	36,047,092	20,347,644	9,011,769	5,086,909
7	28,194,533	14,468,253	1,530,874	785,581	39,699,894	20,372,323
8	23,064,615	10,759,813	16,972,872	7,917,970	55,009,671	25,662,417
9	21,474,074	9,107,104	20,451,716	8,688,074	35,498,778	15,054,947
10	27,995,708	10,793,557	0	0	19,828,642	7,644,800
11	28,542,461	10,003,959	0	0	19,828,642	6,949,818
12	17,194,580	5,724,357	0	0	5,423,171	1,851,880
	179,842,160	77,981,787	256,481,705	167,659,977	250,293,981	125,887,499

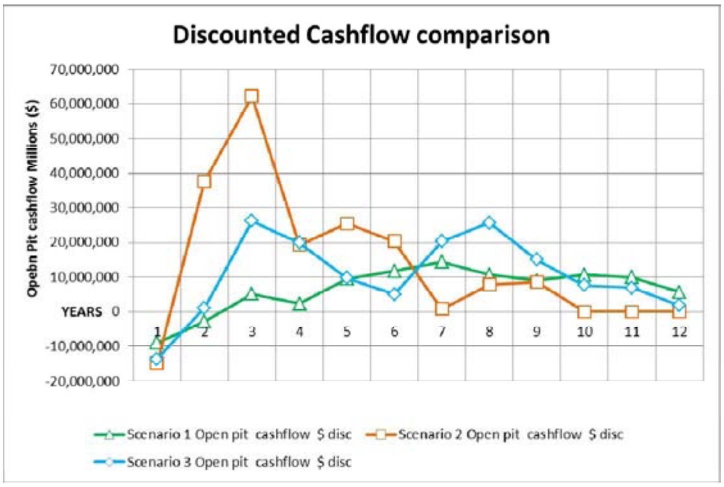

Figure 8 *Graph of comparative presentation of cash flow for all three scenarios of processing*

Difference in the discounted cash flow (total and incremental per year) between the analyzed Scenarios 1 and 2 is significant, while between 2 and 3 is not too large, even in favor of scenario without the use of stock piles, but it may be the result of insufficient knowledge of the actual techno - economic parameters of leaching process.

In this analysis mostly literature data on leaching have been used [1, 7], and partly based data on the assessed values of other's experiences and conclusions and comparisons with pyrometallurgical method of processing, where there is sufficient data. It is especially important for heap leaching to determine: recovery of basic and precious metals, as well as leaching time, also the costs of leaching pad preparation, consumption of acid, consumption of foil for substrate preparation, installation of distribution for acid (cyanide) and other normative materials as well as the costs of obtaining metals from leaching solutions in the metallurgical process of treatment. All of these costs should be kept to a ton of ore, ore a tone of the final product in the way defined by software Whittle and in the analysis of acceptance the input costs.

The authors of the paper work did not have the ambition to deal in this analysis with the technology of leaching (detailed technique and chemistry of the leaching process. They are of the other specialties, but to compare the economic effects of these cases of the applied methods of extraction the primary and associated precious metals, and based on that to make the certain conclusions presented in the paper.

The previous opinion of some experts as well as the inhabitants in the localities of ore deposits – Cerovo-Kraku Bugaresku, Ujova River and other current and potential localities, at which the deposits are located with similar characteristics, is that the leaching process is highly hazardous to the environment. Such opinion is denied in the world, inter alia, and because the total world production of copper, about 20%, is obtained by leaching. The most developed countries in the world do that because they take much more account of environmental protection than we do, and whose regulations in this area are far more stringent than ours (the United States, Chile, Canada, South Africa and others).

The purpose of this analysis is to highlight the potential alternative method which can increase the profit from the exploitation of deposits containing high contents of oxide minerals in the ore, which adversely affect the metal recovery in flotation method of enrichment. The analysis of this type, even it is the case of doubt whether even to exploit such deposits, i.e. whether the economics of exploitation is satisfactory, as there are conflicting opinions in the local professional community, can provide the adequate data for relevant qualified evaluation and decision.

It is important to note that it is the trend of leaching technology is also leaching of sulphide concentrates.

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ANALIZA MOGUĆNOSTI POBOLJŠANJA EKONOMSKIH POKAZATELJA EKSPLOATACIJE LEŽIŠTA CEMENTACIJA KRAKU BUGARESKU – RUDNO POLJE CEROVO***

Izvod

Cementacija Kraku Bugaresku je kompleks rudnih tela u jugoistočnom delu ležišta Cerovo. Sadrži znatan deo rude sa povećanim sadržajem oksida u odnosu na ukupan bakar u rudi, i sa postojećom tehnologijom prerade u dosadašnjem periodu postignutisu skromni rezultati u iskorišćenju metala.

Ovaj članak kroz analizu razmatra moguću kombinaciju metoda prerade klasičnom flotacijskom preradom sa pirometalurškom preradom i luženja na gomili sa hidrometalurškom ekstrakcijom metala postupkom SX-EW, sa aspekta ekonomske isplativosti takvog postupka. U članku je izvršeno najpre upoređenje rezultata optimizacije mogućih kopova na rudnom ležištu (Whittle Fx), u jednom i drugom slučaju za iste ulazne tehnoekonomske podatke. Dobijeni mogući kopovi iz procesa optimizacije (pit shells), za Revenu Factor 1 (tj. prodajnu cenu tone Cu katode od 5000 $), međusobno se razlikuju za oko 8 miliona tona rude u korist kombinovane metode prerade, a količine Cu u rudi za 16.502,44 t, dok je srednji sadržaj (had grade) u slučaju kombinacije metoda prerade veći za 3,27%. Diskontovani novčani tok (Cash Flow) je veći za čak 61,94%, što izraženo u novčanim jedinicama iznosi 47.905.712 $.

Keywords: *luženje na gomili, SX –EV, optimizacija kopova, diskontovani novčani tok.*

UVOD

Rudno polje Kraku Bugaresku (KB) Cementacija je deo kompleksa rudnih ležišta na lokalitetu Cerovo Mali Krivelj, koje se razlikuje od ostatka ležišta prema načinu nastanka i vrsti orudnjenja. To je cementaciona zona sekundarnog obogaćenja, i jedan deo orudnjenja spada u oksidne mineralizacije (oko 40% od ukupnih geoloških rezervi). Sastoji se od rudnih tela Cementacija 1, 2, 3 i 4 od kojih se prema sadržaju oksidne rude u odnosu na ukupne rezerve, izdvajaju cementacija 3 i 4. Prema sadržaju bakra, ovaj kompleks spada u siromašna ležišta čija je ekonomika eksploatacije vrlo osetljiva na pojedine parametre kao što su iskorišćenje metala u procesu obogaćenja, troškove eksploatacije u tehnološkom lancu od otkopavanja do metalurške prerade, pa čak i redosleda otkopavanja rudnih tela (Push backs) unutar cementacione zone.

