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ИЗВЕСТИЯ

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РЕСПУБЛИКИ КАЗАХСТАН

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OF THE REPUBLIC OF KAZAKHSTAN

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ГЕОЛОГИИ И ТЕХНИЧЕСКИХ НАУК

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TECHNOLOGICAL RESOURCES FOR IMPROVING THE QUALITY AND COMPLETENESS OF USE OF THE MINERAL RAW MATERIALS

Abstract. It was noticed, availability of the own mineral reserves is a guarantee of stable development of the economy, the industry, including smart-technologies and cyber-physical systems. Due to non-renewability and exhaustibility of these resources, the processes of their extraction and processing should be subject to the special requirements, which provide the integrated and full use of all the components contained in mineral raw materials. The place of Kazakhstan in the world by the reserves of various kinds of minerals and the role of mining and metallurgical complex (MMC) in the country economy are shown. The data on the minerals extraction and production over the past 5 years are provided. It is noted that in the deteriorating situation on the world metal markets there is an urgent need to diversify the MMC, providing increasing comprehensiveness and completeness of all the useful components contained in mineral raw materials and the mastering of the subsequent repartition. Also a strong demand for noble, rare and rare-earth metals for the needs of high-tech and knowledge-intensive branches of industries is taken into account.

The urgency of the scientific work acceleration is based, aimed at the development and introduction of new technologies, processes and technical tools, providing a more complete extraction in a marketable product of all the components contained in the ore. It is proved that such results can be achieved with the full conformity of the technology of ore processing to its natural properties and technological characteristics.

It is shown that all technologies of geological-prospecting, mining, mineral processing and chemical-metallurgical industries, providing increasing comprehensiveness of the mineral useful components extraction, consist in increase their numbers, enhancing the values of the coefficients of their extraction in the concentrate, metal. These solutions are the technological resources to increase the quality and completeness of the use of mineral raw material. It is illustrated by specific examples. It is calculated that the total revenue from the sale of related noble and rare metals exceeds the income from core metals (copper, molybdenum) in 9.33.

It was noticed, introduction of scientific developments of the scientists - geologists, miners and metallurgists of Kazakhstan – by the full and integrated use of mineral raw material (including oil, uranium, coal) into practice will significantly improve the efficiency of the natural resources sector and the economy as a whole. At the same time it makes an invaluable contribution to the development of high-tech industries and provide srapid joining of Kazakhstan to the number of the 30 most developed countries of the world.

Key words: mining and metallurgical complex, noble, rare and rare-earth metals, technological indices of minerals processing, useful components, integrated use.

State of the integrated use of mineral resources. Availability of the own mineral reserves is a guarantee of stable development of the economy, the industry, including smart-technologies and cyber-physical systems. Due to non-renewability and exhaustibility of these resources, the processes of their extraction and processing should be subject to the special requirements, which provide the integrated and full use of all the components contained in mineral raw materials.

Regarding the assessment of the issue status in Kazakhstan it should be noted that in the last century by the geologists of the Republic under the leadership of an outstanding scientist, academician of the Academy of Sciences of the USSR Kanysh Imantayevich Satpayev, were discovered and registered reserves of all the mineral deposit exploited now [1]. It is ranked first in the world reserves of zinc, tungsten and barite, the second place by the reserves of silver, lead and chromite, the third place by the reserves of copper and fluorite, the fourth place by the molybdenum reserves, the sixth place by the gold reserves. Kazakhstan is the biggest rhenium producer (second-third place), beryllium (first-fourth place), titanium sponge (second place), tantalum, niobium, gallium, technical thallium, arsenic (third place), uranium (first place), vanadium (fifth place), bismuth (sixth place) [2, 3]. Such resources have allowed our Republic to enter the top ten mining nations of the world. Mining and metallurgical complex (MMC) has a great influence on the formation of macroeconomic indicators of the country. Share of the industry branch is 13% of Gross Domestic Product (GDP), 23% – in the total industrial production, 48% – in the production of manufacturing industry output, 20% – in the country's export [4].

In addition, under the leadership of K. I. Satpayev the scientific foundations and pioneering technologies were created for extraction a variety of metals from complex ore raw material. Thanks to this currently Kazakhstan is the biggest producer of rhenium (the second-third place), beryllium (the first-third place), titanium sponge (the second place), tantalum, niobium, gallium (the third place), vanadium (the fifth place), bismuth (the sixth place), etc. [5].

