Joint processing of ore from several gold-silver deposits at one gold-processing factory

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Abstract. The article contains the findings concerning joint processing of ore from several deposits at one gold-processing factory of the ore mining and processing enterprise “Kubaka”. Besides, it includes the findings on the effectiveness of joint processing of ore from deposits “Birkachan” and “Tsokol”. The comparison of three systems was used for the research: with separate thickening of ore from deposits “Birkachan” and “Tsokol” and with joint thickening. Moreover, the authors studied the segmentation of various-sized particles in cramped conditions when ore precipitates in factory’s thickener. They give the differential distribution curves of sedimentation analysis for these three systems: separate thickening of ore from deposits “Birkachan” and “Tsokol” and joint thickening. The sedimentation analysis shows: the joint thickening of two types of ore leads to the intensification of sedimentation at the expense of reducing the turbidity index of thickener underflow. The authors analyzed the sediments obtained by thickening ores under study separately and jointly. They give their electron microscopy. The article shows that aggregate complexes form in the sediment of the third system due to the cohesion and aggregation. Besides, the authors give the data of joint processing of ores with high content of silver and float concentrate. It was ascertained how the quality of finished product obtained in the Merrill-Crowe process depends on the precious metal content in feedstock.

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Introduction

Nowadays, the joint processing of ore from different deposits is one of prospective lines in mineral dressing. Joint processing means processing ore from several deposits at one processing factory. This makes it possible to reduce capital expenditure for building several industrial enterprises at each deposit [1-5].

This line enables people to develop small deposits and deposits with low content of commercial component which could be economically inefficient if separate processing factory is built for each deposit [6-9]. It should be noted as well that joint processing of various-type ore can influence positively such technological parameters as the turbidity of thickener underflow, recovery (due to the influence of certain components), relative uniformity of finished product in mixing rich and poor ores, etc. [10-14].

Main part

Joint processing of ore from different deposits is used in one gold-processing enterprise of JSC Polymetal.

Omolon mining hub was created in 2009 in North-Even District of Magadan Region. It is based on the group of gold-silver deposits (Bikachan, Tsokol, Sopka Kvartsevaya, Dalnyi, etc.) with single center of technological stage in the gold-processing factory of Kubaka enterprise (See Figure 1). After the reconstruction conducted in 2012 there are two ore processing schemes. The first one consists in cyanide leaching with further absorption by activated carbon. The second one consists in cyanide leaching with further zinc precipitation (the Merrill-Crowe process) and additional carbon absorption.

Ore from 5 different deposits will be processed at the Kubaka gold-processing factory. That is why the authors of this article propose to introduce joint processing in order to optimize the operation of the factory at the expense of the constant composition of raw material. This can be made by two schemes at different times of the year.

Processing of the ore from deposits Birkachan and Tsokol

Now we will have a detailed look at the first processing scheme for the ore from deposits Birkachan and Tsokol.

This scheme includes leaching and carbon absorption. It is effective in winter for ore with low content of precious metals. For example, Birkachan and Tsokol have up to 5 gpt of gold and up to 10 gpt of silver. Industrial tests in March 2012 showed the low thickening ability of ore from Tsokol because there was clay in ore. The laboratory investigations on the joint processing of ores from Birkachan and Tsokol were aimed at the intensification of the process. They showed good results. Industrial tests of

October-December 2012 also confirmed the effectiveness of joint processing of these ores. Flocculant A331 was used for thickening the ores.