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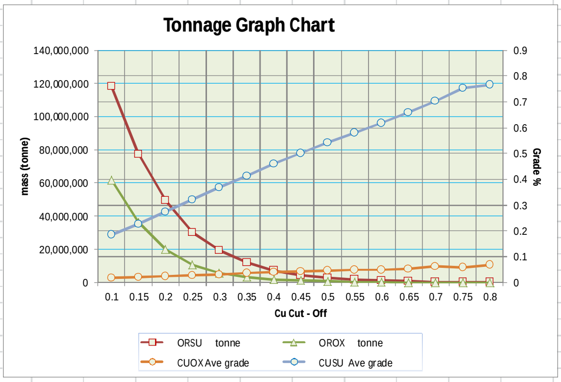
*** *Članak je u sklopu projekata tehnološkog razvoja TR 33038 "Usavršavanje tehnologija eksploatacije i prerade rude bakra sa monitoringom životne i radne sredine u RTB Bor Grupa" i TR 34004 "Nova proizvodna linija za dobijanje bakra solventnom ekstrakcijom rudničkih voda", koji su finansirani od strane Ministarstva prosvete, nauke i tehnološkog razvoja.*

Na sl. 1. prikazana je analiza "Grade tonnage" za različite granične sadržaje (*Cut-off*), što predstavlja karakteristiku ležišta, odakle se vidi odnos količina RSULF i ROXD, tj. količine jedne i druge vrste rude u ležištu.

Najzastupljeniji minerali bakra u gornjem delu ležišta, oksidacionoj zoni su kuprit, malahit i azurit, dok su u zoni sekundarnog sulfidnog obogaćenja najzastupljeniji kovelin i halkozin.

CU Cut-off	ORSU tonne	OROX tonne	CUOX Ave grade	CUSU Ave grade
0.1	118000050	61458241	0.0186	0.1841
0.15	77644440	35989082	0.0217	0.2273
0.2	49637929	20080618	0.0249	0.2721
0.25	30505437	10594773	0.0282	0.3209
0.3	19244147	5625561	0.0312	0.3682
0.35	11857650	3321796	0.0351	0.4136
0.4	7065534	1939478	0.0402	0.4609
0.45	4448241	1231875	0.0443	0.5024
0.5	2869062	700313	0.0472	0.5425
0.55	1847175	371250	0.0501	0.5792
0.6	1168264	151875	0.0502	0.6191
0.65	645079	42188	0.052	0.6597
0.7	287078	25313	0.0605	0.7032
0.75	134847	8438	0.0599	0.7521
0.8	75938	8438	0.068	0.7663

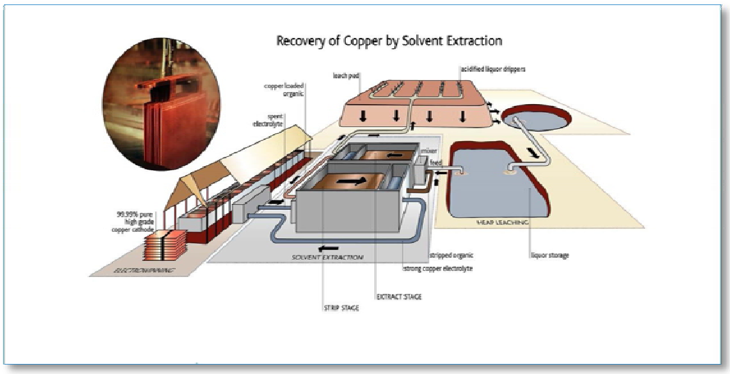


Sl. 1. *"Grade tonnage"analiza za ležište rude bakra KB Cementacija za različite granične sadržaje - tabela i grafik*

Dosadašnji način rada primenjen na eksploataciji ležišta Cementacija 1, koji se sastojao u flotacijskoj preradi celokupne količine rude iznad graničnog sadržaja, bez razdvajanja oksidnih partija rude od sulfidnih, rezultirao je niskim iskorišćenjem bakra u flotaciji koje se kretalo u intervalu između 50 i 70%[1]. To je svakako negativno uticalo i na ostvarene ekonomske rezultate.

Upravo zbog navedenih činjenica vrlo je značajno razmatranje i analiza mogućnosti povećanja NPV-a, odnosno Cashflow-a u eksploataciji ovog kompleksa rudnih tela.

Na sadašnjem nivou tehnološkog razvoja eksploatacije i iskorišćenja metala iz oksidnih i sulfidnih ruda, u poslednje vreme se značaj pridaje *luženju i solventnoj ekstrakciji lužnih* rastvora iz oksidnih ruda, pa čak i iz sulfidnih ruda (ili koncentrata).



Sl. 2. *Šematski Process Flow Diagram - Heap leach, Solvent Extraction and Electro Wining*

[1] *U zvaničnim dokumentima (Godišnji tehnički izveštaji proizvodnje RBB, 1993. -2000. godine) proizvodni rezultati nisu verodostojno prikazani*

ANALIZA U SOFTVERU ZA STRATEŠKO PLANIRANJE WHITTLE FX

Ulazni tehnoekonomski podaci za analizu vršenu u softveru za strateško planiranje Whittle Fx, za scenario 1. i 2., tj. flotiranje sulfidne i oksidne rude zajedno, bez selektivnog otkopavanja i selektivno otkopavanje sa dodatnom metodom metode obogaćivanja - luženjem na gomili rude sa preko 10% oksida, su sledeći:

Tabela 1. *Ulazni tehno-ekonomski parametri eksploatacije za proces optimizacije (input)*

Parametar	Jedinica	Vrednosti
Kapacitet otkopavanja - iskopine	t/god	12Mt od 3.godine 17 Mt
Kapacitet flotacijske prerade - Sulfidna ruda sa max. 10% oksidne	t/god	2,5Mt od 3. Godine 5,5 Mt
Kapacitet luženja na gomili – Oksidna ruda sa preko 10% sadržajem oksida	t/god	2.5 Mt
Cena bakra	$/tkatode	5,000.00
Cena zlata	$/kg	40,000.00
Cena srebra	$/kg	500.00
Troškovi otkopavanja	$/t	2,3.
Troškovi flotacijske prerade	$/t	4,00
Troškovi prerade luženjem na gomili	$/t rude	1.00
Troškovi metalurške prerade bakra	$/t katode	450.00
Troškovi metalurške prerade zlata	$/kg	150.00
Troškovi metalurške prerade srebra	$/kg	15.00
Troškovi hidrometalurške prerade (SXEW)	$/t katode	100.0
Inicijalni kapitalni troškovi luženja i SXEW	$	20,000,000
Ukupno iskorišćenje bakra (flot i metal)	%	0,788
Ukupno iskorišćenje zlata (flot i metal)	%	0,50
Iskorišćenje srebra (flot i metal)	%	0,40
Iskorišćenje bakra iz oksidne rude sa preko 10% sadržajem oksida	%	0,54
Diskontna stopa	%	10.0

Analiza[2] je vršena za 3 scenarija, i to:

1. Scenario 1 – metoda prerade označena sa „MILL“ tj. flotiranje ROXD i RSULF, odnosno dva tipa rude;
2. Scenario 2 – metoda „MILL“ za rudu sa > 10% oksida, i metoda „LEAC“ za rudu sa sadržajem > 10% oksida, pri čemu nije ograničen kapacitet luženja;
3. Scenario 3 – isti kao scenario 2, ali sa ograničenjem kapaciteta luženja na 2.500.000 t, i sa korišćenjem dve vrste skladišta (*Stock Piles*) za rudu do 10% oksida i rudu > 10% oksida (SP1 i SP2). Skladišta su korišćena kao "buffer" za dopunu projektovanog kapaciteta kako u flotaciji, tako i na luženju.

