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Optimization of Process Parameters for Enhanced Up-gradation of Qilla Saifullah Copper ore through Froth Floatation Technique

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Abstract

In this work, we focus on the up-gradation of the copper ore of Qilla Saifullah in Pakistan through the froth flotation technique. The chemical analysis of the head copper ore sample reveal the presence of 2.85% Cu, 22% Fe2O3, 52.9% SiO2, and other minor minerals. The optimum grinding time and liberation size of the copper ore have been determined as 30 minutes and +149-105 µm, respectively, for further processing. The chemical reagents are optimized in order to get a maximum grade and recovery of the copper ore. After comparisons and analysis of the results obtained, it can be concluded that the maximum grade and recovery of the copper ore are achieved at the dosage 300 (g/t) of the collector potassium amyl xanthate (C6H11KOS2), 250 g/t of pine oil, 250 g/t of a depressant (Na2SiO3), conditioning time of 10 minutes for a collector, flotation time of 6 and 10 minutes, and pH of 10 using the froth flotation technique.

1. Introduction

Pakistan has been blessed with several natural resources that include varieties of metallic, non-metallic, and industrial minerals. The most common and valuable metallic ore is copper ore. Different types of copper ores and their deposits are present mostly in the province of Balochistan and Khyber Pakhtunkhwa [1-8]. However, these copper ore deposits are of low grade, and are required to be processed before the market trade. The beneficiation of copper ore is an emerging issue in Pakistan. Some reseachers [9-12] have developed different processing techniques for the beneficiation of copper ore. Among all the processing techniques, froth flotation is one of the most proficient techniques for the up-gradation of copper ore [13]. The froth floatation process is mainly dependent on the use of different types and dosages of chemical reagents such as frothing agents, collectors, and depressants. Several chemical reagents have been employed for the upgradation of copper ore including sodium sulfide (Na_2S), sodium silicate (Na_2SiO_3) , pine oil, mild oil and benzotriazole, etc. [14-20]. The copper ore was upgraded to 27.8% Cu with a recovery of 71.2% [20]. Bao Liang Ge in 2013 treated 0.77% copper oxide ore from a Province in China, Yunnan. The ore consisted of pyrite, hematite, bornite, malachite, and covellite, while the gangue consisted of dolomite, quartzite, chlorite, plagioclase, and calcite. The dosage of the collector was 90 g/t, the frother was 35 g/t, the sulphidization agent was 1000 g/t sodium sulfide, and the pH

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regulator was 30 g/t lime. Consequently, the copper ore was upgraded to18.06% with a recovery of 80.81%. In the flotation studies, K-isobutylxanthate and kamyl xanthate were used as the collectors, and Aeroflat 65 was used as the frother. [10] and [21] have conducted a research work on the Ergani Copper Mining Co. in Turkey's oxide copper ore. According to the analysis of the test sample, the copper ore contained 2.03% copper, 0.15% cobalt, and 3.73% sulfur. Potassium 14 amyl xanthate and Dowfroth 250 were used as the flotation reagents at pH 8.7. The copper ore was upgraded to 9.36% Cu with a recovery of 93.16% [21]. Lee et al. (2008) have worked on Sherwood Copper's Minto Mine Yukon (Canada). According to the analysis, the copper ore sample from the site contained 70% sulfide copper and 30% oxide copper. The total copper content of the ore was 3.6%. Methyl iso-butyl carbinol (MIBC) was used as a frothing reagent, and potassium amyl xanthate (PAX) as a collector. The results obtained showed that the copper ore was upgraded to 33.9% copper with a recovery of 78.5% [22]. The optimum mesh of grind was the liberation size of the ore mineral at which the maximum ore mineral/particles could be unlocked from the gangue [22-25]. The main purpose of an optimum mesh of grind was to prevent over-grinding or under-grinding of the ore, both of which gave poor results and a maximum energy consumption. For the initial analysis of the liberation size of copper ore, McClintock et al. (1995) have suggested the size of the liberation of copper mineral to be 180 mm (mainly chalcopyrite) at a minimum recovery. The maximum recovery of copper of minerals by flotation was possible at the liberation size of the range 10-100µm [23-26]. Later on, the investigations carried out at the laboratory scale suggested 149 µm to be the optimum mesh of grind. That size too gave low recoveries [9].

Froth flotation is the most important beneficiation technique extensively used for the separation of valuable particles from gangue particles utilizing the physio-chemical surface properties of mineral particles [23]. The froth flotation technique gained more attention to be used for the processing of metallic ore in general and copper ore in particular, due to its versatile nature. This technique gave a high recovery as compared to the other processing techniques, and used different chemical reagents in the flotation process [9, 10, 12]. The froth flotation test gave two products, i.e. float (concentrate) and tailing. The concentrate particles were hydrophobic in nature and tended to be attached to air bubbles and be collected as float, while the tailing particles being hydrophilic and dense in nature were collected at the bottom of the flotation cell [12]. A schematic presentation of the froth flotation unit is presented in Figure 11 [22].

