A. MUKHANOVA, N. TUSSUPBAYEV, D. TURYSBEKOV, A. YESSENGAZIYEV

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IMPROVEMENT OF THE SELECTION TECHNOLOGY OF COPPER-MOLYBDENUM CONCENTRATE WITH THE USE OF MODIFIED FLOTORAGENTS

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The flotation of copper-molybdenum ores Aktogay deposit of Republic Kazakhstan has been studied, with application new synthesized modified reagents. Selective flotation of copper-molybdenum collective concentrate was carried out according to standard technology with application of modified flotation agent (diesel fuel: oil = 1:1) in comparison with traditional apolar (kerosene) collector. The use of the modified reagent in the processing of copper-molybdenum ore allows increasing the molybdenum content in the molybdenum concentrate by 3,6, and extraction - by 5,7 %.

Keywords: copper, molybdenum, concentrate, extraction, modified reagents

INTRODUCTION

World resources of molybdenum are estimated at 18.4 million tons. Molybdenum is a rare element, its clarke in the earth's crust is $1,1 \cdot 10^{-4\%}$ by weight.

It is customary to divide molybdenum ores according to the mineral composition and shape of ore bodies into vein (quartz, quartz-sericite and quartz-molybdenite-wolframite), vein-disseminated (quartz-molybdenite-sericite, copper-molybdenum, copper porphyry with molybdenum (molybdenum), tungsten-molybdenum and copper-molybdenum) [1, 2].

On the territory of the former USSR there are more than 60 deposits of molybdenum, with the exploration mainly in Russia, Kazakhstan, Uzbekistan and Armenia. According to InfoMine estimates, molybdenum reserves in the CIS exceed 3 million tons. Molybdenum is also an accompanying element of uranium ores.

About 29 % of USSR molybdenum reserves are located in Kazakhstan, where 34 deposits were explored. The main molybdenum reserves are concentrated in the large Koktenkol deposit, as well as in the tungsten-molybdenum Kairakta and large copper-molybdenum deposits Bozshchekul, Aktogay and Aidarly.

Reserves of molybdenum in complex ores of Kyrgyzstan are currently limited molybdenum-containing ores in the country are not mined.

Mineral resources of Aktogay deposit amount to 1,719 million tonnes with average copper content of 0,33 %. The estimated molybdenum content of the deposit is 115 thousand tons. Aktogay is one of the largest copper and molybdenum deposits in the world, the deposit is one of the unique in the former Soviet Union. The upper part of Aktogay deposit ore body is represented by oxidized ores that are processed by heap leaching technology with copper and molybdenum recovery.

Molybdenum concentrate is obtained by flotation. Apolar reagents are used in the process of flotation. It is known from literature sources that apolar reagents have no solidophilic group molecules in their composition and therefore do not have the ability to chemically fix on the surface of minerals. Since they are represented by liquid hydrocarbons, their fixation on the mineral surface can be associated with the formation of dispersion forces between the hydrocarbon chains of the reagent and the mineral surface. Emulsified apolar reagents are especially useful for flotation of slime minerals.

In recent years, there has been a noticeable increase in interest in heteroorganic oil compounds in terms of their use in flotation of polymetallic ores [8].

MATERIALS AND METHODS

The following methods were used: mineralogical, rational, X-ray phase, chemical, and particle size analysis. The following technological equipment was used:DMD160/100 jaw crusher (Kyrgyzstan); 40ML-000PS ball mill (Russia); Flotation was carried out on flotation machines FL-290, FM-1, FM-2 (Russia), the size of emulsion particles under different conditions was determined on particle size analyzer "Photocor-Compact", "FRITISCH" (Germany), UZDN-A1200T ultrasonic apparatus (Ukraine).

The purpose of this work is to study the effect of a modified reagent based on Kumkolsk oil and diesel fuel

A. Mukhanova (ainura-muhanova@mail.ru), N. Tussupbayev, D. Turysbekov, A. Yessengaziyev, Satbayev University, Institute of Metallurgy and Ore Benefication, Almaty, Kazakhstan

on improving the quality of copper-molybdenum concentrate of Aktogay deposit and its selection.