Dynamics of extraction and production of the base metals over the past five years is characterized by the data in the table 1. They imply that the production volume of the mining and metallurgical complex is located almost on the same level. However, most of them are exported to the foreign countries in the form of a concentrate, even as raw materials, the value of which by one or two orders below the value of the finished product of the second-fourth stage of processing.

The global financial and economic crisis of recent years demonstrates the unpromising character of the industry branch policy. So, in 2015 demand for the production of MMC decreased sharply (in 1.3–1.8 times), and its prices fell in 1.5–2.0 times.

Table 1 – Extraction and production of minerals for 2012–2016 years

Product name	Units	2012	2013	2014	2015	2016 till november
Coal	Th. Tons	120510,9	119 860,1	113 843,5	107 318,8	91 121,7
Uranium	Th. Tons	20,9	22,5	22,83	23,80	24,08
Iron ores	Th. Tons	25997,8	25 241,8	24 628,3	17 111	14 670
Iron in ore components	Th. Tons	7360,3	6 919,7	6 250,5	3 283,6	3 100,3
Chromium ores	Th. Tons	5 233,1	5 255,0	5 410,4	5 382,8	5 048,6
Manganese ores	Th. Tons	2 975,0	2 852,1	2 617,3	1 625,7	1 450,4
Copper ores	Th. Tons	38352,9	41 731,7	38 660,6	42 420,1	69 954,3
Copper powder type	Th. Tons	367 161	350 837	293 948	492 346	377 079
Lead -zinc ores	Th. Tons	4 805,6	4 909,9	5 260,2	5 380	5263,1
Zinc in zinc concentrate	Th. Tons	370,5	361,1	346,6	342,5	293,5
Lead in lead concentrate	Th. Tons	38,5	40,8	37,8	40,7	60,5
Gold ore type	Tons	21,134	23,219	26,680	30,97	36,07
Silver ore type	tons	963,179	963,580	976,434	1 303,361	2093,011
Bauxite ores	Th. Tons	4 852,0	5 170,2	5 192,8	4682,6	4391,8
Asbestos	Th. Tons	241,2	243,3	213,2	179,8	182,1

Technological capabilities of increase the integrated use of mineral resources. In such a situation there is an urgent need for diversification in the mining and metals sector, which should start with a comprehensive and full use of all the useful components contained in mineral raw materials and the development of subsequent stages of processing. Most of the mining and metallurgical enterprises of Kazakhstan often do not extract from the raw material the precious components (platinum, gold, palladium, rhenium, osmium, thallium, etc.), concomitant to the core metals, and they go to waste of the processing and metallurgical industries. At these enterprises the extraction coefficient is very low (about 0.4) [3]. This paradox stems from the fact that by the process of the approval of the deposit's reserves, the concomitant useful components often are not estimated and so are not put to the balance sheet. There are no requirements to the subsoil users on extraction of useful components, identified in ores in the process of the deposit exploitation.

At the same time it is known that with the development of high-tech and knowledge-intensive manufactures (electronics, robotics, aircraft and rocket construction, space technology, software, nanotechnology, nuclear, solar and hydrogen energy, biotechnology, genetic engineering, etc.) demand for noble, rare and rare earth metals grows very quickly. Moreover, the cost per mass unit (ton, kg.) of these elements is in a thousand times higher than the cost of core metals (copper, zinc, lead), and the cost of osmium is more than a million times greater.

In this connection, the question of accelerating scientific work aimed at the development and introduction of new technologies, processes and equipment to ensure a complete recovery in the commercial product of all the components contained in the ore, becomes extremely relevant.

The solution of this major problem could be based on the account of the features of substance transition from one state to the other, respectively, by the geological exploration and mining extraction works, enrichment and metallurgical processing. Selected technologies and means of processing should ensure the maximum extraction of useful products at the each of these stages. These results are achieved with full accordance of the ore processing technology to its natural properties and technological characteristics [2].

By this the control of amount and quality is carried out on the basis of the mathematical models of the material composition of the mineral raw (MR) at each of the processing stages, represented in the form of [5,6]:

$$M_b = \sum_{i=1}^{n} m_i \,;\; M_{oe} = \varepsilon_{oe}\sum_{i=1}^{n} m_i \,;\; M_{lr} = \varepsilon_{oe}\sum_{i=1}^{r} \varepsilon_{yi} m_i \,;\; M_c = \varepsilon_{oe}\sum_{i=1}^{p} \varepsilon_{ci} m_i \,; \qquad (1)$$

