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Extraction of gold from low-sulfide gold-bearing ores by beneficiating method using a pressure generator for pulp microaeration

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ABSTRACT

Research results on the study of the material composition of low-sulfide gold-bearing ore from the East Kazakhstan deposit are presented. The main non-metallic minerals of the original sample and beneficiation products include quartz, chlorite (clinochlore), carbonates (calcite and dolomite). Pyrite is present predominantly in the form of cubic crystals, sometimes in the form of clusters. The grain size is from 0.03 to 0.40.5 mm, the size of the clusters reaches several mm. Iron oxides (goethite, hydrogoethite) were formed on pyrite, possibly magnetite and ilmenite. The assay test found that the test sample contains 6.04 g/t Au and 7.9 g/t Ag. The content of sulfide minerals is 11.81%. A significant part of gold (85.51%) is in a finely disseminated state in sulfides, as well as in rock-forming minerals 1.22%. The paper presents the results of laboratory studies of the gold- ore beneficiation ability using gravity concentration processes. Gravity enrichment tests were performed on laboratory equipment: Knelson KS-MD 3 centrifugal concentrator, SKO-05 concentration table, and a two-chamber diaphragm jig (OML TsNIGRI type (jig of Central Geological Research Institute for Nonferrous and Precious Metals)). The obtained results of ore beneficiation on the concentration table show the possibility of obtaining a gravity concentrate with a gold grade of 48.9 g/t with a gold recovery of 40.08%. When separating the gravity concentrate on a jig, the gold extraction was 31.6% at a content of 51.4 g/t. It was found that that according to a single-stage beneficiation scheme in a centrifugal concentrator, a gold-bearing concentrate with a gold content of 58.3 g/t was obtained with a recovery of 80.6%. The dependence of the gold extraction and its content in the gravity concentrate on the output at the Knelson centrifugal concentrator is shown. The results of ore flotation beneficiation show the possibility of obtaining waste grade flotation tailings with a gold grade of 0.8 g/t. The extraction of gold into the combined concentrate, with a gold content of 49.7 g/t, is 88.88%.

Key words: gold-bearing low-sulfide ore, mineral composition, phase composition, gravitational beneficiation, gold extraction, concentrate, tailings, oxidizing agent.

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Introduction

At present, gold-bearing ores classified as "refractory" are involved in processing. The "refractoriness" of ores is explained by the fine dissemination of gold in sulfides and rock - forming minerals. Gold-pyrite and gold-arsenic ores and their concentrates take pride of place among sulfide gold-bearing raw materials. The reserves of such ores are continuously replenished with new promising objects. One of these objects is the additionally explored sulfide gold-bearing ores of the East Kazakhstan deposit.

In order to avoid losses of coarse gold (more than 200 µm) during the processing of gold-bearing ore, the scheme includes gravity concentrate production processing using such equipment as classifying screens, jigs, concentration tables, centrifugal concentrators before flotation [[1], [2], [3]]. The existing process flow schemes for the processing of gold-bearing ores include the production of gravity concentrates and tailings. Centrifugal concentrators (Knelson, Itomak) are used to extract fine and thin gold.

Data shows [[4], [5], [6]] that due to poor, refractory and technogenic raw materials, it is possible to increase the mineral resource base of gold, which can be achieved as a result of increasing the efficiency of processing technology and the completeness of extraction of a valuable component. A significant part of noble metals in sulfide ores is concentrated in a finely dispersed phase. Free and sulfide-bound gold is efficiently recovered by gravity methods.

The combination of jigging and centrifugal gravitational enrichment technologies allows for separating minerals with a small difference in density. The authors proposed an ore processing scheme using a Knelson concentrator at a lower pulp feed rate and lower pressure to ensure higher accuracy (instead of 1000 g/min at 25 kPa, the feed was 400 g/min at 12 kPa). The total extraction of gravitational gold was 61.85 % with content in the concentrate of 1037.04 g/t [[7], [8], [9]]. In the course of investigations, it was also decided to work out a variant of the experiment on gravitational enrichment using alternative parameters taking into account the results of the above mentioned experiment.

