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IMPROVEMENT OF THE TECHNOLOGY RELATED GOLD-CONTAINING RAW MATERIALS WITH THE USE OF ULTRAMICROHETEROGENEOUS FLOTOREAGENT

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The material composition of the gold-containing tailings of the flotation beneficiation of the Zholymbet ore deposit was studied. It was determined that the samples contain 0,9 g/t of gold, 1,22 g/t of silver. The flotation technologices of technogenic gold-containing raw materials with the use of basic and ultramicroheterogeneous flotation reagents were developed. The content of gold in a draft gold concentrate, in comparison with the basic mode, increases by 2,28 g/t - with 19,56 to 21,84 g/t. The extraction of gold in concentrate increased - by 5,52 % - with 66,07 % to 71,59 %. Thus the consumption of collectors is cut for 50 g/t, with 130 to 80 g/t.

Keywords: flotation, tailings, gold, ultramicroheterogeneous flotation reagent, X-ray research.

INTRODUCTION

Special attention should be paid to the combined use of ionic and apolar collectors in the field of mineral processing, whose combination ensures high efficiency of the flotation process. The initial hydrophobization of minerals with ionic collectors followed by the introduction of an apolar reagent that is fixed on the surface areas with a hydrophobized ionic reagent, can significantly improve the technological parameters of the flotation process [1, 2]. The reasonable use of this flotation method opens up prospects for the use of apolar reagents.

Glembotsky V.A. et al. note in their works [3] that, since apolar reagents are insoluble in water, the surface fixation is the easier, the less it is hydrated. Minerals exhibiting the highest natural hydrophobic properties actively interact with apolar reagents. Since apolar collectors cannot displace water from the mineral surface, the apolar reagent fixation occurs in a droplet form [4, 5], and if the number of droplets is sufficient, then they combine to form a continuous apolar layer of the reagent on the surface of the mineral. It has also been established that the nature of the relationship between the apolar collector and the surface of the mineral is typical for physical adsorption.

To date, there is a marked increase in interest in organosulfur compounds of oil in terms of their use in the flotation of polymetallic ores. [6-9]. Sulfur organic compounds of oil were considered as an undesirable and harmful component of many petroleum products but now technological processes are being developed and mastered, providing for the separation of organic sulfur-containing compounds from petroleum products. It is noted that organic sulfur compounds of oil mainly consist of sulfides, thiophenes and mercaptans, and 80,0 – 95,0 % of sulfides and thiophenes have various structures.

The purpose of this work was to develop the reagent flotation mode for technogenic gold-containing raw materials from the Zholymbet deposit using an ultramicroheterogeneous flotation agent [10]. An ultramicroheterogeneous flotation reagent was obtained based on butyl xanthate and high-sulfur dehydrated oil from the Zhanazhol field. A stable emulsion of ultramicroheterogeneous flotation reagents was obtained due to high-frequency ultrasonic treatment.

Ultramicroheterogeneous flotation reagents can simultaneously contain microemulsions and microemulsion bubbles of sulfur-containing organic compounds of petroleum nature that implies an increase in the flotation efficiency of sulfide minerals.

The tailings of the gold-containing ore beneficiation from the Zholymbet deposit were used as an object of study. At the beneficiation plants of Kazakhstan - Aksu, Bestobe and Zholymbet - over 25,6 million tons of waste - gold-containing tailings - have been accumulated. For example, it occupies an area of 88,5 ha in the waste dumps of the Zholymbet deposit. Gold in these beneficiation products is represented by three morphogenetic types: dispersed microscopic gold in pyrites, vein native gold, gold in metasomatic quartz veins [11-12]. In this regard, it is of great interest to develop in-

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novative solutions for their involvement in commercial operation using modern physical and chemical technologies, often different from the main technologies for the extraction and beneficiation of gold ore deposits of this type.

EXPERIMENTAL PART AND DISCUSSION OF THE RESULTS

Studies have been performed to research the material composition of the initial tailings of flotation beneficiation. X-ray fluorescence analysis of the original ore was performed on a PANalyical Venus 200 X-ray fluorescence spectrometer with wave dispersion / %: 23,776 Si, 55,264 O, 7,342 Al, 3,586 Ca, 0,831 K, 4,726 Fe, 0,499 Ti. Chemical analysis showed that in the studied initial tailings, the gold content is 0,9 g/t, the silver content is 1,22 g/t.

X-ray phase analysis of these tails was performed with a D8 Advance diffractometer (BRUKER), Cu-Kα radiation with the results shown in Table 1.

Table 1 **Results of X-ray fluoresconse analysis of gold-containing tailings**

Compound Name	Formula	Compound contents / %
Quartz	SiO_2	62,07
Clinoclore, ferroan	$(Mg_{2.8}Fe_{1.7}Al_{1.2})(Si_{2.8}Al_{1.2})O_{10}(OH)_8$	11,32
Albite	$AlNaO_8Si_3$	10,14
Calcite	CaO_3	9,14
Muscovite	$KAl_2(Si,Al)_4O_{10}(OH)_2$	4,02
Riebeckite	$Na_2Fe_3Fe_2Si_8O_{22}(OH)_2$	3,31

Dispersion analysis was performed to determine the particle size distribution of technogenic raw materials. The results of the dispersion analysis of gold by size classes are shown in Figure 1.