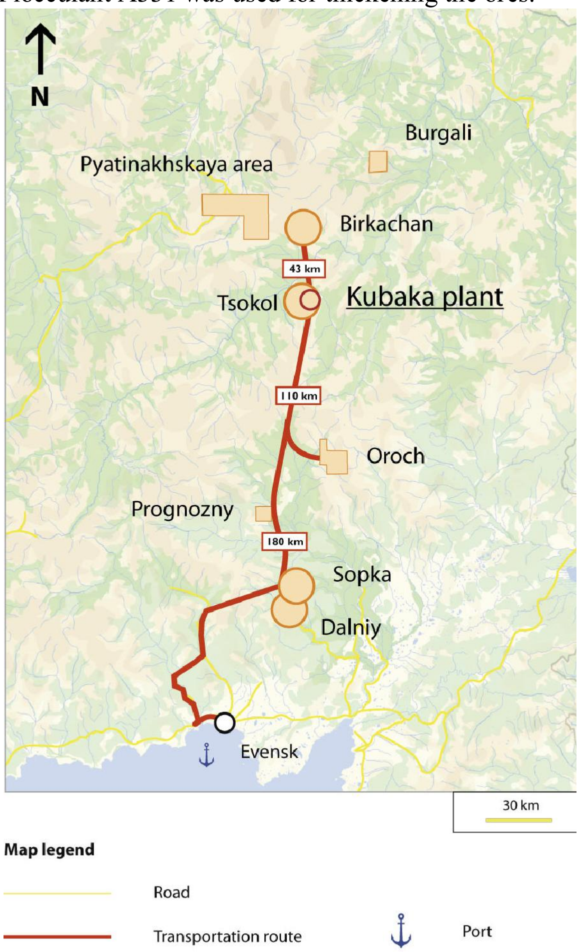

Figure 1. Parts of the Omolon hub

In separate processing of Tsokol ore, thickener underflow T-1 grow turbid because of white clay particles (the turbidity index is 40%). Underflow turbidity is the fundamental qualitative factor which determines the fitness of this solution for CIC process (carbon in columns). The high content of fine particles in the underflow promotes the degradation of active centers on sorbent surface. This lowers sorbent's effectiveness and, as a consequence, reduces its sorption ability in precious metal recovery.

In order to prevent the degradation of thickening and sorption, the authors propose to adopt joint processing of ores from Birkachan and Tsokol which consists in joint mixing. In this case, the volume of the finished product will increase and become stable, the recovery will go up, the tailing loss will be reduced and the production costs will be cut.

The experiments on joint and separate thickening of the ore from Birkachan and Tsokol were conducted in a laboratory environment. It should be noted that the underflow of Tsokol ore was very turbid (the turbidity index was 40%). This can be explained by the presence of white clay particles. In joint thickening, clay particles act as a "turbidity agent" intensifying the co-precipitation of various-sized particles.

The speed constants of precipitation and sediment consolidation were calculated by graphic method. The data obtained are reported in Table 1.

Table 1. Qualitative indexes of particle sedimentation

	Birkachan	Tsokol	Mixture 1:1
1.Particle size, % cl.-0.075 mm	82	90	85
2.Optimal flocculant doze, gpt	25	40	30
3.Underflow turbidity index, %	90	40	80
4.Optimal time for sedimentation, s	80	100	90
5.Sedimentation speed constant, s^{-1}	$166 \cdot 10^{-3}$	$50 \cdot 10^{-3}$	$125 \cdot 10^{-3}$
6.Consolidation speed constant, s^{-1}	$681 \cdot 10^{-5}$	$625 \cdot 10^{-5}$	$669 \cdot 10^{-5}$

As the table shows, the underflow turbidity after the joint ore thickening is 1.23 times less than their total average value individually; the sedimentation speed constant is 1.2 times more; the speed constant of sediment consolidation is 1.1 times more. Moreover, joint processing leads to slight increase of precious metal recovery.

The authors conducted the sedimentation analysis of systems Birkachan, Tsokol and Birkachan-Tsokol based on the Stokes' law. This analysis was aimed at ascertaining the relative fractional composition of various-sized particles.

The principle of sedimentation analysis is in measuring the speed of particle sedimentation of dispersed phase in dispersive medium. The dependence of sedimentation speed on the particle radius can be expressed by the Stokes's law:

$$V = \frac{2gr^2}{9} x \frac{d - d_1}{n}$$

Where V is the speed of particle sedimentation, m/s; r is the radius of a particle, m; g is the gravitational acceleration, m/s^2; d and d_1 are the density of a particle and liquid, respectively, kg/m^3; n is the viscosity of liquid, ns/m^2 $(1 \cdot 10^{-3})$.