The paper [10] presents the results of benefecation of various types of raw materials: sulfide ores of the Balakhchino deposit. The content of sulfides in ores exceeds 10%, gold is mostly finely disseminated in sulfides. It is known [[11], [12], [13], [14]] that gold is extracted from weathered ores by leaching, therefore, the use of gravity concentration at the head of the process flow scheme will make it possible to extract coarse gold and thereby reduce its losses and increase the productivity of the cyanidation process.

In order to achieve the best results in the processing of refractory sulfide gold-bearing ores, it is necessary to study their material composition and, based on the results obtained, develop a technology for obtaining gold-bearing concentrate, taking into account modern technological solutions [[15], [16], [17], [18]].

During gravitational enrichment, coarse, film-coated gold gets into the concentrate; however, its further extraction from the concentrate requires the use of special methods [19]. Based on previously published data [20], the authors selected the optimal conditions for extracting gold from low-sulfide gold-bearing ore by combining the processes of gravity and flotation beneficiation.

One of the promising technologies for processing gold-bearing raw materials is the choice of an efficient leaching system using oxidizing agents, which does not require large material costs [[19], [21], [22]]. It is most difficult to extract dispersed gold from sulfide minerals, especially with a finely disseminated structure of ores. In order to intensify the process of refractory ores oxidation and increase the extraction of gold, the laboratory staff proposed to perform combined oxidation. In this case, it is possible to ensure high rates of gold recovery during subsequent cyanidation using a chlorine-containing oxidizing agent for the oxidation of sulfide fragments. Previous studies have shown the use of various chemical additives, oxidizers, and an activator reagent [[2], [22]] including biooxidation [23] to intensify the cyanidation process by dissolving films of compounds that passivate the metal surface.

Employees of the "Institute of Metallurgy and Ore Beneficiation" JSC special hydrometallurgy methods laboratory named after Beisembaev B.B. performed work, which resulted in the selection of technological equipment for extracting gold from gold ore into gravity concentrate. Development of a highly efficient technology for extracting gold from finely dispersed gold-bearing raw materials using a pressure generator for pulp microaeration on a column flotation machine of the apparatus and an algorithm for calculating its design parameters in order to implement the technology for efficient flotation of fine particles and emulsion impurities of gold-bearing raw materials. One of the new and effective methods created on the basis of the physical action on the flotation process, which makes it possible to achieve simultaneously high recovery and selectivity in the separation of finely dispersed components with increased specific productivity of the apparatus. The structure and principle of operation of this column flotation machine are characterized by the possibility of simultaneously obtaining finely dispersed bubbles and using them at an increased speed of the downward pulp flow, which provides a higher specific productivity of the pulsating layer of the column compared to pneumatic flotation machines currently used.

Dispersion elements in the column body, fixed on the aeration fittings provide the formation of microbubbles while air supplies under pressure. A vortex pulp flow aeration fitting is mounted in the bottom cone of the installation column with the inclusion of a reagent tank for the injection of basic and additional reagents [[24], [25], [26], [27], [28]].

The purpose of the work is to study the material composition of the gold-bearing ore of the East Kazakhstan deposit, and conduct research on the gravity and flotation enrichment of low-sulfide ore and the choice of technological equipment for obtaining gravity and flotation concentrate, to study the extraction of gold from ore, gravity and flotation concentrate and beneficiation tailings using pressure pulp microaeration generator.

Experimental part

The fundamental possibility of the investigated initial size material beneficiation was studied on Knelson KS-MD 3 centrifugal separators [[4], [7]], as well as on the SKO-05 concentration table and a two-chamber diaphragm laboratory OML type (TsNIGRI) jig.

The extraction of gold into the combined concentrate was 40.08% at 60% fineness of the 0.074 + 0 mm class on the concentration table. When separating the gravity concentrate on a jigging machine, the extraction of gold amounted to 31.6%. While testing the ore sample on the Knelson concentrator, standard production technological parameters were initially worked out: centrifugal acceleration of 60 G; flow rate of fluidizing water 3.5 l/min.; solid productivity 0.5-0.6 kg/min; excess pressure of fluidizing water 15 kPa; the solids content in the pulp fed to gravity separation is 25-30%.