Other researchers also worked on the upgradation of copper ore in order to get a maximum grade and recovery of copper ore. Upgradation of copper ore through the froth floatation technique is still arguable and under discussion, and the researchers are trying to find suitable reagents and dosages for the better recovery and upgradation of copper ore. The determination of proper chemical reagents and its optimization involved experimental investigations.

In this research work, a comprehensive experimental investigation of the copper ore samples collected from Qillah Saifullah Baluchistan (Pakistan) was carried out. The optimum grinding and liberation size were determined for further processing of copper ore. The dosage of chemical reagents was optimized using the froth flotation techniques in order to attain a maximum grade and recovery of copper ore through a proper selction of the reagents. Differentt quantities of collector, frothers, and flotation times were applied for an optimum recovery.

2. Geology of study and surrounding area

The hunting survey Co. (1961) divided the Muslim Bagh area into three geologic terrains from the north to the south of the Flysch zone, Axial zone, and Calcareous zone. Each zone generally trends from the east to the west, and is bounded by the thrust faults.

The Flysch zone mainly consists of the Flysch type of interbedded sandstone and shale ranging in the age from Eocene to Miocene.

The Axial zone is characterized by complex sequences of ultramafic rocks, pillow lavas, and deep-sea sediments, and divided into the Muslim Bagh ophilites in the upper part and bagh complex in the lower part. The Muslim Bagh ophilites are reperesented by ultramafic tectonites, ultra mafc and mafic cumulates, and sheeted dikes complexes. The Bagh complex overlained by the Muslimbagh ophilites largely consists of tectonic mélanges, silvers of ultramafic rocks, basaltic rock units, and cretaceous. The Muslim Bagh ophilites are considered to have been emplaced in Paleocene o early Eocene because the ophilites not only overlie the upper maestrichian sediments but also unconformably underly the lower Eocene to early middle Eocene sediments [1-4].

3. Materials and methods

The representative sample of copper ore (chalcopyrite) weighing 60 kg was collected from Qillah Saifullah, Baluchistan province (Pakistan). The sample was prepared according to the feeding specification for different chemical and processing studies through froth flotation using crushing, grinding, and siew analysis. The different processes discussed below are shown in the flow diagram in Figure 2.

3.1. Sample collection

About 60 kg of the copper ore samples were collected from Qilla Saifullah. These samples were collected from three different locations of the mine sites of the Qilla Saifullah region.

