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Comparison of different methods on the enrichment of Konya Inlice epithermal gold ores

Ayşe Nur Döğme Selçuk, Ali Güney

Istanbul Technical University, Faculty of Mines, Mineral Processing Department, 34469 Maslak-İstanbul, Turkey

Corresponding author: dogmeaysenur@gmail.com (Ayşe Nur Döğme Selçuk)

Abstract: In this study, firstly, enrichment experiments were carried out on the epithermal gold ore belonging to the Konya-İnlice region containing 2.38 ppm Au-containing oxide type ore and 1.39 ppm Au-containing sulfur ore with using Falcon device as a gravity enrichment method. In these group experiments, the effects of parameters such as centrifugal force, bowl type effect, and a solid ration of feeding were investigated. As the second enrichment method, the conventional flotation technique was applied. In these enrichment experiments, appropriate grain size, flotation time, amount of reagent, and amount of depressant, and pH effect were investigated. The results of these tests showed that while a concentrate assaying 4.79 ppm Au content was obtained with 7 % recovery with Falcon Concentrator, a concentrate with 8.37 ppm Au content with 36.37 % recovery was obtained with flotation tests. Thus, if the middlings were theoretically distributed, the final concentrate recovery increased to 78.10% recovery increases to 78.10%.

Keywords: enrichment, falcon concentrator, gold flotation, gold recovery

1. Introduction

Gold is a glowing yellow color and a soft chemical element, represented by the Latin symbol Au (from the shining). Due to the availability of gold in nature, easy handling, resistance to acids, and the presence of a bright yellow color, gold has attracted the attention of the people of the day. In Anatolia, 5000 BC, ornaments made of gold started to be used. The first gold coin was minted by the King of Lydia Krezus in the Salihli-Sart region at 700 BC. (DPT 2001).

The world's gold mining has been on a rising trend since the 1970s. This has increased the importance of the epithermal, porphyry, and listvenite deposits of gold production.

Western and Central Anatolia contains geothermal systems which are essential in terms of epithermal mineral deposits. It is also observed that elements such as Sb-As-Hg, which are trace elements of epithermal gold deposits, concentrate in these regions. In Central and Eastern Anatolia, ophiolites closely related to listvenites cover large areas. There are massive sulphur type ore and porphyry deposits in the eastern Black Sea region, which are important for the gold deposits. All these data, Turkey's geological terms, reveals that it is very conducive to the formation of gold. (DPT, 2001; Ünal et al., 2016).

In the world, 84% cyanide, 10% gravity, and 4% flotation are used for gold enrichment. Gravity, amalgamation, and agglomeration methods are used for the enrichment of coarse-grained ores containing gold, while flotation and hydrometallurgical methods can be applied for fine-grained and low-grade ores. However, cyanide leaching is widely applied to such ores. Centrifuged gravity separators may also be preferred when relatively fine and free-grained gold ores are enriched. (Celep et al., 2006).

There are over twenty hydrothermal alteration zones discovered on the Konya volcano. The first zone discovered in these is İnlice. The gold bed in İnlice is epithermal, and the beds are formed when the temperature is lowest in the magmatic phase. The gold content is usually 1-2 g /t. Epithermal gold

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deposits are near-surface deposits resulting from complex chemical reactions between rocks and mineral-bearing hot waters. These epithermal systems in the volcanic regions (hot water systems) are stored in various geological structures and formations starting from 1000 m to the surface in the form of hot water formations after dissolving metals from the rocks they transferred. (Kırıkoğlu, 1990)

Different methods (physical, chemical and metallurgical methods) can be applied to the bed in which gold or silver ore is enriched in the world depending on the quantity, grad, and mineralogical structure of the ore. (Celep 2005).

As a result of pioneering work carried out by Mac Nicol in the 1930s, the Falcon separator was designed in 1994. In these separators, which have a vertical axis and a fluid bed, the force generated by the centrifugal force can be up to 300 times (300 G) of the gravity force. It can operate between high capacity and low separation densities. (Ancia et al.1997; Kökkılıç 2011; Güney et al., 2014).

Falcon separator is used in basic mineral enrichment studies in the industry, especially in gold (especially plaser type gold) and coal. (Abela 1997).