When enriching ore with an 85% size of -1.7 + 0 mm class on a 3-inch Knelson centrifugal concentrator, the recovery was 66.0%. 90% size ore of -0.071 mm class was beneficiated also using Knelson centrifugal concentrate according to a one-stage scheme. In addition to increasing the grinding fineness of the supplied raw materials, the following technological parameters were also worked out: centrifugal acceleration 60 G; flow rate of fluidizing water is 1.75 l/min., productivity of solid is 0.3 kg/min.; excess pressure of fluidizing water is 15 kPa; the solids content in the pulp fed to gravity separation is 25-30%.

The results obtained showed that after grinding the ore in a ball mill to 90% fineness of the -0.071 mm class and with a centrifugal acceleration of 60 G (Table 1), the extraction of gold into the gravity concentrate increased to 80.6% with 8.3 product yield.

Table 1. Results of laboratory experiments of gravitational benefication of an ore sample at a 90% fineness of -0.071 mm class

Product name	Yield		Content	Extraction
	g	%	Au, g/ton	Au, %
Concentrate	166	8.3	58.3	80.6
Tailings	1834	91.7	1.27	19.4
Total:	2000	100	6.03	100.0

The gold content averaged 58.3 g/ton in concentrate and 1.27 g/ton in tailings. The estimated content (according to the balance) of gold in the ore is 6.03 g/toBeneficiationion at standard parameters made it possible to achieve almost the same recovery (80.1%) but at the expense of a higher concentrate yield of 12.5%. The gold content in the concentrate was only 40 g/t.

Thus, from the considered processes, the best performance when grinding ore to a fineness of 90.0% of the class -0.071 + 0 mm was obtained on the Knelson concentrator with the preservation of such parameters as centrifugal acceleration 60 G, fluidizing water pressure 15 kPa, but with a simultaneous decrease in the pulp feed rate (capacity for solids 0.3 kg/min, the flow rate of fluidizing water 1.75 l/min).

The results of chemical and X-ray phase analysis of the ore indicate the presence of a small amount of pyrite in the ore.

An experiment on the original ore was set up to develop a flotation concentrate for hydrometallurgical research. Staged flotation (Table 2) was performed in a closed cycle: I main flotation — at the 80–85% grinding size of the -0.074+0 mm class, II main flotation – at 90–95% of the -0.044+0 mm class. Total flotation time is 40 min, consumption of reagents amounts to 75 g/ton copper sulphate, 290 g/ton butyl xanthate, T-92 - 130.

Table 2 - Results of flotation beneficiation of ore from the East Kazakhstan deposit

Product	Yield, %	Gold content, g/ton	Extraction, %
Concentrate 1+2	8.33	57.5	75.17
Concentrate 3	3.07	28.5	13.71
United concentrate	11.4	49.7	88.88
Flotation tailings	88.6	0.8	11.12
TOTAL	100.0	6.37	100.0

The results of staged flotation ore enrichment show the possibility of obtaining dump gold flotation tailings with a gold grade of 0.8 g/ton. The extraction of gold into the combined concentrate, with a gold content of 49.7 g/ton, is 88.88%. The beneficiation products were sent for hydrometallurgical research.

The experiment in the flotation column required the process of at least 90 kg of initial ore, crushed to minus 0.071 mm 80% - taking into account the working volume of the column 360 l and the solids content of 25% in the pulp. The ore raw materials pulp obtained was loaded using slurry pumps in the open upper part of the column.

As a result of the experiment at a pressure in the pressure generator of 2.0 atm., the concentrate yield was 7.0% with a gold content of 8.0 g/ton, which gives 66.7% recovery. Increasing the pressure to 4.0 atm. contributed to an increase in the concentrate yield up to 8.6%, while the gold content was 7.22 g/ton, and already 73.9% was extracted into the concentrate. The mass yield of the concentrate reached 9.0% at a pressure of 6.0 atm. in the pressure generator dispersion system and with a gold content of 8.12 g/ton, the extraction increased to 87.0%.

