Concentracion possibility examination of ore from „Ćulav Brajšor” field, near Medveđa

Đurica Nikšić, Predrag Lazić, Branko Zečević

CONCENTRACION POSSIBILITY EXAMINATION OF ORE FROM „ĆULAV BRAJŠOR" FIELD, NEAR MEDVEĐA

Đurica Nikšić[a], Predrag Lazić[a], Branko Zečević[b]

[a] *Faculty of Mining and geology, Mineral Processing Department, 11000 Belgrade-Serbia*
[b] *Metalfer d.o.o. - Sremska amitrovica-Serbia*

1 ABSTRACT

Laboratory results of concentration possibility examination of Pb-Zn- Au-Ag ore from "Ćulav Brajšor" field, near Medveđa are shown in this article. This result are product of concentration possibility research on Pb-Zn- Au-Ag ore which is part of study of reserves. Study of reserves is property of "Metalfer d.o.o." from Sremska Mitrovica.

Results of laboratory research led to conclusion that ore has significant flotation properties and that is possible to produce lead and zinc concentrate with an astonishing quality. Lead concentrate contains high amount of gold with good recovery. Prognostic value of quality and recovery of metals in lead and zinc concentrates are shown based on laboratory flotation research.

Key words: Flotation concentration, concentrate quality, recovery.

Corresponding Author: djurica.niksic@rgf.bg.ac.rs

2 INTRODUCTION

2.1 Sample Processing

Representative ore sample with mass around of 120 kg was transported to laboratory of Department of Mineral processing on Mining and geology faculty in Belgrade. Sample was processed on usual way according to:

- downsizing ore sample particle size to a 100% - 5mm
- homogenization
- sample mass reduction Q/2 (half of mass was used for research, other half was kept as reserve)
- taking samples for chemical analysis and determination of humidity
- complete chemical analysis, mandatory on: Pb, Zn, Ag, Au, As, S, SiO_2, i Al_2O_3
- taking samples for technology reserach (30 samples with mass of 1 kg)

Sample of ore prepared on this way was subjected to a complete chemical analysis, mineralogy analysis and flotation concentration experiments. Flotation concentration experiments were conducted according to improved „Lece" mine flotation regime.

Table 1. Complete chemical analysis of composite ore sample „Ćulav Brajšor".

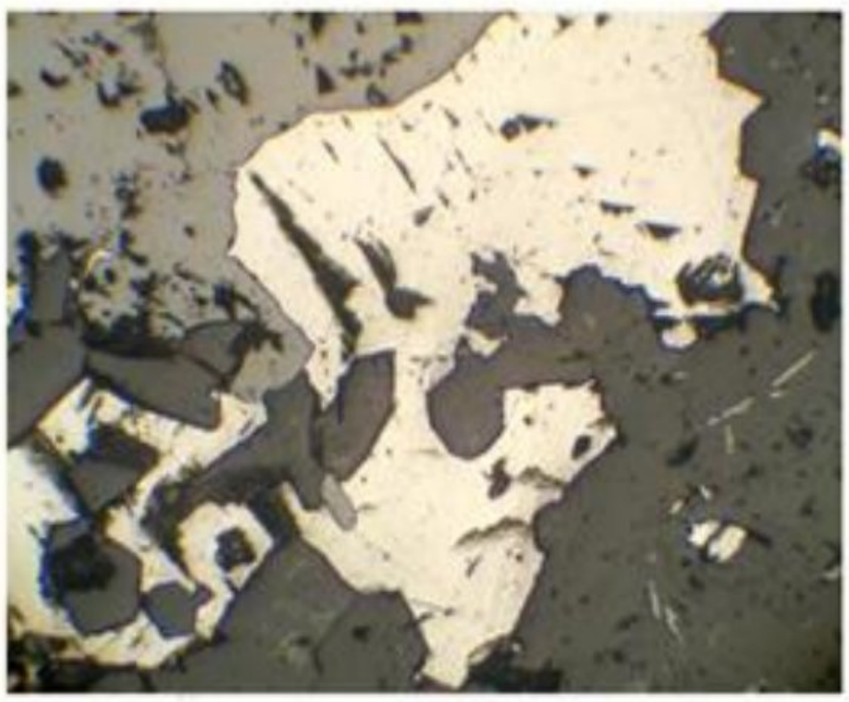
Element	Pb(%)	Zn(%)	Au(g/t)	Ag(%)	As(%)	Sb(%)	Cu(%)	Fe(%)
Composite	1,04	3,16	3,44	6,63	0,0006	0,0020	0,011	3,24

Composite ore sample contain around 1% lead, around 3% zinc, around 4 g/t gold and around 6 g/t silver.

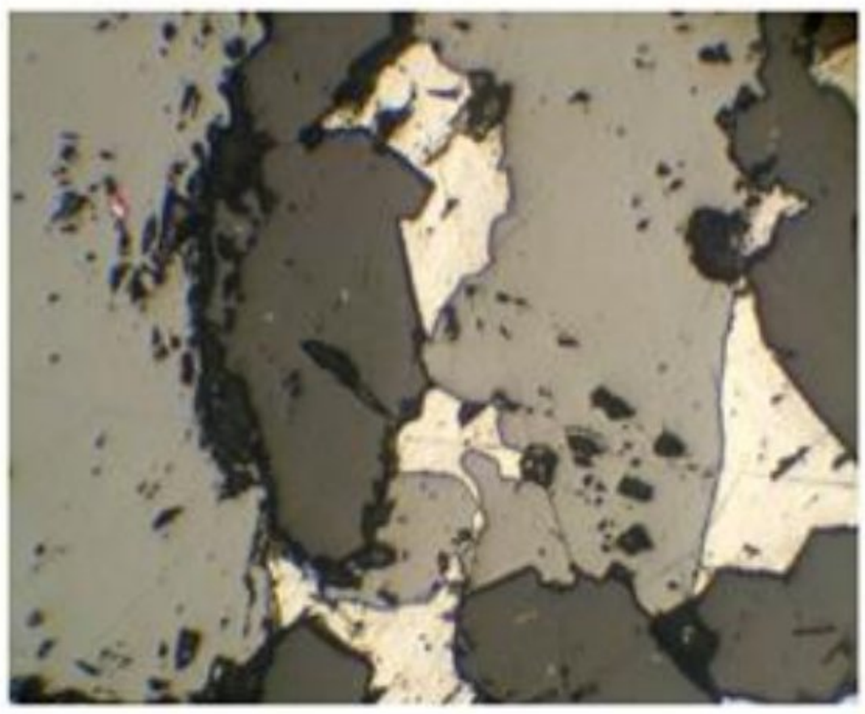
2.2 Mineralogical Analysis

Identification of minerals present in ore, determination type of mineral structure (size and type of mineral association) and mineral preparations photos presentations were conducted during mineralogical research.