$$M_t = \varepsilon_{oe}\sum_{i=1}^{s} \varepsilon_{ti} m_i \,;\; M_м = \sum_{i=1}^{q} M_{mi} = \varepsilon_{oe}\sum_{i=1}^{q} \varepsilon_{ci}\varepsilon_{mi} m_i \,;\; M_{mw} = \varepsilon_{oe}\sum_{i=1}^{l} \varepsilon_{wi} m_i \,.$$

where, M_b are the ore mass at the counter of the balance reserves; M_{oe} is mass of the extracted ore; M_{lr} is mass of the lumpy rock, removed from ore mass; M_c is mass of the all concentrate (concentrates); M_t is mass of the tails of enrichment; M_{mi} is mass of the *i*-th finished product (metal); $M_м$ is mass of the whole finished product (all metals); M_{mw} is mass of the waste of metallurgical processing; m_i is mass of the *i*-th component in the balanced reserves; ε_{oe} is the coefficient of ore extraction of mineral; ε_{yi} is the coefficient of removal of the *i-th* lumpy rock from ore; ε_{ci} is the coefficient of extraction of the *i*-th component from ore into the concentrate; ε_{ti} is the coefficient of extraction of the *i*-th component from ore to tails; ε_{mi} is the coefficient of extraction of the *i*-th component from concentrate to metal; ε_{wi} is the coefficient of extraction of the *i*-th component in waste of metallurgical processing; n is the number of all the components in the reserves volume, including waste; r is the number of components extracted from ore; p is the number of minerals extracted from ore to the concentrate; s is the number of components extracted to tails; q is the number of minerals extracted from concentrate to metal; *l* is the number of components in waste of metallurgical processing.

By the wide used technologies of the ore extraction and processing, n>p>q, ε_{oe}=0,5÷0,97 (the low limit corresponds to underground mining, the upper limit – to open-cast mining), ε_{yi}=0,15÷0,4, ε_{ci}=0,4÷0,98, ε_{ti}=0,02÷0,5, ε_{mi}=0,85÷0,98, ε_{wi}=0,02÷0,15.

For the sustainable exploration of the mineral reserves, full and comprehensive use of MR at every stage of its processing it is necessary to perform a certain amount of the survey and measurement works, as well as provide the possibility of application of the advanced and efficient technologies of processing.

For example, during the exploration phase with the use of modern high-precision equipment it is necessary to improve the completeness and reliability of the geological study of the individual blocks of deposits, determine more thoroughly the material composition of the core components as well as of the concomitant useful components, explore more fully the technological properties of ores, limit clearly the volume of the balance reserves. For each deposit it is necessary to approve the list of the useful components, subject to extraction, with indicating the minimum value of the extraction coefficient into the concentrate and metal.

By mining works it is necessary to refine systematically the mineralogical and technological parameters of useful components, provide the most complete extraction from the depths of all the balance reserves, envisage extraction of the over-balanced reserves.

At the stage of enrichment it is necessary to build and use several technological schemes of the ore processing into collective concentrate, which sharply increase the extraction coefficient for each useful component.

In the cycle of metallurgical processing it is necessary to create additional manufactures, non-standard technologies, ensuring maximum extraction of all the useful components, apply the repeat sequential processing of the concentrates.

Technical and economic impact of improving the quality and completeness of the use of minerals. Analysis of the mathematical models of the material composition of the ore production (1) at each processing stage shows that all the technologies of geological prospecting, mining extraction, mineral processing, chemical and metallurgical industries, providing improvement of quality, increase fullness and completeness of extraction of the core and concomitant components of minerals, consist in increasing of the numbers n, aspiration the numbers p and q to n, increase the values of the extraction coefficients ε_{oe}, ε_{yi}, ε_{ci}, ε_{mi} and decrease the values of the extraction coefficients ε_{ti}, ε_{wi}. These solutions are the technological resources to increase the quality and completeness of the use of mineral raw material. This conclusion reflects the essence of the technical, technological and organizational solutions to improve the completeness and the complexity level use of ore raw materials [2, 5].

