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TO A QUESTION OF THE ARSENIC EXTRACTION FROM THE CONCENTRATES OF THE REFRACTORY GOLDCONTAINING ORES OF THE ISHTAMBERDY DEPOSIT (KR)

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Annotation. Concentrates of refractory gold-bearing ores of the deposit were investigated Ishtamberdy (Kyrgyz Republic). It has been found that the content of gold, silver and arsenic in 2 samples is: Au - 51.8 and 50.4 (ppm), Ag - 5.06 and 4.89 (ppm), As - 7.56 and 6.88 (%), respectively, in the 1st and 2nd samples. Investigated samples of concentrate samples subjected to oxidative firing, acid and alkaline decomposition methods, the most feasible under the conditions of the experiment. It was revealed that at oxidative roasting of gold-arsenic-containing ore concentrate at a temperature 450-500°C for 5 hours. up to 82% of arsenic is removed. With acid decomposition concentrate of arsenic-bearing ore with 58% nitric acid solution removed 90.72% of arsenic. With alkaline decomposition of the concentrate Only 0.28% of arsenic is removed from gold-arsenic ore. Analysis of results research on removal of arsenic from samples of gold-arsenic concentrates ores of the Ishtamberdy deposit (Kyrgyz Republic) indicates that the best results in removing arsenic from these concentrates are shown by the method acid decomposition with nitric acid, the recoverability of arsenic according to which is 90.72% As.

Keywords*:* concentrates, gold-bearing ores, removal of arsenic, roasting, acid stripping, decomposition of the content of gold, silver, arsenic deposit

К ВОПРОСУ УДАЛЕНИЯ МЫШЬЯКА ИЗ КОНЦЕНТРАТОВ УПОРНЫХ ЗОЛОТОСОДЕРЖАЩИХ РУД МЕСТОРОЖДЕНИЯ ИШТАМБЕРДЫ (КР)

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Аннотация. Исследованы концентраты упорных золотосодержащих руд месторождения Иштамберды (Кыргызская Республика). Установлено, что содержание золота, серебра и мышьяка в 2-х пробах составляет: Au - 51,8 и 50,4 (г/т), Ag - 5,06 и 4,89(г/т), As - 7,56 и 6,88(%), соответственно в 1- и 2-й пробах. Исследованные образцы проб концентрата подвергнуты окислительному обжигу, кислотному и щелочному разложению-методами, наиболее осуществимыми в условиях проведения эксперимента. Выявлено, что при окислительном обжиге концентрата золотомышьяксодержащей руды при температуре 450-500°С в течение 5 час. удаляется до 82% мышьяка. При кислотном разложении концентрата золотомышьякосодержащей руды раствором 58% азотной кислоты удаляется 90,72% мышьяка. При щелочном разложении концентрата золотомышьякосодержащей руды удаляется всего 0.28% мышьяка. Анализ результатов исследования по удалению мышьяка из проб концентратов золотомышьякосодержащих руд месторождения Иштамберды (Кыргызская Республика) свидетельствует о том, что наилучшие результаты по удалению мышьяка из данных концентратов показывает метод кислотного разложения азотной кислотой, извлекаемость мышьяка по которому составляет 90,72% As.

Ключевые слова: концентраты, золотосодержащие руды, удаление мышьяка, обжиг, кислотное вскрытие, разложение содержание золота, серебра, мышьяка месторождение

Introduction. In modern conditions, due to the increase in gold production, refractory arsenic-containing raw materials are involved in processing, which entails the need to solve important problems of removal, disposal, disposal or use of arsenic. Industrial use of arsenic does not exceed 1.5% of the amount received together with raw materials at non-ferrous metallurgy enterprises, and the disposal or disposal of arsenic products is associated with high costs. Arsenic compounds which are poorly soluble in water, being in a finely dispersed state in tailing dumps and dumps, mixed with salts and reagents of concentration plants under conditions of a mobile acid-base and oxygen balance can oxidize, dissolve in filtering waters and pollute the environment For this reason, a comprehensive processing of raw materials with the preliminary conversion of arsenic from a concentrate to a low-toxic product is necessary. [2-3].

The high content of arsenic in ores significantly complicates the extraction of gold, so one of the most important problems in processing gold-arsenic-containing ores is the removal of arsenic from technological processes, its transfer to a low-toxic product and safe disposal.

Purpose of work. To test various methods of removing arsenic from gold-arsenic-containing ores on samples of gold-arsenic-containing ore concentrate of the Ishtamberdy deposit (KR).

Research Methods - Chemical spectral

Object of study - samples of concentrate of gold and arsenic-containing ores of the Ishtamberdy deposit (south of the Kyrgyz Republic). The content of gold, silver and arsenic in 2 samples is respectively: Au 51.8 and 50.4 g / t, Ag 5.06 and 4.89 g / t, As 7.56 and 6.88%, respectively, in the 1st and 2nd samples.

