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EXTRACTION OF GOLD FROM FLOTATION TAILS OF GOLD-PROCESSING PLANT

Abstract. A representative sample of dump flotation tailings is selected and its chemical, phase and mineralogical composition is studied. It is shown that gold is in association with quartz, and is present mainly in a finely dispersed form in the intergrowths, which requires a careful choice of conditions and the way it is extracted. In the course of the studies, a direct cyanidation of the tailings was carried out, as well as with the preliminary action of the oxidants. Oxidation with chemical reagents - sodium peroxide and calcium hypochlorite and various strains of biocultures was used. Studies have shown that preliminary re-grinding and oxidation of tailings makes it possible to increase the degree of leaching of gold at the subsequent cyanidation stage by 2.34% compared to direct cyanidation.

The most effective oxidizer is calcium hypochlorite, then the biocultures and sodium peroxide follow the oxidation state, the bioculture strain isolated from the one with the flotation tailings of the deposit is the most active oxidizer, so that the microorganisms adapt quickly to the material composition of the object under study and the biooxidation process takes place much more intensively, than when using bacterial cultures isolated from other deposits.

The results of the cake study after biooxidation by the method of electron-raster microanalysis (SEM) showed a visible change in its structure relative to the initial feedstock: after biooxidation, the gaps and openings formed are clearly visible on the topographic image. The result of such a change in structure is the destruction of the bonds of gold with rock-forming minerals and, as a consequence, an increase in the degree of leaching of gold during cyanidation.

The conducted researches established that the use of oxidizing agents as intensifiers allows to increase the degree of gold recovery from man-made waste, bio-oxidation should be considered the most environmentally safe.

Key words: gold, flotation tails, biooxidation, cyanidation, hydrometallurgy.

Introduction

In connection with the depletion of gold ore reserves, low-grade, off-balance raw materials are increasingly involved in production, and as a result, the amount of man-made waste is growing. Tailings of flotation are one type of such waste. As a rule, it is a stubborn, difficult-to-hide raw material that did not lend itself to opening during the processing of the original ore. However, the content of precious metals in such raw materials is often higher than in low-grade mineral.

The development and development of technology for extracting gold from accumulated technogenic and mineral objects, first of all from dumps, tailings of gold recovery factories and industries, acquires special significance for many gold mining enterprises, where the raw stock of conditioned ore is close to depletion. In this connection, researchers pay great attention to the development of new methods that can be competitive and effective in extracting precious metals from low-grade and technogenic raw materials.

The youngest and most promising direction is biotechnology, which mainly provides for biooxidation. Bio-oxidation of gold and related metals from technogenic raw materials is considered as the most acceptable, less expensive and environmentally safe method [1-20].

The experimental part

In the process of research, the tailings of the flotation of the gold recovery plant (ZIF) Altynau Kokshetau were used as a raw material, their chemical, mineralogical and phase composition was studied.

According to the chemical analysis the composition of the feedstock is the following,%: Fe - 1.578; S is 0.2; Cu - 0.002; Pb 0.0001; Zn = 0.001; Bi-0.0006; As is 0.108; MgO: 1.100; Al2O3 - 14.60; SiO2 = 66.98; CaO = 3.765; So4-2 - 0.0196; Au - 0.43 g / t.

The phase composition of flotation tailings tailings presented in Table 1.

Table 1 - Phase composition of flotation tailings tailings

Name	Formula	S-Q, %
Albite	$Na(AlSi_3O_8)$	29,4
Microcline	$(K_{95}Na_{05})AlSi_3O_8$	27,8
Quartz, syn	SiO_2	19,5
Magnesiohornblende	$Ca_2Mg_4(AlFe\text{-}3)Si_7AlO_{22}(OH)_2$	11,2
Calcium Iron Aluminium Oxide	$Ca_4Fe_{1.5}Al_{17\cdot67}O_{32}$	9,1
Clinochlore	$Mg_{4\cdot88}Fe_{0.22}Al_{1\cdot881}Si_{2\cdot96}O_{10}(OH)_8$	1,7
Cristobalite	SiO_2	1,3
Total:		100,0

It can be seen from the table that, in general, the phase composition is represented by minerals of silicon, iron and aluminum, calcium and magnesium are less present.

The results of the mineralogical analysis confirm these conclusions and point to the minerals with which gold is associated.

According to mineralogical research, the associated ore components are:

- sulphides: arsenopyrite (FeAsS) - 46%, chalcopyrite (CuFeS2) -10%, pyrite (FeS2) - 9%, marcasite (FeS2) and bismuthine (Bi2S3) are very rare.

- iron oxides and hydroxides: magnetite (FeFe2O4) - 35%, in small amounts there are hematite (αFe2O3), goethite / hydrogoethite (HFeO2 / HFeO2 • ag).

Of the rock-forming minerals, quartz, feldspar, and less often mica are noted.

It can be seen from the above results that in the flotation tailings tailings, gold is in association with quartz, and is present mainly in a finely dispersed form in the intergrowths, which requires a careful choice of conditions and the way it is extracted.

In the course of the studies, the flotation tailings were further ground on a ball mill with a yield of 92% of the -0.044 mm class and their direct cyanidation was carried out. In fine material, gold is more fully disclosed, which provides maximum access to cyanide solution during agitation.