Table 2 – Mass of the separate components in ore and price of the same metal

Components in ore	Content of components	m_i, t	ε_{oe}	$m_{iи}$, t	ε_y	M_{lr}, t	$m_{iф}$, t	c_i, $/t
Copper (Cu)	0,7%	7000	0,95	6650	0	0	6650	$5,5 \cdot 10^3$
Molybdenum (Mo)	0,015%	150	0,95	142,5	0	0	142,5	$27 \cdot 10^3$
Gold (Au)	1,0g/t	1,0	0,95	0,95	0	0	0,95	$34,23 \cdot 10^6$
Silver (Ag)	10 g/t	10	0,95	9,5	0	0	9,5	$0,44 \cdot 10^6$
Bismuth (Bi)	0,0005%	5,0	0,95	4,75	0	0	4,75	$19 \cdot 10^3$
Platinum (Pt)	0,0005%	5,0	0,95	4,75	0	0	4,75	$27,81 \cdot 10^6$
Palladium (Pd)	0,0005%	5,0	0,95	4,75	0	0	4,75	$18,08 \cdot 10^6$
Cobalt (Co)	0,0005%	5,0	0,95	4,75	0	0	4,75	$24 \cdot 10^3$
Selenium (Se)	3,8g/t	3,8	0,95	3,61	0	0	3,61	$21 \cdot 10^3$
Tellur (Te)	2,6g/t	2,6	0,95	2,47	0	0	2,47	$44 \cdot 10^3$
Cadmium (Cd)	0,4g/t	0,4	0,95	0,38	0	0	0,38	$0,1 \cdot 10^6$
Rhenium (Re)	0,3 g/t	0,3	0,95	0,285	0	0	0,285	$1,4 \cdot 10^6$
Indium (In)	2,0 g/t	2,0	0,95	1,9	0	0	1,9	$0,26 \cdot 10^6$
Osmium (Os)	0,02g/t	0,02	0,95	0,019	0	0	0,019	$20 \cdot 10^9$
Thallium (Ti)	0,0002 %	2,0	0,95	1,9	0	0	1,9	$0,7 \cdot 10^6$
Useful components		7192,2	0,95	6832,514	0	0	6832,514	
Waste rocks		992807,8	0,95	943167,486	0,2	188633,49	754533,99	
All components		1000000	0,95	950000		188633,49	761366,5	

Let us demonstrate the possibility of implementing a processed ore quality management system on example of the model deposit, developed by the open pit method. It is close in ore composition to the real copper-molybdenum deposits as Aktogay and Bozschakol. The content of useful components in the ore, the mass of the individual components at the ore and the value of 1 ton metal of the same name is shown at table 2. As can be seen from the table 2, the mass of the extracted ore from the quarry field is taken to be 950,000 tons, taking into account ε_{oe}=0,95. Coefficient of the lumpy rock removal from the ore mass is assumed to be ε_{y} = 0.2. The mass of all the useful components (UC), received at the processing plant, is 6832.514 tons, including the noble and rare earth metals of 40.014 tons, mass of the waste rock (WR) is 754,933.99 tons, all components (AC), including the waste rocks, are 761,366.5 tons.

Let consider change in the mass of all components, depending on the indices of mineral raw processing. The mass values of specific useful components in the concentrate, the metal, by various values of the coefficients of component extraction from ore in the concentrate, from the concentrate to metal, are shown at the table 3. At the first option, for the core metal, ε_c varies in limits 0,7-0,8, ε_m – in limits 0,7-0,85, for concomitant components ε_c = 0,5-0,6, ε_m = 0,6-0,75. At the second option, for the core metal ε_c=0,8-0,9, ε_m=0,8-0,9, for concomitant components ε_c = 0,6-0,7, ε_m= 0,7-0,85. Masses of the useful components and waste rock in the ore and concentrate at the second option of the processing are adduced at the figure 1.

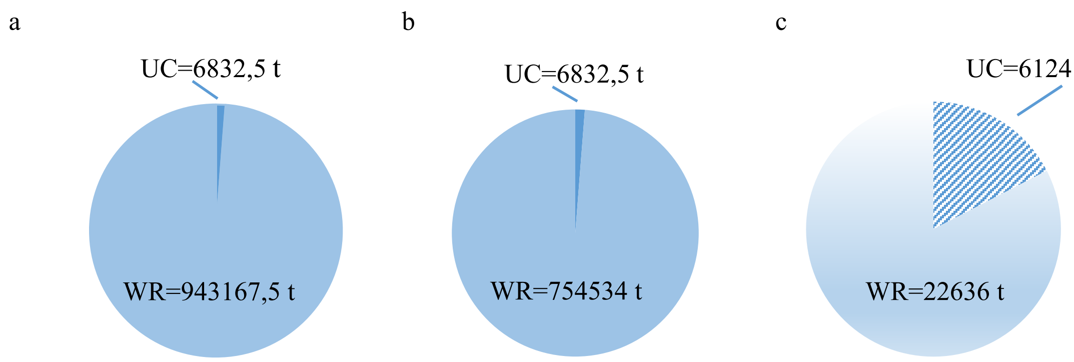

Figure 1 – Masses of useful components and waste rocks in:
the loaded ore (a), ore received at the processing plant (b) and in the concentrate (c)