3.2. Mineralogical studies of copper ore samples

3.2.1. Thin section study and analysis

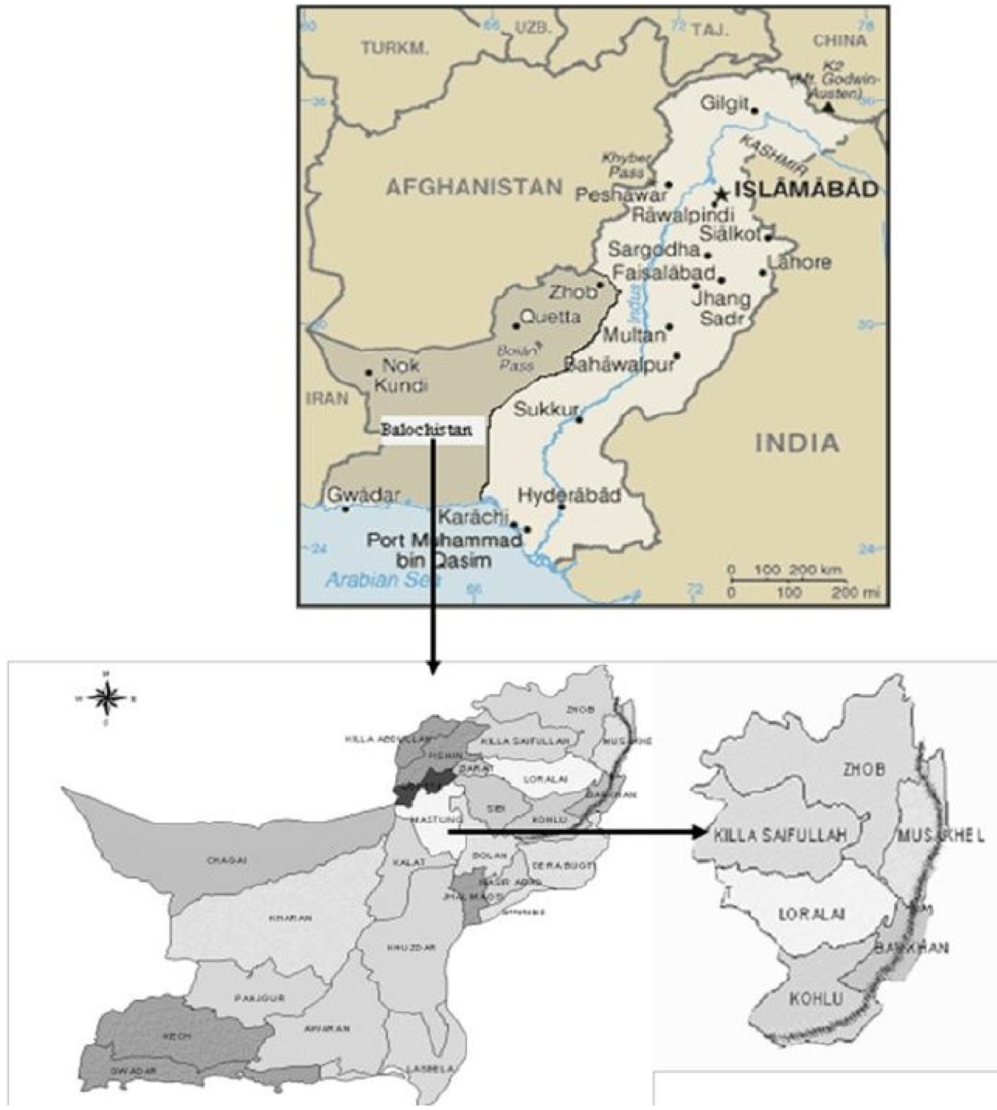
In the hand specimen, it was observed that these samples were composed of three different phases, and their relative proportions may vary from sample to sample. The distinctive physical properties of each phase were quite helpful in differentiating them from one another (Ineson, 2014). The most abundant phase was golden yellow in color, and had an opaque diaphaneity with a specific gravity of ~4. Its hardness was between 3 and 4, and it produced a black streak. The second phase usually surrounding the first phase had a brass-pale yellow color, opaque diaphaneity, and a specific gravity above 5. Its hardness was around 6, and gave a brownish black streak. The third phase filling the fractures and veins possessed very different physical properties. Its color was black with transparent to translucent diaphaneity. The specific gravity ranged above 4, and the hardness was 3-3.5, and it had brownish to grayish black streak.

3.2.2. Unadded eye assessments

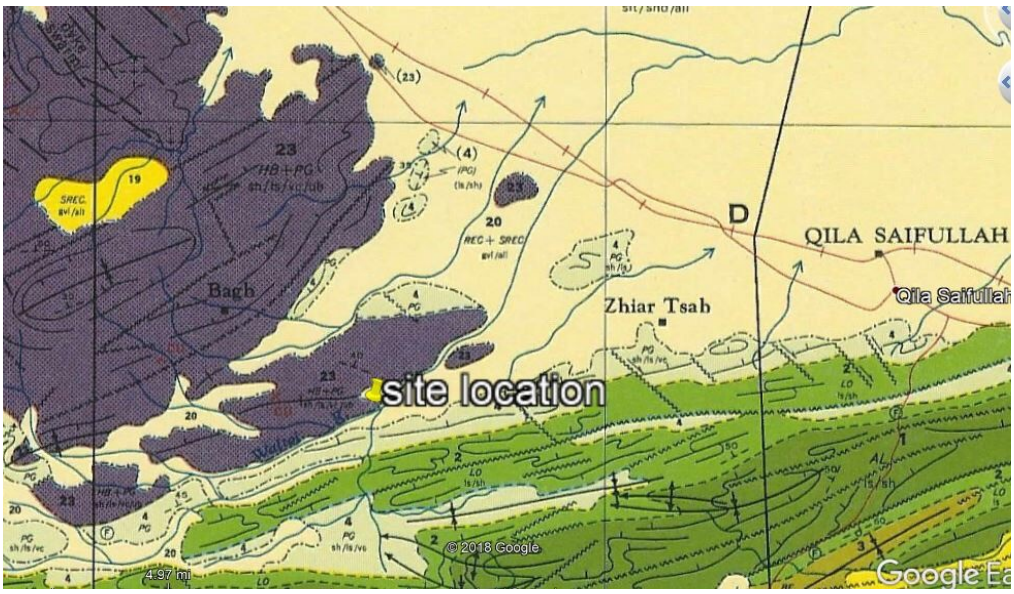
Three major phases were identified through the visual assessment of the specimens, and by using the geostatistical image processing software. It is evident that sample 1 hosts all the three developmental stages of this system. The dominant portion of the specimen was occupied by phase 1 (P-1), which made up to 60% of the modal proportion. P-1 was surrounded by phase 2, which was about 25% of the total model proportion. Phase 3 occurred in the form of very thin veins/fracture fillings, and its modal proportion did not exceed 15% .