Experimental part. There are different ways of opening ores in order to remove arsenic [1-2]. These include:

- acidic, oxidative decomposition in acidic and alkaline environments;
- oxidative firing;
- autoclave oxidation;
- bacterial leaching, etc.

The studied samples of concentrate samples were subjected to oxidative calcination in the presence of atmospheric oxygen, acid and alkaline decomposition. These methods were chosen by us as the most feasible in the conditions of the experiment.

I.Oxidative firing. To conduct oxidative firing, three samples of a concentrate weighing 200 g were prepared. Samples were pre-ground in an agate mortar and sieved through a sieve (0.068 mm.)

Oxidative firing was carried out in a muffle furnace at 4500-5000C for 3-4 hours, since at this temperature intense oxidative arsenopyrite begins with the formation of pyrrhotite and magnetite as intermediate products:

$$2FeAsS + 1,5O_2 = 2FeS + As_2O_3\uparrow$$

$$3FeS + 5O_2 = Fe_3O_4 + 3SO_2\uparrow$$

$$2Fe_3O_4 + 0,5O_2 = 3Fe_2O_3.$$

At temperatures above 6000°C, the oxidation of arsenopyrite is preceded by its decomposition:

$4FeAsS \rightarrow 4FeS + As4\uparrow$

$As_4 + 3O_2 \rightarrow 2As_2O_3\uparrow$

The resulting As_2O_3 has high volatility, however, with an excess of oxygen, arsenic trioxide can oxidize to pentoxide:

$As_2O_3 + O_2 \rightarrow As_2O_5$

With iron oxides, arsenic pentoxide can form iron (II) and (III) arsenates $FeAsO_4$ and $Fe_3(AsO_4)_2$, which are practically non-volatile, as well as arsenic pentoxide. In subsequent processing, the arsenic remaining in the cinder is completely transferred to the solution and prevents the extraction of gold.

Given these circumstances, samples of the concentrate are calcined at a temperature of 450-500^{0}C. *Methodology.* Three samples of 200 g concentrate were ground in an agate mortar, placed in porcelain cups and calcined in a muffle furnace at a temperature of 450-5000C for 5 hours to constant weight. The calcined samples were cooled in a desiccator and then weighed. The mass of the concentrate after calcination turned out to be equal to an average of 175.2 g, i.e. weight loss averaged 24.8 g or 12.4%.

The average sample of the concentrate after calcination was transferred to determine the As content to the Central Laboratory of the Ministry of Natural Resources.

The results of the analysis of the average sample of the concentrate after calcination are shown in table 1.

Table 1.

Arsenic content in concentrate samples sfter calcunation

№ try	Try mass, g.	Temperature calcination,^{0} C	Try mass after calcin ,g	As content in the middle sample, %.		arsenic removal %
				Before calcination	After calcination	
1	200	450-500	175,2	7,22	1,30	82%
2	200	450-500	175,1			
3	200	450-500	175,3			

Thus, when calcining the concentrate of gold-arsenic-containing ore at a temperature of 450-5000C for 5 hours, up to 82% of arsenic is removed.

The concentrate, after calcination, was subjected to thiocarbamide recovery of gold.

II. Arsenic Removal Using Acid Autopsy

An acid autopsy involves the chemical oxidation of sulfides and arsenopyrites by nitric acid in the presence of atmospheric oxygen. In this case, the problem of neutralizing arsenic is removed.

The chemistry of acid opening of sulfide minerals consists in the following reactions:

$3FeAsS + 20HNO_3 = 3Fe^{3+} + 3H_3AsO_4 + 3HSO_4^- + 14NO + 6NO_3^- + 4H_2O$ (1)

$FeS_2 + 6HNO_3 = Fe^{3+} + 2HSO_4^- + 5NO + NO_3^- + 2H_2O$.

The resulting nitric oxide (II) - interacts with atmospheric oxygen, passes into nitrogen dioxide (NO_2), then, the resulting nitrogen dioxide interacts with water:

$2NO_2 + H_2O = HNO_2 + HNO_3$

The resulting nitric and nitrous acids contributes to the further catalytic dissolution of pyrite and arsenopyrite, while arsenic changes to a safer form of arsenic acid.

Methodology. Three samples of 100 g of gold-arsenic-containing ore concentrate were treated with nitric acid, the amount of which was calculated based on reaction (1). Based on the calculation, 328 ml of 58% nitric acid were added to 100 g of the concentrate sample.

