Application of X-ray absorption method for tin-copper ore from the Pravourmiyskoye deposit

INTRODUCTION

The Pravourmiyskoye field (Khabarovsk Krai) is one of the largest tin and related metal mining facilities in the Russian Far East. In addition to tin, the ores of the deposit contain copper, tungsten, silver and a number of other elements, which forms a high industrial value of raw materials. At the same time, the mineral composition is characterized by high heterogeneity and a significant proportion of empty rocks, which complicates traditional enrichment schemes and increases the cost of processing.

In the context of increasing energy and reagent costs, the introduction of pre-dry enrichment technologies is becoming particularly relevant. X-ray adsorption separation (XRT) allows you to remove a significant proportion of waste rock at the early stages of processing, increasing the content of useful components in the feed of the processing plant and reducing the load on subsequent stages of grinding and flotation.

The aim of this work was to assess the applicability of XRT separation for pre-enrichment of tin-copper-containing ore from the Pravourmiyskoye deposit and determine the technological and economic effects of the introduction of this technology.

METHODS AND PRINCIPLES

The principle of X-ray adsorption separation is based on measuring the degree of attenuation of X-ray radiation when passing through ore particles. Minerals with high atomic mass and density (cassiterite, wolframite, chalcopyrite) They are characterized by stronger X-ray absorption compared to rock-forming minerals.

During the sorting process, the crushed ore stream is fed to the conveyor, passes through the X-ray scanning zone, after which the detector system and software form a digital image of the density distribution in each piece. At the specified threshold values, the control system activates the pneumatic ejectors that separate the material into concentrate and tailings.

Figure 1-General operating principle of the X-ray adsorption separator

In general terms, the principle of operation of the X-ray absorption method (Fig. 1) can be represented as follows: the higher the atomic number of elements that make up minerals and rocks, the less X-rays will pass through this material. The amount of attenuation of the X-ray intensity by a material depends on the atomic number of the object's substance, the thickness of the piece, and the energy of X-ray quanta.

RESEARCH

Tests were carried out in laboratory and semi-industrial conditions using specialized XRT installations. Methods of chemical analysis, X-ray diffraction analysis, and statistical data processing were used to evaluate the results.

The host rocks of the Pravourmiyskoye deposit are represented грейзенизацииby acidic volcanites and quartz-topaz veins modified to varying degrees during greisenization (Figs. 2, a, b). The color of the samples varies from light gray to dark gray, depending on their mineral composition. The rock texture is massive, interspersed, veined, and banded (Fig. 3, a-d). In addition, researchers at the field additionally distinguish drusan, breccia-like, and crustacean-banded textures. The structure is variously grained, from fine to medium-grained, and porphyritic in parts.

Technological samples of ore of various size classes were selected for research.

The subject of the study was three groups of rocks with different degrees of mineralization of the machine class (concentrate and tailings) of size from 20 mm to 60 mm and one non-machine class of size from 5 mm to 20 mm.

Each fraction underwent a series of XRT tests with varying density thresholds and detector sensitivity.

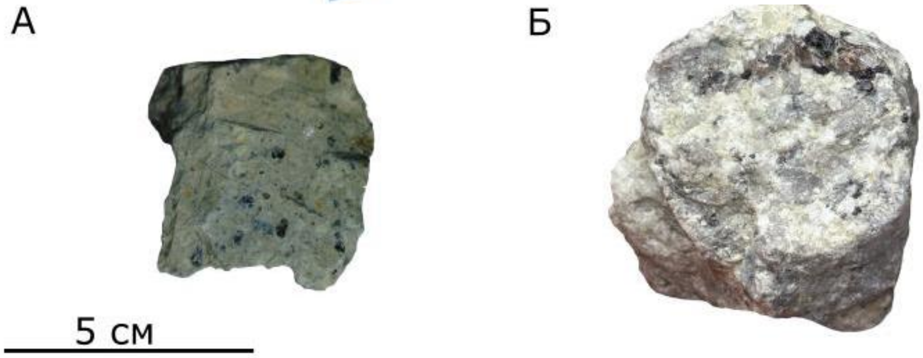

Figure 2. Samples of host rocks: (a – rhyolite, (b) quartz veining.