Direct cyanidation conditions (variant 1): sample mass 100 g (90% -0.044 mm), alkaline cyanide solution with concentration 0.2%, time 24 h, T: F = 1: 3 with air supply. During the cyanidation Au- 0.1 mg / l passed into the solution; Cu- 2.2 mg / l; Fe 6.1 mg / l.

At the next stage of the study, the influence of preliminary influence of chemical and biological oxidants on the cyanidation process of pre-ground tails of flotation was studied (experiments 1 and 2). Sodium peroxide and calcium hypochlorite were used as chemical oxidants. Various strains of thionic bacteria A.ferrooxidans isolated from the initial ore of the Vasilkovsky deposit - strain 1 (experiment 3), heap leaching of the same deposit - strain 2 (experiment 4) and a laboratory strain - strain 3 (experiment 5) served as a biological oxidizer. In the process of biooxidation, the biological properties of these strains were studied in parallel, which directly determine their activity: changes in the pH of the medium, cell density, oxidizing properties (oxidation of Fe2 + to Fe3 +).

Conditions for preliminary chemical oxidation:

Experiment 1: sample mass 100 g (90% -0.044 mm), time 10 h, T: F = 1: 3, sodium peroxide - 10 g / l (in the presence of sulfuric acid 5%). The content of gold and impurities in the liquid phase after 10 hours: Cu - 0.14 mg / l; Fe-0.53 mg / l, oxidation-reduction potential (ORP) - 305 mV, pH = 1.85.

experiment 2: sample mass 100 g (90% -0.044 mm), time 10 h, T: F = 1: 3, calcium hypochlorite 10 g / l (in the presence of sulfuric acid 5%). The content in the liquid phase after 10 hours: Cu - 0.55 mg / l; Fe - 1.23 g / l, ORP - 310, pH = 1.8.

The conditions of preliminary biological oxidation for the three strains are the same:

- experiments 3,4,5: sample weight 100 g (90% -0,044 mm), preliminary flushing tailings washing out of traces of impurities (T: Ж = 1: 4; H2SO4 1-2%; temperature 25 ° C; h); bacterial oxidation of the washed cake (T: F = 1: 5, pH - 1.8-2.5, Fe3 + - 8.5 g / dm3, concentration of bacterial cells of A. ferrooxidans - 106 cells / ml, duration of biooxidation - 240 h with by continuous stirring on a shaker at 230 rpm). After biooxidation, the obtained cake was neutralized with an alkaline solution to pH-10.

- cyanide leaching of the pre-ground flotation tailings after preliminary chemical and biological oxidation was carried out under the following conditions: NaCN concentration 0.2%, T: F = 1: 3, duration 24 h. The process was accompanied by air supply.

As mentioned above, during the biooxidation process, the properties of the strains were studied in parallel, the following parameters were determined: pH change of the medium, bacterial cell density, and oxidation of the two-iron iron to the trivalent state. It should be noted that all three cultures were cultivated on synthetic medium 9K (Silverman and Lundgren). The results of the studies are shown in Figures 1, 2.

Figure 1 - The degree of iron oxidation (Fe^{2+} to Fe^{3+}) by thiobacteria in the process of biological recovery

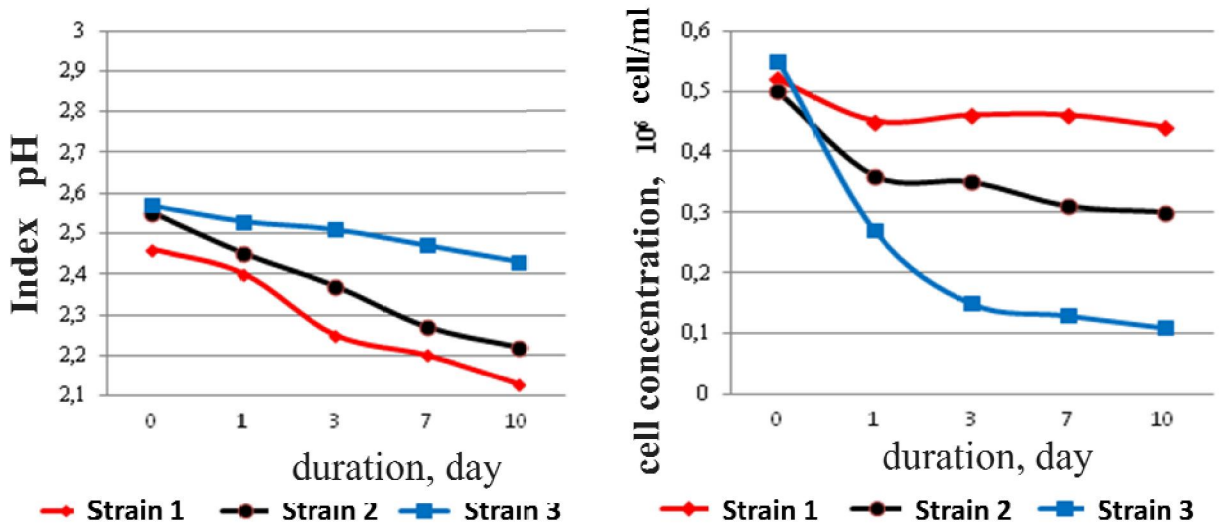

Figure 2 – pH change of medium and cell concentration during biological recovery