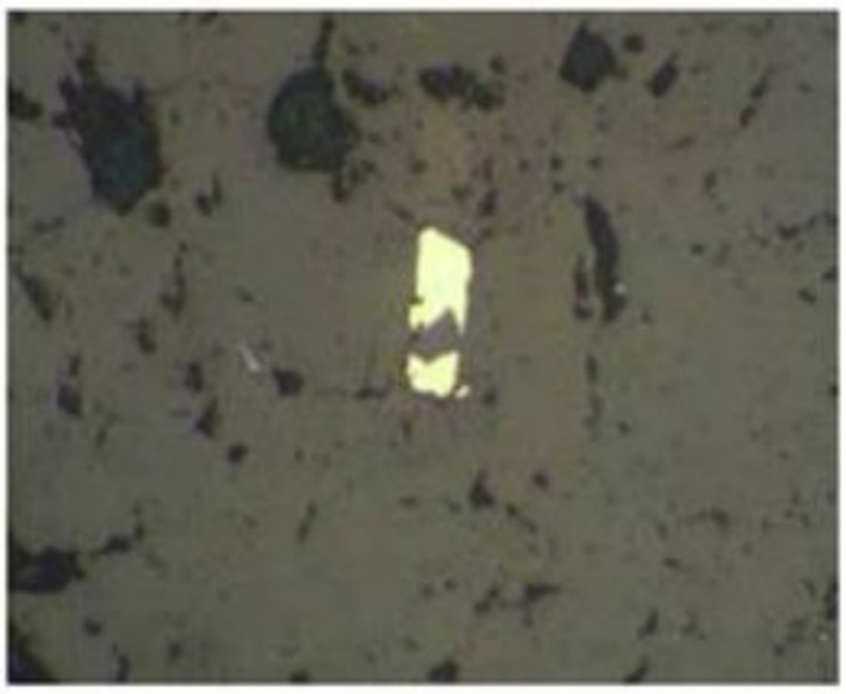
In mineral veins is mostly present large crystals of older galena, which are cemented with younger sphalerite (picture 1 and 2). Galena often has structure with rarely appearance of corosion on edges, suppressed with sphalerite. Sphalerite have relativly large crystal structure in petrogene mineral in cases when there is not asociation with galena. Associations are simple, without jagged on contact surface, which is a reason of relativly simple separation between those minerals. Beside this minerals, pyrite is present in subordinated amount in fine crystals. Elementary gold is identified in several places (picture 3 and 4).



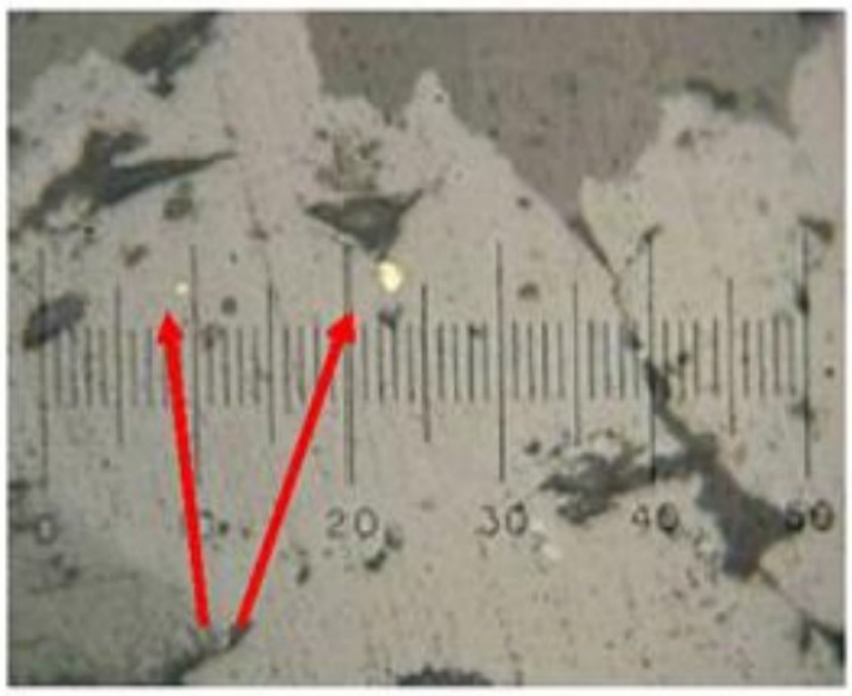
Picture 1. Older galena suppressed with marmatite in form of simple concrescence



Picture 2. Concrescence of galena suppressed with younger sphalerite



Picture 3. Particle of gold in rock mass, mullock



Picture 4. Particles of gold as inclusion in sphalerite

Picture 1, 2, 3, 4. Minerals present in ore (1 unit = 0,014 mm.)

Mineralogical examinations were led to conclusion that is small amount of gold associated with quartz tailings, in form of small particles. That is the main reason for unsuccessful probe of gold gravity concentration. Further grinding it's not economically justified due to small content of gold in a tailings.

Results of laboratory technology examination were led to conclusion that gold is mainly associated with galena and valorized through lead concentrate. This is usual for ore from „Lece“ area.

3 TECHNOLOGICAL RESERACH

During technological examinations particle size distribution of definitely crushed ore and grinding characteristic of definitely crushed ore were determined. For determination of grinding characteristic of crushed ore laboratory ball mill was used. One experiment of flotation concentration was conducted acording to usual parametars for sulfid Pb-Zn-Au ore. This experiment was included primary flotation (rough and scavenger) and two stage cleaning of rough lead and zinc concentrate. Seven more experiment of flotation concentration was conducted in open cycle and one more in a Locked cycle. Sample used for Locked cycle experiment had mass of 4 kg. All product of concentration were analyzed for content Pb, Zn, Au and Ag. Answers on technological questions are given on the end of research, based on examination result.