Subsequent options with pressure increase up to 8.0 and 10.0 atm. led to the increase in the mass yield of concentrates to 12.1-14.65%, while the gold content decreased to 5.42 and 4.28 g/t, respectively. This also led to a decrease in recovery to 78.1% at 8.0 atm. and 74.6% at 10.0 atm. The diagram in Figure 9 shows the dependence of the recovery and quality indicators of gold concentrates, on the parameters of the pressure generator, and the pressure in the disperser system. As a result of the experiment at a pressure in the pressure generator of 2.0 atm., the concentrate yield was 7.0% with a gold content of 8.0 g/t, which gives a recovery of 66.7%. Increasing the pressure to 4.0 atm. contributed to an increase in the concentrate yield up to 8.6%, while the gold content was 7.22 g/t, and already 73.9% was extracted into the concentrate.

Table 3 – Results of experiments on flotation beneficiation in a column unit under different pressure conditions.

Pressure generator parameters, pressure, atm	Name of products	Yield, %	Au Content, g/ton	Au Extraction, %
2.0	Concentrate	7.0	8.0	66.7
	Tailings	93.0	0.3	33.2
	Total	100.0	0.84	100.0
4.0	Concentrate	8.6	7.22	73.9
	Tailings	91.4	0.24	26.1
	Total	100.0	0.84	100.0
6.0	Concentrate	9.0	8.12	87.0
	Tailings	91.0	0.12	13.0
	Total	100.0	0.84	100.0
8.0	Concentrate	12.1	5.42	78.1
	Tailings	87.9	0.21	22.0
	Total	100.0	0.84	100.0
10.0	Concentrate	14.65	4.28	74.6
	Tailings	85.35	0.25	25.4
	Total	100.0	0.84	100.0

At a pressure of 6.0 atm. in the dispersion system of the pressure generator, the mass yield of the concentrate reached 9.0%, and with a gold content of 8.12 g/t, the extraction increased to 87.0%. Subsequent options with an increase in pressure to 8.0 and 10.0 atm., led to an increase in the mass yield of concentrates to 12.1-14.65%, while the gold content decreased to 5.42 and 4.28 g/t, respectively. (Figure 1).

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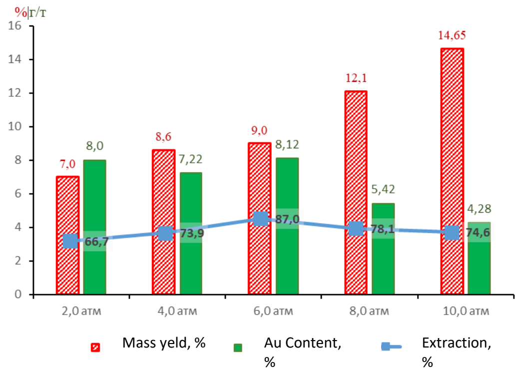

Figure 1 - The dependence of the extraction and quality of concentrates on the air pressure in the dispersion system.

Results and discussion

A sample of sulfide ore from the East Kazakhstan deposit was used as a feedstock during the research. In preparation for the research, the entire sample was crushed in stages to a particle size of -25+0 mm, cut, mixed, and reduced in accordance with the standard method of sampling (sampling) for technological research and study of the material composition.

Samples are mainly represented by quartz (54.7%), calcite, and dolomite.

The chemical composition of the studied ore sample is represented by the following components, %: 4.27 Fe; 0.952 total; 0.010As; 0.072 Zn; 0.016 Cu; 6.4 g/t Au; 7.9 g/t Ag. The other components were determined by X-ray fluorescence and X-ray phase analysis: the ore is represented by oxides that are part of the rock-forming components, the main of which is silica (54.7%) and alumina (10.8). Calcite (12%) and clinochlore (11.2%) are also present, dolomite (6.3%), and albite (5.0%) are present in small amounts.

The products of the gravitational beneficiation of the ore — concentrate, and tailings — were analyzed by atomic adsorption and assay methods.

Mineralogical analysis of an ore sample with an initial fineness of 89% class 10 microns (-0.01 mm) was performed to find the looks of gold. The polished section (∅ = 25 mm, sub-sample weight = 10-15 grams) formed from this material was studied with Axio Scope.A1 optical microscope.

