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INTENSIVE CYANIDATION OF GOLD FROM GRAVITY CONCENTRATES INA DRUM-TYPE APPARATUS

Abstract. Gravimetric, chemical, and mineralogical analyses of a gold-bearing gravity concentrate have been performed. Intensivecyanidation process of the concentrate was carried out in the presence of an organic reagent, while the concentration of sodium cyanide was changed in a drum-type reactor. The use of a reagent activator increased the gold extraction, reduced the time of the reaction, and reduced the leaching losses of gold in to tailings, even when using low concentrations of sodium cyanide.
Keywords: intensive cyanidation, gravity concentration, reagent-activator, gold, leaching.

Introduction. Since the early 1990s, the introduction of centrifugal concentrators, such as Knelson or Falcon concentrators, has significantly increased the percentage of extraction of gold into gravity concentrates by 1-3%, including the processing of ores with a highsulfide content [1-3]. However, standard methods for processing gravity concentrates allow gold recovery at a level of no more than 70% [4]. To solve this problem, intensive cyanidation plants have been tested, which have made it possible to achieve a high extraction of gold from gravity concentrates in an acceptable amount of time for a general technological cycle [5, 6].

The behavior of gold during cyanidation depends on many factors; the main factor is the relationship of gold to ore and rock-forming minerals. Gold can be present in both a free state and in the form of splices with minerals. Any of these conditions can affect the under-extraction of gold during dissolution and can cause an increase in the consumption of reagents. The presence of sulfides in cyanate pulp often inhibits the dissolution of gold, as it tends to form a protective film on the surface of gold. As a result of the oxidation of sulfide minerals in an alkaline solution (pH 10-11) insoluble compounds, such as Ag_2O, FeOOH, CuO, $Cu(OH)_2$ and $Zn(OH)_2$ [7-13], can form on the surface of gold. The intensification of the process of gold leaching uses chemical additives to dissolve passivating films of insoluble compounds on the gold surface. However, these additives are expensive and use an increasing concentration of sodium cyanide that ranges from 2–4% [10, 14-16].

The intensive cyanidation of gravity concentrates on an industrial scale has been successfully demonstrated using a drum machine-reactor ILR (Gekko). The drum-type apparatus contains a different prostate device that consists of built ribs, which can improve mass transfer [1, 10].

Therefore, we examined the parameters of intensive cyanidation of gold-bearing concentrate in a drum-type apparatus, along with the addition of a reagent-activator that was based on an aliphatic acid. This process does not require the use of high concentrations of sodium cyanide.

Experimental. The original composition of the gravity concentrate, as determined by an x-ray fluorescence technique on a portable analyzer [Alpha InnovXSystems] shows (in %): Ti – 0.68; Mn – 0.09; Fe – 27.87; Co – 0.15; Cu – 0.16; Zn – 0.04; Pb – 0.05 and Zr – 0.08 as main metals with other materials adding up to 70.88%. A wet chemical analysis of the gravity concentrate of the major components shows (in %): Cu – 0.11; Zn – 0.025; Fe – 35.02; S_{total} – 32.14; $S_{sulphate}$ – 0.034; and $S_{sulfide}$ – 32.1. The goldcontent used for research on the gravity concentrate ranged between 77–92 g/t[17], and silver content ranged from 39.7–49.8 g/t. It was previously determined [18, 19] that the gravity concentration and cyanidation of the original ore indicates that the gold is in free form and dissolves easily, which is consistent with the results of optical analysis (figure 1).