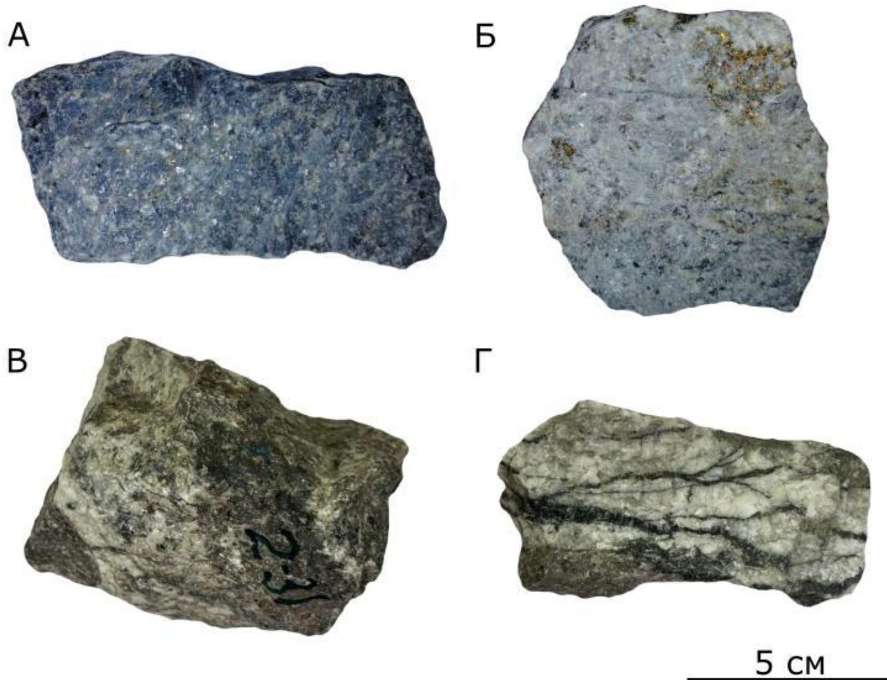

Figure 3. Samples of tin-copper-containing samples: a-massive texture; b – interspersed texture; c-veined texture; d-banded texture.

RESULTS AND DISCUSSIONS

Based on the test results, it was found that XRT separation provides a significant increase in the tin content in the preliminary concentrate. Total fractionation of the mixed sample (average Sn+Cu content in a piece – 0.92%) showed the potential for obtaining 56.9% of dump tailings containing 1569 g / t of Sn+Cu, with losses of 9.7% of Sn+Cu, and the area of the useful component (MD) of 13-20% of the total area of the rock piece. At the same time, the concentrate is 2.1-fold enriched in comparison with the initial ore and contains 19,195 g / t of Sn+Cu (recovery of 90.3%, yield of 43.1%).

Up to 70-75 % of the mass of the initial material was attributed to dump tailings with a residual tin and copper content of less than 0.1 %.

The results of XRT sorting tests were processed both in summary tables and graphically. Below are the key figures for the non-machine size class of the original sample:

Ore type	Size class	Productivity by class		Concentration ratio	Concentrate, t / h	Tailings, t / h
		t/g	t/h			
Sn-Cu ore	-20+5 mm	150000 200000	17-23	2.94	8-11	9-12

Results of sorting by the -20+5 mm fraction of Pravourmian ore (according to the test data).

The table shows that X-ray adsorption separation of tin-copper-containing ore of the -20+5 mm fineness class will allow obtaining 8-11 t / h of ore suitable for further enrichment and 9-12 t/h of tail product.

This approach will increase the quality of the concentrate and reduce operating costs, as between 9 and 12 tons of waste rock will go to the dump before the ore enters the processing plant.

The proportion of waste rock removed was very significant. According to the test results, about 70-75% of the mass of the initial sample was allocated to dumps with a low metal content (less than 0.1% Sn). This is consistent with practice: for low-grade areas of Pravourmian ore, up to 3/4 of the mass can be almost empty. In fact, XRT sorting "cuts off" this worst part, leaving only the enriched pieces in the factory. Together with cassiterite, some other ore minerals inevitably enter the concentrates: chalcopyrite (CuFeS$CuFeS_2$) and wolframite((Fe,Mn)WO$_{WO4}$), whichalso have a high density (about 4-7 g/cm3). This means additional pre-enrichment of copper andtin. In practice, the obtained "raw materials" for flotation are noticeably richer in Cu and W, which usually leads to an increase in the yield of commercialconcentrates.

CONCLUSIONS

The conducted studies have shown high efficiency of using X-ray adsorption separation for preliminary enrichment of tin-copper-containing ore of the Pravourmiyskoye deposit.

Thus, taking into account the results obtained from the study of tin-copper-containing ore from the Pravourmiyskoye deposit, the X-ray adsorption separation method implemented on the RGS-6A mineral separator with a capacity of up to 160 t / h with the possibility of loading ore pieces from6 to 100 mm, produced by the Burevestnik Research Center, can significantly increase the recovery rates of the useful component at the pre-enrichment stage source ore by including it in the process chain.

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