Parameters that were determined:

- Technological parameters of ore grinding, with clearly defined fineness of grinding
- Parameters of primary flotation stage
- Parameters of cleaning flotation stage
- Prognostic flotation results of Pb, Zn, Au and Ag based on ore, cleaned concentrate and tailings.
- Discussion of examination results and technological achievement

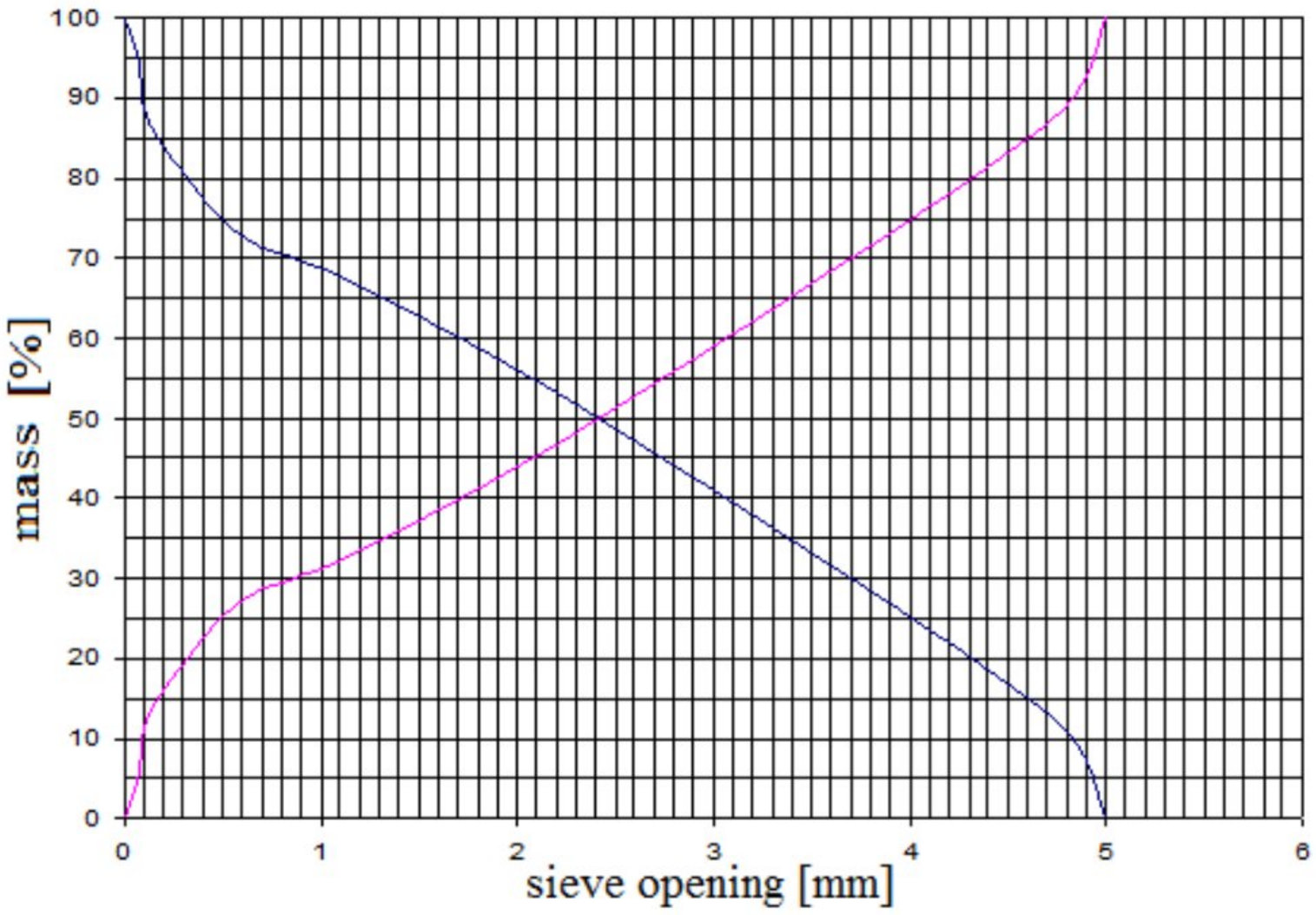
Conclusion and literature are given on the end.

3.1 Particle Size Distribution

Particle size distribution of crushed ore to -5 mm was determined with wet sieving on Tyler series of sieves. Crushed ore was used in further flotation experiments. Results of particle size distribution analysis are presented in table 2 and graphic on picture 5.

Table 2. Particle size distribution of crushed ore „Lece“

Particle size [mm]	**Mass [%]**	**Cumulative oversize [%]**	**Cumulative undersize [%]**
+4,699	13,25	13,25	100
-4,699 +2,362	37,56	50,81	86,75
-2,362 +1,168	16,03	66,84	49,19
-1,168 +0,589	6,01	72,85	33,16
-0,589 +0,208	11,02	83,87	27,15
-0,208 + 0,104	4,76	88,63	16,13
-0,104 +0,074	6,21	94,84	11,37
-0,074 +0	5,16	100	5,16



Picture 5. Particle size distribution (- cumulative undersize, -cumulative oversize)

