УДК 622.06

https://doi.org/10.31996/mru.2019.2.40-45

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ГЕОЛОГО-ЕКОНОМІЧНА ОЦІНКА РОДОВИЩ РУДНИХ КОРИСНИХ КОПАЛИН НА ОСНОВІ РК ООН 2009

(НА ПРИКЛАДІ КУСМУРИНСЬКОГО РОДОВИЩА МІДІ В РЕСПУБЛІЦІ КАЗАХСТАН)

GEOLOGICAL AND ECONOMIC ASSESSMENT OF ORE MINERAL DEPOSITS BASED ON UN FRAMEWORK CLASSIFICATION 2009

(ON EXAMPLE OF KUSMURYN COPPER FIELD IN THE REPUBLIC OF KAZAKHSTAN)

(Матеріал друкується мовою оригіналу)

Нова модель економічного зростання Казахстану зорієнтована на зниження виробничої залежності від імпорту та зростання внутрішньої стабільності. У статті показано, що зростання інвестиційної привабливості гірничо-металургійної галузі багато в чому зумовлене впровадженням у Казахстані міжнародної системи стандартів звітності по запасах корисних копалин CRIRSCO. На основі геолого-економічної оцінки родовища Кусмурин надано рекомендації щодо її вдосконалення, наближення до міжнародних стандартів.

Ключові слова: *Казахстан, запаси, CRIRSCO, геолого-економічна оцінка, родовище.*

The new model of economic growth in Kazakhstan is focused on reducing production dependence on imports and increasing internal stability. The paper shows that the growth of investment attractiveness of the mining-and-smelting industry is largely caused by introducing in Kazakhstan the international system of reporting standards for mineral reserves CRIRSCO. Based on the geological and economic assessment of the Kusmuryn deposit, recommendations have been given for its improvement, approximation to the international standards.

Keywords: *Kazakhstan, reserves, CRIRSCO, geological and economic assessment, field.*

Introduction. Despite all the changes in the economy of Kazakhstan, the fuel and raw materials complex remains the key source of its income. The main features of the Kazakhstan economy are as follows: an active government intervention in the economy; a poorly diversified structure of the economy with the predominance of industries and segments focused on the extraction of natural rent; a growing dependence on foreign investments [1].

The national economy progress is constrained by internal problems of the mining-and-smelting industry: depletion of the mineral resource base, deterioration in the quality of mined ores and slow development of new deposits, a low degree of complexity in the use of mineral raw materials, low production volumes of high conversion, an obsolete technical base [2]. The situation is aggravated by the growth of the environmental security of the state not only in the segments of oil-and-gas and coal production that are the main sources of environmental pollution, but also as part of the pace of developing nuclear power generation. The above-said confirms the need of attracting investments in exploration to replenish the resource base. Moreover, Kazakhstan is set to comply with the Extractive Industries Transparency Initiative Standards.

Presentation of the material. *Reducing the production dependence of the economy of Kazakhstan on imports and the growth of its internal stability* is mainly reflected in the forming the basis for the growth of non-oil exports; the involvement of raw materials in the Kazakhstan production chains. New measures of the government support for commodity producers stimulate developing the Kazakhstan content, open up prospects for modernizing the existing industries and provide transition to producing the goods necessary to meet the needs of the domestic market with a corresponding parity of price and quality. In nonferrous metallurgy emphasis will be placed on expanding the production of base metals (copper, gold, titanium, aluminum); increasing the production of various articles (wire rod, wire, rolled metal, profiles and alloys, foil, jewelry) [3].

To overcome the "trap of average income" on the way to entering the thirty developed countries of the world, Kazakhstan is forming a new model of economic growth. It is based on stimulating export-oriented production by increasing the productivity and complexity of the economy, developing the human capital and attracting private funds in the conditions of increasing competition, the leading role of the private sector and realizing the development potential of the country's regions. The goal has been set: to double non-commodity exports by 2025, to intensify industrialization with the emphasis on competitive export production in priority sectors of the economy [4] (Table 1).