U daljoj analizi za SCENARIO 1 i 2 su tabelarno prikazani rezultati optimizacije u tabelama tipa *Pit By Pit Garph, tj.* kopovi iz optimizacije sa sračunatim novčanim tokom i diskontovanim novčanim tokom za svaki kop iz seta ugnježdenih kopova. Ekonomski pokazatelji su sračunati za tri moguća slučaja – *Best Case*, *Worst Case* i *Specific Case*, tj za radne uglove kosina na kopu jednakim 0^{o}, maksimalni radni ugao i specifičan (izabrani) kop. Merodavan za ocenu i izbor optimalnog kopa po kriterijumu optimalnog profita je diskontovani novčani tok (*cash flow)* za maksimalni radni ugao. To znači da se izabrani kop (*Final pit*) otkopava po fazama (*Push backs*).

Za sva tri slučaja je projektovana i sračunata dinamika otkopavanja za vek eksploatacije izabranog kopa po navedenom kriterijumu, sa odgovarajućim grafičkim prikazom. Takođe su u tabelama prikazane i obračunate količine po vrstama rude (kao *Rock Type*), sa manjim i većim sadržajem oksida, odnosno ostvarenim kapacitetima za metodu "MILL" i metodu"LEAC", u scenariju 3. - sa dodatnim obračunatim količinama rude koje idu na skladište i koje sa skladišta idu u procese.

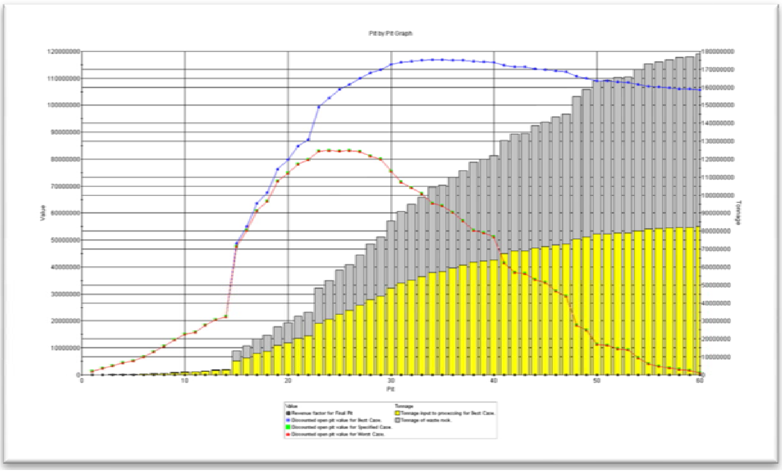
[2] *Pored napred navedenih ulaznih podataka, u softver Whittle se unosi i blok model ležišta, tzv. mod fajl. U kreiranju navedenog u osnovnom softveru, u ovom slučaju Gemcom, koristi se i topografija terena, odnosno stanje rudarskih radova na rudniku. U slučaju ove analize, stanje terena je 10.08.2001., tj. stanje pre ponovnog aktiviranja kopa, upravo zbog toga što analiza nije rađena u sklopu Studije ili projekta, nego je urađena sa svrhom da ukaže na mogućnosti povećanja ekonomskih efekata proizvodnje i pokrene značajnija istraživanja u pravcu extrakcije Cu i pratećih plemenitih metala hidrometalurškim postupkom.*

SCENARIO 1. Jedan tip prerade MILL (flotiranje) sulfidne i oksidne rude zajedno

Tabela 2. *Tabelarni prikaz rezultata optimizacije po Scenariju 1, sa obračunatim novčanog toka*