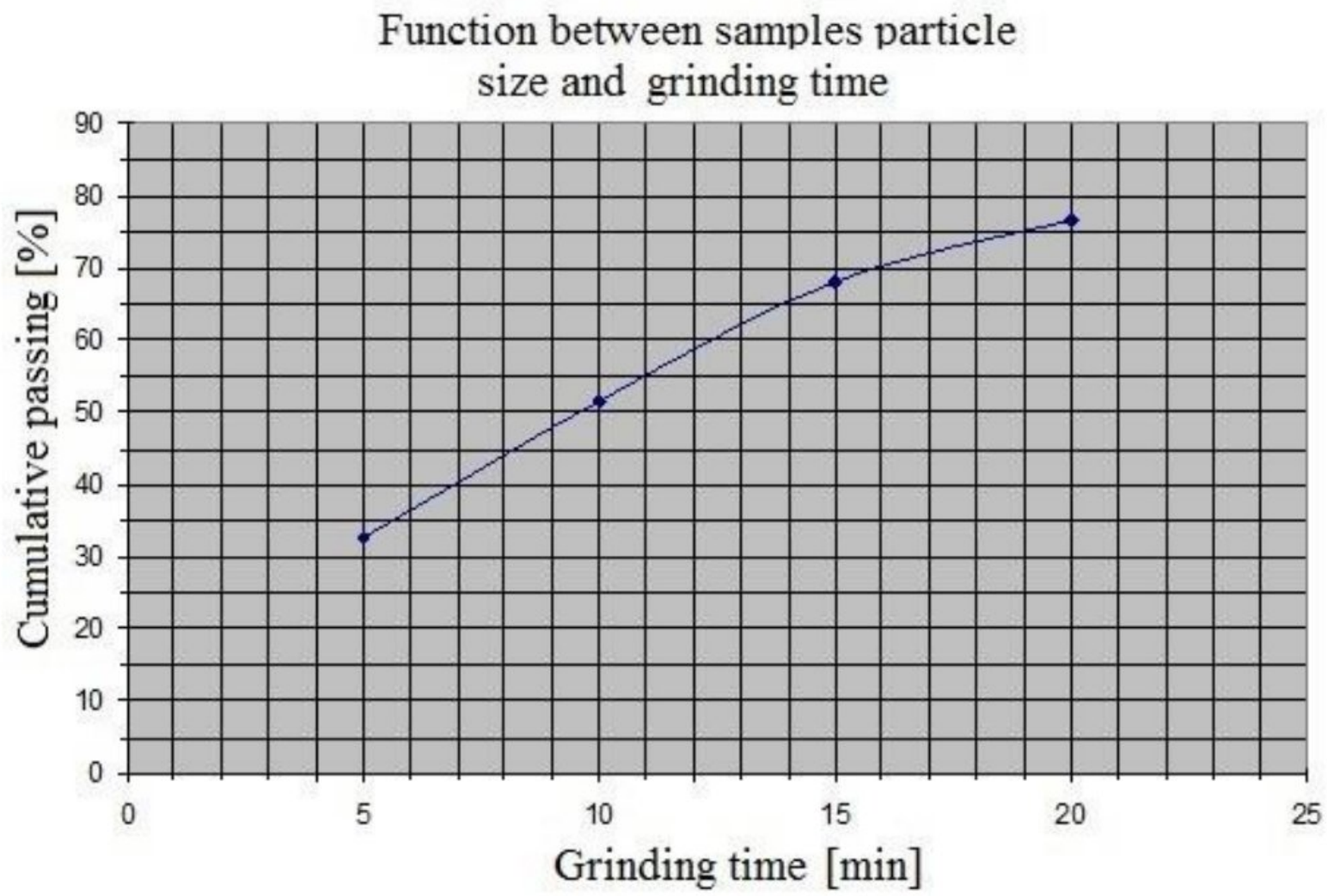
Curves of particle size distribution of crushed ore showing that particle size in sample 100% -5mm, upper size limit (d95) around 5 mm and average particle size (d50) around 2,5mm. There is 5% of mass of crushed ore size -0,074 mm. That is an indicator for relatively soft material, with low grinding resistance. Value of Bond working index is 12,8 kWh/t.

3.2 Experiments of Grinding Definitely Crushed Ore Samples

Experiments of grinding definitely crushed ore samples are conducted using laboratory ball mill "Denver". During grindg was used constant solid to water ratio S:W = 1:0,5, which is usual for this type of ore. Grinding time were: 5, 10, 15, 20 and 25 min. After grinding ore samples are been wet sieved on sieve opening 200# (0,074mm). Products of sieving were dried and mass was measured. Function between samples particles size and grinding time is presented in table 3 and graphic on picture 6.

Table 3. Function between samples particles size and grinding time

Grinding time [min]	**Mass of particles size -0,074 + 0mm [%]**
5	32,5
10	51,5
15	68
20	76,5



Picture 6. Function between samples particles size and grinding time

Based on constructed function curve between grinding time and samples particle sizes was determined duration of grinding. Grinding time to achieve fineness 65% -0,074 mm in grinded product is 14 min.

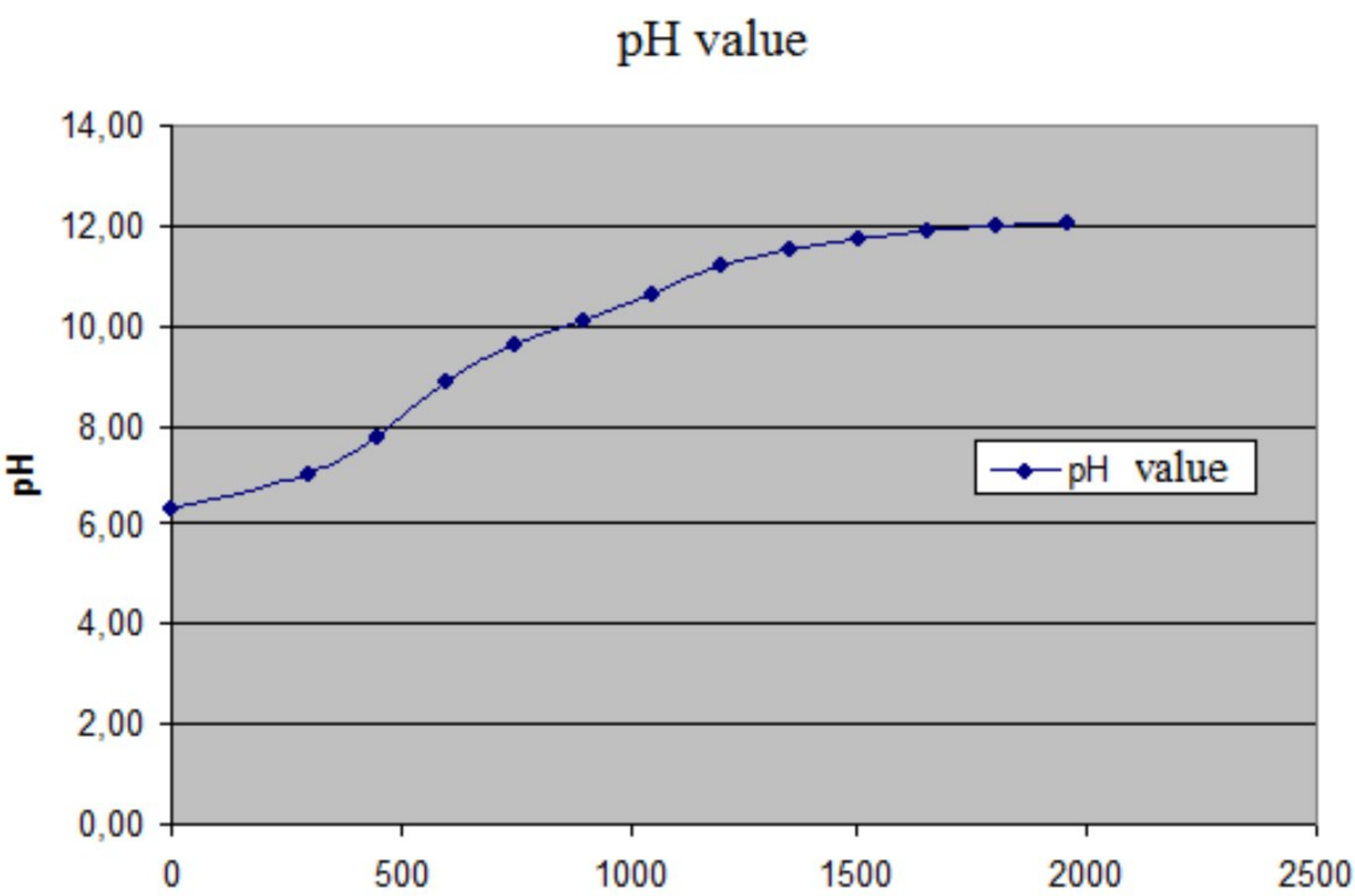
3.3 Determination pH Value of Flotation Pulp