Flotation is a physicochemical separation/enrichment method based on the principle of floatation for enriching ores that cannot be enriched by physical methods in very fine size. Flotation, which is usually used as a pre-enrichment method for gold recovery, is also applied to enrich the pre-concentrate enriched by gravitation in some plants. Flotation, at this point, has taken the process of enrichment with amalgamation, which is very harmful to the environment. (Celep 2005).

Relatively gold particles are natural hydrophobic particles. With this feature, if the mineralogical property of the ore is also suitable, gold can be separated by the industrial flotation method. (Chryssoulis & Dimov, 2004; Taşköprü, et al.,2014).

Collectors such as xanthates, dithiophosphates, Aerofloat 208, Aerophine 3418A, Aeroprometer 404, Aeroprometer 407, di-ksantogenats, Aero 3477, Aeroprometer 41, Aerofloat 25 and Aerofloat 31 are used in the selective-collective flotation process of native gold, native silver, and gold sulphur type ore minerals. Reagents such as pine oil, cresylic acid, Dowfroth 250, oleic acid are used as frothing agents (Monte et al., 1997 and 2002, Pyke et al., 2000, Bayoğlu, 2013 and 2014).

Cyanidation is used in cases where physical and physicochemical methods do not allow gold recovery or are inadequate in order to economically evaluate low grade and very fine size liberating gold ores, except complex ores containing pyrite and arsenopyrite. In today's gold-enrichment industry, this method is the only way to enrich ores that contain gold grains of this type. In order to use cyanidation in pyrite and arsenopyrite gold ores, cyanide consumption needs to be reduced. For this reason, the ore must be subjected to oxidation or roasting after pre-concentration with ore flotation before cyanidation. (Yıldız, 2010; Önel, 2011; Yüce, 1997).

2. Materials and methods

2.1. Material characterizations

The ore from the Konya-İnlice region is defined as a "Sulphur type ore Samples" with a high content of sulfuric minerals. The "Oxide type ore Samples " name is given if the sulphur type ore minerals are less abundant and the oxidized minerals are more abundant. According to the results of the chemical analysis on the samples, it was found that 1.39 ppm Au and 2.38 ppm Au were present in the Sulphur type ore Samples and the Oxide type ore Samples. The chemical analysis results of the samples are given in Table 1.

For mineralogical examinations, samples of polished sections were prepared from selected samples. Mineralogical analyses were carried out with these polished sections of carbon-coated surfaces using Oxford's energy-dispersive X-ray spectrometry (EDS detector) connected to Jeol type JSM-6010 LV model scanning electron microscope (SEM). As a result of the examinations made on the sulfur sample; galena (PbS) with a size of 6 µm, barite (38% SO_3+62% BaO) with a size of 150 µm and rare silver with a size of 15-20 µm with a small amount of pyrite (72% SO_3+28% Fe_2O_3) in the quartz (Ag) was detected. On the oxide type ore sample; (71% SO_3+28% Fe_2O_3), barite (37% SO_3+63% BaO), and rarely silver (Ag) and ilmenite (20% $FeTiO_3$) were determined. It is not possible to see gold (Au) particles in the polished section of both samples. Microscopic views of the sulphur type ore and oxide type ore sample are shown in Figure 1 and Figure 2.

Table 1. Chemical analysis of samples

Elements	Sulphur type ore Sample	Oxide type ore Sample	Elements	Sulphur type ore Sample	Oxide type ore Sample
Au, ppm	1.39	2.38	La, ppm	2.22	1.00
Au, ppb	1458.56	2626.26	Mg, %	0.01	0.01
Ag, ppm	0.30	0.54	Mn, ppm	41.80	348.65
Al, %	0.78	0.62	Mo, ppm	3.74	4.47
As, ppm	25.25	49.87	Na, %	0.01	0.00
B, ppm	37.38	11.47	Ni, ppm	24.78	14.02
Ba, ppm	111.86	1092.69	P, %	0.01	0.02
Bi, ppm	1.71	1.46	Pb, ppm	37.38	11.47
Ca, %	0.02	0.01	S, %	4.12	0.07
Cd, ppm	0.96	0.10	Sb, ppm	1.05	1.59
Co, ppm	39.95	9.89	Sc, ppm	0.50	0.39
Cr, ppm	99.57	126.20	Se, ppm	2.67	0.71
Cu, ppm	35.58	25.23	Sr, ppm	133.41	12.49
Fe, %	3.89	1.82	Te, ppm	2.49	1.69
Ga, ppm	1.27	1.00	Th, ppm	1.00	0.68
Hg, ppm	0.04	0.07	Tl, ppm	1.89	0.16
K, %	0.05	0.01	U, ppm	35.58	25.23
La, ppm	2.22	1.00	V, ppm	5.16	4.52