PIT BY PIT GRAPH - SCENARIO 1

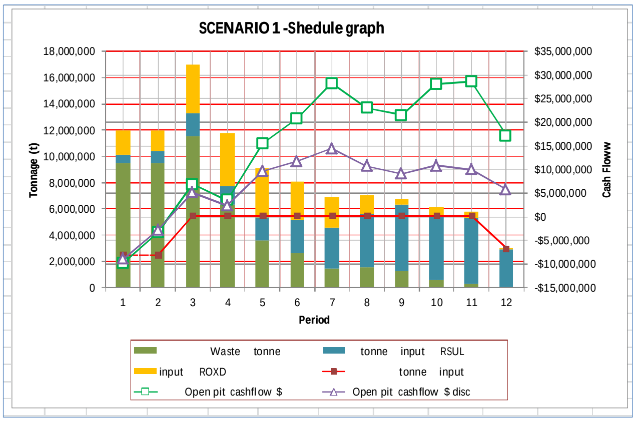
Final pit	Revenue factor for final pit	Open pit cashflow best $ disc	Open pit cashflow specified $ disc	Open pit cashflow worst $ disc	tonne input best	Waste best tonne	Mine life years best	Mine life years specified	Mine life years worst
1	0.32	1,257,649	1,257,649	1,257,649	64,520	9,407	0.03	0.03	0.03
2	0.34	2,340,019	2,340,019	2,340,019	127,897	9,971	0.05	0.05	0.05
3	0.36	3,265,188	3,265,188	3,265,188	188,088	10,150	0.08	0.08	0.08
4	0.38	4,415,908	4,415,908	4,415,908	272,142	14,544	0.11	0.11	0.11
5	0.4	5,121,194	5,121,194	5,121,194	326,594	28,340	0.13	0.13	0.13
6	0.42	6,782,948	6,782,948	6,782,948	475,371	39,226	0.19	0.19	0.19
7	0.44	8,622,922	8,622,922	8,622,922	654,558	64,086	0.26	0.26	0.26
8	0.46	10,525,070	10,525,070	10,525,070	868,580	85,685	0.35	0.35	0.35
9	0.48	13,053,414	13,053,414	13,053,414	1,188,709	111,857	0.48	0.48	0.48
10	0.5	15,071,636	15,071,636	15,071,636	1,480,565	120,560	0.59	0.59	0.59
11	0.52	15,737,824	15,737,824	15,737,824	1,589,257	128,947	0.64	0.64	0.64
12	0.54	18,383,286	18,383,286	18,383,286	2,040,985	229,016	0.82	0.82	0.82
13	0.56	20,388,697	20,388,697	20,388,697	2,429,329	299,806	0.97	0.97	0.97
14	0.58	21,534,215	21,532,415	21,532,415	2,663,808	335,688	1.07	1.07	1.07
15	0.6	48,788,934	47,538,914	47,538,914	7,875,043	5,582,314	2.52	2.52	2.52
16	0.62	55,146,867	53,508,008	53,508,008	9,599,654	6,485,167	2.84	2.84	2.84
17	0.64	63,570,562	60,902,078	60,902,078	11,991,784	7,986,686	3.27	3.27	3.27
18	0.66	67,546,940	64,308,942	64,308,942	13,194,047	8,727,104	3.49	3.49	3.49
19	0.68	76,251,473	71,761,565	71,761,565	16,394,020	10,505,786	4.07	4.07	4.07
20	0.7	79,816,489	74,837,962	74,837,962	17,911,544	11,034,033	4.35	4.35	4.35
21	0.72	84,775,931	78,120,000	78,120,000	20,275,932	12,509,270	4.78	4.78	4.78
22	0.74	87,297,954	79,729,295	79,729,295	21,721,280	13,173,614	5.04	5.04	5.04
23	0.76	99,408,000	82,884,123	82,884,123	28,647,492	19,642,382	6.30	6.55	6.55
24	0.78	102,648,142	83,151,343	83,151,343	31,079,978	21,409,083	6.74	7.05	7.05
25	0.8	105,911,193	82,932,523	82,932,523	33,864,262	24,482,200	7.25	7.62	7.62
26	0.82	107,796,516	83,166,000	83,166,000	36,026,740	25,479,248	7.64	8.02	8.02
27	0.84	109,864,961	82,857,682	82,857,682	38,690,541	27,906,217	8.13	8.52	8.52
28	0.86	112,055,441	81,155,078	81,155,078	41,754,095	31,007,667	8.68	9.10	9.10
29	0.88	113,121,606	80,039,265	80,039,265	43,695,298	33,065,173	9.04	9.46	9.46
30	0.9	115,083,888	75,541,273	75,541,273	48,341,430	37,235,782	9.88	10.32	10.32
31	0.92	115,955,763	71,519,775	71,519,775	50,942,253	40,014,353	10.35	10.89	10.89
32	0.94	116,329,206	69,437,935	69,437,935	52,691,741	42,144,430	10.67	11.24	11.24
33	0.96	116,577,596	67,166,852	67,166,852	54,558,738	44,257,231	11.01	11.62	11.62
34	0.98	116,812,522	63,546,156	63,546,156	56,940,722	47,520,092	11.44	12.10	12.10
35	1	116,822,322	62,763,271	62,763,271	57,462,570	48,143,878	11.54	12.20	12.20
36	1.02	116,733,132	60,247,593	60,247,593	59,523,326	50,336,326	11.91	12.60	12.60
37	1.04	116,570,305	57,088,898	57,088,898	61,004,701	52,645,714	12.18	12.91	12.91
38	1.06	116,246,697	53,548,340	53,548,340	62,679,665	55,723,640	12.49	13.27	13.27
39	1.08	116,104,201	52,612,974	52,612,974	63,285,683	56,807,448	12.60	13.38	13.38
40	1.1	115,890,094	51,230,325	51,230,325	63,973,933	57,909,775	12.72	13.51	13.51
41	1.12	114,776,583	41,519,881	41,519,881	67,492,199	62,846,779	13.36	14.34	14.34
42	1.14	114,282,584	37,924,212	37,924,212	68,822,070	65,024,645	13.60	14.65	14.65
43	1.16	114,198,024	37,513,600	37,513,600	69,049,326	65,188,415	13.65	14.69	14.69
44	1.18	113,547,212	35,394,348	35,394,348	70,505,451	68,088,287	13.91	14.96	14.96
45	1.2	113,180,094	34,216,439	34,216,439	71,313,473	69,376,637	14.06	15.11	15.11
46	1.22	112,692,740	31,159,282	31,159,282	72,264,584	71,233,186	14.23	15.34	15.34
47	1.24	112,393,820	29,204,421	29,204,421	72,820,099	72,285,894	14.33	15.48	15.48
48	1.26	110,665,910	18,407,558	18,407,558	75,656,596	79,276,775	14.86	16.25	16.25
49	1.28	109,992,003	16,490,497	16,490,497	76,759,211	81,937,428	15.15	16.46	16.46
50	1.3	109,028,005	11,329,090	11,329,090	78,333,172	85,123,865	15.43	16.80	16.80
51	1.32	108,936,513	10,951,659	10,951,659	78,476,259	85,430,456	15.46	16.83	16.83
52	1.34	108,604,954	9,631,895	9,631,895	78,947,606	86,580,421	15.54	16.93	16.93
53	1.36	108,528,079	9,319,586	9,319,586	79,090,693	86,744,802	15.57	16.96	16.96
54	1.38	107,646,094	6,399,243	6,399,243	80,168,057	89,781,653	15.77	17.17	17.17
55	1.4	106,959,546	4,034,446	4,034,446	81,102,333	92,015,091	15.94	17.35	17.35
56	1.42	106,704,144	3,213,701	3,213,701	81,439,009	92,833,624	16.00	17.41	17.41
57	1.44	106,461,667	2,659,448	2,659,448	81,716,767	93,627,441	16.06	17.47	17.47
58	1.46	106,136,964	1,975,632	1,975,632	82,087,111	94,621,529	16.14	17.53	17.53
59	1.48	106,087,512	1,742,133	1,742,133	82,154,446	94,741,304	16.15	17.55	17.55
60	1.5	105,680,501	702,770	702,770	82,533,207	96,158,579	16.25	17.62	17.62