One of the primary conditions for the growth of investment attractiveness of the mining industry and the mineral resource complex of Kazakhstan is transition to the international system of reporting standards for mineral reserves CRIRSCO. In accordance with this system, geological and technical information is determined for the projects being developed that enterprises should show to the public. Only such an approach can guarantee investors the confidence that the information provided to them is as reliable and truthful as possible.

Table 1. The key national indicators

Indicator	Unit	Years			
		2016	2021	2025	2050
The GDP per capita	in current dollars in nominal terms	7715	13190	18500	33270
The labor productivity growth	% increase of the 2016 level in 2016 prices	–	24	51	363
The volume of non-commodity exports of goods and services	billion dollars	19,2	29,2	41,0	90,0
The share of non-observed (shadow) economy	% of the GDP	25,8	23	20	15
Fixed investments	% of the GDP	16,4	17,1	19,4	30,0
The Logistics Performance Index (World Bank)	the place	77	40	38	30
The GDP energy intensity (the indicator of proxy impact on the environment, according to the IEA)	% decrease of the 2008 level	13	20	25	50

Source: Strategic Plan of the Republic of Kazakhstan Development till 2025. Approved by the Republic of Kazakhstan President's Decree № 636 dated 15/02/18.

Achieving the sustainable development of Kazakhstan requires intensification of extracting and processing natural resources into finished products. To solve the problem of growing the quality of rude minerals of non-ferrous metallurgy, it is necessary to improve the quality management system based on geological and technological typification of ores. And here not only geological and geophysical studies will have an invaluable role, but also a detailed, reliable geological and economic assessment of various fields.

The object of this study is the Kusmuryn pyrite-copper-lead-zinc deposit, a structural unit of the Kazakhmys Corporation LLP, one of the three largest copper producers in Kazakhstan. The Kusmuryn field is an object of the exploratory study within the framework of the state assignment for studying the promising areas for attracting investments.

Kazakhstan accounts for about 6 % of the globally proven copper reserves, or more than 41 million tons. At present copper is used at 64 objects, of them 14 are mined, 35 are explored and 15 are explored and mined. In the ranking for investments in the subsoil use of copper the Kazakhmys Corporation LLP accounts for 73 % of capital investments and 56 % of the annual copper production in the country. According to forecasts for 2018, the amount of investments in the copper industry will amount to $876 million including $10 million that will be spent on geological exploration [5].

The Kazakhmys Corporation LLP that has all the necessary capacities in the cities of Zhezkazgan and Satpayev for extracting, processing and producing finished products, is the main potential consumer of copper in the Zhezkazgan region. In the coming years the Kazakhmys Corporation plans to build a processing plant and to further explore the Akbastau-Kosmurun ore field in order to detect copper, gold and other minerals.

In the post-Soviet period the Kazakhmys Corporation LLP developed the field by the open method with further mining by the underground method. Until 2009 the deposit was one of the main sources of raw materials for copper and copper-zinc ore for the Karagaily concentrator, a member of the corporation.

However, the mixed type of ores with a higher content of copper and zinc oxides, the high labor intensity of dressing copper-zinc ores, the long-term transportation of ore by dump trucks along the grader road to the processing plant and insufficient knowledge of the technology for processing copper-zinc ores negatively affected the cost of concentrate obtained from them. Therefore, at the end of 2009 the Kazakhmys Corporation LLP was forced to stop mining operations in the field, and in the middle of 2010 permission was received for the "conservation" of mining operations until 2012.

At the same time the Corporation carried out geological exploration in the field to select a representative technological sample, to carry out tests and to further develop a scheme for processing copper-zinc ores. It was necessary to carry out drilling work with taking the core material for technological mapping, additional exploration of the flanks of the field, both along strike and to the dip. Due to the need of revising the depth of the field, studying stability of the future pit walls, it was planned to carry out engineering and geological drilling followed by tests for determining physical and mechanical properties of the rocks.