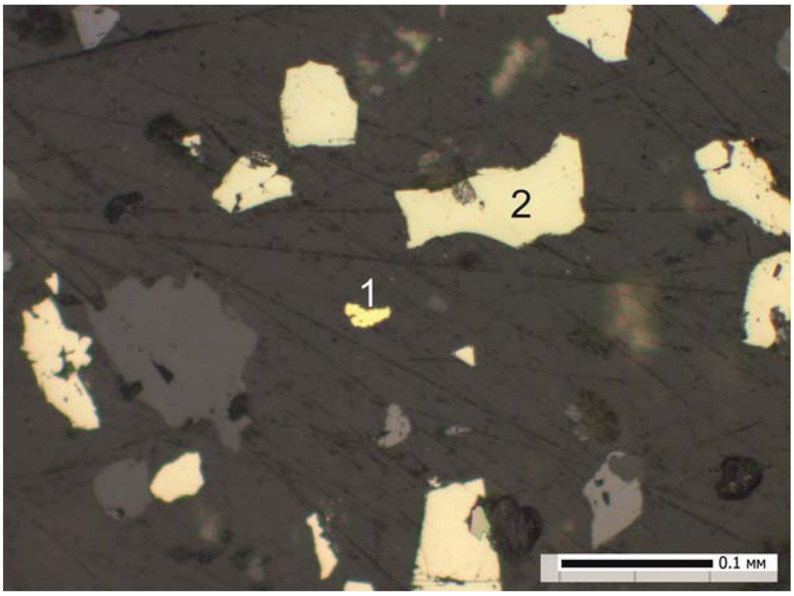


Figure 1 – Micrographofagravityconcentrate: 1 – gold; 2 – pyrite

Through an X-ray diffraction method using an automated diffractometer DRON-3, it was revealed that the concentrate is represented by the following percentages of minerals: pyrite – 78.5; chalcopyrite – 5.5; feldspars – 5.9; and quartz – 10.0. Magnetite, covellite, and iron hydroxides are all present in small quantities (figure 2 and table 1).

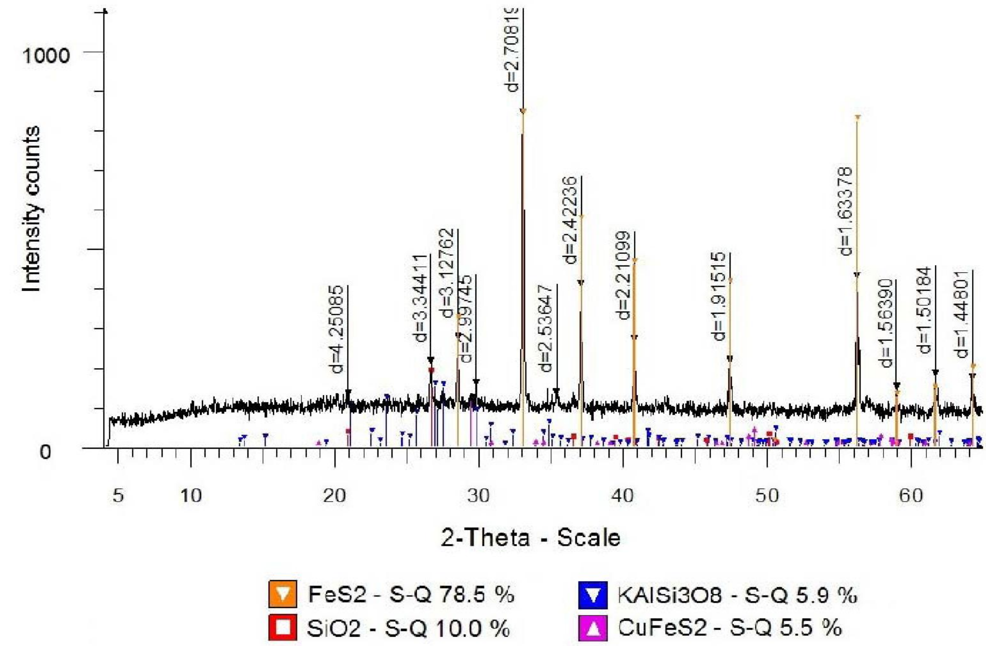


Figure 2 – X-ray diffraction of gravity concentrate

Table 1 – Interplanar distances and phase composition of the gravity concentrate

d-spacing, Å	Rel.int. %	Mineral	Chemical formula
4.25085	15.3	quartz	SiO_2
3.34411	24.9	quartz	SiO_2
3.24011	16.6	feldspars	$KAlSi_3O_8$
3.12762	32.2	pyrite	FeS_2
3.02968	15.6	chalcopyrite	$CuFeS_2$
2.99745	18.4	feldspars	$KAlSi_3O_8$
2.70819	100.0	pyrite	FeS_2
2.53647	15.5	magnetite	Fe_3O_4
2.42236	48.2	pyrite	FeS_2
2.21099	31.5	pyrite	FeS_2
1.91515	25.2	pyrite	FeS_2
1.63378	50.7	pyrite	FeS_2
1.56390	17.2	pyrite	FeS_2
1.50184	21.2	pyrite	FeS_2
1.44801	20.0	pyrite	FeS_2

The results of physico-chemical analysis confirmed that the concentrate mainly consists of sulfide minerals that can form through the dissolution of oxide films on the surface of gold. To destroy the oxide films that passivate the gold surface requires the introduction of special reagent activators under intensive mass-transfer phases.

To achieve this goal, we used a drum apparatus ILR[17], an intensive cyanidationreactor, that simulates industrial installation. The parameters of the drum-type laboratory agitator were as follows: drum diameter, 98 mm; drum length, 214 mm; drum full volume, 1.6dm^3; drum usable volume, 0.38 dm^3; and rotation speed of the agitator, 4.25 rpm.