Sl. 3. *Pit by Pit graph - Grafik optimizacije po Scenariju 1*

Tabela 3. *Dinamika otkopavanja po Scenariju 1*

					SCENARIO 1_ SHEDULE GRAPPH										
	PB: 19, 26,3														
Period	tonne input	Waste tonne	Strip ratio	tonne input RSUL	Units input RSUL CU	Grade input CUS	tonne input ROXD	Units input ROXD CU	Grade input CUOX	Grade input CU	Grade input PRCU	Grade input AU	Grade input AG	Open pit cashflow $	Open pit cashflow $ disc
					x 100			x100							
1	2,497,779	9,502,221	3.8	601,834	241,726	0.2449	1,895,945	462,625	0.0413	0.282	15.4797	0.0753	1.1065	-9,847,862	-8,952,602
2	2,499,693	9,500,307	3.8	917,321	451,536	0.3076	1,582,372	426,201	0.0484	0.3511	15.7806	0.0802	1.0753	-3,387,689	-2,799,743
3	5,495,999	11,504,001	2.09	1,769,556	816,733	0.2808	3,726,443	952,774	0.0458	0.322	16.0559	0.0718	1.0124	6,867,290	5,159,496
4	5,499,999	6,315,358	1.15	1,462,051	427,596	0.2038	4,037,947	887,950	0.0393	0.2392	16.1273	0.0693	1.1278	3,452,064	2,357,806
5	5,500,000	3,586,533	0.65	1,785,345	533,392	0.2303	3,714,655	929,696	0.0397	0.266	14.6026	0.0791	1.1537	15,477,799	9,610,495
6	5,500,000	2,599,697	0.47	2,570,586	823,796	0.2542	2,929,414	753,057	0.0361	0.2867	13.4667	0.0727	1.0313	20,814,587	11,749,292
7	5,500,000	1,403,682	0.26	3,146,090	1,044,249	0.2634	2,353,910	553,530	0.0301	0.2905	11.1239	0.0848	1.0792	28,194,533	14,468,253
8	5,499,999	1,557,531	0.28	4,021,808	1,109,667	0.2397	1,478,191	300,803	0.0186	0.2564	7.6091	0.0862	1.0487	23,064,615	10,759,813
9	5,500,000	1,263,215	0.23	5,082,426	1,282,422	0.2367	417,573	85,504	0.0133	0.2487	5.3879	0.0827	1.031	21,474,074	9,107,104
10	5,500,000	605,505	0.11	4,879,546	1,326,078	0.252	620,454	125,263	0.0133	0.2639	5.2266	0.0996	1.2105	27,995,708	10,793,557
11	5,500,000	271,792	0.05	5,017,944	1,395,811	0.2582	482,056	88,229	0.0129	0.2698	5.0344	0.0848	1.3015	28,542,461	10,003,959
12	2,969,102	34,036	0.01	2,916,661	803,531	0.2654	52,440	12,601	0.0105	0.2749	3.7942	0.0994	1.3529	17,194,580	5,724,357
	57,462,571	48,143,878		34,171,168			23,291,400							179,842,160	77,981,787

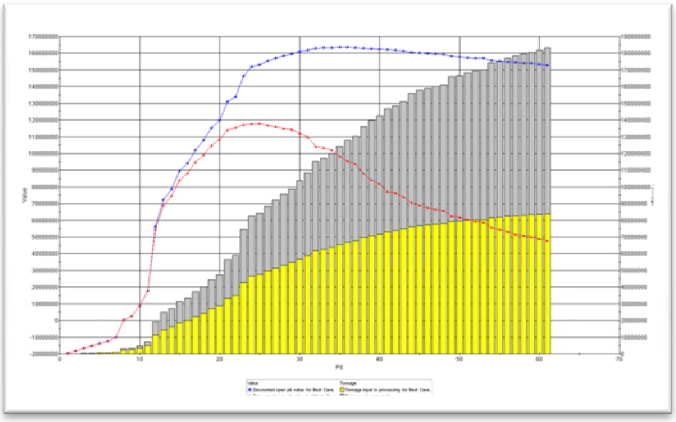


Sl. 4. *Grafički prikaz DINAMIKE otkopavanja po Scenariju 1, sa jednom metodom prerade – MILL; ukupne količine rude bez selektivnog otkopavanja idu u flotacijsku preradu i koncentrat na pirometalurški postupak*

SCENARIO 2. Dva tipa prerade MILL (flotiranje) i HEAP LEACHING (luženje na gomili)

Tabela 4. *Tabelarni prikaz rezultata optimizacije po Scenariju 2, sa obračunatim CashFlow*