In terms of its material composition (pyrite up to 90 %), the ore of the Kusmuryn field is classified as a copper-pyritic industrial type with such main ore-forming minerals, as pyrite, chalcopyrite, sphalerite, galen [7]. In accordance with the approved reserves, the field is recognized as small. Since the Kusmuryn deposit is an object of exploratory research in the framework of the state assignment for studying promising areas for attracting investments, in 2013 the exploration work was resumed. Taking into account a significant effect of the steeply inclined occurrence of some ore bodies on stability of the ore and rock massif in the course of developing, more geomechanical research was needed to monitor the rock massif state, mine safety and adjustments to mining technology.

For subsequent developing the technology of processing copper-zinc ores and building a new concentrator near the deposit, additional exploration was carried out. Technological samples of copper and copper-zinc ores from cores of ore bodies drilled in the contours of ore bodies were picked with intersecting at various horizons; the

Table 2. Summary table of reserves in the contour of the Kusmuryn open pit for the side copper content of 0,7 % on 01/01/2018

Category	Content										Block volume, t.m^3	Ore reserves, t.t	Mineral reserves								
	Cu, %	Zn, %	Pb, %	Au, g/t	Ag, g/t	S pyr., %	S tot., %	Cd, g/t	Se, g/t	Te, g/t			Cu, t.t	Zn, t.t	Pb, t.тг	Au, kg	Ag, t	S pyr., t.t	S tot., t.t	Cd, t	Se, t	Te, t
Upper ore body																						
C_1	4,26	2,55	0,61	3,01	33,60	23,15	37,46	198,26	195,24	131,49	344,69	1464,9	62,4	37,4	9,0	4407,1	49,2	339,2	548,8	290,4	286,0	192,6
Lens III																						
C_2	1,72	0,23	0,00	0,03	2,14	13,55	14,37	3,44	0,50	0,30	71,51	303,9	5,2	0,7	0,0	9,9	0,7	41,2	43,7	1,0	0,2	0,1
Total																						
$C_1 + C_2$	3,82	2,15	0,51	2,50	28,20	21,50	33,49	164,78	161,78	108,95	416,20	1768,8	67,6	38,0	9,0	4417,1	49,9	380,4	592,4	291,5	286,2	192,7

Table 3. Reserves movement at the Kusmuryn deposit on 01/01/2018 in the contour of the project open pit

Elements for computing	Unit	Reserves approved by the USSR GKZ: Balance			Off-balance	Amortized on 01/01/2016	*Remainder on 01/01/2012*			Off-balance	Recount on 01/01/2018			Increment (+) Loss (-)	*Increment, rel. %*
		C_1	C_2	C_1+C_2			C_1	C_2	C_1+C_2		C_1	C_2	C_1+C_2	C_1+C_2	C_1+C_2
For open development															
Mixed ores											Mixed and sulfide ores. Upper and Lens III ore bodies				
Ore reserves	th.ton	3084,5	323,2	3407,7		2593,3	562,2	252,2	814,4		1464,9	303,9	1768,8	954,4	117
copper	th.ton	140,2	5,8	146,0		112,3	28,9	4,8	33,7		62,4	5,2	67,6	33,9	101
zinc	th.ton	69,0	0,8	69,8		58,4	10,9	0,5	11,4		37,4	0,7	38	26,6	233
gold	kg	7385	772	8157		6072,8	1469,5	614,7	2084,2		4407,1	9,9	4417,1	2332,9	112
silver	t	102,3	10,7	113,0		98,1	6,4	8,5	14,9		49,2	0,7	49,9	35	235
selen	t	642	67	709		536,6	120,3	52,1	172,4		286	0,2	286,2	113,8	66
tellur	t	376	39	415		320,5	64,4	30,1	94,5		193	0,1	192,7	98,2	104
cadmium	t	484	51	535		427,7	68,4	38,9	107,3		290	1,0	291,5	184,2	172
sulfur sulfide	th.ton	1226,3	128,5	1354,5		723,76	530,9	100,1	631,04		548,8	43,7	592,4	-38,64	-6
incl. pyrite	th.ton	1107,4	115,9	1223,3							339,2	41,2	380,4		
Average content:															
copper	%	4,54	1,80	4,28		4,33	5,14	1,90	4,14		4,26	1,72	3,82	-0,32	-8
zinc	%	2,25	0,26	2,05		2,25	1,94	0,20	1,40		2,55	0,23	2,15	0,75	54
gold	g/t	2,39	2,39	2,39		2,34	2,61	2,44	2,56		3,01	0,03	2,50	-0,06	-2
silver	g/t	33,17	33,17	33,17		37,83	11,38	33,70	18,30		33,60	2,14	28,20	9,90	54
selen	%	0,0208	0,0208	0,0208		0,0207	0,0214	0,0207	0,0212		0,0195	0,0001	0,0162	-0,005	-23
tellur	%	0,0122	0,0122	0,0122		0,0124	0,0115	0,0119	0,0116		0,0131	0,0000	0,0109	-0,001	-6
cadmium	%	0,0157	0,0157	0,0157		0,0165	0,0122	0,0154	0,0132		0,0198	0,0003	0,0165	0,003	25
sulfur sulfide	%	39,76	39,76	39,76		27,91		39,69			37,46	14,37	33,49		
incl. pyrite	%	35,90	35,90	35,90							23,15	13,55	21,50		