As a result, 36 gold particles were found, of which: 30 particles in free form - 83.33%, Au size from 0.5 to 18.8 mkm, gold; 4 particles in intergrown with waste rock - 11.11%, with parameters - Au from 0.7 to 7.4 mkm (Figure 1);

2 facts of the gold particles occurrence in waste rock with thin phenocrysts of arsenopyrite particles in it - 5.56%, the size range of gold particles is within: Au from 0.5 to 6.8 mkm. The particle size is within: Au (0.5-18.8mkm), i.e. ultrafine (0.1-1.0 mkm) finely dispersed gold (1.0-10.0 mkm) and visible pulverized gold (10.0-50.0 mkm), (“nuggets” according to Petrovskaya's classification).

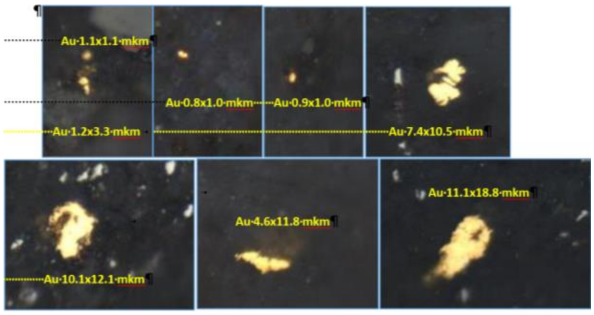

Figure 2 - Free gold particles in polystyrene

Figure 3 below shows the occurrence of gold particle “inclusions” in grains of waste rock with thin arsenopyrite phenocrysts in it.

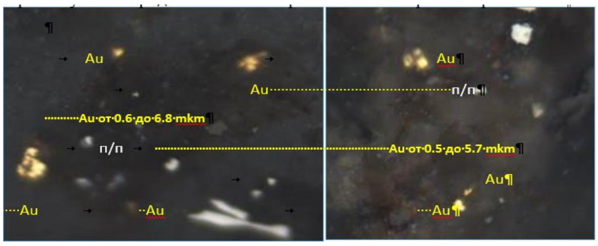

Figure 3 - The fact of the occurrence of gold particles in grains of waste rock with thin arsenopyrite phenocrysts in it

The gold deportment, the nature of gold’s relationship with ore and non-metallic components, and assessment of its disclosure during grinding were determined through a phase (rational) analysis of a head ore sample, crushed to 95% fineness of the -0.071 mm class (Table 3).

The phase analysis technique included a number of operations. The 1st operation is the determination of free gold and gold in open aggregates – cyanidated gold. The 2nd operation is treatment of the first cyanidation tailings with a solution of hydrochloric acid in the presence of tin chloride to dissolve iron oxide films on gold particles. The 3rd operation is the determination of gold covered with films. The 4th operation is welding of the tails of the second cyanidation in aqua regia. The content of finely dispersed gold in waste rock was determined in the residue after parting. The amount of gold associated with sulfides was determined from the difference in the contents in the tails of the second cyanidation and the parting tails.

Table 3 - Results of phase analysis for gold of a crushed head ore sample with a size of 95% of the class -0.071 mm

Gold deportment	Gold distribution	
	g / ton	%
Free and in the form of intergrown	5.02	85.51
Associated with acid soluble minerals (carbonates, hydroxides, chlorites, etc.)	0.12	1.46
Associated with sulfides	0.97	11.81
Finely disseminated in rock-forming minerals	0.10	1.22
Total in the sample (according to balance)	6.21	100.0

It is shown that the content of free gold and gold in open intergrown (cyanidated gold) is 85.51% in total. Gold grains are dendritic, octahedral, and needle-shaped. The sizes of gold grains range from 0.025 mm to 0.05 mm, dominated by 0.025-0.075 mm. The presence of finely disseminated gold in sulfides is one of the main reasons why gold is extracted from minerals with difficulties. 11.81% of gold is associated with sulfides, 1.46% is associated with acid-soluble compounds, and 1.22% is with rock-forming minerals.

Based on the results of rational analysis, it can be stated that rather high rates of gold dissolution up to 90% of the extracted gold should be expected during the cyanidation of ore.

The data of X-ray phase analysis of the sample showed that the total content of pyrite is 1.8%. The main rock-forming mineral is quartz, 54.7%. The content of albite, a mineral of the plagioclase group, is about 5%.