Natural pH value of ore was determined. Hydrated lime was used for pH value regulation. Lime producer is "Jelen Do" and lime activity was 63,06%. Also, lime consumption was determined for achieve different pH value of flotation pulp. Results of this examinations are shown in table 4 and graphic on picture 7.

Table 4. Hydrated lime consumption in function of pH

Hydrated lime[g/t]	0	300	450	600	750	900	1050	1200	1350	1500	1650	1800	1950
pH value	6,35	7,04	7,76	8,85	9,60	10,08	10,60	11,21	11,51	11,71	11,89	12,01	12,05

Based on lime consumption curve for achieve pH value around 8 consumption of lime is 500 g/t and for pH value around 10 lime consumption is 1000 g/t. pH value 8 is suitable for galena flotation and pH value 10 is suitable for sphalerite flotation. Lime consumption in cleaning stage flotation was determined afterward.



Picture 7. pH value in function of lime consumption

3.4 Primary Flotation and Cleaning Rough Concentrate Experiments in Open Cycle

Laboratory examinations goal was to determine parameters of primary flotation (rough and scavenger) lead and zinc minerals in function of consumption of collector, deprimator, activator and particle size. Type of collector, pulp pH and other parameters were the same as in Lece mine flotation. Reason for choosing this parameters is assumption that ore from “Ćulav Brajšor” is going to be concentrated in "Lece" mine flotation. "Lece" mine flotation is nearest to the mineral deposit “Ćulav Brajšor”.

Research was conducted based on "Lece" mine flotation technological scheme. Flotation experiments were contained rough and scavenger lead minerals flotation with two stage cleaning and rough and scavenger zinc minerals flotation with two stage cleaning. On the end of research experiment in so-called Locked cycle was perform. Locked cycle experiment was conducted in 4 circle, 1 kg sample in each circle. Duration of experiment was longer than 10 hours. Locked cycle experiment goal was to simulate concentration of "Ćulav Brajšor" ore in industrial facility. Experiment was completely successful.

Based on results of Locked cycle experiment were given prognostic quality and recovery of metals in concentrate produced in industrial flotation facility. Based on prognostic results in industrial flotation facility is calculated gross market value of "Ćulav Brajšor" ore.

3.4.1 Flotation Experiment Number 1

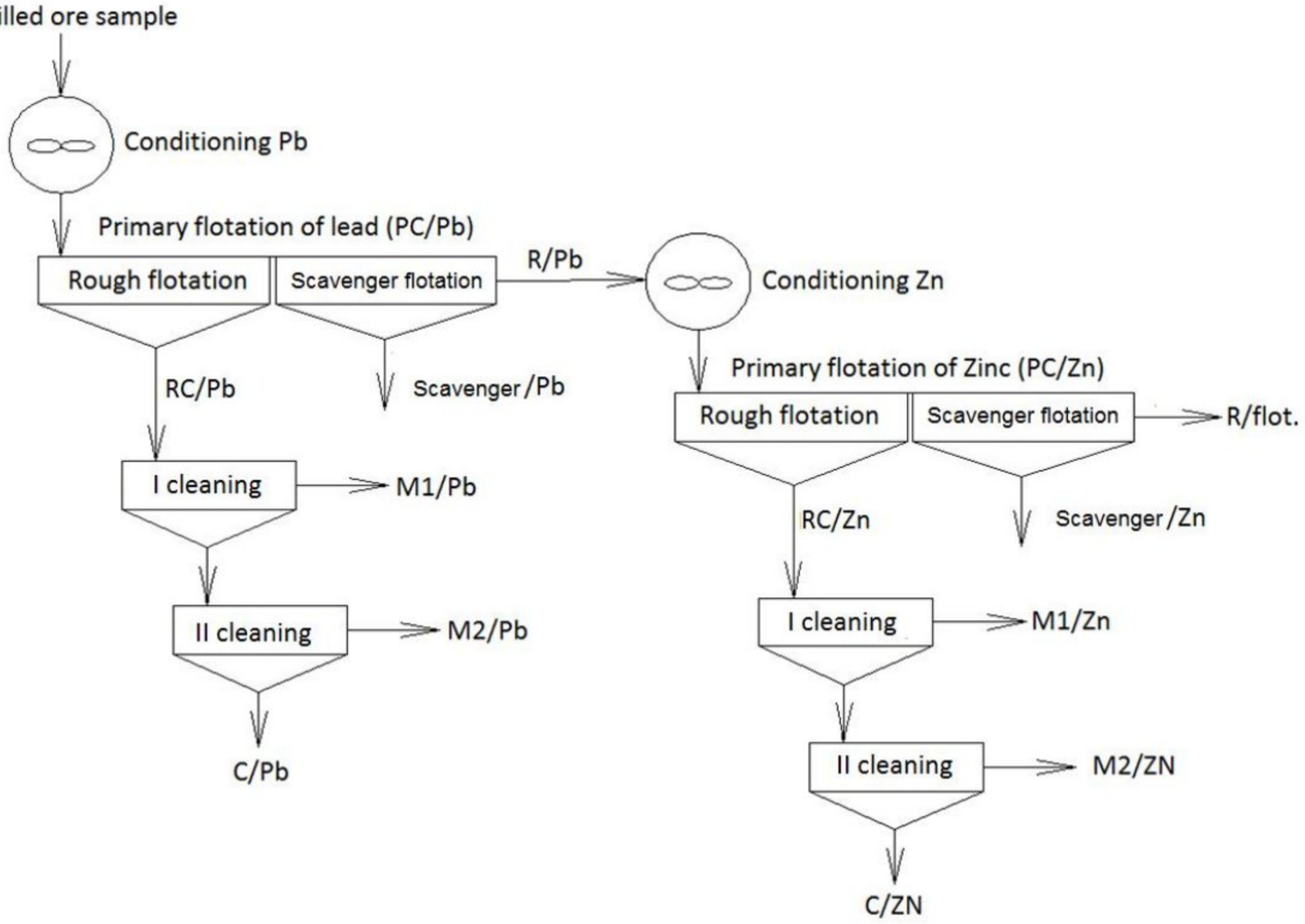
Experiments were performed on composite ore sample. Reagents regime is shown in picture number8. Open cycle experiments (1-8) technological scheme is presented on picture 9. Balance of metals in experiment number 1 is shown in table number 5.