structural-tectonic structure of the deposit rocks was studied by drilling wells using electronic core guide and geotechnical documentation, and physical and mechanical properties of rocks were studied on samples taken from the core and contouring of the field, by drilling a well in the extreme northern and southern profile across the strike.

According to the complexity of the structure, the Kusmuryn field belongs to the second group: a network of drilled wells and mine workings meets the requirements of studying deposits of this category of complexity.

In 2016–2017 the remaining reserves of copper ore in the contour of the project open pit were calculated on 01/01/2018. The Upper and Lens III ore bodies fell into mining, their reserves are listed in Table 2.

Table 3 shows the comparison of reserves recorded in the state balance of the Republic of Kazakhstan, remaining in the mine according to the mine data and calculated again. It follows from the Table that there are still fairly large reserves of copper in the project contour of the mine: 67,6 thousand tons (3,82 %), zinc: 38.0 thousand tons (2,15 %), gold: 4417 kg (2,5 g/t) and silver: 49,9 t (28,2 g/t). As the studies show, it is necessary to make an adjustment to the project of mining the reserves of the field in the open pit, in case of a positive assessment to produce the remaining reserves.

As it can be seen from Table 4, the comparison of reserves suitable for underground mining due to the additional exploration of 2010–2012, a significant increase in reserves was obtained: the ore relative increase was 89 % (15656 thousand tons), copper 55 % (306 thousand tons), zinc 32 % (43 thousand tons), gold 42 % (6,4 tons), silver 49 % (150 tons). The content of useful components decreased: copper by 8 % (from 3,14 % to 2,58 %), zinc by 30 % (from 0,76 % to 0,53 %), gold by 24 % (from 0,86 g/t to 0,65 g/t), silver by 21 % (from 17,5 g/t to 13,8 g/t). However, they remain high enough for deposits of this type.

Table 5 shows the remaining reserves in the contour of the project pit in terms of the grade of conditional copper 0,7 % on 01/01/2018.

In general, the comparative analysis of reserves by conventionally accepted parameters of conditions allowed drawing the following conclusions:

a) the grade of conditional copper – in mixed and sulfide ores it is 0,7 % – (as in the current conditions); 0,6 %; 0,5 %; 0,4 %; 0,3 %; 0,2 %.

Ore sub-cuttings along the ditches, underground mine workings and wells were allocated for the specified grades of conditional copper, but the reserves were calculated only by options of 0,7 %, 0,6 %, 0,5 % and 0,4 %.

b) We recommend referring to mixed ores the ores with a copper and zinc content in the oxidized and secondary forms more than 20 % of their total content, to solid sulfide ores the ores with the sulfur content of more than 35 %.