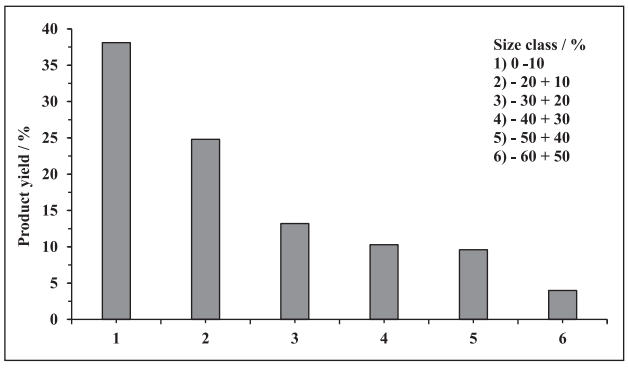

Figure 1 Results of dispersion analysis of gold-containing tailings from Zholymbet deposit

It was found that most part of the gold (43,75 – 59,95 %) is concentrated in the fraction - 10 + 0 μm under the variance analysis.

Studies intended to determine the optimal conditions for the flotation of gold-containing tailings using basic reagents were performed when the object of study was ground to 79,32 and 89,04 % according to the class - 71 microns. That is, the grinding fineness was con-

Table 2 **Results of flotation of gold-containing tailings at various collector rates and at various grinding**

Name of products	Exit / %	Content Au / g/t	Extraction Au / %	Experiment conditions
Draft Au concentrate.	1,0	30,68	33,94	grinding - 79,32% BCs –80 g/t T- 80 – 50 g/t
Intermediate product 2	1,.94	2,82	6,05	
Intermediate product 1	5,72	1,8	11,39	
Foam flotation concentrate	2,64	3,2	9,34	
Tails	88,7	0,4	39,25	
Source ore	100	0,90	100	
Draft Au concentrate.	0,9	32,66	32,55	grinding – 89,04% BCs –80 g/t T- 80 – 50 g/t
Intermediate product 2	1,96	2,8	6,07	
Intermediate product 1	7,12	1,72	13,57	
Foam flotation concentrate	5,58	1,83	11,32	
Tails	84,44	0,39	36,47	
Source ore	100	0,90	100	
Draft Au concentrate.	2,38	24,68	58,24	grinding– 79,32% BCs –130 g/t T- 80 – 70 g/t
Intermediate product 2	2,76	0,29	0,79	
Intermediate product 1	6,48	0,1	0,64	
Foam flotation concentrate	2,04	3,0	6,06	
Tails	86,34	0,4	34,24	
Source ore	100	1,0	100	
Draft Au concentrate.	3,4	19,56	66,07	grinding– 89,04% BCs –130 g/t T- 80 – 70 g/t
Intermediate product 2	3,4	0,57	1,94	
Intermediate product 1	8,48	0,59	5,02	
Foam flotation concentrate	3,3	1,31	4,31	
Tails	81,42	0,28	22,64	
Source ore	100	1,0	100	
Draft Au concentrate.	2,2	12,45	30,35	grinding– 79,32% BCs –180 g/t T- 80 – 90 g/t
Intermediate product 2	2,64	2,2	6,43	
Intermediate product 1	5,38	2,5	14,90	
Foam flotation concentrate	5,4	1,82	10,89	
Tails	84,38	0,4	37,40	
Source ore	100	0,90	100	
Draft Au concentrate.	2,0	22,21	46,23	grinding– 89,04% BCs –180 g/t T- 80 – 90 g/t
Intermediate product 2	2,14	2,3	5,12	
Intermediate product 1	6,04	0,6	3,77	
Foam flotation concentrate	3,26	2,6	8,82	
Tails	86,56	0,4	36,04	
Source ore	100	0,96	100	

Table 3 **Results of flotation of gold-containing tailings using an ultramicroheterogeneous flotation reagent**

Name of products	Exit / %	Content Au / g/t	Extraction Au / %	Consumption of ultramicroheterogeneous flotation reagent
Draft Au concentrate.	2,98	21,84	71,59	80 g/t
Intermediate product 2	7,36	0,6	4,85	
Intermediate product 1	23,18	0,3	7,65	
Foam flotation concentrate	2,3	0,7	1,77	
Tails	64,18	0,2	14,12	
Source ore	100	0,9	100	
Draft Au concentrate.	2,84	20,6	64,77	100 g/t
Intermediate product 2	6,26	0,6	4,15	
Intermediate product 1	19,6	0,3	6,51	
Foam flotation concentrate	5,24	0,45	2,61	
Tails	66,06	0,3	21,94	
Source ore	100	0,90	100	
Draft Au concentrate.	1,8	22,54	45,37	150 g/t
Intermediate product 2	4,96	1,6	8,87	
Intermediate product 1	23,6	0,5	13,19	
Foam flotation concentrate	4,18	0,7	3,27	
Tails	65,46	0,4	29,28	
Source ore	100	0,89	100	

trolled by the class of - 71 microns. Butyl xanthate was used at different rates of 80, 130 and 180 g/t.