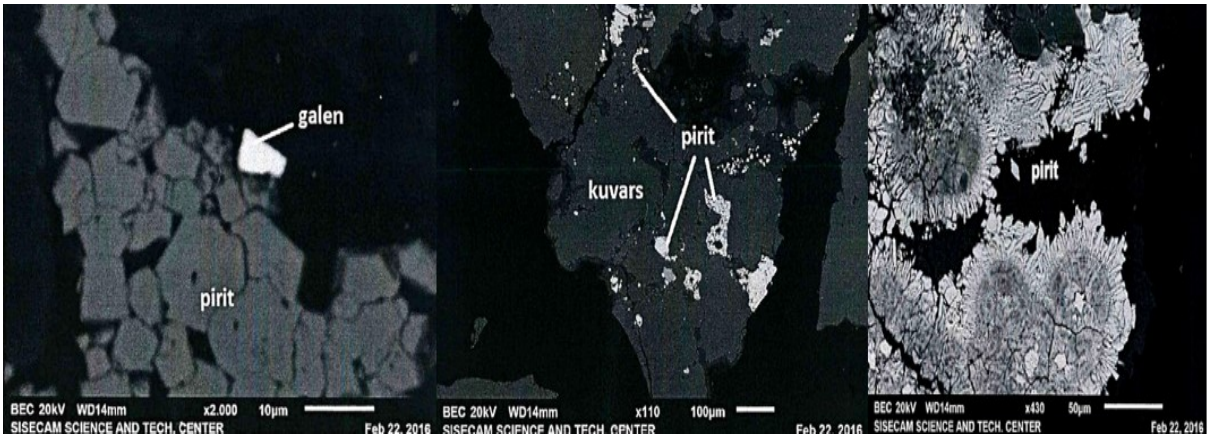

Fig. 1. Microscopic images of Sulphur type ore sample

Fig. 2. Microscopic images of Oxide type ore sample

Grinding experiments on three different sizes, on sulfur and oxide type ore samples, are shown in Table 2.

Table 2 Grinding experiments on three different sizes, on Sulphur type ore and oxide type ore samples

Grinding results for Sulphur type ore Sample				Grinding results for oxide type ore sample			
Size (µm)	Grinding Time (min.)	d50 (µm)	d80 (µm)	Size (µm)	Grinding Time (min.)	d_{50} (µm)	d_{80} (µm)
-74	30+20+10	21.46	54.59	-74	30+20+20+15+10	25.89	58.75
-53	30+25+25+25+15	20.74	40.69	-53	30+20+20+20+20	16.23	33.90
-38	30+30+30+30+35+20	12.51	26.30	-38	30+30+30+30+25+20+20+20	11.51	23.07

2.2. Methods

In this study, the pre-concentration efficiency of epithermal gold ore belonging to Konya-Inlice region was investigated by physical and physicochemical methods. Grinded ore is first pre-concentrated with Falcon device, which separates according to specific gravity difference. Later, enrichment was carried out by flotation, which is an alternative to gravity enrichment (Falcon Separator). Finally, the results obtained using both methods are compared with each other.

Experiments were carried out to investigate the effect of milling time, milling media type, grain size, pulp solid ratio, centrifugal force, and reagent type used in flotation and flotation efficiency of the applied cleaning process to rough concentrates. In addition, chemical and mineralogical studies have been carried out on representative samples used in experiments. In this context, two types of representative samples from the region were named and grouped according to their mineralogical structure and gold content.

Preliminary enrichment tests of samples of Sulphur type ore and oxide type gold ore from Konya İnlice region were carried out using a laboratory type L40 model Falcon separator. The Falcon L40 separator is shown in Figure 3, and the technical specifications are given in Table 3.