Table 4. Reserves movement at the Kusmuryn deposit on 01/01/2018. All the reserves in the main ore bodies

Elements for computing	Unit	Reserves approved by the USSR GKZ				Amortized on 01/01/2016	*Remainder on 01/01/2012*			Off-balance	Recount on 01/01/2018			Increment (+) Loss (-)	*Increment, rel. %*
		Balance			Off-balance										
		C_1	C_2	C_1+C_2			***C_1***	***C_2***	C_1+C_2		C_1	C_2	C_1+C_2	***C_1+C_2***	***C_1+C_2***
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	For open development														
	Oxidized ores														
Ore reserves	th.ton	143,2	21,3	164,5											
gold	kg	2063	381	2444											
silver	t	34,3	3,0	37,3											
Average content:															
gold	g/t	14,34	17,87	14,86											
silver	g/t	238,5	140,9	226,7											
	Mixed ores										Mixed and sulfide ores. Upper and Lens III ore bodies				
Ore reserves	th.ton	3084,5	323,2	3407,7		2593,3	562,2	252,2	814,4		2183,1	939,6	3122,7	**2308,3**	***283***
copper	th.ton	140,2	5,8	146,0		112,3	28,9	4,8	33,7		94,4	15,7	110,2	**76,5**	***227***
zinc	th.ton	69,0	0,8	69,8		58,4	10,9	0,5	11,4		51,9	2,7	54,5	**43,1**	***378***
gold	kg	7385	772	8157		6072,8	1469,5	614,7	2084,2		6005	158	6163	**4078,8**	***196***
silver	t	102,3	10,7	113,0		98,1	6,4	8,5	14,9		67,5	3,4	70,9	**56**	***376***
selen	t	642	67	709		536,6	120,3	52,1	172,4		392	68	460	**287,6**	***167***
tellur	t	376	39	415		320,5	64,4	30,1	94,5		242	11	252	**157,5**	***167***
cadmium	t	484	51	535		427,7	68,4	38,9	107,3		300	12	312	**204,7**	***191***
sulfur sulfide	th.ton	1226,3	128,5	1354,5		723,76	530,9	100,1	631,04		809,1	122,6	931,7	**300,66**	***48***
incl. pyrite	th.ton	1107,4	115,9	1223,3											
Average content:															
copper	%	4,54	1,80	4,28		4,33	5,14	1,90	4,14		4,33	1,67	3,53	***-0,61***	***-15***
zinc	%	2,25	0,26	2,05		2,25	1,94	0,20	1,40		2,38	0,29	1,75	***0,35***	***25***
gold	g/t	2,39	2,39	2,39		2,34	2,61	2,44	2,56		2,75	0,02	0,20	***-2,36***	***-92***
silver	g/t	33,17	33,17	33,17		37,83	11,38	33,70	18,30		30,93	3,60	22,71	***4,41***	***24***
selen	%	0,0208	0,0208	0,0208		0,0207	0,0214	0,0207	0,0212		0,0180	0,0072	0,0147	***-0,006***	***-31***
tellur	%	0,0122	0,0122	0,0122		0,0124	0,0115	0,0119	0,0116		0,0111	0,0011	0,0081	***-0,004***	***-30***
cadmium	%	0,0157	0,0157	0,0157		0,0165	0,0122	0,0154	0,0132		0,0138	0,0013	0,0100	***-0,003***	***-24***
sulfur sulfide	%	39,76	39,76	39,76		27,91		39,69			23,12	11,72	19,69		
incl. pyrite	%	35,90	35,90	35,90											