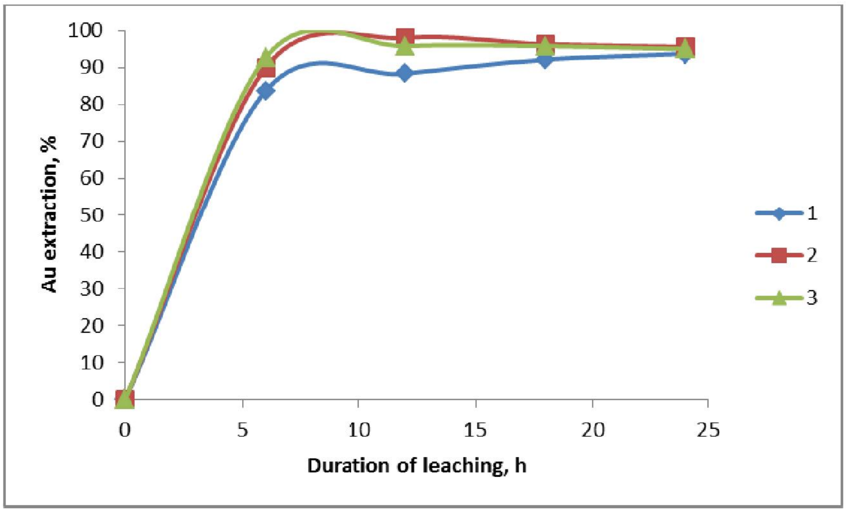
The conditions for leaching of the gold-containing gravity concentrate in the laboratory apparatus were: mass of the gravity concentrate, 0.05 kg; a solid-to-liquid ratio of 1:14; volume of cyanide-containing solution, 0.7 dm^3; and a pH of 10.5. As an additive, a reagent activator based on an aliphatic acid with 1.5 and 3.0 kg/t of sodium cyanide was used at a concentration of 0.1, 0.3, and 0.5%.

After the completion of leaching, the filtered solutions were analyzed by atomic-absorption spectroscopy to determine their gold content. Solid phase tailings were washed with water, dried, and were also analyzed for gold content with the assay-gravimetric method.

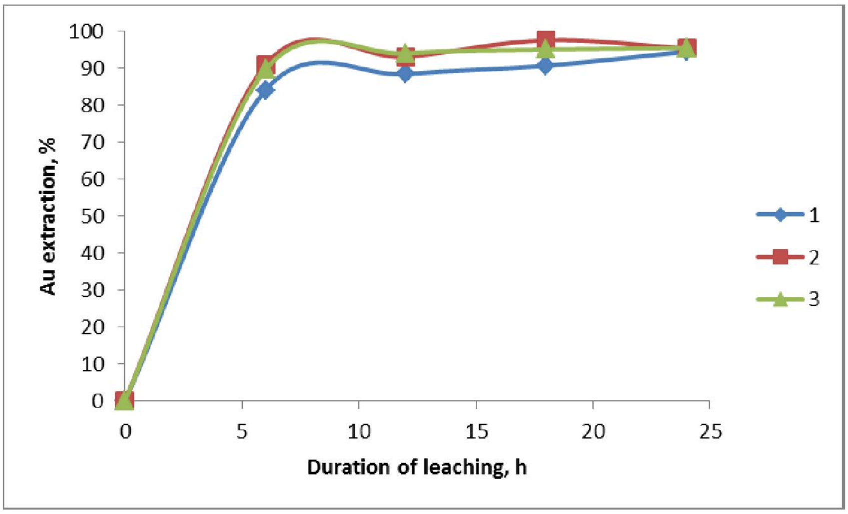
Results and discussion. Figure 3 shows the results of studies on intensive cyanidation of gravity concentrate in a drumtype apparatus.

The data obtained shows that the extraction of gold from the gravity concentrate in a drum-type apparatus, with the addition of a reagent-activator based on an aliphatic acid, was up to 95,5%, while without the addition, it did not exceed 94.5%. It should be noted that in the presence of a reagent-activator, gold dissolves quite rapidly. The duration of the process to dissolve gold is ~12 hours, which shortens the process by more than half of its normal duration.