Samples were kept in nitric acid for 5-6 hours. Then the samples were filtered through a Buchner funnel, washed with water and dried in an oven at 1000C. to constant weight and cooled in a desiccator. After treatment with a solution of nitric acid, the average sample weight of the concentrate was 82 g, i.e. weight loss is on average 18g or 18%.

An average sample of the concentrate was transferred to the Central Laboratory of the

Ministry of Natural Resources for determination of arsenic content.

The results of the study to determine the average arsenic content in the samples were as follows table2:

Table 2.

The arsenic content in the concentrate after acid opening.

№ try	Try mass, g.	Tempe-rature pa, ^0C	Volume HNO_3 conce. мл	Sample mass after acid opening g	Content As, %		% remove As from concentrate
					Before. HNO_3 %	After. HNO_3 , %	
1	100	20	328	82,1	7,22	0,67	90,72
2	100	20	328	82,9			
3	100	20	328	82,0			

Thus, during acid decomposition of the concentrate of gold-arsenic-containing ore with a solution of 58% nitric acid, up to 90.72% of arsenic is removed, i.e. its almost complete removal is achieved.

III. The decomposition of sulfide ores in alkaline environments

In an alkaline environment in the presence of air oxygen as an oxidizing agent, the decomposition of the concentrate of gold-arsenic-containing ores proceeds with the formation of sulfur and arsenic compounds in higher oxidation states. In this case, sulfates, arsenites and sodium arsenates, iron hydroxide accumulate in the solution:

$$2FeAsS + 10NaOH + 7O_2 = 2Fe(OH)_3 + 2Na_2SO_4 + 2Na_3AsO_4 + 2H_2O. \quad (2)$$

Methodology. Alkaline decomposed 3 samples of 100 g of the concentrate of gold-arsenic-containing ores of the Ishtamberdy deposit. Leaching was carried out in a 40% sodium alkali solution at a temperature of 50-600C for 5-6 hours.

The required amount of alkali was calculated based on a chemical reaction (2). After leaching, the samples were filtered through a Buchner funnel, washed with water and dried in an oven to constant weight at 1000C. After cooling in a desiccator, the samples were weighed.

The weighing results revealed an increase in the mass of the sample after processing it with a 40% alkali solution by an average of 21.6 g. Under the action of alkali, the treated mass became viscous, difficult to filter. The increase in mass could be explained by the formation of insoluble calcium arsenites or arsenates after the reaction of sodium arsenites or arsenates with calcium salts, which may have been contained in the concentrate.

The analysis of the average arsenic sample was carried out in the Central Laboratory of the Ministry of Natural Resources of the Kyrgyz Republic.

The results of the study on the content of arsenic were as follows (table. 3)

Table 3.

The arsenic content in the concentrate after alkaline decomposition

№ try	Try mass, g.	Tempera-ture, 0 C	Mass of 40% NaOH	Sample weight after processing NaOH, g.	As content in the middle sample, %		% remove As
					Before NaOH, %	after alkaline decomposition %	
1	100	50-60	300	122	7,22	7,20	0,28
2	100	50-60	300	121,6			
3	100	50-60	300	122,4			

Thus, when alkaline decomposition of the concentrate of gold-arsenic-containing ore of Ishtamberda, only 0.28% of arsenic is removed, which makes this method of removal of it unsuitable under these conditions.

An important problem when removing arsenic from concentrates and ores is its disposal.

Oxidative roasting at a temperature of 450-5000C, leads to the formation of arsenic trioxide - As_2O_3, having high volatility, is elusive and poses a danger to the environment.

The acid opening of the arsenic-containing concentrate leads to the formation of a safer arsenic acid - H_3AsO_4;

During alkaline decomposition of the concentrate, arsenic passes into sodium arsenites and arsenates, which can be converted into insoluble calcium arsenites and arsenates - $Ca_3(AsO_3)_2$, $Ca_3(PO_4)_2$ for further burial.

An analysis of the data obtained on the removal of arsenic from samples of concentrates of gold-arsenic-containing ores of the Ishtamberdy deposit (south of the Kyrgyz Republic) indicates that the best results are shown by the method of acid decomposition with nitric acid. (table 4)

Table 4.

Comparative table of data on the removal of arsenic from concentrates of gold-arsenic ores of the Ishtamberdy deposit

Denomination	% removal of arsenic using various methods for the removal of arsenic from concentrates of gold-arsenic-containing ores		
Sample of gold concentrate of arsenic-containing ores of the Ishtamberdy deposit (in the Kyrgyz Republic)	Oxidative firing	Acid decomposition	In alkaline environments
	82	90,72	0,28

Conclusion:

Thus, the results of the studies allow us to conclude that the use of acid decomposition by nitric acid in the presence of atmospheric oxygen proved to be the most effective for removing arsenic from concentrates of gold-arsenic-containing ores of Ishtamberd.

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