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	For underground development														
	Sulfide ores														
Ore reserves	th.ton	16034	1538,7	17572,7	1182,6		16034	1538,7	17572,7	1182,6	21225,1	12003,6	33228,6	**15655,9**	***89***
copper	th.ton	504,6	48,1	552,7	13,1		504,6	48,1	552,7	13,1	576,3	281,9	858,2	**305,5**	***55***
zinc	th.ton	122,0	11,7	133,7	1,0		122,0	11,7	133,7	1,0	81,9	94,7	176,7	**43**	***32***
gold	кг	13770	1323	15093	639		13770	1323	15093	639	12323	9134	21457	**6364**	***42***
silver	t	280,6	27,0	307,6	11,9		280,6	27,0	307,6	11,9	301,8	155,7	457,5	**149,9**	***49***
selen	t	1122	110	1232	97		1122	110	1232	97	1590	800	2390	**1158**	***94***
tellur	t	433	42,0	475	57		433	42,0	475	57	516	285	801	**326**	***69***
cadmium	t	1363	133	1496	47		1363	133	1496	47	668	302	970	**-526**	***-35***
sulfur sulfide	th.ton	3539,2	323,3	3862,5	209,2		3539,2	323,3	3862,5	209,2	3242,1	2613,2	5855,3	**1992,8**	***52***
incl. pyrite	th.ton	2966,9	284,6	3251,5	170,6		2966,9	284,6	3251,5	170,6	3043,7	1860,7	4904,4	**1652,9**	***51***
Average content:															
copper	%	3,15	3,11	3,14	1,11		3,15	3,11	3,14	1,11	2,71	2,35	2,58	***-0,56***	***-18***
zinc	%	0,76	0,76	0,76	0,08		0,76	0,76	0,76	0,08	0,39	0,79	0,53	***-0,23***	***-30***
gold	g/t	0,86	0,86	0,86	0,54		0,86	0,86	0,86	0,54	0,58	0,76	0,65	***-0,21***	***-24***
silver	g/t	17,50	17,50	17,50	10,05		17,50	17,50	17,50	10,05	14,22	12,97	13,77	***-3,73***	***-21***
selen	%	0,007	0,007	0,007	0,008		0,0070	0,0070	0,0070	0,0080	0,0075	0,0067	0,0072	***0,0002***	***3***
tellur	%	0,0027	0,0027	0,0027	0,0048		0,0027	0,0027	0,0027	0,0048	0,0024	0,0024	0,0024	***-0,0003***	***-11***
cadmium	%	0,0085	0,0085	0,0085	0,0040		0,0085	0,0085	0,0085	0,0040	0,0031	0,0025	0,0029	***-0,0056***	***-66***
sulfur sulfide	%	22,05	22,05	21,98	17,69		22,05	22,05	21,98	17,69	15,27	21,77	17,62	***-4,36***	***-20***
incl. pyrite	%	18,50	18,50	18,50	14,43		18,50	18,50	18,50	14,43	14,34	15,50	14,76	***-3,74***	***-20***
	TOTAL at the deposit														
	Mixed + Sulfide ores														
Ore reserves	th.ton	19118,5	1861,9	20980,4	1182,6		16596,2	1790,9	18387,1	1182,6	23408,2	12943,2	36351,3	**17964,2**	***98***
copper	th.ton	644,8	53,9	698,7	13,1		533,5	52,9	586,4	13,1	670,7	297,6	968,4	**382**	***65***
zinc	th.ton	191	12,5	203,5	1,0		132,9	12,2	145,1	1,0	133,8	97,4	231,2	**86,1**	***59***
gold	кг	21155	2095	23250	639		15239,5	1937,7	17177,2	639	18328	9292	27620	**10442,8**	***61***
silver	t	382,9	37,7	420,6	11,9		287	35,5	322,5	11,9	369,3	159,1	528,4	**205,9**	***64***
selen	t	1764	177	1941	97		1242,3	162,1	1404,4	97	1982	868	2850	**1445,6**	***103***
tellur	t	809	81	890	57		497,4	72,1	569,5	57	758	296	1053	**483,5**	***85***
cadmium	t	1847	184	2031	47		1431,4	171,9	1603,3	47	968	314	1282	**-321,3**	***-20***
sulfur sulfide	th.ton	4765,5	451,8	5217	209,2		4070,1	423,4	4493,54	209,2	4051,2	2735,8	6787	**2293,46**	***51***
incl. pyrite	th.ton	4074,3	400,5	4474,8	170,6		2966,9	284,6	3251,5	170,6	3043,7	1860,7	4904,4	**1652,9**	***51***
Average content:															
copper	%	3,37	2,89	3,33	1,11		3,15	3,11	3,14	1,11	2,87	2,30	2,66	***-0,48***	***-15***
zinc	%	1,00	0,67	0,97	0,08		0,76	0,76	0,76	0,08	0,57	0,75	0,64	***-0,12***	***-16***
gold	g/t	1,11	1,13	1,11	0,54		0,86	0,86	0,86	0,54	0,78	0,72	0,76	***-0,10***	***-12***
silver	g/t	20,03	20,25	20,05	10,05		17,50	17,50	17,50	10,05	15,78	12,29	14,54	***-2,96***	***-17***
selen	%	0,0092	0,0095	0,0093	0,008		0,0070	0,0070	0,0070	0,0080	0,0085	0,0067	0,0078	***0,0008***	***12***
tellur	%	0,0042	0,0044	0,0042	0,0048		0,0027	0,0027	0,0027	0,0048	0,0032	0,0023	0,0029	***0,0002***	***7***
cadmium	%	0,0097	0,0099	0,0097	0,0040		0,0085	0,0085	0,0085	0,0040	0,0041	0,0024	0,0035	***-0,0050***	***-59***
sulfur sulfide	%	24,93	24,27	24,87	17,69		22,05	22,05	21,98	17,69	17,31	21,14	18,67	***-3,31***	***-15***
incl. pyrite	%	21,31	21,51	21,33	14,43		18,50	18,50	18,50	14,43	13,00	14,38	13,49	***-5,01***	***-27***