Experiment 1			fineness of grinded ore, 65% - 74 µm
Milling of sample			**I Cleaning Pb min.**
Sample, kg	1		
CaO, kg/t	0,5 to	pH-8,2-8,5	CaO, kg/t 0,1 pH-8,2-8,5
NaCN, g/t	5		NaCN 30
ZnSO4, g/t	900		ZnSO4 150
Grinding time, min	14		pH value ____
Fineness of grinding ore, % -74 µm	65		Flotation time, min 6
			II Cleaning Pb min.
Conditioning			Flotation time, min 4
PAX, g/t	40		
D-200, g/t	20		
Conditioning time, min	5		**I Cleaning Zn min.**
pH value	____		CaO, kg/t 0.5 to pH-11.5-12
Rough flotation Pb min.			D-200, g/t 10
5 min. flot. PAX. g/t	20		pH value ____
Flotation time, min	8		Flotation time, min 4
Scavenger flotation Pb min.			**II Cleaning Zn min.**
PAX, g/t	20		CaO, g/t 0,2 to pH-11.5-12
Flotation time, min	12		D-200, g/t 5
Flotation of zinc minerals			pH value ____
Conditioning			Flotation time, min 3
CaO, kg/t	0,5 to	pH-9,2-10,0	
CuSO4, g/t	300		
PAX, g/t	40		
Conditioning time, min	5 + 5		
pH value	____		
Rough flotation Zn min.			
D-200, g/t	10		
PAX, g/t	20		
Flotation time, min	8		
Scavenger flotation Zn min.			
PAX, g/t	20		
Flotation time, min	12		

Picture 8. Reagents regime

Table 5. Balance of metals

Products	W g	W %	Pb %	Zn %	Au g/t	Ag g/t	R Pb %	R Zn %	R Au %	R Ag %
Ore	969.9	100.00	1.27	4.09	4.94	7.61	100.0	100.0	100.0	100.0
C/Pb	13.25	1.37	79.54	1.92	300.00	350.00	85.43	0.64	82.97	62.85
M1/Pb	23.66	2.44	1.24	6.36	2.92	12.29	2.38	3.79	1.44	3.94
M2/Pb	1.68	0.17	11.83	16.02	68.11	102.86	1.61	0.68	2.39	2.34
RC/Pb	38.59	3.98	28.59	5.26	107.76	132.19	89.42	5.11	86.80	69.14
S/Pb	43.78	4.51	1.29	8.33	8.29	15.57	4.58	9.19	7.58	9.24
PC/Pb	82.37	8.49	14.08	6.89	54.89	70.20	94.00	14.30	94.38	78.38
R/Pb	887.53	91.51	0.08	3.83	0.30	1.80	6.00	85.70	5.62	21.62
C/Zn	46.34	4.78	0.04	64.84	1.74	17.71	0.15	75.72	1.68	11.12
M1/Zn	23.23	2.40	0.18	2.30	0.87	3.14	0.34	1.35	0.42	0.99
M2/Zn	4.17	0.43	0.21	30.01	2.76	17.14	0.07	3.15	0.24	0.97
RC/Zn	73.74	7.60	0.09	43.17	1.52	13.09	0.56	80.22	2.35	13.08
S/Zn	48.57	5.01	0.28	1.17	1.34	4.00	1.10	1.43	1.36	2.63
PC/Zn	122.31	12.61	0.17	26.49	1.45	9.48	1.66	81.65	3.70	15.71
R	765.22	78.90	0.07	0.21	0.12	0.57	4.34	4.05	1.92	5.91