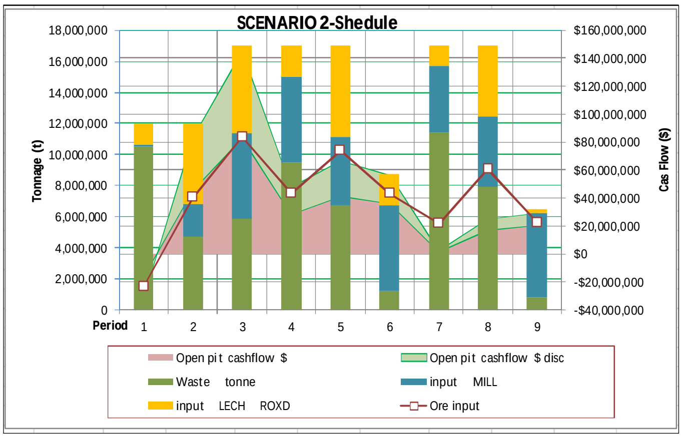
PIT BY PIT GRAPH - SCENARIO 2											
Final pit	Revenue factor for final pit	Open pit cashflow best $disc	Open pit cashflow specified $disc	Open pit cashflow worst $disc	tonne input best	Waste best tonne	Mine life years best	Mine life years specified	Mine life years worst	Internal rate of return best %	Internal rate of return worst %
1	0.3	-19,672,238	-19,672,238	-19,672,238	26,916	67	0.00	0.00	0.00	0	0
2	0.32	-18,172,452	-18,172,452	-18,172,452	117,064	11,192	0.03	0.03	0.03	0	0
3	0.34	-16,598,225	-16,598,225	-16,598,225	236,298	14,400	0.05	0.05	0.05	0	0
4	0.36	-15,206,239	-15,206,239	-15,206,239	356,166	17,900	0.08	0.08	0.08	0	0
5	0.38	-13,815,237	-13,815,237	-13,815,237	471,549	24,595	0.11	0.11	0.11	0	0
6	0.4	-12,477,700	-12,477,700	-12,477,700	623,194	47,353	0.13	0.13	0.13	0	0
7	0.42	-10,006,388	-10,006,388	-10,006,388	879,677	89,393	0.20	0.20	0.20	0	0
8	0.44	244,677	244,677	244,677	2,221,015	757,403	0.29	0.29	0.29	4.03	4.03
9	0.46	2,673,733	2,673,733	2,673,733	2,552,183	830,394	0.36	0.36	0.36	17.29	17.29
10	0.48	8,658,819	8,658,819	8,658,819	3,431,323	1,262,659	0.48	0.48	0.48	50.03	50.03
11	0.5	17,861,713	17,861,713	17,861,713	5,020,490	2,005,231	0.69	0.69	0.69	102.2	102.2
12	0.52	56,166,769	54,806,665	54,806,665	11,373,660	7,933,596	2.07	2.19	2.19	174.16	136.69
13	0.54	72,345,544	68,906,902	68,906,902	14,459,921	10,464,136	2.36	2.49	2.49	183.73	116.43
14	0.56	78,651,502	74,683,218	74,683,218	15,955,469	11,180,073	2.49	2.64	2.64	187.33	116.22
15	0.58	89,657,379	83,964,252	83,964,252	18,628,312	12,656,334	2.74	2.97	2.97	193.51	112.76
16	0.6	94,177,326	88,262,713	88,262,713	19,906,020	13,491,902	2.86	3.11	3.11	196.05	110.79
17	0.62	102,041,906	94,967,147	94,967,147	22,306,910	14,818,353	3.20	3.44	3.44	198.55	103.31
18	0.64	107,825,197	99,135,151	99,135,151	24,190,047	15,786,074	3.44	3.72	3.72	199.57	98.3
19	0.66	115,263,766	104,855,424	104,855,424	26,963,760	17,384,509	3.78	4.11	4.11	200.93	92.92
20	0.68	119,827,401	109,467,857	108,368,981	28,858,724	18,643,233	4.03	4.36	4.39	201.72	87.95
21	0.7	131,018,438	119,070,774	114,123,936	33,311,000	23,050,589	4.59	4.92	5.07	202.39	74.82
22	0.72	133,849,985	121,691,295	115,646,776	34,870,282	24,119,422	4.77	5.10	5.35	202.58	71.9
23	0.74	146,289,750	134,152,102	117,198,533	42,640,316	31,908,409	5.74	5.84	6.58	202.61	54.6
24	0.76	151,869,938	139,491,522	117,668,350	46,568,407	35,916,783	6.18	6.24	7.17	202.7	49.49
25	0.78	153,176,720	140,648,407	117,997,340	47,586,853	36,658,979	6.32	6.38	7.36	202.71	48.83
26	0.8	155,346,218	141,567,411	116,920,205	49,572,609	38,908,109	6.48	6.75	7.70	202.73	46.22
27	0.82	157,052,532	143,038,162	116,146,307	51,466,413	40,623,250	6.70	6.96	8.01	202.75	44.61
28	0.84	158,467,534	144,384,440	115,089,056	53,107,709	42,556,953	6.92	7.18	8.32	202.76	42.8
29	0.86	159,647,264	145,337,729	114,353,244	54,648,002	44,289,647	7.13	7.40	8.59	202.76	41.68
30	0.88	160,916,422	146,339,541	112,147,672	56,769,062	46,725,984	7.39	7.65	8.95	202.76	39.53
31	0.9	161,913,154	146,964,713	109,851,681	58,780,703	49,642,105	7.63	7.89	9.28	202.77	37.45
32	0.92	162,816,991	147,314,004	104,105,169	61,768,704	53,527,893	8.03	8.11	9.82	202.77	33.85
33	0.94	163,095,472	147,660,882	103,368,020	62,694,563	54,471,675	8.16	8.24	9.98	202.77	33.5
34	0.96	163,321,340	147,887,443	101,824,917	63,822,428	56,193,108	8.31	8.39	10.19	202.77	32.62
35	0.98	163,417,237	147,538,011	98,291,386	65,463,725	58,731,018	8.53	8.61	10.49	202.77	30.92
36	**1.00**	163,413,866	147,208,895	95,534,405	66,860,931	61,005,204	8.75	8.81	10.74	202.77	29.78
37	1.02	163,350,325	146,984,292	93,855,435	67,618,452	62,402,200	8.88	8.92	10.90	202.77	29.17
38	1.04	162,990,167	146,391,624	88,142,664	69,621,676	66,530,279	9.24	9.10	11.32	202.77	26.95
39	1.06	162,687,631	146,011,943	84,136,112	70,825,293	69,012,059	9.45	9.22	11.61	202.77	25.54
40	1.08	162,418,596	145,687,328	81,941,941	71,675,400	70,757,066	9.61	9.32	11.78	202.77	24.91
41	1.1	161,958,663	145,239,954	77,022,384	73,114,691	73,794,528	9.87	9.43	12.01	202.77	23.38
42	1.12	161,715,486	144,974,952	76,337,965	73,754,376	74,761,151	9.97	9.54	12.12	202.77	23.23
43	1.14	161,282,789	144,524,440	74,139,095	74,713,903	76,282,487	10.12	9.66	12.28	202.77	22.64
44	1.16	160,393,985	143,478,731	70,610,743	76,271,030	79,628,190	10.40	9.93	12.63	202.77	21.87
45	1.18	160,009,540	143,005,599	68,802,935	76,927,549	80,809,058	10.51	10.05	12.77	202.77	21.46
46	1.2	159,750,944	142,701,727	67,614,646	77,306,309	81,529,923	10.57	10.12	12.87	202.77	21.21
47	1.22	159,499,447	142,341,707	66,256,070	77,676,653	82,319,161	10.64	10.17	12.96	202.77	20.91
48	1.24	159,295,897	142,113,953	65,799,438	77,945,994	82,837,707	10.69	10.22	13.02	202.77	20.84
49	1.26	158,015,015	139,922,517	62,328,616	79,410,535	86,639,495	11.00	10.79	13.35	202.77	20.18
50	1.28	157,863,368	139,693,840	61,865,282	79,595,707	86,985,252	11.03	10.85	13.39	202.77	20.09
51	1.3	157,367,328	139,021,808	60,337,557	80,134,389	88,212,094	11.13	11.01	13.52	202.77	19.79
52	1.32	157,072,032	138,672,839	59,388,993	80,428,981	88,960,379	11.19	11.11	13.59	202.77	19.61
53	1.34	156,925,269	138,858,175	58,867,463	80,580,485	89,306,146	11.22	11.15	13.63	202.77	19.51
54	1.36	155,676,400	136,824,618	55,643,325	81,582,097	92,525,863	11.47	11.45	13.85	202.77	18.95
55	1.38	155,395,291	136,336,916	54,535,636	81,851,438	93,245,125	11.53	11.51	13.91	202.77	18.73
56	1.4	154,835,151	135,675,444	53,218,993	82,339,618	94,564,453	11.64	11.64	14.02	202.77	18.52
57	1.42	154,365,417	135,440,033	51,467,525	82,785,714	95,738,141	11.73	11.70	14.11	202.77	18.15
58	1.44	154,006,200	134,626,269	50,782,641	83,063,472	96,541,596	11.79	11.76	14.17	202.77	18.05
59	1.46	153,778,993	134,710,293	50,099,768	83,248,644	97,114,026	11.84	11.79	14.22	202.77	17.92
60	1.48	153,362,897	133,681,893	48,817,500	83,534,819	98,184,577	11.92	11.84	14.30	202.77	17.69
61	1.5	152,867,204	133,127,020	47,673,571	83,863,078	99,432,262	12.03	11.90	14.39	202.77	17.49