Fig. 3. A Laboratory-Type L40 Model Falcon Separator

The flotation experiments were carried out on crushed, sieved, and graduated mills, all on a sulfur sample milled below 74 microns. Since this sample is d_{80}: 53 microns, it has been decided that grinding to below 74 microns is sufficient. During the experiments, Sodium Silicate (Na_2SiO_3) was used in varying amounts of 10% concentration to disperse the pulp and to depress the silicate minerals. Sodium

Silicate After conditioning, Aerophine 3418A, Aero 208 at 1% concentration as collector and MIBC as a foaming agent was used. The collector and foaming reagents were mixed in the pulp for 3 minutes. pH adjustment was performed, and then coarse flotation was done. Foam collection was done for 3 + 3 + 4 minutes, and flotation was performed in 3 steps. Flotation experiments were not performed because there was not enough sulfur mineral in the oxide type ore sample. The reagents and properties used in the flotation of gold ores are given in Table 4.

In the flotation experiments, 2.5-5 liters of cells were used, and the mixing speed was set at 1500-1600 rpm. Experiments were performed with Denver type D-12 laboratory flotation device and Unal (Turkey) laboratory flotation device. The flotation devices used in the experiments are shown in Fig 4.

Table 3. Technical specifications of laboratory-type L40 Model Falcon Separator

Technical Specifications	
Feeding capacity	0-300 kg/h Solid (depending on the material)
Maximum feed density	weight %70-75 solid (Recommended)
Maximum pulp capacity	38 lt/min
Particle size	-12 mesh (-1.7 mm) +1250 mesh (+10 µm)
Process Water Amount for operation	0.24-1.2 m^3/h
Centrifuge Area	0-300 G
Volume of concentration	65 ml
Surface area used in concentration	285 cm^2
Concentrate weight	0.07-0.15 kg
Concentrator net weight	32 kg
Concentrator Power	½ HP (360 watts) (inlet-115/230VAC/1/50/60 Hz.)

Table 4. The reagents and properties used in the flotation of gold ores.

Reactive Name	Reactive Type	Chemical Formula	Explanations
Sodium Silicate	Depressant	Na_2SiO_3	It is used to silicate and carbonate minerals in alkaline media in the flotation of sulfur, oxide type ore, and salt type minerals. It is a good dispersant and depressant depending on pH value.
Aerophine 3418A	Collector	$C_8H_{18}PS_2Na$ (Dialkyl dithiophosphnate)	It is an efficient collector for enriching complex polymetallic and massive Sulphur type ore ores. The use of 30% -50% less than Xanthate shows the same effect.
Aero208	Collector	Dialkyl dithiophosphate	It is one of the most efficient collectors for Au, Ag and Cu ores.
MIBC	Frother	$C_6H_{14}O$ (Methyl isobutyl Carbinol)	It is a weak and neutral frother that forms a brittle foam. Widely used. It is suitable for flotation with fine particle size.

3. Results and discussion

3.1. Falcon tests

In Falcon experiments using Super bowl with riffles, extra washing water is needed. Thus, the ratio of the solid of the feed was slightly increased (20% PKO per group). An average of 2 kg of material ground to below 53 microns was fed to a Falcon device operating at 300 G. The tailing product obtained from the 300 G test was subjected to three times for 200 G and 4 times for 100 G, respectively, to obtain a clean tailing product (McAlister and Amstrong 1998, Kökkılıç 2011) The conditions of these experiments are

Fig. 4. The flotation devices used in the experiments

Table 5. The conditions of falcon experiments using the super bowl with riffles

Test Conditions	Specifications
Particle size	-53 µm
Amount of feed to Falcon device (net)	1600 g (Sulphur type ore Sample), 1300 g (Oxide type ore Sample)
Average feed rate	2.9 lt/min
Solid ratio	%20
Bowl Type	Super bowl with riffles
Wash water pressure	1 bar

Table 6. Falcon L40 test results with the Super bowl with riffles

Sample	G Force	Products	Amount (%)	Au Content (Au, ppm)	Recovery (Au, %)
Sulphur type ore Sample	300 G	Concentrate	2.07	4.79	7.12
	200 G	Concentrate	8.70	3.13	19.59
	100 G	Concentrate	4.82	2.76	9.57
		Total Concentrate	15.58	3.61	40.48
		Total Tailing	84.42	0.98	59.52
		Feed	100.00	1.39	100.00
Oxide type ore Sample	300 G	Concentrate	1.69	2.70	1.92
	200 G	Concentrate	4.31	1.36	2.46
	100 G	Concentrate	6.39	0.84	4.24
		Total Concentrate	2.69	1.75	10.45
		Total Tailing	15.09	1.65	89.55
		Feed	84.91	2.51	100.00

given in Table 5. The test results are given in Table 6.