From the data of the table 3 it follows that with increasing εc from 0.8 to 0.9 the copper mass in the concentrate increased to 5985 from 5320 tons (per one million tons of ore), i.e. on 12.5%. By increasing εc from 0.5 to 0.6 the bismuth mass in concentrate increases from 2.375 to 2.85 m, i.e. on 20%. By increasing εm from 0,6 to 0,75 the platinum mass increases from 142,5 t to 213,75 t, i.e. for 50%. By changing εc from 0,6 to 0,7 the gold mass increases from 0,57 to 0,655 t, i.e. for 16,6%, changing εm from 0,7 to 0,85 increases the gold (metal) mass from 0,399 to 0,5652 t, i.e. for 41,65%, etc.

Data of the table 3 clearly demonstrate the role of technologies of mineral raw processing in raising of the level of the useful components extraction from the raw material, and their high potential. Through the development and implementation of the innovative technologies and technical facilities the current level of extraction of noble and rare metals can be increased in 2 times.

The economic consequences of fuller use of the mineral raw are required careful attention. To their determination it is necessary the values M_{oe}, M_c and M_m from the formula (1) to multiply by the cost of the 1 t of the i-th finished product.

Calculations by the prices for the metals, listed at the table 2, show that in the second option of the ore processing with mass 761366.5 t (see the table 3, the column with the value $m_{mi\,2}$) the cost of the obtained copper is 30 613 275, cost of molybdenum is 2 616 300, cost of gold is 19 348 507,5, silver - 2 481 100, bismuth - 43 320, platinum - 63 406 800, palladium - 41 222 400, cobalt - 54 720, selenium - 36 388,8, tellurium - 52 166,4 cadmium - 18 240 , rhenium - 191 520, indium - 237 120, osmium - 182 400 000, thallium - 638 400, cost of the total final production is 343 366 257,7 US dollars. If the cost of core metals (Cu, Mo) is 33 229,575 US dollars, the cost of the noble and rare earth metals is 310 136 682,7 US dollars. Masses and costs of the core and rare metals are plotted at the figure 2.

In these conditions, total revenue from the sale of concomitant noble and rare metals exceeds the income from the core metals (copper, molybdenum) in 9.33 times. Income from the possible sale of osmium is 5.5 times higher than the total revenue of the core metals. This example also shows that the current size of the revenue from the sales of MMC production by integrated use of ores can be achieved when the ore amount in at least 8.0-10.0 times less than at present.

For large-scale implementation of the measures to improve the comprehensive utilization of mineral raw materials on the legislative, the state level it is necessary to solve the question of the necessity of extraction all concomitant, especially high-value mineral components from raw material. This naturally requires the construction of additional workshops, industries, tangible investments, to which investors are reluctant. However, the state's interests require the decisive action.

Table 3 – Mass of the separate component in the concentrate,
in the enrichment tails, in the metals and in the waste depending on the processing indices