Tailings were prepared for research with regrinding in a ball mill 40 ML-000PS. Flotation studies were performed on laboratory flotation machines - FL-290, FM-1, FM-2.

Direct flotation was adopted when the research on the flotation beneficiation of gold-containing tailings, was performed. The cycle was consisted of main and control flotation, two crude gold concentrate refining stages. Sodium sulfide was fed into grinding as a sulfidizing agent, copper sulphate was used as an activator of gold, and soda was fed to the main and control flotation to create a pH of the medium at the rate of 8,5 – 9,0.

Table 2 shows the results of tailings flotation at various collector flow rates and with product grinding of 79,32 and 89,04 % for the class of - 71 microns.

Analysis of the obtained data under the basic flotation scheme shows that the optimal consumption of butyl xanthate is 130 g/t. A rough concentrate was obtained with a gold content of 24,68 g/t with an extraction of 58,24 % at grinding 79.32 % in the class of 71 microns; a rough concentrate with a gold grade of 19,56 g/t with an extraction of 66,07 % at grinding 89,04 % in the class of 71 microns. Thus, the most acceptable grinding fineness of gold-containing tailings was established – 89,04 % in the class of 71 microns.

Further experiments were performed using an ultramicroheterogeneous flotation agent, with flow rates (80, 100 and 150 g/t) and with the grinding degree of raw materials – 89,04 % in the class of 71 microns. The consumption of foaming agent T-80 was 50 g/t. The results of flotation experiments are presented in Table 3

It follows from the obtained data shown in the table that the optimal consumption of ultramicroheterogeneous flotation reagent is 80 g/t. In this case, a crude concentrate was obtained with a gold grade of 21,84 g/t with a recovery of 71,59 %. The gold content in the concentrate increases by 2,28 g/t, the gold extraction into concentrate - by 5,52 %, while the reagent consumption is reduced to 50 g/t compared to the main technology, with the use of ultramicroheterogeneous flotation reagents.

Images of a sample of the gold-containing rough concentrate obtained on an electron probe microanalyzer of the brand JEOL JXA 8230 are shown in Figure 2.

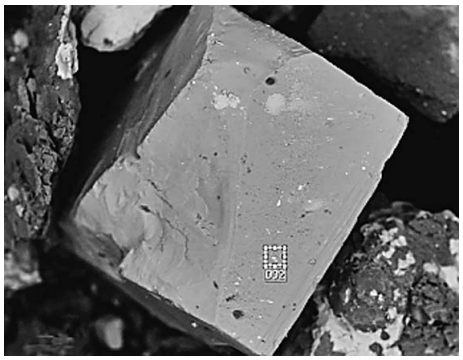

Figure 2 Micro-probe analysis of gold-containing rough concentrate

Electron probe microanalysis has shown the presence of fine gold inclusions in sulfide minerals such as pyrite.

The analysis results of original gold-containing tailings contain compounds / %: O - 6,64; Na – 3,64; S – 45,82; Fe – 32,39; Au – 11,32.

Thus, it has been established that gold in the concentrate is in the form of thin (micron) inclusions in minerals of gangue.

CONCLUSIONS

The material composition of gold-containing technogenic raw materials has been studied. Under the results of X-ray fluorescence and chemical analysis in the original sample, the main mass is / wt. %: 23,776 Si, 55,264 O, 7,342 Al, 3,586 Ca, 0,831 K, 4,726 Fe, 0,499 Ti. The gold content in the raw material is 0,9 g/t, the silver content is 1,22 g/t. The following minerals are present in the composition of the sample of gold-con-

taining tailings / % according to the results of X-ray diffraction analysis: quartz – 62,07, clinochlore – 11,32, albite – 10,14, calcite – 9,14, muscovite – 4,02, ribescite – 3,31.

The reagent flotation mode of technogenic gold-containing raw materials has been developed with the use of main and ultramicroheterogeneous flotation reagents. In the optimal basic mode (grinding 89,04% according to the class of 71 microns, the consumption of butyl sodium xanthate 130 g/t), a gold-containing concentrate was obtained with a gold content of 19,56 g/t when 66,07 % is extracted. A gold-containing concentrate with an gold content of 21,84 g/t was obtained with a recovery of 71,59 % AS a result of the use of ultramicroheterogeneous flotation reagents. An analysis of comparison with the base technology showed that the gold content in the concentrate increases by 2,28 g/t, the gold recovery into concentrate by 5,52 %, while the reagent consumption decreases to 50 g/t.

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