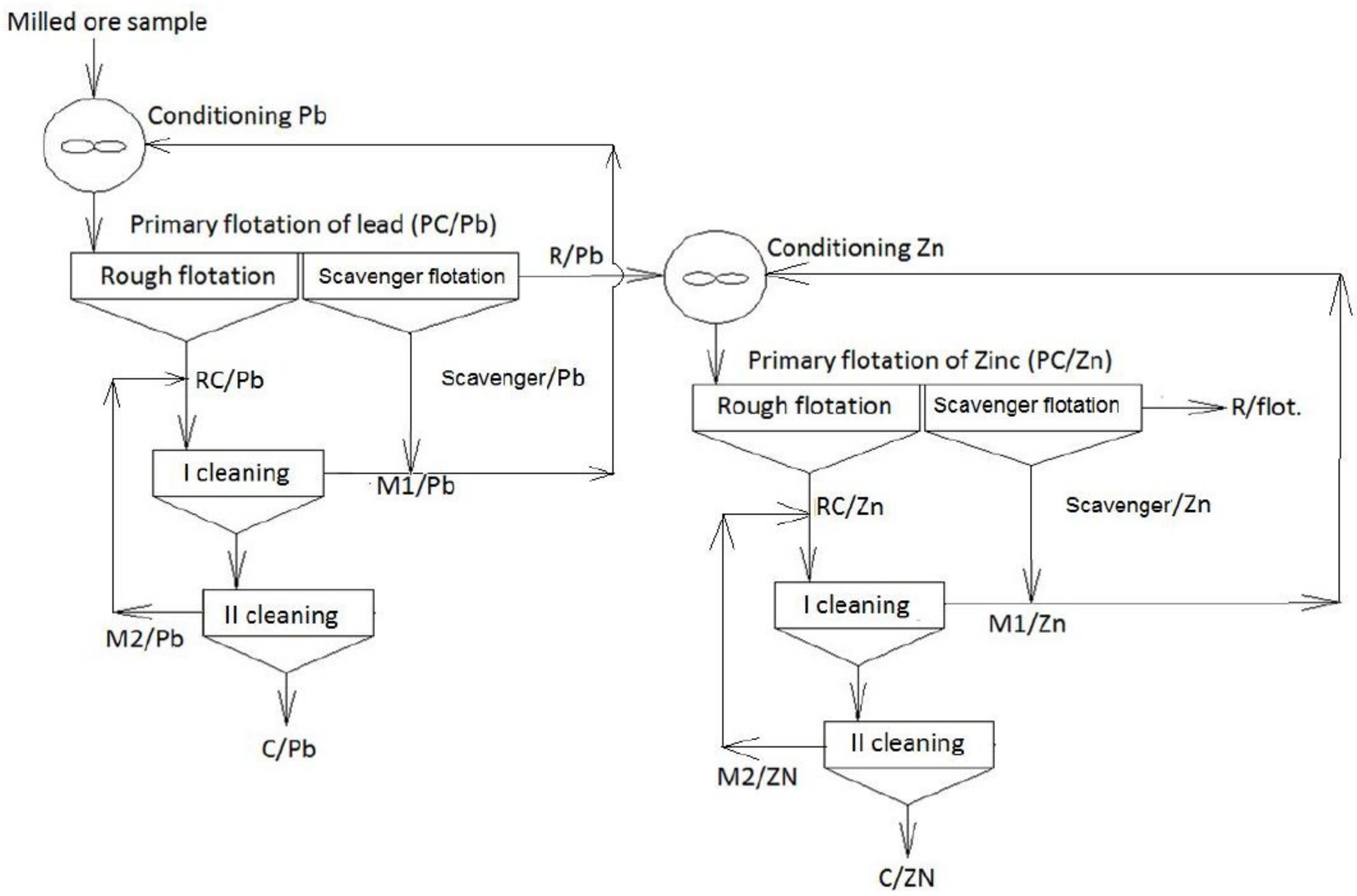


Picture 9. Open cycle experiments technological scheme

3.5 Locked Cycle Experiment

3.5.1 Experiment Number 9

This experiment was performed in order to confirm results from previous experiments and to simulate industrial flotation process. Reagents regime is shown in picture 11. Locked cycle experiment technological scheme is presented on picture 10. Balance of metals in locked cycle experiment is presented in table 6. Prognostic balance of metals for "Ćulav Brajšor" ore is given based on results of laboratory experiments in table7.



Picture 9. Locked cycle experiment technological scheme

Experiment 9

Milling of sample

Sample, kg		1	
CaO, kg/t	0,5	**to**	pH-8,2-8,5
NaCN, g/t		20	
ZnSO4, g/t		1000	
Grindig time, min		14	
Fineness of grinding ore, % -74 µm		65	

Conditioning ← M1+scavenger/Pb

PAX, g/t	30
D-200, g/t	20
Conditioning time, min	5
pH value	

Rough flotation Pb min.

5 min. flot. PAX, g/t	0
Flotation time, min	6

Scavenger flotation Pb min.

PAX, g/t	10
Flotation time, min	8

Flotation of zinc minerals ← M1+scavenger/Zn

Conditioning

CaO, kg/t	0,5	**to**	pH-9,2-10,0
CuSO4, g/t		300	
PAX, g/t		40	
Conditioning time, min		5 + 5	
pH value			

Rough flotation Zn min.

D-200, g/t	10
PAX, g/t	20
Flotation time, min	8

Scavenger flotation Zn min.

PAX, g/t	20
Flotation time, min	12

fineness of grinding ore, 65% - 74 µm

I Cleaning Pb min. ← M2/Pb

CaO, kg/t	0,1		pH-8,2-8,5
NaCN		30	
ZnSO4		150	
pH value			
Flotation time, min		6	

II Cleaning Pb min.

Flotation time, min	4

I Cleaning Zn min. ← M2/Zn

CaO, kg/t	0.5	**to**	pH-11.5-12
D-200, g/t		10	
pH value			
Flotation time, min		4	

II Cleaning Zn min.

CaO, g/t	0,2	**to**	pH-11.5-12
D-200, g/t		5	
pH value			
Flotation time, min		3	

Picture 10. Reagents regime

Table 6. Balance of metals in locked cycle experiment

Products	W g	W %	Pb %	Zn %	Au g/t	Ag g/t	R Pb %	R Zn %	R Au %	R Ag %
Ore	3850.48	100.00	1.04	3.21	4.53	6.77	100.0	100.0	100.0	100.0
C/Pb	48.69	1.26	73.90	4.03	316.22	350.00	89.95	1.59	88.21	65.38
M1/Pb	2.78	0.07	1.91	5.12	2.43	11.43	0.13	0.12	0.04	0.12
M2/Pb	0.85	0.02	9.86	9.35	16.22	61.90	0.21	0.06	0.08	0.20
RC/Pb	52.32	1.36	69.03	4.17	294.67	327.33	90.29	1.77	88.33	65.71
S/Pb	3.52	0.09	12.87	7.71	63.95	88.57	1.13	0.22	1.29	1.20
PC/Pb	55.84	1.45	65.49	4.40	280.13	312.28	91.42	1.99	89.62	66.90
R/Pb	3794.64	98.55	0.09	3.19	0.48	2.27	8.58	98.01	10.38	33.10
C/Zn	168.86	4.39	0.09	65.18	1.95	18.46	0.38	89.02	1.89	11.96
M1/Zn	10.71	0.28	0.92	11.51	5.07	13.82	0.25	1.00	0.31	0.57
M2/Zn	2.04	0.05	0.80	44.80	7.30	31.59	0.04	0.74	0.09	0.25
RC/Zn	181.61	4.72	0.15	61.79	2.19	18.33	0.67	90.75	2.28	12.77
S/Zn	11.53	0.30	2.45	12.27	10.13	28.29	0.71	1.14	0.67	1.25
PC/Zn	193.14	5.02	0.28	58.83	2.67	18.93	1.37	91.90	2.95	14.03
R	3601.5	93.53	0.08	0.21	0.36	1.38	7.20	6.12	7.43	19.07