	ε_c	m_{ki}, t	ε_{ti}	m_{ti}, t	ε_{mi_1}	m_{mi_1}, t	ε_{mi2}	m_{mi2}, t	ε_{wi1}	m_{wi_1}, t	ε_{wi2}	m_{wi2}, t
First option												
Cu	0,8	5320	0,2	1330	0,8	4256	0,85	4522	0,2	1064	0,15	798
Mo	0,7	99,75	0,3	42,75	0,7	69,825	0,75	74,8125	0,3	29,925	0,25	24,9375
Au	0,6	0,57	0,4	0,38	0,7	0,399	0,75	0,4275	0,3	0,171	0,25	0,1425
Ag	0,6	5,7	0,4	3,8	0,7	3,99	0,75	4,275	0,3	1,71	0,25	1,425
Bi	0,5	2,375	0,5	2,375	0,6	1,425	0,7	1,6625	0,4	0,95	0,3	0,71,25
Pt	0,5	2,375	0,5	2,375	0,6	1,425	0,7	1,6625	0,4	0,95	0,3	0,71,25
Pd	0,5	2,375	0,5	2,375	0,6	1,425	0,7	1,6625	0,4	0,95	0,3	0,71,25
Co	0,5	2,375	0,5	2,375	0,6	1,425	0,7	1,6625	0,4	0,95	0,3	0,71,25
Se	0,5	1,805	0,5	1,805	0,6	1,083	0,7	1,2635	0,4	0,722	0,3	0,5415
Te	0,5	1,235	0,5	1,235	0,6	0,741	0,7	0,8645	0,4	0,494	0,3	0,3705
Cd	0,5	0,19	0,5	0,19	0,6	0,114	0,7	0,133	0,4	0,076	0,3	0,057
Re	0,5	0,1425	0,5	0,1425	0,6	0,0855	0,7	0,09975	0,4	0,057	0,3	0,04275
In	0,5	0,95	0,5	0,95	0,6	0,57	0,7	0,665	0,4	0,38	0,3	0,285
Os	0,5	0,0095	0,5	0,0095	0,6	0,0057	0,7	0,00665	0,4	0,0038	0,3	0,00285
Ti	0,5	0,95	0,5	0,95	0,6	0,57	0,7	0,665	0,4	0,38	0,3	0,285
UC		5440,80		1390,6		4339,08		4611,86		1101,72		828,94
WR	0,04	30181,36	0,96	724352,63	0	0	0	0	1,0	30181,36	1,0	30181,36
AC		35622,16		725743,23		4339,08		4611,86		31283,08		30930,30
Second option												
Cu	0,9	5985	0,1	665	0,9	5386,5	0,93	5566,05	0,1	598,5	0,07	418,95
Mo	0,8	114	0,2	28,5	0,8	91,2	0,85	96,9	0,2	22,8	0,15	17,1
Au	0,7	0,665	0,3	0,285	0,8	0,532	0,85	0,56525	0,2	0,133	0,15	0,09975
Ag	0,7	6,65	0,3	2,85	0,8	5,32	0,85	5,6525	0,2	1,33	0,15	0,9975
Bi	0,6	2,85	0,4	1,90	0,75	2,1375	0,8	2,28	0,25	0,7125	0,2	0,57
Pt	0,6	2,85	0,4	1,90	0,75	2,1375	0,8	2,28	0,25	0,7125	0,2	0,57
Pd	0,6	2,85	0,4	1,90	0,75	2,1375	0,8	2,28	0,25	0,7125	0,2	0,57
Co	0,6	2,85	0,4	1,90	0,75	2,1375	0,8	2,28	0,25	0,7125	0,2	0,57
Se	0,6	2,166	0,4	1,444	0,75	1,6245	0,8	1,7328	0,25	0,5415	0,2	0,4332
Te	0,6	1,482	0,4	0,988	0,75	1,1115	0,8	1,1856	0,25	0,3705	0,2	0,2964
Cd	0,6	0,228	0,4	0,152	0,75	0,171	0,8	0,1824	0,25	0,057	0,2	0,0456
Re	0,6	0,171	0,4	0,114	0,75	0,12825	0,8	0,1368	0,25	0,04275	0,2	0,0342
In	0,6	1,14	0,4	0,76	0,75	0,855	0,8	0,912	0,25	0,285	0,2	0,228
Os	0,6	0,0114	0,4	0,0076	0,75	0,00855	0,8	0,00912	0,25	0,00285	0,2	0,00228
Ti	0,6	1,14	0,4	0,76	0,75	0,855	0,8	0,912	0,3	0,342	0,2	0,228
UC		6124,05		708,46		5496,86		5683,36		627,19		440,69
WR	0,03	22636,02	0,97	731897,97	0	0	0	0	1,0	22636,02	1,0	22636,02
AC		28760,07		732606,43		5496,86		5683,36		23263,21		23076,71

An example of increasing the integrated use of mineral raw material,as in Soviet times,shows the LLP "Kazzinc", where the number of the useful components extracted from the ore has reached 20. This result was achieved due to producing a bulk concentrate, its multiple sequential processing, the construction of additional productions for extraction from the concentrate the accompanying expensive elements [6].

Moreover, the implementation of these measures may cover the investments over and aboveand provide obtaining of the high revenues due to increasing the range of the produced metals. And this is achieved with a much smaller volume of raw materials, which will allow go to the extended wise use of subsoil resources and reduce the negative impact on the environment.