Sl. 5. *Pit by Pit Graph optimizacije po Scenariju 2. – output Whittle Fx*

Tabela 5. *Dinamika otkopavanja po Scenariju 2.*

							SCENARIO 2							
							Shedule Graph							
							PB: 19,25,35; Methods: MILL, LEAC,							
Period	Ore input tonne	Waste tonne	Strip ratio	input **MILL** **RSUL** tonne	Grade input CUS %	RSUL Units t	input **LECH** **ROXD** tonne	Grade input CUOX %	ROXD Units t	Grade input CU %	Grade input AU gram/t	Grade input AG gram/t	Open pit cashflow $	Open pit cashflow $disc
1	1,483,848	10,516,152	7.09	95,351	0.1952	186	1,388,497	0.0364	505.4129	0.228	0.0641	1.0903	-16,257,162	-14,779,238
2	7,256,451	4,743,549	0.65	2,031,516	0.2616	5,314	5,224,935	0.0544	2842.365	0.3105	0.0678	1.0799	45,641,783	37,720,482
3	11,130,003	5,869,998	0.53	5,498,265	0.3002	16,506	5,631,737	0.0413	2325.907	0.3374	0.0851	1.0354	82,715,224	62,145,172
4	7,496,487	9,503,513	1.27	5,491,447	0.2717	14,920	2,005,040	0.0198	396.9979	0.2895	0.0896	1.2142	28,267,692	19,307,214
5	10,270,649	6,729,351	0.66	4,397,961	0.2189	9,627	5,872,689	0.0273	1603.244	0.2435	0.0814	1.1178	41,111,614	25,527,078
6	7,517,886	1,213,627	0.16	5,500,000	0.2387	13,129	2,017,886	0.0194	391.4699	0.2561	0.0751	1.0332	36,047,092	20,347,644
7	5,577,058	11,422,942	2.05	4,277,886	0.2268	9,702	1,299,172	0.0157	203.9700	0.2409	0.0944	1.2623	1,530,874	785,581
8	9,084,645	7,915,355	0.87	4,530,802	0.1891	8,568	4,553,843	0.0226	1029.169	0.2094	0.0663	1.1096	16,972,872	7,917,970
9	5,646,698	816,532	0.14	5,403,277	0.2183		243,421	0.0101	24.58552	0.2275	0.0884	1.1575	20,451,716	8,688,074
	65,463,725	58,731,019		**37,226,505**	0.2094	77,952	**28,237,220**	0.0330	9323.121				**256,481,705**	**167,659,977**



Sl. 6. *Grafik dinamike otkopavanja po Scenariju 2– dve metode prerade MILL i LEAC, selektivno otkopavanje rude na kopu;*

SCENARIO 3. Dva tipa prerade MILL (flotiranje) i LEAC (Heap leaching) – korišćenjem skladišta (Stock pile)

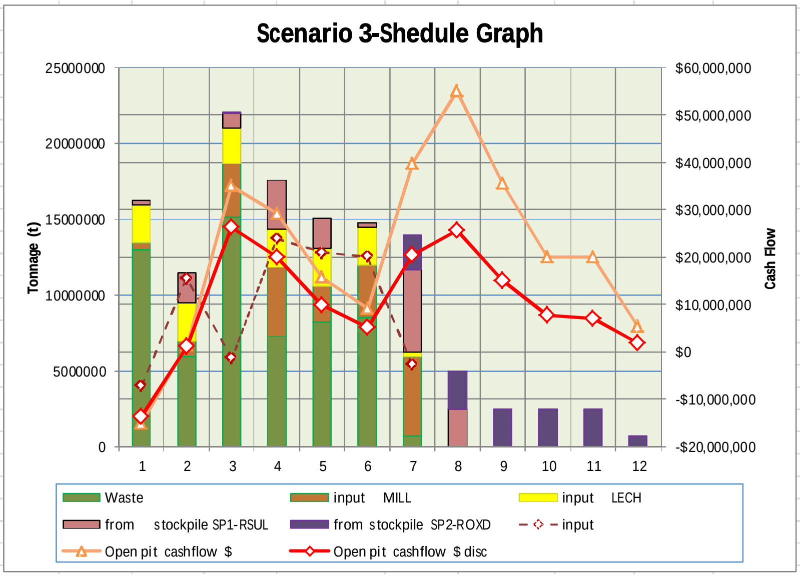
Tabela 6. *Dinamika otkopavanja po Scenariju 3*

SCENARIO 3

Shedule graph, PB 19,26,35

METHODS: MILLS, LEAC,using STOCK PILE

Period	tonne input	Waste tonne	Grade input CU	Strip ratio	tonne input MILL	Grade input CUS	**Total tonne RSUL input MILL**	tonne input LECH	**Total tonne ROXD input LEAC**	Grade input CUOX	to stockpile SP1-RSUL	to stockpile SP2-ROXD	from stockpile SP1-RSUL	from stockpile SP2-ROXD	Grade input AU	Grade input AG	Open pit cashflow $	Open pit cashflow $ disc
	tonne	tonne	%		tonne	%	**Total tonne**	tonne	Total tonne	%	tonne	tonne	tonne	tonne	gram/t	gram/t		
1	4007473	12992527	0.248	4.73	466151	0.2103	**466,151**	2500000	**2,500,000**	0.042	285,841	755,480	0	0	0.0627	1.0459	-15,069,161	-13,699,237
2	11090720	5909280	0.3211	3.82	1024734	0.27	**1,310,575**	2500000	**2,500,000**	0.057	2,969,891	4,596,095	285,841	0	0.0697	1.1192	1,348,967	1,114,849
3	5854174	15145826	0.2866	2.59	3483203	0.2619	**5,500,000**	2370971	**2,500,000**	0.030	0	0	2,016,797	129,029	0.0985	1.0567	34,882,993	26,208,109
4	13715438	7284562	0.2878	1.97	4566208	0.2679	**5,500,000**	2500000	**2,500,000**	0.027	3,166,789	3,482,440	933,792	0	0.0919	1.2133	29,060,028	19,848,390
5	12774591	8225409	0.2487	3.36	2314153	0.2233	**5,500,000**	2500000	**2,500,000**	0.026	6,210,311	1,750,127	3,185,847	0	0.0749	1.0548	15,770,587	9,792,294
6	12525343	8474657	0.2297	2.52	3472467	0.2118	**5,500,000**	2500000	**2,500,000**	0.013	4,065,003	2,487,872	2,027,533	0	0.0862	1.3173	9,011,769	5,086,909
7	5442522	752221	0.2274	0.14	5201753	0.2183	**5,500,000**	240769	**2,500,000**	0.012	0	0	298,247	2,259,231	0.0891	1.166	39,699,894	20,372,323
8	0	0	0	999.99	0	0	**5,500,000**	0	**2,500,000**	0	0	0	5,500,000	2,500,000	0	0	55,009,671	25,662,417
9	0	0	0	999.99	0	0	**2,449,779**	0	**2,500,000**	0	0	0	2,449,779	2,500,000	0	0	35,498,778	15,054,947
10	0	0	0	999.99	0	0	**0**	0	**2,500,000**	0	0	0	0	2,500,000	0	0	19,828,642	7,644,800
11	0	0	0	999.99	0	0	**0**	0	**2,500,000**	0	0	0	0	2,500,000	0	0	19,828,642	6,949,818
12	0	0	0	999.99	0	0	**0**	0	**683,755**	0	0	0	0	683,755	0	0	5,423,171	1,851,880
	65,410,261	58,784,482					**37,226,505**		**28,183,755**		16,697,835	13,072,014	16,697,836	13,072,015			250,293,981	125,887,499



Sl. 7. *Grafik Dinamike otkopavanja po Scenariju 3 - dve metode prerade MILL i LEAC, selektivno otkopavanje rude na kopu;*

ZAKLJUČAK

Dobijeni mogući kopovi iz procesa optimizacije (*pit shells*), za *Revenu Factor 1*[3] *(*tj. prodajnu cenu tone Cu katode od 5000$*),* međusobno se razlikuju za oko 8 miliona tona rude u korist kombinovane metode prerade, a količine Cu u rudi za 16,502. 44 t,