As a result of the Falcon experiments with the Super bowl with riffles, a total of 16% concentrate was obtained from the Sulphur type ore sample, while 15% concentrate was obtained from the oxidized sample. The best enrichment result for the Sulphur type ore sample was obtained at 300 G. In this experiment; A product with 4.79 ppm gold content was obtained with a recovery of 7% gold. Optimum content and recovery (3.13 ppm Au, 19.59% Au recovery) were obtained in the experiment carried out at 200 G. The total recovery of gold in the pre-enrichment experiment with the Falcon separator of the Sulphur type ore sample is about 41%.

The best enrichment result for the Oxide type ore sample is that the product with a content of 2.70 ppm Au at 300 G is obtained with a recovery of 2% gold, but it is seen that there is no efficient enrichment due to the final tailing of the sample being 2.51 ppm Au. In the pre-enrichment experiment with the Falcon concentrator of the oxidized sample, the total recovery of gold was about 11%.

3.2. Flotation tests

Flotation experiments, which are physicochemical enrichment methods, have been carried out in addition to physical enrichment in order to help the chemical enrichment of gold from the ore. In these experiments, the effect of the amount of the reagent, the effect of the amount of sodium silicate, the pH effect, and the effect of the cleaning cycle are investigated to determine the optimum flotation condition. Experiments were conducted to investigate the effect of reagent species and amount on flotation using Aerophine 3418A, Aero 208 reagents on Konya Inlice Sulphur ore. Rough flotation experiments were carried out by increasing the amount of reagent in each experiment to 120, 240, 480, 960 and 1920 g/t, respectively, in equal amounts from both reagents (Forrest et al., 2001; Acarkan et al., 2010; Bayoğlu, 2013). The test conditions for these experiments are given in Table 7, the quantities of reagents used, and the results of experiments in which the effect of the reagent amount is examined are given in Tables 8 and 9, respectively.

When the experimental results were compared according to the amounts of reactive use, 480 gr/ton Aero 208 and 480 gr/ton Aerophine 3418A collector were used, and the highest content of 4.62 ppm Au was obtained. The highest recovery with 85% was obtained in the experiment using 960 + 960 g/t collector. However, optimum grade and yield were obtained in the experiment using 240 + 240 g/t collector. In this experiment, the Au content was 4.21 ppm, and the recovery was 73%. The recovery (Au, %) and content (Au, ppm) change depending on the amount of reagent are shown in the graph in Figure 5.

The effect of sodium silicate (Na_2SiO_3) on floatation was investigated to depress silicates and disperse the pulp. In these experiments; 240 + 240 g / ton Aerophine 3418A, Aero 208 reagents and 500-1000-1500-2000 g/ton Na_2SiO_3 were used. Coarse flotation experiments were carried out in 3 stages.

Table 7. The test conditions

Parameters	Amount
Na_2SiO_3	2000 g/t (1000+500+500)
3418 A	60, 120, 240, 480, 960 g/t
Aero 208	60, 120, 240, 480, 960 g/t
MIBC	60 g/t (20+20+20)
Na_2SiO_3 conditioning time	10+5+5
Conditioning time of collectors	3+3+3
Flotation time	3+3+4
pH	4-4.5
Solid Ratio	%20

Table 8. Quantities of reagents used in the tests

Experiments	Amount of Aerophine 3418A (g/t)	Amount of Aero 208 (g/t)
Test 1	60 (20+20+20)	60 (20+20+20)
Test 2	120 (40+40+40)	120 (40+40+40)
Test 3	240 (80+80+80)	240 (80+80+80)
Test 4	480 (160+160+160)	480 (160+160+160)
Test 5	960 (320+320+320)	960 (320+320+320)

The conditions of the experiments in which the effect of the depressant amount is examined are given in Table 10, the distribution of the depressant amount, and the test results are given in Tables 11 and 12, respectively.