Conclusions

The study of the material composition found that the calculated gold content in the test sample is 6.04 g/t, silver 7.9 g/t. Gold is found in the form of very small grains in sulfides (pyrite, arsenopyrite), as well as in a finely disseminated state in silicate minerals. The ore is characterized by a multicomponent mineral composition with a predominance of pyrite.

The mineralogical and X-ray phase analysis of the sample showed that the main ore part is represented by pyrite, and quartz as rock-forming minerals. The rational analysis found that gold is distributed in the studied ore, crushed to a fineness of 95.0% of the class 0.071 + 0 mm, as follows: 85.51% free and in intergrown, 11.81% gold associated with sulfides, 1.46%associated with acid-soluble compounds, 1.22% in rock-forming minerals.

When enriched in a centrifugal concentrator, a gold-bearing concentrate was obtained with a gold content of 58.3 g/t with the extraction of 80.6%, and the loss of gold with the tailings of the centrifugal separator is 19.4% with a content of 1.27 g/t.

Centrifugal gravity separators, and in particular the Knelson concentrator, have proven to be a very effective circuit element in the technological chains of modern enterprises processing precious metal ores and sands. In this regard, the most preferable is the use of gravity technologies for extracting gold using gravity equipment that can provide a high degree of concentration of valuable components, the safety of the process, and a favorable state of the environment.

The obtained results of ore beneficiation on the concentration table show the possibility of obtaining a gravity concentrate with a gold grade of 48.9 g/t with a recovery of 40.08%. The tailings of the concentration table with a gold content of 3.8 g/t can be directed to additional extraction of gold by the flotation method.

When separating the gravity concentrate on a jig, the extraction of gold was 31.6%, with a content of 51.4 g/t. Based on the results of gravity beneficiation of ore in a centrifugal separator, it was found that the optimal size of grinding is 90% of -0.071 + 0 mm class.

Thus, based on the results obtained, it can be concluded that the Knelson centrifugal concentrator using of optimized operating mode is the best equipment for obtaining gravity concentrates from the ore of the East Kazakhstan deposit.

The head ore of the East Kazakhstan deposit is enriched by flotation quite effectively. The experiment on the head ore benefication with a particle size of 80% 0.074 mm is resulted with a flotation concentrate with a gold grade of 49.7 g/t with a yield of 11.4% and a recovery of 88.88%. The gold content in the flotation tailings was 0.8 g/t.

The results of the experiments showed that the most optimal parameter of the pressure generator in terms of pressure supplied to the dispersion system is 6.0 atm. A further increase in pressure promotes intensive transfer of waste rock into concentrates, which significantly increases the mass yield, but at the same time reduces the gold content in them. The 6.0 atm. indicator allows for achieving the optimal balance in terms of mass yield and content of the noble metal in the concentrate.

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Conflict of Interest Statement

On behalf of all authors, the correspondent author declares that there is no conflict of interest.

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Аз сульфидті кендерден қысымды микроаэрация генераторын қолдану арқылы байыту жолымен алтын алу