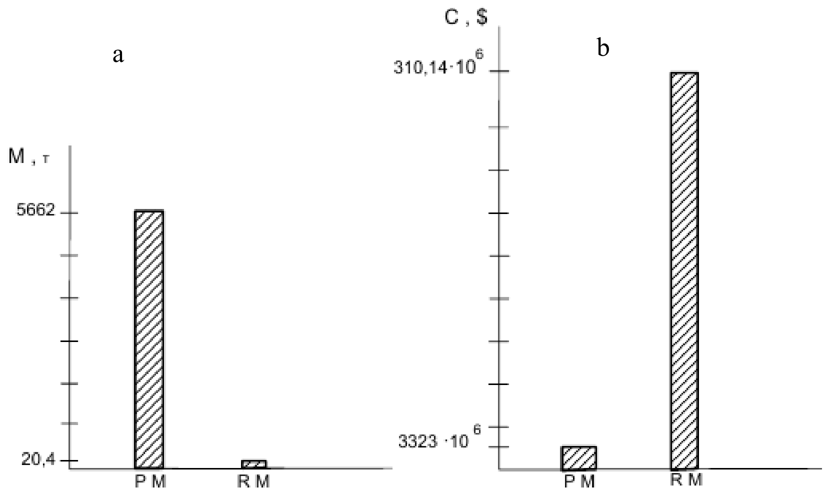

Figure 2 – Masses (a) and costs (b) of the obtained core and rare metals from 950 000 tons of ore

In 2015 LLP JC «SARECO» produced 67 tons of bulk concentrate of rare-earth metals (REM). JSC Ulba Metallurgical Plant produced 404.05 tons of beryllium, 30.08 tons of tantalum and 4.67 tons of niobium production. In 2016, it is planned to build another plant that will separate the rare-earth oxides and metals from the ore concentrate [7].

For the production of REM some kinds of coals are suitable (Karazhyra deposit, East Kazakhstan Region), and also natural shungites, phosphates, fluorides, etc. The raw material for extraction of the dispersed rare metals (indium, thallium, selenium, tellurium, germanium, gallium, rhenium) are the products of processing of lead-zinc, copper and aluminum-containing ores, ash from burning coal, as well as solutions and sledges of producing sulfuric acid [8].

Together, these sources could provide REM in sufficient amounts to Kazakhstan could take its rightful place in the global rare-earth metal market.

Conclusions.

1. The developed mathematical models of the material composition of the mineral raw successfully interconnect the indices of MR processing with the final results. They allow to estimate objectively the level of the applied technology of processing and to find ways to improve the extraction of core and concomitant useful components from MS.

2. Technical facilities and technologies adapted to the natural and technological properties of mineral raw provide a high level of extraction of noble and rare metals.

3. These solutions are the technological resources to increase the quality and completeness of the use of mineral raw material.

4. An important direction of the MMC diversification is a deep processing of the obtained product, the creation of high-tech and knowledge-intensive industries and obtaining of the products of higher commodity readiness.

5. Introduction of scientific developments of thescientists - geologists, miners and metallurgists of Kazakhstan - by the full and integrated use of mineral raw material (including oil, uranium, coal) into practice will significantly improve the efficiency of the natural resources sector and the economy as a whole. At the same time it makes an invaluable contribution to the development of high-tech industries and provide srapid joining of Kazakhstan to the number of the 30 most developed countries of the world.

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МИНЕРАЛДЫ ШИКІЗАТТАР ӨНІМДЕРІНІҢ САПАСЫ МЕН ТОЛЫҚТЫҒЫН КӨТЕРУДІҢ ТЕХНОЛОГИЯЛЫҚ РЕСУРСТАРЫ

Аннотация. Әр елдің өзінің пайдалы қазбалар қорлары болуы оның өнеркәсіп, оның ішінде смарт-технологиялар және киберфизикалық жүйелерді, экономикасының тұрақты дамуының кепілі болып табылады. Бұл қайта өндірілмейтін және жаңартылмайтын зат болғандықтан минералды шикізаттың құрамындағы барлық компоненттерін тегіс және толық пайдаланылуды қамтамасыз ететін, нақты талаптар қою керек.

Әртүрлі пайдалы қазбалардың әлемдегі қорлары бойынша Қазақстанның және елдегі тау-кен-металлургия кешенінің (ТКМК) орыны көрсетілген. Соңғы 5 жыл ішіндегі пайдалы қазбаларды игеру мен өндірудегі мәліметтері келтірілген. Әлемдік металл нарығындағы жағдайдың нашарлауына байланысты барлық минералды шикізаттарды құрайтын барлық пайдалы компонентерді толықтай пайдалану, сонымен қатар келесі шектердегі өнімдерді толықтай пайдалану мақсатында ТКМК диверсификация қажеттілігі көрсетілген. Сондай-ақ асыл, сирек және өте сирек кездесетін металдардың жоғары өндірістерді технологияларға қажеттіліктері, оған үлкен сұраныс бар екендігі айқындалған.