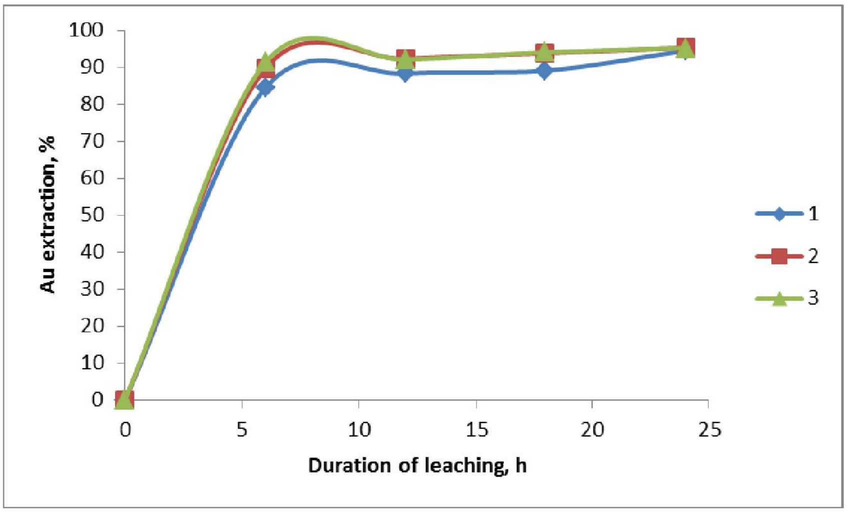
It has been established that the content of gold in tailings after intensive cyanidation by using a reagent-activator falls below 0.5-0.6 g/t, in contrast with the same process without the use of this reagent (table 2).



C_{NaCN} = 0,1%



C_{NaCN} = 0,3%



C_{NaCN} = 0,5%

Figure 3 – Degree of gold extraction in solutions from gravity concentrates.
Line 1 – without the addition of a reagent-activator; Line 2 – with the addition of a reagent-activator at 1.5 kg/t;
Line 3 – with the addition of a reagent-activator at 3.0 kg/t

Table 2 – Gold content in the tails after the process of leaching the gravity concentrate

Name of materials	Indicators								
Concentration of NaCN, %	0,1			0,3			0,5		
Content of reagent-activator, kg/t	w/o*	1,5	3,0	w/o	1,5	3,0	w/o	1,5	3,0
Content of gold in tailings, g/t	4,33	3,80	3,90	4,40	3,83	3,85	4,33	3,83	3,70
Note: *w/o – without the addition of a reagent-activator based on an aliphatic acid.									

Conclusion. The data presented show that the use of an effective reagent-activator based on an aliphatic acid as a chemical additive in intensive cyanidation of gold-bearing concentrates in a drumtype apparatus increases gold extraction by 0.7–1.1%, reduces the overall leaching time by half, and reduces the loss of gold with tailings, even when using low concentrations of sodium cyanide.

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БАРАБАН ТИПТЕС ҚҰРЫЛҒЫДА ГРАВИТАЦИЯЛЫҚ КОНЦЕНТРАТТАН АЛЫНҒАН АЛТЫНДЫ ҚАРҚЫНДЫ ЦИАНИРЛЕУ

Аннотация. Алтынқұрамды гравитациялық концентратта пробирді-гравиметриялық, химиялық және минералдық талдау әдістері жүргізілді. Барабан типтес құрылғыда гравитациялық концентратты қарқынды цианерлеу үрдісі бойынша зерттеу жұмыстары жүргізілді. Қарқынды цианирлеу үрдісін натрий цианидінің концентрациясының өзгеруімен алифаттық қышқылға негізделген органикалық реагентті қолдану арқылы жүргізілді. Жұмыс нәтижесі бойынша, гравитациялық концентратты қарқынды цианирлеуде реагент-активаторды қолдану арқылы алтынды өндіру мөлшері ұлғайтылатыны, байыту уақытын қысқартылатыны, сонымен қатар натрий цианидінің төмен концентрациясын пайдаланған кезде алтынның қалдықтармен жоғалуы азаятыны анықталып көрсетілді.

Түйін сөздер: қарқынды цианирлеу, гравитациялық концентрат, реагент-активатор, алтын, байыту.

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ИНТЕНСИВНОЕ ЦИАНИРОВАНИЕ ЗОЛОТА ИЗ ГРАВИТАЦИОННЫХ КОНЦЕНТРАТОВ В АППАРАТЕ БАРАБАННОГО ТИПА

Аннотация. Проведены пробирно-гравиметрические, химические и минералогические анализы золотосодержащего гравитационного концентрата. Проведены исследования по интенсивному цианированию гравитационного концентрата в аппарате барабанного типа. Процесс интенсивного цианирования проводили в присутствии органического реагента на основе алифатической кислоты при изменении концентрации цианида натрия. Показано, что использование реагента-активатора при интенсивном цианировании увеличивает извлечение золота, сокращает время выщелачивания, а также снижает потери золота с хвостами даже при использовании низкой концентрации цианида натрия.

Ключевые слова: интенсивное цианирование, гравитационный концентрат, реагент-активатор, золото, выщелачивание.

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