The sedimentation speed or the size of particles allows us to assess the sedimentation stability of disperse system – the ability of the system to keep unchanged the distribution of particles in the volume of the system. In systems with sedimentation stability particles have size 10^{-7} – 10^{-3} sm (for instance, clay particles). In systems without sedimentation stability the particle size is more than 10^{-3} sm, and the particles sediment quickly.

The most convenient method of sedimentation analysis is the method of continuous weighing – the estimation of how fast the sediment accumulates on the scale pan of torsion balance. The researchers took the samples of ore from Tsokol and Birkachan, and the mixture of these ores 1:1. According to the data obtained, they made sedimentation curves which express the dependence of sediment particles mass on the duration of the experiment.

The results of the sedimentation analysis can be presented more visually in the form of differential distribution curve based on the sedimentation curve. The sedimentation curve for the system Birkachan+Tsokol is shown at Figure 2.

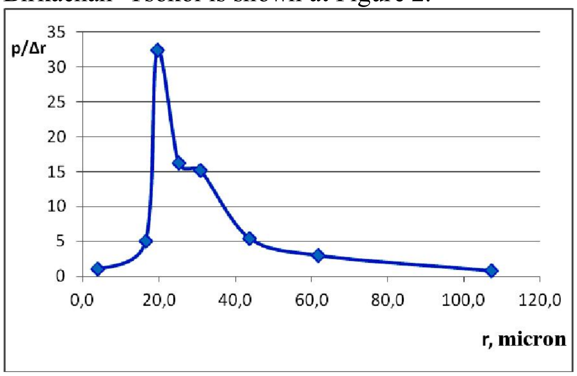

Figure 2. Distribution curve, type Birkachan+Tsokol

The curve charts of sedimentation distribution show that particles with size 18-25 mcm prevail in the ore from Birkachan deposit; class -75 mcm accounts for 89.7%. Particles with size 22-30 mcm prevail in the ore from Tsokol deposit; class -75 mcm is 99.2%. Particles with size 20-40 mcm prevail in the system Birkachan+Tsokol; class -75 mcm is 92.2%.

As Figure 2 shows, if ores sediment jointly, a flattening section forms for particles of 26-32 mcm on the differential curve. This section can be caused by aggregate complexes made of fine clay particles in Tsokol ore and larger particles in Birkachan ore which account for 14.6%.

The main goal of thickening is to obtain a clear underflow. When processing Tsokol ore which includes minute clay particles, the underflow becomes turbid. Minute clay particles sediment slowly due to the low rate of fall. When two ores are processed jointly, the system loses its aggregative stability and coagulation starts – particles stick together and form large aggregates. Coagulation is a spontaneous process because it leads to the reduction of phase contact area and, consequently, to the decrease of free surface energy.

The samples of sediments obtained by thickening the ores under study were analyzed in the laboratory of electron microscopy situated in the Physicotechnical Institute of the Irkutsk National State Research Technical University. Photographies were made with the help of scanning electron microscope JIB-Z4500 and X-ray detector OXFORD INSTRUMENTS X-MAX.