RESULTS AND DISCUSSION

Apolar reagents - collectors are hydrocarbon fluids produced during oil processing. They include: kerosene, industrial oils and extracts of phenolic fraction. Recently, technological processes that provide for separation of organic sulfur-containing products from oil products and their use as flotation agents have been developed and mastered. It have shown in previous researches that oil of Kazakhstan deposits is characterized by specific physical and chemical properties such as: high content of paraffin fractions, sulfur-containing compounds, resins and asphaltenes. Thus, according to the obtained IR-spectrum of the Kumkolsk oil sample, it has been established [10, 11] that paraffin structures of normal and isotropic structure prevail in the investigated sample, and long paraffin chains are present. The presence of naphthenic and aromatic structures was noted. These compounds are contained in much smaller quantities than paraffin ones. The carbonyl group is absent, oil is not oxidized [4-7]. It has been shown that the use of Kumkolsk oil in combination with diesel fuel as a flotation agent for flotation of copper-molybdenum ore at Shatyrkol deposit allows to increase molybdenum recovery rates.

In the present work the possibility of using this mixture as an apolar flotation flotation agent of copper-molybdenum ore of Aktogay deposit is investigated.

The ratio of diesel fuel to oil at the Kumkolsk field in the mixture was equal to 1:1. The resulting mixture of diesel fuel and oil was subjected to ultrasonic treatment within 7 minutes. Ultrasonic vibrations can be used as one of the methods to intensify flotation.

Ultrasound, affecting the processes of mass exchange, contributes to cleaning the surface of minerals from hydrophilic coatings, provides dispersion of reagents, and in combined technologies accelerates the dissolution of the treated particles by opening the capillary channels. The mechanism of mass exchange in the ultrasonic field is quite complex and is determined, in particular, by cavitation and acoustic effects that contribute to the flotation of minerals [6-9]. In our case, the effect of ultrasound is determined by the formation of an emulsion with a certain size of particles from a mixture of original components.

At the first stage, the material composition of ore at Aktogay deposit was studied for research purposes. Mineralogical analysis showed that in the investigated sample of ore of the deposit the main copper-containing mineral - chalcopyrite. It is characterized by a relatively uniform distribution. The most representative form of its extraction is inclusions of 0,003 – 1,0 mm in size. Molybdenite forms single plates (0,001 – 0,1 mm) in quartz, kalispathian and chlorite quartz-kalispathian veins. It is corrupted by faint ore and forms chalcopyrite grains. The quartz-molybdenite veins are split by veins of late carbonate. Ore minerals are quartz, albite, anorite, wedge chorus and a number of less important minerals (Figure 1).

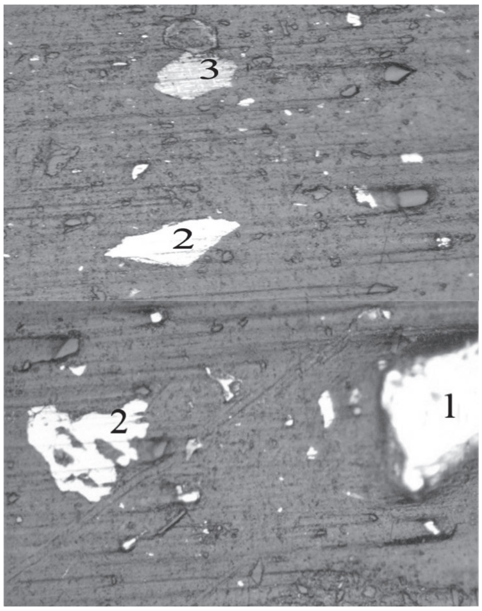

Figure 1 Results of mineralogical analysis of ore from Aktogay deposit: 1 - pyrite; 2 - chalcopyrite; 3 - bornite.

Table 1 - **Rational ore analysis of Aktogay deposit**

Phases	Contents / %	
	absolute	relative
Copper:		
Chalcopyrite	0,25	73,5
Bornite	0,03	8,8
Chalcosin	0,05	14,7
Azurite	0,01	3,0
Total	0,34	100,0
Molybdenum:		
Molybdenite	0,0096	96,0
Povellite	0,0004	4,0
Total	0,01	100,0

Table 1. presents the results of the rational analysis of the ore sample under study.