Table 7. Prognostic balance of metals for "Ćulav Brajšor" ore

Products	W t	W %	Pb %	Zn %	Au g/t	Ag g/t	R% Pb	R% Zn	R% Au	R% Ag
Ore	10000	100	0.98	3.11	4.11	6.12	100	100	100	100
C/Pb	120	1.20	73.50	4.00	300.00	330.00	90.00	1.55	87.94	64.90
C/Zn	427	4.27	0.10	62.00	2.00	18.00	0.43	85.00	2.08	12.56
R	9453	94.53	0.10	0.44	0.43	1.46	9.57	13.45	9.98	22.55

Data analysis presented in prognostic balance of metals confirmed that is possible to produce quality lead and zinc concentrate. Lead concentrate has mass of 1,2%, with content of around 73,5% Pb, around 300 g/t Au and around 330 g/t Ag. Recovery of metals in lead concentrate is 90% for Pb, 88% for gold and 65% for silver. Zinc concentrate has mass of 4,27%, with content of around 62% Zn and recovery of zinc around 85%.

4 CONCLUSION

Conclusion was formed based on all examination results conducted in this study. Previous geological researches, data from drill core samples and samples taking for technological examination led to conclusion that is ore from "Ćulav Brajšor" is "poor" lead ore with high content of zinc, gold and silver.

Geological reserves study is going to give answer on question how much quantity of ore is in mineral deposit. Study of "Concentration possibility examination of ore from “Ćulav Brajšor” field, near Medveđa" is going to be a part of geological reserves study.

Based on research in this study is determined that ore from "Čulav Brajšor" can be relatively easy concentrated using direct selective flotation of galena and zinc minerals.

Following technological results could be expected:

- Lead concentrate mass of 1,2%, with content of around 73,5% Pb, around 300 g/t Au and around 330 g/t Ag. Recovery of metals in lead concentrate 90% for Pb, 88% for gold and 65% for silver.

Content of penalizing elements in lead concentrate is: Cu=0,22%; Fe=1,8%; As=0,11%; Sb=0,1%. These contents are significantly lower than maximum allowed values that market requires.

– Zinc concentrate mass of 4,27%, with content of around 62% Zn and recovery of zinc around 85%. Content of penalizing elements in zinc concentrate is: Cu=0,15%; Fe=0,85%; As=0,0%; Sb=0,004%. These contents are significantly lower than maximum allowed values that market requires.

Ore from "Čulav Brajšor" can be concentrated using direct selective flotation of galena and zinc minerals. Using direct flotation concentration it can be produced quality lead and zinc concentrates as shown in prognostic balance of metals.

Flotation technological scheme of "Lece" mine is completely suitable for processing "Ćulav Brajšor" ore.

5 LITERATURE

Bulatovic S., (2007) Handbook of Flotation Reagents Chemistry, Theory and Practice: Flotation of Sulfide Ores, Elsevier Science & Technology Books

STUDIJA, (2016) Laboratory-technological examinations Pb-Zn ore from field Ćulav-Brajšor -Medveđa, RGF Beograd,

Bogdanov O.S., Golman A.M., Kakovskij I.A., Klassen V.I., Melik-Gajkazjan V.I., Rjaboj V. I., Soloženkin P.M., Čanturija V.A., Fiziko-hemičeskie osnovi teorii flotacii, Moskva, Nauka 1983

Lazić P., Ćalić N., (2000). Boltzmann's model of flotation kinetics, Proceedings of the XXI International Mineral Processing Congres, Roma, pp. 87- 93;

Lazić P., Ćalić N., (2000). New model of flotation kinetics vs collector consumption, Proceedings of the Third Jordanian International Mining Conference, Amman, pp.101-106;

Lazić P., Ćalić N., (2001) Influence of collector consumption on flotation kinetics, 9th Balkan Conference of Mineral Processing, Istanbul, pp.193-196;

Cvetićanin, L., Lazić, P., (2005). Kinetics of galena flotation as a function of potassium butyl Xanthate consumption, Proceedings of the XI-th Balkan Mineral Processing Congress "Mineral Processing in Sustainable Development", Durres-Albania, pp. 183-190, ISBN: 99943-694-6-6;

Cvetićanin, L., Lazić, P., (2005). Kinetics of galena flotation as a function of the size of mineral particle, Proceedings of the XI-th Balkan Mineral Processing Congress "Mineral Processing in Sustainable Development", Durres-Albania, pp. 202-210, ISBN: 99943-694-6-6;

Cvetićanin, L., Lazić, P., Vučinić, D., Knežević, D., (2012). The Galena Flotation in Function of Grindability, Journal of Mining Science, Vol. 48, No. 4, pp. 760-764;

Cvetićanin , L., Vučinić, D., Lazić, P., Kostović, M., (2015). Effect of galena grain size on flotation kinetics, Journal of Mining Science, Vol. 51, No. 3, pp 591-595, DOI: 10.1134/S1062739115030230

Small, G.L., Grano S.R., Ralston J., Johnson N.W., (1997). Methods to increase fine minerals recovery in the Mount Isa Mines lead/zinc concentrator, Minerals Engineering, Vol. 10, No 1, pp. 1-15;

Stanojev J., Cvetićanin L., Tomanec R., Knežević D., (2000). The galena flotation in functions of grindiability, International Conference New trends in mineral processing IV, Ostrava, Czech Republik., ISBN: 80-7078-885-2;

D. Vučinić, M. Kostović, P. Lazić, Effect of galena surface oxidation on ethylxanthate adsorption on galena, Physical Chemistry 2014, Proceedings of the 12th International Conference on Fundamental and Applied Aspects of Physical Chemistry, Volume III, September 22-26, 2014, Belgrade, Serbia, L -07-P, pp. 1015-1018, ISBN 978-86-82475-32-3