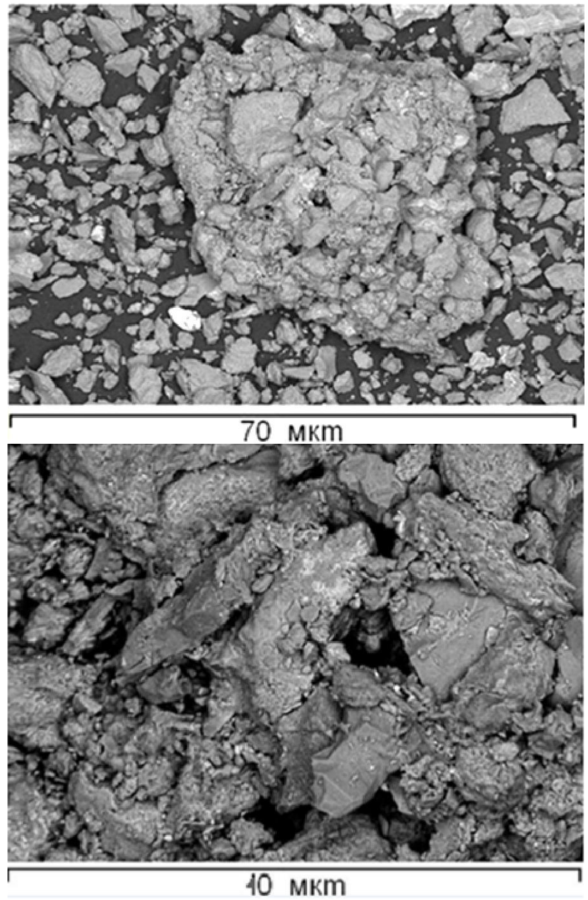

Figure 3. Obtained aggregate. Mixture of Birkachan and Tsokol

The photos of ore mixture sediment (Figure 3) show the aggregates formed of fine particles of Tsokol ore and coarse particles of Birkachan ore. The formation of aggregates during the joint sedimentation of various-sized ore particles is conditioned by the cohesion of fine particles on the surface of coarse particles and by the aggregation when clay particles act as “bridges” connecting coarse particles. Such processes take place with the use of turbidity agents, particularly clay, in cleaning and preparing water.

Processing of the ore from deposits Sopka Kvartsevaya, Dalnyi and float concentrate

The second scheme (leaching with zinc precipitation and carbon absorption) is effective in processing ore with high silver content – the Merrill-Crowe process is used in dressing rich silver ores. For example, these are ore from deposits Sopka Kvartsevaya and Dalnyi (gold is 7-15 gpt, silver is 180-300 gpt), float concentrate from the Dukat plant (gold is 35-40 gpt, silver is more than 20 gpt) and other ores. The scheme works in summer because the design of thickeners on the zone of counter-current decantation is not intended to operate at low ambient temperature. This scheme can be used in processing the ore from Sopka Kvartsevaya and Dalnyi and float concentrate from the Dukat plant. These materials have similar characteristics and high silver content. The laboratory experiments of joint processing of two ores and the ores + the concentrate. They showed the high effectiveness. Flocculant Praestol 2500 was used for these ores.

The increase of precious metal content in raw material received by a factory raises the precious metal content in product solution. In its turn, the precious metal content of product solution influences in direct proportion the sedimentation of precious metals on zinc and, consequently, the quality of finished product (zinc precipitate). That is when adding float concentrate to the ore from Sopka Kvartsevaya and other deposits, the precious metal content increases in product solution in processing (on an average from 60.8 mg/l AU+AG in 2012 to 92.7 mg/l AU+AG in 2013). Thus the quality of finished product is improved (from 70% AU+AG to 85% AU+AG).

Conclusion

Taking into account the above given data, one can safely say that the gold processing factory Kubaka is one of unique facility of ore-dressing sector. It can process ores from deposits of different types, float concentrate and products. It manufactures two types of finished products – Dore bars and zinc precipitate ingots. Then they go to refinery plant for further processing and producing affined gold and silver.

The following basic scientific and practical findings come from the research:

1. The distribution of raw material processing between two technological schemes – "carbon-in-pulp" in winter and "Merrill-Crowe" in summer – makes it possible to process different types of raw material at one factory. This precludes capital expenditure for building several factories;

2. The effective stabilization of ore composition ensures the completion of plan and uniform ore feed with certain content;

3. Joint thickening of ore with different size of particles taken from deposits Bikachan and Tsokol leads to the intensification of their sedimentation, promotes the decrease of underflow turbidity index and, as a consequence, helps to cut production costs;

4. The increase of precious metal content in product solution improves the quality of finished product. That means, the content of raw material directly influences the content of zinc precipitate.

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