From Table 1 it follows that the main minerals of copper in the composition of ore are chalcopyrite and chalcosine. in smaller amounts there is bornite. The main amount of molybdenum is molybdenite.

According to the results of chemical analysis of the investigated sample of copper-molybdenum ore of Aktogay deposit contains/ %: 0,4 Cu; 0,009 Mo; 0,58 S; 5,2 Fe; 4,6 CaO; 16,5 Al_2O_3; 55,7 SiO_2; 4,6 MgO; 0,27 Ti.

Particle-size analysis of the source ore was performed. The content and distribution of copper and molybdenum were determined in each particle size class. The analysis of crushed ore showed that about half of copper (50,1 %) and molybdenum (46,7 %) are in larger of - 2,5 + 0,5 mm classes. Then. the ore was crushed to 90 % of – 0,071 mm - 2,5 + 0,5 mm classes. Dispersion analysis was performed to determine the particle size distribution composition of the milled ore, the results of which are shown in Table 2.

Table 2 **Particle size distribution of milled ore**

Size class, micron	Yield/ %	Content/ %		Distribution/ %	
		Cu	Mo	Cu	Mo
+60	19,9	0,41	0,017	21,2	30,9
-60+50	12,3	0,37	0,009	11,8	10,1
-50+40	12,3	0,38	0,011	12,1	12,3
-40+30	2,0	0,43	0,011	2,3	2,0
-30+20	10,7	0,38	0,009	10,5	8,7
-20+10	23,6	0,39	0,011	23,8	23,7
-10+0	19,2	0,37	0,007	18,3	12,3
Initial ore	100	0,39	0,011	100,0	100,0

The Table shows that most of the copper and molybdenum during the grinding process is distributed in classes of + 50 µm and - 20 µm. The particle size class + 50 microns contains 33,0% copper and 41,0 % molybdenum; the class - 20 microns contains 42,1 % copper and 36,0 % molybdenum.

In the course of flotation process studies, the collective-selective scheme applied to copper-molybdenum ore was adopted as a basis (Figure 2).

The collective cycle consisted of main and control flotation and three peelings of collective copper-molybdenum concentrate. In the process of grinding. lime for creation of pH medium and sodium sulfide for sulphidization of minerals were supplied. Butyl oxantogenate of sodium with foaming agent T-80 was used as a collector. In all peelings liquid glass was added to depress the waste rock.

Researches in a collective cycle were carried out at different degree of crushing of initial ore. It was found out that the best performance was achieved at grinding 94 % of ore up to - 0,074 mm class.

Then it determined the optimal consumption of traditional xanthate in obtaining a collective copper-molybdenum concentrate. Xanthate consumption in the experiments ranged from 100 to 190 g/t. Optimal consumption of traditional butyl xanthate is 160 g/t. At the same time a collective copper-molybdenum concentrate with copper content of 21,3 % was obtained at 84,0 % extraction and with molybdenum content of 0,35 % at 37,7 % extraction.

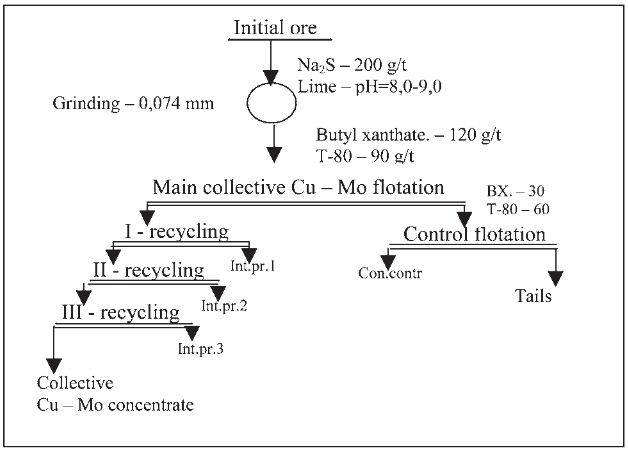

Figure 2 Full-sheet of collective copper-molybdenum flotation of ore at Aktogay deposit