Table 9. The results of experiments in which the effect of the reagent amount is examined

Experiments	Amount of Reagents (g/t)	Products	Amount (%)	Content (Au, ppm)	Recovery (Au, %)
Test 1	60+60	Concentrate	21.7	4.17	65.1
		Tailing	78.3	0.62	34.9
		Feed	100.0	1.39	100.0
Test 2	120+120	Concentrate	25.3	3.90	71.0
		Tailing	74.7	0.54	29.0
		Feed	100.0	1.39	100.0
Test 3	240+240	Concentrate	24.0	4.21	72.7
		Tailing	76.0	0.50	27.3
		Feed	100.0	1.39	100.0
Test 4	480+480	Concentrate	19.7	4.62	65.3
		Tailing	80.3	0.60	34.7
		Feed	100.0	1.39	100.0
Test 5	960+960	Concentrate	45.9	2.57	84.8
		Tailing	54.1	0.39	15.2
		Feed	100.0	1.39	100.0

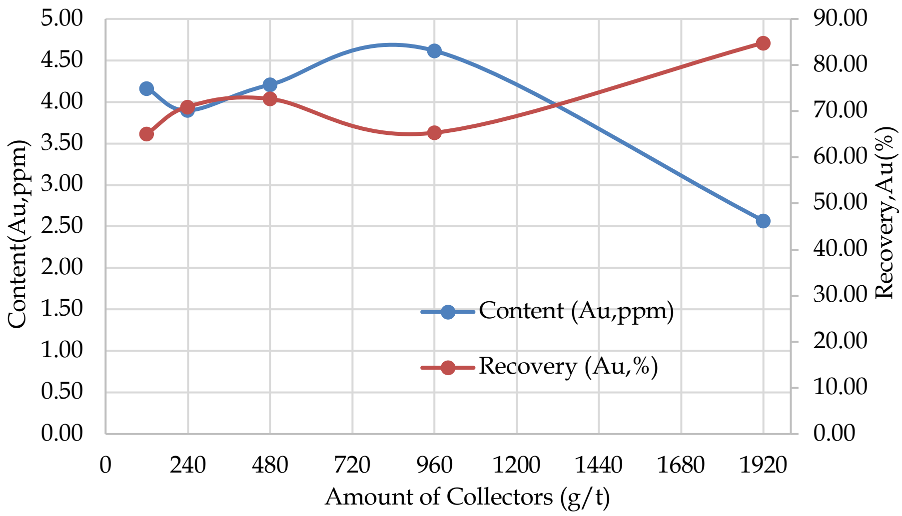

Fig. 5. The recovery (Au, %) and content (Au, ppm) change depending on the amount of reagent

Table 10. The conditions of the experiments in which the effect of the depressant amount is examined

Parameters	Amount
Na_2SiO_3	500, 1000, 1500, 2000 g/t
3418 A	240 g/t (80+80+80)
Aero 208	240 g/t (80+80+80)
MIBC	60 g/t (20+20+20)
Na_2SiO_3 conditioning time	10+5+5
Conditioning time of collectors	3+3+3
Flotation time	3+3+4
pH	4-4.5
Solid Ratio	%20

Table 11. The depressant amounts used the tests

Tests	Amount of Na_2SiO_3 (g/t)
Test 1	500 (300+100+100)
Test 2	1000 (600+200+200)
Test 3	1500 (900+300+300)
Test 4	2000 (1000+500+500)

Table 12. The results of the experiments in which the effect of the depressant amount is examined

Tests	Amount of Depressant (Na_2SiO_3) (g/t)	Products	Amount (%)	Content (Au, ppm)	Recovery (Au, %)
Test 1	500	Concentrate	26.2	3.76	70.8
		Tailing	73.8	0.55	29.2
		Feed	100.0	1.39	100.0
Test 2	1000	Concentrate	42.5	2.84	86.8
		Tailing	57.5	0.32	13.2
		Feed	100.0	1.39	100.0
Test 3	1500	Concentrate	51.0	2.39	87.6
		Tailing	49.0	0.35	12.4
		Feed	100.0	1.39	100.0
Test 4	2000	Concentrate	24.0	4.21	72.7
		Tailing	76.0	0.50	27.3
		Feed	100.0	1.39	100.0

Compared with experiments using different amounts of depressant, the highest content was obtained with 4.21 ppm Au in the experiment where 2000 gr/ton depressant was used. The highest gold recovery rate (88%) was obtained from the experiment in which 1500 g/t depressant was used. According to the results of the experiment using 1000 g/t depressant, the gain is lower than the 1500 g/t depressant, although the gain is relatively increased. Gold recovery and content changes depending on the amount of depressant are given in Fig. 6.