Пайдалы қазба құрамындағы барлық компоненттерден толықтай өнім алуды қамтамасыздандыратын техникалық құралдарды және процесстерді, жаңа технологияларды игеруге және енгізуге бағытталған ғылыми жұмыстарды жеделдетудің өзектілігі негізделген. Аталған жұмыстардың нәтижелілігі технологиялық сипаттамалармен және пайдалы қазбаларды өңдеудегі олардың табиғи қасиеттері технологиясымен толықтай сәйкестендірілгенде ғана қол жеткізуге болатындығы дәлелденді. Тиымды технологияларды пайдалану арқылы ілеспелі асыл және сирек металдарды шығарып алу, онаң түсетін табыс бейінді металдармен (мыс, молибден) салыстырғанда 9,33 есе көп болатыны дәлелденген.

Қазақстан геологтарының, кеншілерінің және металлургтерінің минералды табиғи ресурстарды пайдалану жолындағы ғығылыми-зерттеулер жұмыстары өте жоғары деңгейде. Оны толықтай өндіріске енгізсе, минералды шикізаттарды тиімді пайдалануға себебін тигізеді, ел экономикасын жан жақты көтереді. Сонымен қатар бұл шаралар жоғарғы технологиялық өндір істерді дамытуға баға жетпес үлес қосып, Қазақстанның әлемнің ең дамыған 30 елінің қатарына кіруге мүмкіндік береді.

Түйін сөздер: тау-кен кешендері, түсті, асыл, сирек металлдар, минералды шикізатты өндірудегі технологиялық көрсеткіштер, кешенді пайдалану, дайын өнім, қайта құру.

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ТЕХНОЛОГИЧЕСКИЕ РЕСУРСЫ ПОВЫШЕНИЯ КАЧЕСТВА И ПОЛНОТЫ ИСПОЛЬЗОВАНИЯ МИНЕРАЛЬНОГО СЫРЬЯ

Аннотация. Отмечено, что наличие собственных запасов полезных ископаемых является гарантом стабильного развития экономики страны, всей индустрии, включая смарт-технологии и киберфизические системы. В силу невозобновляемости и исчерпаемости таких ресурсов, к процессам их добычи и переработки должны предъявляться особые требования, предусматривающие комплексное и полное использование всех компонентов, содержащихся в минеральном сырье.

Показаны место Казахстана по запасам различных видов полезных ископаемых в мире, роль горно-металлургического комплекса (ГМК) в экономике страны. Приведены данные по добыче и производству полезных ископаемых за последние 5 лет. Отмечено, что в условиях ухудшения ситуации на мировых рынках металлов возникла острая необходимость в диверсификации ГМК, предусматривающей повышение комплексности и полноты использования всех полезных компонентов, содержащихся в минеральном сырье и освоение последующих переделов. Учтен также большой спрос на благородные, редкие и редкоземельные металлы для нужд высоких технологий, наукоемких отраслей промышленности.

Обоснована актуальность ускорения научных работ, направленных на разработку и внедрение новых технологий, процессов и технических средств, обеспечивающих более полное извлечение в товарный продукт всех компонентов, содержащихся в руде. Доказано, что такие результаты достигаются при полном соответствии технологий переработки руды ее природным свойствам и технологическим характеристикам.

Показано, что все технологии геолого-разведочного, горнодобычного, обогатительного и химико-металлургического производств, предусматривающие повышение комплексности извлечения полезных компонентов ископаемых, состоят в увеличении их числа, повышении значений коэффициентов их извлечения в концентрат, металл. Они представляют собой технологические ресурсы повышения качества и полноты использования минерального сырья. Это проиллюстривано на конкретных примерах. Подсчитано, что совокупные доходы от реализации сопутствующих благодарных и редких металлов превышает доходы от профильных металлов (меди, молибдена) в 9,33 раза.

Внедрение научных разработок ученых - геологов, горняков и металлургов Казахстана по полному и комплексному использованию минерального сырья (в том числе нефти, урана, угля) в практику существенно улучшит эффективность работы минерально-сырьевого сектора и экономики страны в целом. Одновременно оно вносит неоценимый вклад в развитие наукоемких отраслей промышленности и быстрейшее вхождение Казахстана в число 30 наиболее развитых стран мира.

Ключевые слова: горно-металлургический комплекс, цветные, благородные, редкие металлы, технологические показатели переработки минерального сырья, комплексное использование, готовая продукция, диверсификация.

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