Table 5. Reserves that remained in the project open pit contour by the grade of conditional copper 0,7 % on 01/01/2018

Category	Ore reserves t.t	Content of useful components									
		Cu, t.t	Zn, t.t	Pb, t.t	Au, kg	Ag, t	S pyr., t.t	S tot., t.t	Cd, t	Se, t	Te, t
Upper ore body											
C_1	1464,9	62,4	37,4	9,0	4407,1	49,2	339,2	548,8	290,4	286,0	192,6
		4,26	2,55	0,61	3,01	33,60	23,15	37,46	198,3	195,2	131,5
Lens III											
C_2	303,9	5,2	0,7	0,0	9,9	0,7	41,2	43,7	1,0	0,2	0,1
		1,72	0,23	0,00	0,03	2,14	13,55	14,37	3,4	0,5	0,3
Total											
$C_1 + C_2$	**1768,8**	**67,6**	**38,0**	**9,0**	**4417,1**	**49,9**	**380,4**	**592,4**	**291,5**	**286,2**	**192,7**
		3,82	2,15	0,51	2,50	28,20	21,50	33,49	164,8	161,8	109,0

c) The coefficients for conversion into conditional copper:

for mixed ores: copper – 1,0; zinc – 0,4; lead – 0,4; for sulfide ores: copper – 1,0; zinc – 0,3; lead – 0,2.

When converting to conditional copper, do not take into account the copper content of less than 0,4 %, zinc 0,4 % and lead 0,5 %.

d) The minimum industrial thickness of the ore body and grade interval for the open-pit mining is 4,0 m; for underground mining it is respectively 2,0 and 4,0 m. At a smaller thickness there is permitted contouring according to the corresponding GT (grade x thickness).

e) The maximum thickness of the interlayers of dredged rocks and substandard ores included in the calculation contour is 4,0 m for open-pit mining and 3,0 m for underground mining.

Conclusions. The studies have established that calculation of solid and vein-disseminated sulfide ores reserves should be made in a single contour with separating copper and copper-zinc technological ore grades in the statistical way.

In the contour of balance ores, besides the main useful components, it is necessary to calculate the reserves of gold, silver, cadmium, total sulfide and pyrite sulfur, rare and trace elements.

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Рукопис отримано 2.04.2019.