Sample 2 was primarily composed of phase 1 and phase 2, in which phase 2 was relatively dominant as compared to phase 1. This phase occurred as the main host rock as well as the filling of fracture. Phase 3 occurred in a minor amount, mostly in the form of cavity fillings. On the basis of visual estimation, 70% of the specimen was composed of phase2, while the modal proportion of phase 1 went up to 25% only. Phase 3 made only 5% of the total modal mineralogy. In sample 3, the visual estimation showed that the sample was predominantly composed of phase 1, which was uniformly distributed throughout the specimen. Phase 2 was either absent or occurred in a trace amount as small patches. Phase 3 showed its presence in the form of fracture fillings only. Around 95% of the specimen was composed of phase 1, and phase 3 contributed the remaining 5% of the modal proportion.

Sample 4 mainly consisted of phase 1 and phase 2 in relatively equal proportions, while phase 3 was also present in a significant amount. Phase 1 and phase 2 collectively made 80% of the modal proportion, while phase 3 made only 20% fraction of the total mineralogy. Sample 5 was mineralogically similar to sample 3. Phase 1 was dominant, and its proportion went up to 85-90% of the modal mineralogy, and phase 2 was absent or occurred in a trace amount. This sample was texturally/structurally different from sample 3 as it showed moderate to intensive early-stage fracturing, which was filled by phase 3 in the later stages. However, the modal proportion of phase 3 went up to 10-15% only.



(a)



(b)

Figure 1. (a) Location map of the studied area [33] b) Geological canadain map of the area.

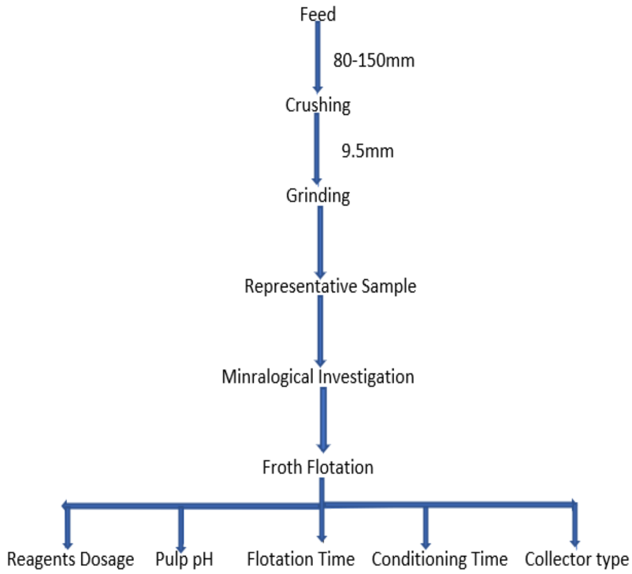


Figure 2. Research methodology flow chart.

Figure 3. Google earth image showing location site of the sample location.

3.2.3. Reflected light petrography

The polished specimens of all the three samples were studied under a reflected light microscope. On the basis of the optical behaviors/properties of the studied minerals, phases 1, 2, and 3 were chalcopyrite, pyrite, and sphalerite, respectively.

3.3. X-Ray diffraction analysis

a. Sample preparation

The ore sample were ground pass through a 300-mesh British standard sieve screen. The samples were characterized using an X-ray diffractometer Jeol-JDX3532 under the conditions of 40 KV and 30 mA, Tube voltage, and current respecting. The peaks appeared at 30 angle values and onwaed. The values at verying intesions were converted into lattice space (d in A units). The minerals were idintifed with the help of conversion charts .

Three ore samples were studies by the X-ray diffraction (XRD) method. Table 1 shows the results of the XRD analysis.

b. Results

The results of these method confirmed the presence of iron, quartz, copper, cilicon, sulfide, manganese, and zinc in the samples, as shown in Table 1.