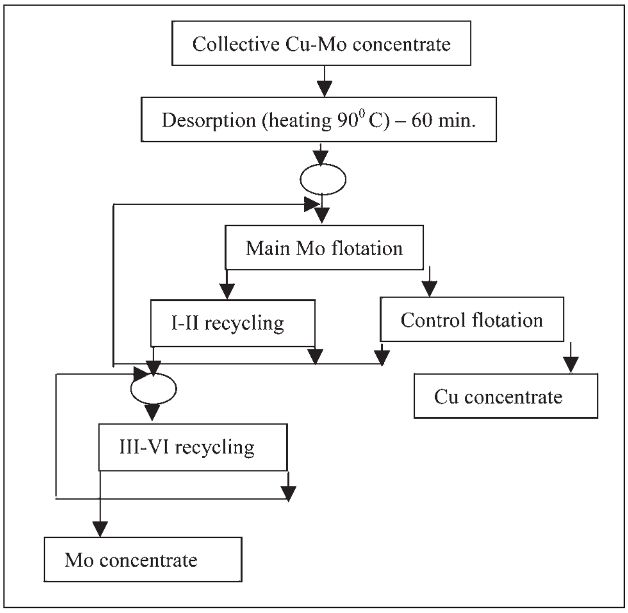

Figure 3 Principal scheme of selection of collective copper-molybdenum concentrate of Aktogay deposit using modified flotation agent.

The technological scheme of selective flotation included desorption of the collective concentrate by steaming with sodium sulphide at 85-90ºC, washing, main, control molybdenum flotation and six purification of molybdenum concentrate. In all operations of selective flotation the pH of medium was 8,5-9,0. kerosene, depressor - sodium sulphide and liquid glass, foaming agent - T-80 were used as a collector.

Selective flotation of copper-molybdenum collective concentrate obtained from ore of Aktogay deposit was carried out according to standard technology (Figure 3) with application of modified flotation agent (diesel fuel: oil = 1:1) in comparison with traditional apolar (kerosene) collector.

The standard technological scheme included grinding of the initial ore to a size of 94 % of class - 0.074 mm. collective flotation to produce copper-molybdenum concentrate, its desorption.

In the cycle of selective flotation of copper-molybdenum concentrate used the main, control flotation and six refinements of molybdenum concentrate. In addition, two stages of refinement were used in the course of selection. The first stage included after grinding of 95 % - 0,074 mm class, the second stage – 98 % - 0,074 mm class. The obtained results are shown in Table 3.

The Table shows that selective flotation in a closed cycle with the use of a basic apolar kerosene collector produced a molybdenum concentrate with a molybdenum content of 35,0 % during extraction of 76,71 % and a copper concentrate with a copper content of 20,6 % during extraction of 99,77 %.

At flotation with application of modified flotation agent we obtained copper concentrate with copper content of 20,6 % at extraction of 99,84 % and molybdenum concentrate with molybdenum content of 38,6 % at extraction of 82,42 %.

Table 3 **Results of flotation of collective copper-molybdenum ore concentrate in a closed cycle compared to the basic technology**

Sample Title	Yield/ %	Content/ %		Distribution/%	
		Cu	Mo	Cu	Mo
Kerosene/ 4 g/t					
Mo conc.	1,3	3,6	35,0	0,23	76,71
Cu conc.	98,7	20,6	0,14	99,77	23,29
Mo - Cu concen.	100	20,38	0,59	100	100
Modified flotation reagent/ 4 g/t					
Mo conc.	1,2	2,7	38,6	0,16	82,42
Cu conc.	98,8	20,6	0,1	99,84	17,58
Mo - Cu concen.	100	20,39	0,56	100	100

Thus, the conducted studies and obtained results show the possibility of using modified flotation agent based on Kumkolsk oil and diesel fuel for selective flotation of collective copper-molybdenum ore concentrate of Aktogay deposit.

CONCLUSION

Collective and selective copper-molybdenum flotation of ore at Aktogay deposit was studied using standard technological full-sheet and using both traditional flotation agents and flotation agent based on Kumkol oil and diesel fuel. The optimal conditions for the process have been established.

It is shown, that application of modified flotation agent based on Kumkolsk oil and diesel fuel allows increasing molybdenum content in molybdenum concentrate by 3,6 % and recovery by 5,7 %. Extraction of copper into copper concentrate increased by 0,7 % and the copper content remained unchanged.

Acknowledgments

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