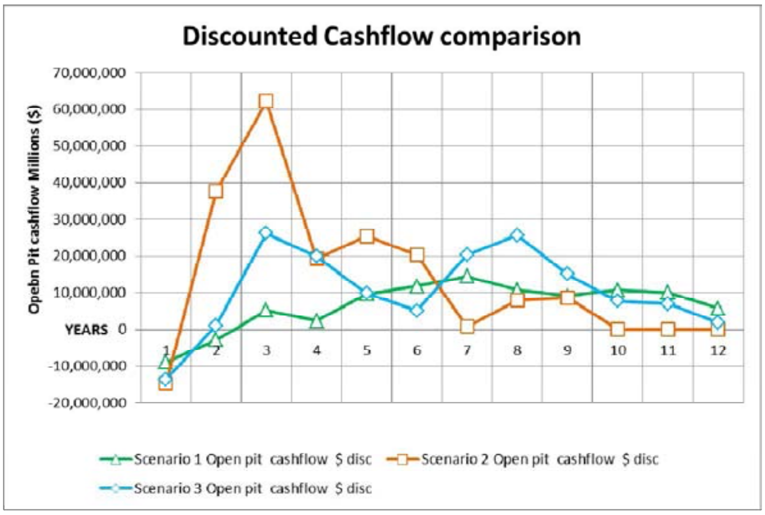
[3] *Revenue Factor je koeficijent kojim se množi bazna prodajna cena metala. U slučaju ove optimizacije bazna cena je $5000, a RevFtr se kreće od 0.3 do 1.5.*

dok je srednji sadržaj (*had grade*) u slučaju kombinacije metoda prerade veći za 3.27%. Diskontovani novčani tok (Cash Flow) je veći za čak 61.94%, što izraženo u novčanim jedinicama iznosi 47.905.712 $.

Navedeni rezultati analize, i pored toga što je deo ulaznih podataka vezanih za luženje, solventnu ekstrakciju i elektrolizu - procenjeno na osnovu literature i iskustava u svetu, pa je stepen njihove tačnosti smanjen, ukazuju, principijelno, na značajna poboljšanja tehno - ekonomskih rezultata u slučaju korišćenja kombinovane metode prerade. To upućuje nato da je potrebno uraditi detaljnija ispitivanja (*metallurgical test*), čime će se povećati stepen tačnosti rezultata do nivoa relevantnosti za donošenje poslovnih odluka.

Tabela 7. *Uporedni prikaz vrednosti novčanog toka (Cash Flow) za sva tri scenarija prerade*

Period	Scenario 1		Scenario 2		Scenario 3	
	Open pit cashflow $	Open pit cashflow $ disc	Open pit cashflow $	Open pit cashflow $ disc	Open pit cashflow $	Open pit cashflow $ disc
1	-9,847,862	-8,952,602	-16,257,162	-14,779,238	-15,069,161	-13,699,237
2	-3,387,689	-2,799,743	45,641,783	37,720,482	1,348,967	1,114,849
3	6,867,290	5,159,496	82,715,224	62,145,172	34,882,993	26,208,109
4	3,452,064	2,357,806	28,267,692	19,307,214	29,060,028	19,848,390
5	15,477,799	9,610,495	41,111,614	25,527,078	15,770,587	9,792,294
6	20,814,587	11,749,292	36,047,092	20,347,644	9,011,769	5,086,909
7	28,194,533	14,468,253	1,530,874	785,581	39,699,894	20,372,323
8	23,064,615	10,759,813	16,972,872	7,917,970	55,009,671	25,662,417
9	21,474,074	9,107,104	20,451,716	8,688,074	35,498,778	15,054,947
10	27,995,708	10,793,557	0	0	19,828,642	7,644,800
11	28,542,461	10,003,959	0	0	19,828,642	6,949,818
12	17,194,580	5,724,357	0	0	5,423,171	1,851,880
	179,842,160	77,981,787	256,481,705	167,659,977	250,293,981	125,887,499



Sl. 8. *Grafik uporednog prikaza Cash Flow za sva tri scenarija prerade*

Razlika u diskontovanom cashflow (zbirno i *incremental* po godinama) izmedju analiziranih scenarija 1. i 2. je značajna, dok između 2. i 3. nije prevelika, čak je u korist scenarija bez korišćenja stok pajlova, ali to može biti i posledica nedovoljnog poznavanja stvarnih tehno – ekonomskih parametara procesa luženja.

U ovoj analizi su korišćeni delom literaturni podaci o luženju [1,7], delom su vrednosti procenjene na osnovu drugih, tuđih iskustava ili zaključaka i poređenja sa pirometalurškim načinom prerade gde postoji dovoljno podataka. Naročito je bitno za luženje na gomili (*Heap Leaching*) utvrditi: iskorišćenja osnovnog i plemenitih metala, kao i vremena luženja, troškove same metode luženja od pripreme podloga za gomile rude koje će se tretirati, utroška kiseline, utroška folije za pripremu podloge, instalacije za razvod kiseline (cijanida) i drugih normativnih materijalakao i troškove dobijanja metala iz lužnih rastvora u metalurškom procesu prerade. Sve navedene troškove treba svesti na tonu rude, odnosno tonu finalnog proizvoda, na način kako softwer Whittle definiše i u analizi prihvata input troškova.

Autori članka nisu imali ambiciju da se u ovoj analizi bave samom tehnologijom luženja (detaljnom tehnikom i hemizmom procesa luženja) obzirom da su drugih specijalnosti, već da uporede ekonomske efekte za navedene slučajeve primenjenih metoda ekstrakcije osnovnog i pratećih plemenitih metala i na osnovu toga izvuku određene zaključke, prezentirane u radu.

Dosadašnje mišljenje dela stručne javnosti kao i stanovništva na lokalitetima rudnih ležišta - Cerovo Kraku Bugaresku, Ujova reka i drugih sadašnjih i potencijalnih lokaleta na kojima su ležišta sa sličnim karakteristikama, je da je postupak luženja vrlo rizičan po zaštitu životne sredine.Takvo mišljenje je demantovano u svetu, pored ostalog i time što se od ukupne svetske proizvodnje bakra, oko 20% dobija luženjem. To rade i najrazvijenije države u svetu, koje mnogo vise vode računa o zaštiti životne sredine nego mi, i čiji su propisi iz ove oblasti daleko strožiji od naših (SAD, Čile, Kanada, Južnoafrička Republika i dr.).

Svrha ove analize je da ukaže na potencijalnu, alternativnu metodu kojom se može uvećati dobit od eksploatacije ležišta koja sadrže povećani sadržaj oksidnih minerala u rudi koji negativno utiču na iskorišćenje metala pri flotacijskoj metodi obogaćivanja. Analiza ovog tipa čaki ako se radi o dilemi da li uopšte eksploatisati takva ležišta tj. da li je ekonomika eksploatacije zadovoljavajuća, o čemu postoje u ovdašnjoj stručnoj javnosti oprečna mišljenja, mogu dati odgovarajuće podatke za relevantnu kvalifikovanu ocenu i odluku.

Važno napomenuti i to da je trend tehnologije luženja – luženje i sulfidnih koncentrata.

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