Many sources point out that gold is depressed at high pH. It is also stated that other minerals found in the ore may affect the yield of gold by flotation at different pH (Monte et al., 1997; Forrest et al., 2001). However, in fact, the collector used to recover gold by flotation is more effective than pH. Good results obtained using two different collectors at pH 4.5 with the same ore are obtained at pH 12 to (Forrest et

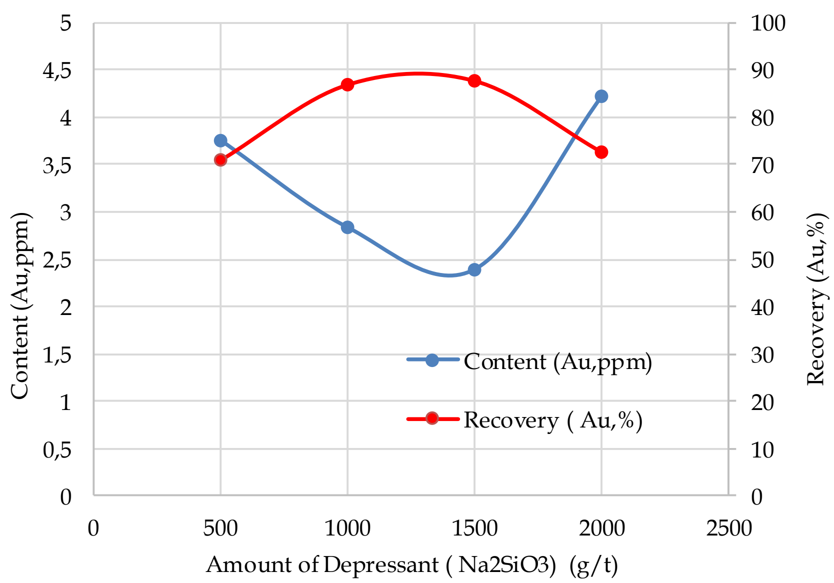

Fig. 6. The recovery (Au, %) and content (Au, ppm) change depending on the amount of depressant

al., 2001). In this study, 3418A and Aero 208, which are the highest yielding collectors in gold flotation, were used, and the best results in the other studies were taken at pH 4.5. For this reason, flotation experiments were carried out at pH 6.6-6.9 (natural pH), and pH 4-4.5 on Konya İnlice gold ore, and the pH effect in gold recovery was investigated (Acarkan et al., 2010). As a result of these experiments, at pH 4-4.5, better results were obtained in terms of gold content and yield like other literature studies.

The experimental conditions for these experiments are given in Table 13, and the results of the experiments are given in Table 14.

Table 13. Experimental conditions in which the pH effect is examined

Parameters	Amount (Test 1)	Amount (Test 2)
Na_2SiO_3	2000 g/t (1000+500+500)	2000 g/t (1000+500+500)
3418 A	240 g/t (80+80+80)	240 g/t (80+80+80)
Aero 208	240 g/t (80+80+80)	240 g/t (80+80+80)
MIBC	60 g/t (20+20+20)	60 g/t (20+20+20)
Na_2SiO_3 conditioning time	10+5+5	10+5+5
Conditioning time of collectors	3+3+3	3+3+3
Flotation time	3+3+4	3+3+4
pH	4-4,5	6,5-7 (Average 6.7)
Solid Ratio	%20	%20

Table 14. Experimental results in which the pH effect is examined

Tests	pH	Products	Amount (%)	Content (Au, ppm)	Recovery (Au, %)
Test 1	4-4,5	Concentrate	24,0	4,21	72,7
		Tailing	76,0	0,50	27,3
		Feed	100,0	1,39	100,0
Test 2	6,5-7	Concentrate	33,6	1,73	41,7
		Tailing	66,4	1,22	58,3
		Feed	100,0	1,39	100,0

Table 15. The results of the cleaning flotation experiments

Tests	pH	Products	Amount (%)	Content (Au, ppm)	Recovery (Au, %)
Collector Additive Cleaning Circuit	4-4,5	Concentrate	6,0	8,37	36,4
		Middling-4	1,5	2,51	2,7
		Middling -3	1,9	0,82	1,1
		Middling -2	5,7	1,90	7,8
		Middling -1	23,1	2,20	36,5
		Tailing	61,8	0,35	15,5
		Feed	100,0	1,39	100,0

As a result of the systematic experiments carried out, the most suitable flotation conditions were determined as follows: Na_2SiO_3 - 1500 g/t, 3418 A - 240 g/t, Aero 208 - 240 g/t, pH = 4 - 4.5.