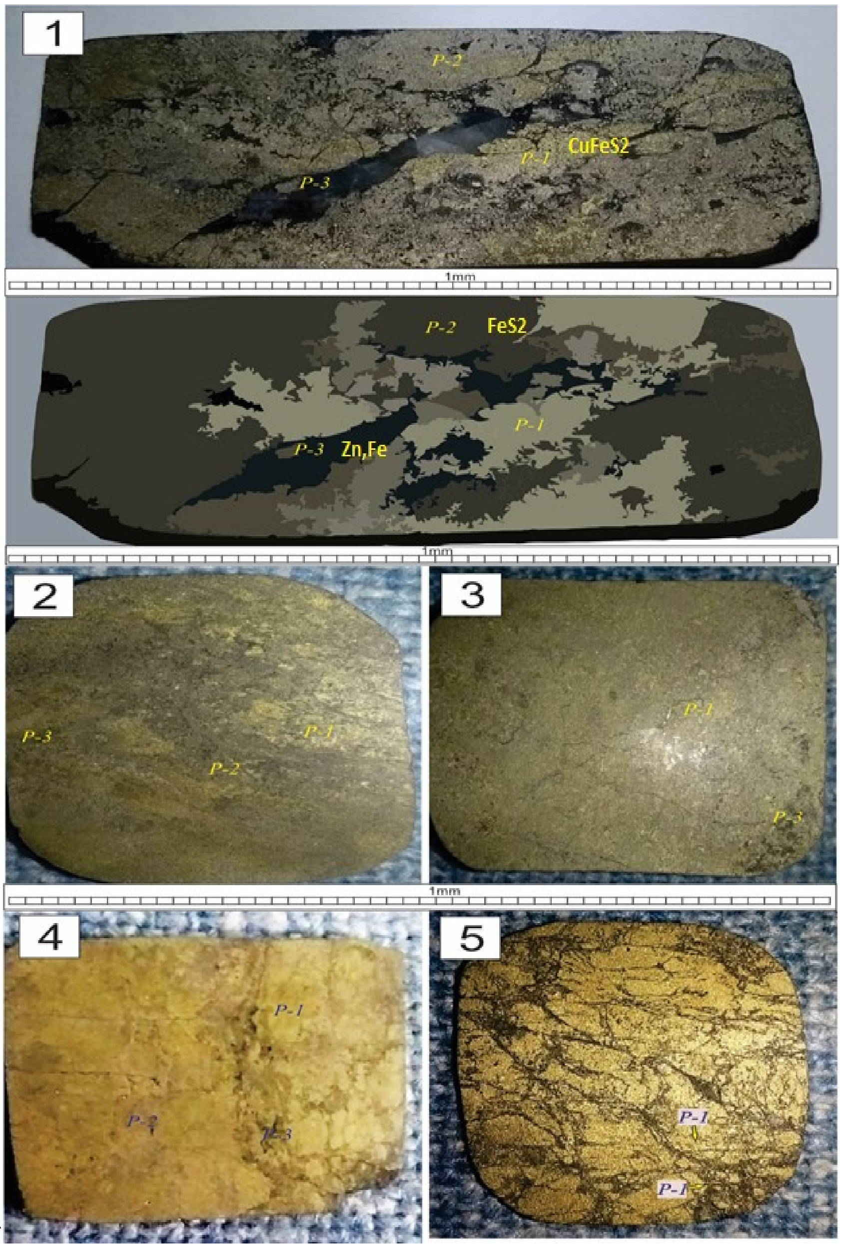


Figure 4. Polished surface appearance of each sample with clear visuals of different formational phases.

Table 1. Results of XRD analysis.

Content	S1	S2	S3
SiO_2	4.381	26.949	12.909
SO_3	21.537	16.241	47.457
Fe_2O_3	14.461	43.418	27.091
Al_2O_3	10.161	7.308	6.125
CuO	7.919	3.648	4.962
MnO	0.047	0.372	0.060

3.4. X-ray florescence speotrometer analysis

a. Sample preperation

The elemental analysis of the chalocopyrie ore was carried out on EDX-7000 atmosphare air collimer 10 (mm). A sample 6-12 g was filtered and dried. The dried sample was grounded upto 75 micron and analyzed for elemental analysis in X-ray florascence spectrometer model EDX-7000.

b. Analysis and results

The elemental analysis gave the fillowing assay of copper ore from Nisai area Qilla Saifullah: 0.42-2.8% Cu, 0.05-0.201% Zn, 23-32.5% Fe_2O_3, 18.4-12% silica, and 0.422-0.35% CaO.

3.5. Sieve analysis

The mineralogical investigation was performed on different size fractions of the grounded sample, which showed that about 71% of copper-containing particles was liberated below 149 microns (µm). 92.52% of the particles was passed through 149 microns (µm), which showed 30-

minute grinding when the size feed material was used. All the samples for the test were grounded by a rod mill for 20, 25, and 30 minutes in order to find out the optimum grinding time to achive the required grind size. The sieve size range was between 250 microns and 44 microns. The grinding tests results are presented in Figure 8.

3.6. Optimum grinding time and mesh of liberation size studies of chalcopyrite ore

For an optimum mesh of liberation size, different sieve size samples were analyzed under an atomic absorption spectrometer for the copper ore of Qilla Saifullah. The results obtained are presented in Figure 9.