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ТҮЙІНДЕМЕ

Шығыс Қазақстан кен орнының құрамында күкірті аз алтын бар кеннің заттық құрамын зерттеу бойынша зерттеу нәтижелері келтірілген. Бастапқы сынама мен байыту өнімдерінің негізгі кенсіз минералдары кварц, хлорит (клинохлор), карбонаттар (кальцит және доломит) болып табылады. Пирит негізінен текше тәрізді кристалдар түрінде, кейде кластерлер түрінде болады. Дәндердің мөлшері 0,03-тен 0,40,5 мм-ге дейін, кластерлердің мөлшері бірнеше мм-ге жетеді. темір оксидтері (гетит, гидрогетит) пирит, мүмкін магнетит және ильменит арқылы түзілген. Сынамалық талдаумен зерттелетін сынамада 6,04 г/т Au және 7,9 г/т Ag бар екендігі анықталды. Сульфидті минералдардың мөлшері 11,81% құрайды. Алтынның едәуір бөлігі (85,51%) сульфидтерде, сондай-ақ 1,22% тау жыныстарын құрайтын минералдарда жұқа қапталған күйде. Жұмыста гравитациялық байыту процестерін қолдана отырып, құрамында алтыны бар кенді байытуды зертханалық зерттеу нәтижелері ұсынылған. Гравитациялық байыту бойынша сынақтар зертханалық жабдықта: knelson КС-МД 3 орталықтан тепкіш концентраторында, СҚО-05 концентрациялық үстелінде және екі камералы диафрагмалық шөгу машинасында (ЗНИГРИ АМЛ типі) өткізілді. Концентрациялық үстелде кенді байытудың алынған нәтижелері 40,08 % алтын алу кезінде құрамында 48,9 г/т алтын бар гравитациялық концентрат алу мүмкіндігін көрсетеді. Шөгу машинасында гравитациялық концентрат бөлінгенде, құрамында 51,4 г/т болған кезде алтын алу 31,6% құрады. Бір сатылы байыту схемасы бойынша ортадан тепкіш концентраторда 80,6% алу кезінде құрамында 58,3 г/т алтын бар концентрат алынғаны анықталды. Алтын алу мен оның гравитациялық концентраттағы құрамының Knelson орталықтан тепкіш концентраторының шығуынан тәуелділігі көрсетілген. Кенді флотациялық байыту нәтижелері құрамында 0,8 г/т алтын бар флотацияның алтын бойынша үйінді қалдықтарын алу мүмкіндігі туралы көрсетеді, құрамында 49,7 г/т алтын болған кезде Алтынды біріктірілген концентратқа алу 88,88% - ды құрайды.

Түйінді сөздер: құрамында алтыны бар аз сульфидті кен, минералды құрамы, фазалық құрамы, гравитациялық байыту, алтын алу, концентрат, қалдықтар, тотықтырғыш

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Извлечение золота из малосульфидных золотосодержащих руд методом обогащения с использованием напорного генератора микроаэрации пульпы

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АННОТАЦИЯ

Приведены результаты исследований по изучению вещественного состава малосульфидной золотосодержащей руды месторождения Восточного Казахстана. Основными нерудными минералами исходной пробы и продуктов обогащения являются кварц, хлорит (клинохлор), карбонаты (кальцит и доломит). Пирит присутствует преимущественно в виде кристаллов кубической формы, иногда в виде скоплений. Размер зерен от 0,03 до 0,40,5 мм, размер скоплений достигает нескольких мм. Оксиды железа (гетит, гидрогетит) образовались по пириту, возможно магнетиту и ильмениту. Пробирным анализом установлено, что в исследуемой пробе содержится 6,04 г/т Au и 7,9 г/т Ag. Содержание сульфидных минералов составляет 11,81 %. Значительная часть золота (85,51 %) находится в тонковкрапленном состоянии в сульфидах, а также в породообразующих минералах 1,22 %. В работе представлены результаты лабораторных исследований обогатимости золотосодержащей руды с использованием процессов гравитационного обогащения. Тесты по гравитационному обогащению проведены на лабораторном оборудовании: центробежном концентраторе Knelson КС-МД 3, концентрационном столе СКО-05 и двухкамерной диафрагмовой отсадочной машины (типа ОМЛ ЦНИГРИ). Полученные результаты обогащения руды на концентрационном столе показывают возможность получения гравитационного концентрата с содержанием золота 48,9 г/т при извлечении золота 40,08 %. При выделении гравитационного концентрата на отсадочной машине извлечение золота составило 31,6 % при содержании 51,4 г/т. Установлено, что по одностадиальной схеме обогащения на центробежном концентраторе получен золотосодержащий концентрат с содержанием золота 58,3 г/т при извлечении 80,6 %. Показана зависимость извлечения золота и его содержания в гравитационном концентрате от выхода на центробежном концентраторе Knelson. Результаты флотационного обогащения руды показывают о возможности получения отвальных по золоту хвостов флотации с содержанием золота 0,8 г/т. Извлечение золота в объединенный концентрат, при содержании золота 49,7 г/т составляет 88,88 %.

Ключевые слова: золотосодержащая малосульфидная руда, минеральный состав, фазовый состав, гравитационное обогащение, извлечение золота, концентрат, хвосты, окислитель.

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