Four-stage cleaning was carried out on the rough concentrate obtained as a result of the flotation experiment on the most suitable conditions. It is used in each of the cleaning circuits (25 g/ t 3418A + 25 g / t Aero 208). The results of the cleaning flotation experiments are given in Table 15, and the results obtained in the case of the theoretical distribution of the middling products are given in Table 16.

Rough flotation was performed in three stages using 240 g/t Aerophine 3418A and 240 g/t Aero 208 collectors (1500 g/t Na_2SiO_3, 60 g/t MIBC and pH 4-4,5). In order to increase the gold content, the rough concentrate obtained was subjected to cleaning in 4 stages. In these experiments, both the cleaning step

Table 16. The results obtained in the case of theoretical distribution of the middling products

Tests	pH	Products	Amount (%)	Content (Au, ppm)	Recovery (Au, %)
Collector Additive Cleaning Circuit	4-4,5	Concentrate	13,0	8,37	78,1
		Tailing	87,0	0,35	21,9
		Feed	100,0	1,39	100,0

number and collector addition effect were investigated. This group of experiments was done using the same amount of collector in the cleaning stages and the second, without using any collector.

As a result of 4 stages of cleaning flotation experiments with the addition of 25 g/t Aerophine 3418A and 25 g/t Aero 208 collectors at each stage, the gold content in the final concentrate increased to 8.37 ppm and the yield was 36.37%. In the case of the distribution of the middling, the concentrate increased theoretically to 78.10%.

4. Conclusions

According to the results of chemical analysis on representative samples from Konya-Inlice region, 1.39 ppm Au was found in sulfur-rich run-off ore and 2.38 ppm Au in oxidized run-off ore.

For mineralogical examinations, samples of polished sections were prepared from selected samples. As a result of the examinations made on the sulfur sample; galena (PbS) with a size of 6 µm, barite (38% SO3+62% BaO) with a size of 150 µm and rare silver with a size of 15-20 µm with a small amount of pyrite (72% SO3+28% Fe2O3) in the quartz (Ag) was detected. On the oxide type ore sample; (71% SO3+28% Fe2O3), barite (37% SO3+63% BaO), and rarely silver (Ag) and ilmenite (20% FeTiO3) were determined. It is not possible to see gold (Au) particles in the polished section of both samples.

As a result of the Falcon experiments with the Super bowl with riffles, the best enrichment result for the Sulphur type ore sample was obtained at 300 G. In this experiment; A product with 4.79 ppm gold content was obtained with a recovery of 7% gold. Optimum content and recovery (3,13 ppm Au, 19,59% Au recovery) were obtained in the experiment carried out at 200 G. The total recovery of gold in the pre-enrichment experiment with the Falcon separator of the Sulphur type ore sample is about 41%.

The best enrichment result for the Oxide type ore sample is that the product with a content of 2,70 ppm Au at 300 G is obtained with a recovery of 2% gold, but it is seen that there is no efficient enrichment due to the final tailing of the sample being 2.51 ppm Au. In the pre-enrichment experiment with the Falcon concentrator of the oxidized sample, the total recovery of gold was about 11%.

As a result of systematic flotation experiments with the sulphur type ore ground to 74 microns, the most suitable rough flotation conditions were Na_2SiO_3: 1500 g/t, 3418 A: 240 g/t, Aero 208: 240 g/t, pH: 4-4.5.

In order to increase the gold content, the rough concentrate obtained was subjected to cleaning in 4 stages. As a result of 4 stages of cleaning flotation experiments with the addition of 25 g/t Aerophine 3418A and 25 g/t Aero 208 collectors at each stage, the gold content in the final concentrate increased to 8.37 ppm and the recovery was 36.37%. In the case of the distribution of the middling, the concentrate recovery increased theoretically to 78.10%.

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