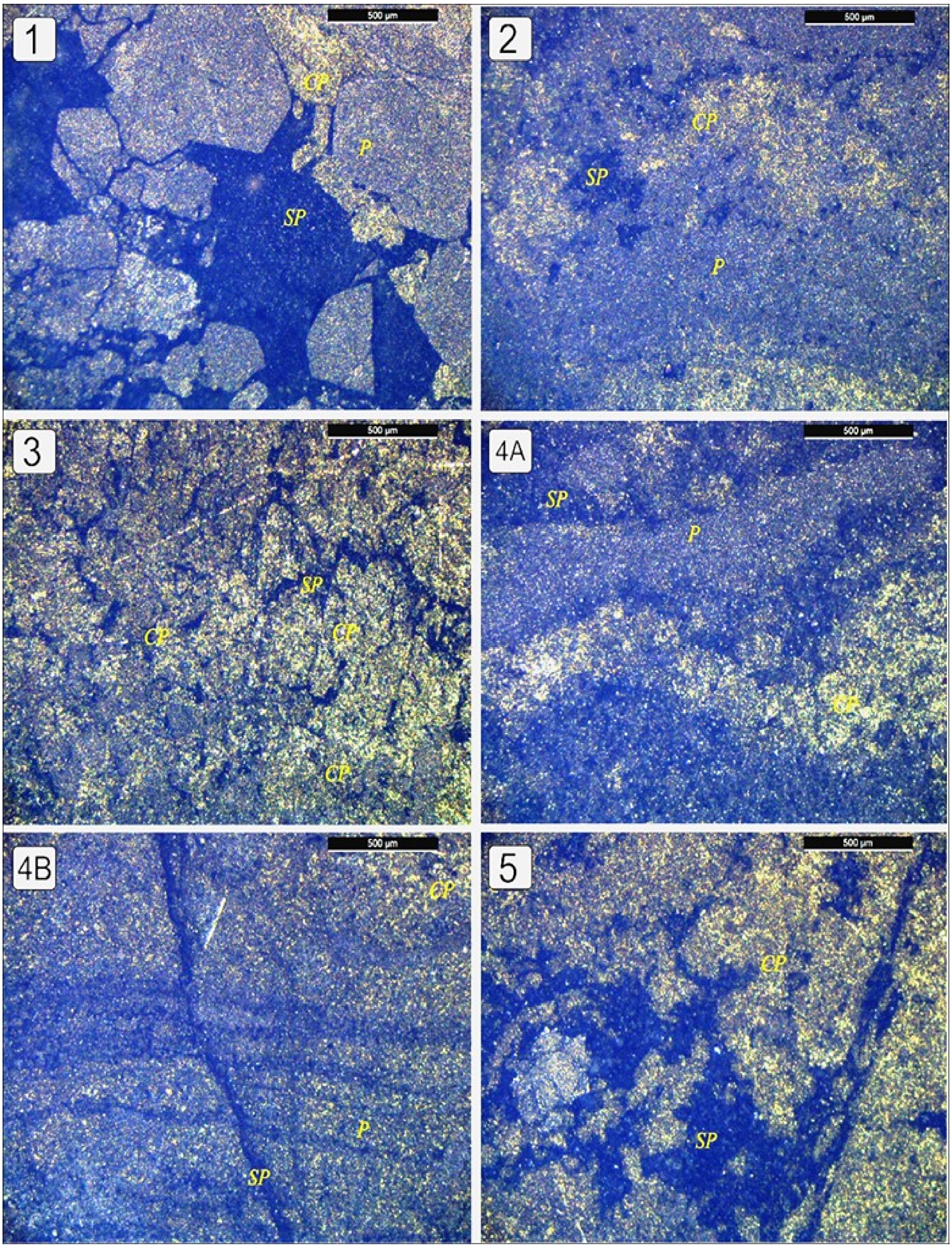


Figure 5. Appearance of samples under a reflected light microscope.*CP:* Chalcopyrite; *P:* Pyrites; *SP:* Sphalerites.

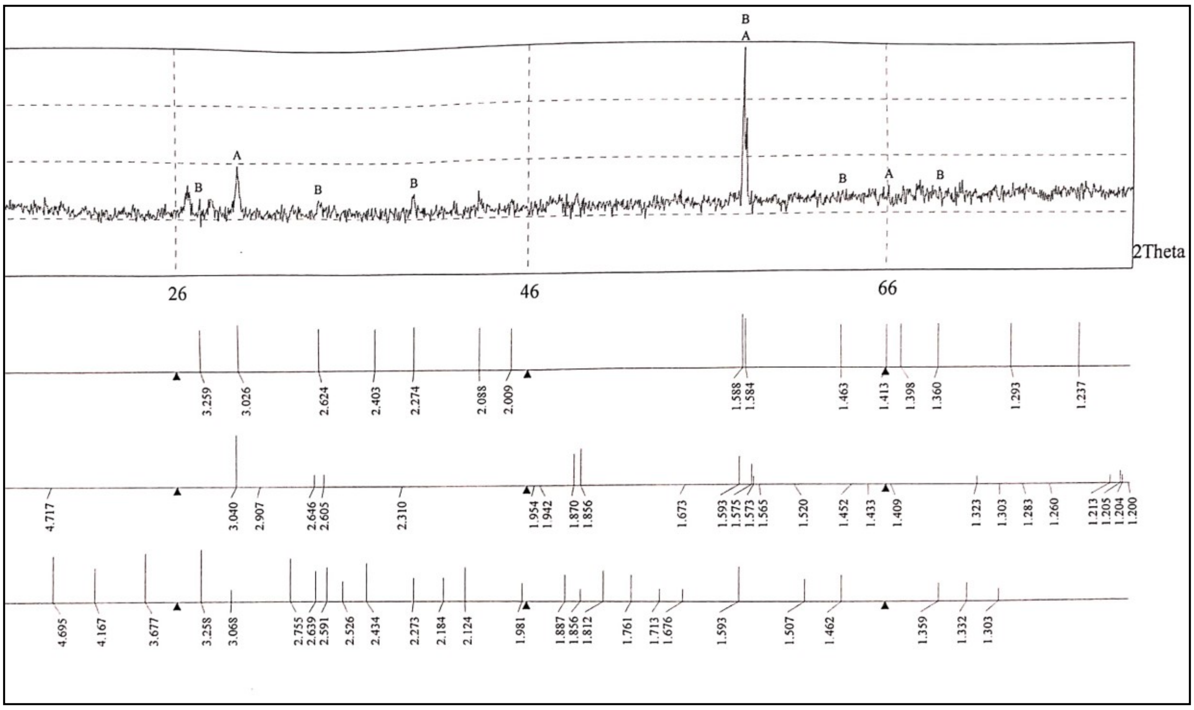


Figure 6. XRD pattern of test sample.


Figure 7. X-Ray Florascence spectrometer model EDX-7000.

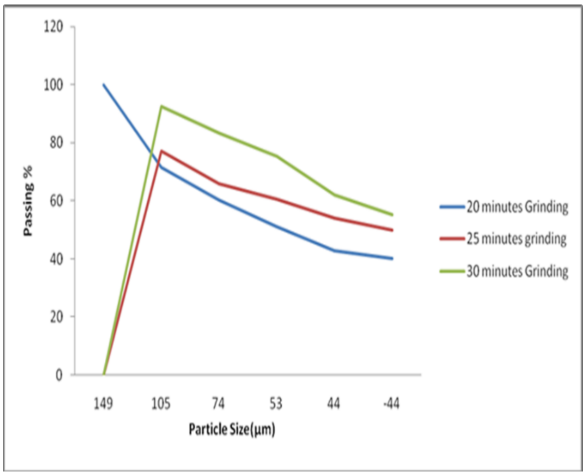


Figure 8. A graphical representation of sieve analysis.

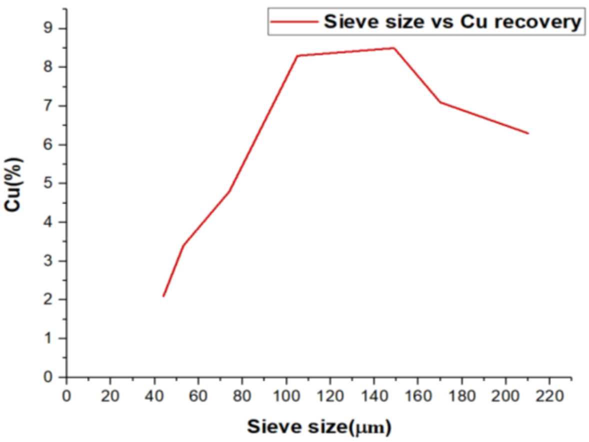


Figure 9. Influence of ore particle size on Cu recovery.

3.7. Froth llotation technique

In this work, the collected copper ore was upgraded using the froth flotation process at a varying dosage of chemical reagents in order to get the optimum dosage, maximum grade, and recovery of copper. The details of the results obtained are discussed in the results and discussion section.

3.8. Results and discussion of comminution studies

It was concluded that the loss of copper was higher in the coarse size range (-210 + 125 μm) and below 44 μm. For the coarser size range, the loss can be compensated by regrinding the material, and the loss in the fine size range can be decreased by reducing an overginding of material. However, between the size range of -75 μm and +44 μm, the percentage of free Fe was higher; it could be deduced that the large percentage of Fe that was depressed was below -44 μm and copper percentage higher in 149 μm.

3.9. Chemical analysis of feed sample

After grinding, three different samples were analyzed by an atomic absorption spectrometer in order to determine the copper grade in the feed. A copper grade of 2.85% was used throughout this research work. Table 2 shows the chemical analysis of the feed sample.

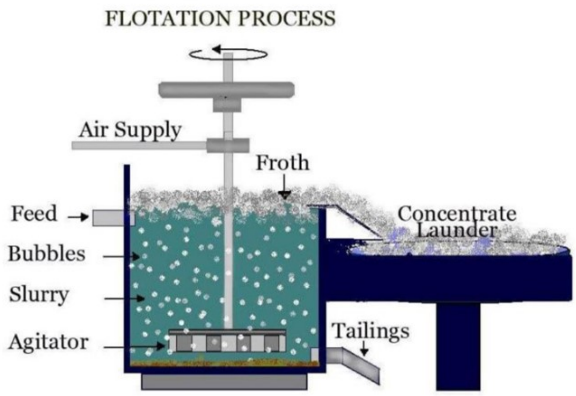


Figure 10. A schematic presentation of froth flotation unit.

Table 2. Chemical analysis of feed sample.

S. No	Cu %	Ag (ppm)	Fe_2O_3 (%)	SiO_2
1	2.85	< 0.5	22	52.9

3.9. Feed preparation for flotation

The flotation feeds were prepared by subjecting the ore samples to primary and secondary crushing, followed by wet grinding. The ground material was then classified and subjected to flotation in steps.

3.10. Froth flotation

A variety of flotation tests were carried out with the purpose of looking at the impacts of the diverse flotation parameters. The studied parameters were the fineness of feed, type and dosage of the collector, dosage of other reagents, and pH of the pulp. The flotation was accomplished via a froth flotation machine. Tap water was used throughout the flotation test. In this work, the froth flotation methods were implemented to locate the most appropriate operating conditions that gave the best recoveries. The flotation reagents were dissolved in tap water, and delivered into the flotation cell in dilute solutions.

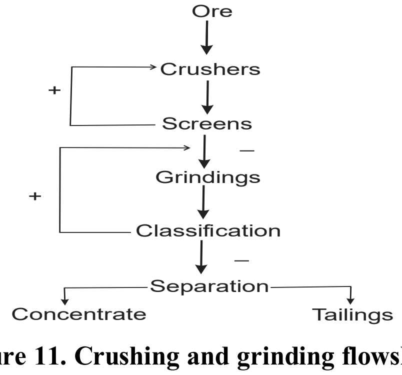


Figure 11. Crushing and grinding flowsheet.

4. Results and discussion

In this section, the experimental work regarding the investigation carried out at the laboratory scale on some of the flotation process parameters such as the effects of varying pH, depressant, frother, collector, conditioning time, flotation time, type of collector, and recovery of chalcopyrite.

In this research work, after grinding, different sieve sizes were studied to obtain the maximum liberation size. The froth flotation was carried out by potassium amyl xanthate and potassium ethyl xanthate as the collector. A total of 26 tests was performed. Out of the total tests, five tests were performed by varying the reagent dosage. After achieving the best dosage of reagents in the next six tests, the dosage of the reagents was kept constant, while the pH of the pulp was varied from 4 to 12. Five tests were carried out on the condition time, five tests on the flotation, and the remaining two tests were performed using potassium amyl xanthate and potassium ethyl xanthate as the collector. All the tests were performed at the Mineral Testing Lab in Peshawar.

4.1. Dosage of collector

PAX (C6H11KOS2) was used for the gold, copper, lead, and zinc mineral flotation processes. The response of potassium amyl xanthate to the grade recovery of the chalcopyrite ore is shown in Figure 13. The curves in this figure show that with an increase in the dosage of the collector (300 g/t), the recovery of the valuable mineral is not much improved. This may be due to the non-specific adsorption of the collector by the gangue particles, and possibly due to the development of collector multi-layers on the particles, reducing the proportion of hydrocarbon radicals oriented into the solution [27]. Thus reducing the grade of the concentrate the critical dosage of potassium amyl xanthate observed at this stage was 3000 g/t.

Figure 12. Laboratory reagents used in flotation.

Table 3. Results of tests by varying dosage of PAX.

Dosage of collectors (g/t)		200	250	300	350	400
Avg. feed grade (%)	**f**	2.85	2.85	2.85	2.85	2.85
Feed weight (g)	**F**	1000	1000	1000	1000	1000
Concentrate grade (%)	**c**	6.45	7.5	22.5	17.2	10.2
Concentrate weight (g)	**C**	192.3	184.5	100.2	120.8	166.5
Tailings grade (%)	**T**	1.7	1.5	0.4	0.6	1.1
Tailing weight (g)	**T**	807.7	815.5	899.1	879.2	834.5
Recovery = Cc/Ff*100 (%)		47.34	52.8	86.049	79.30	64.82

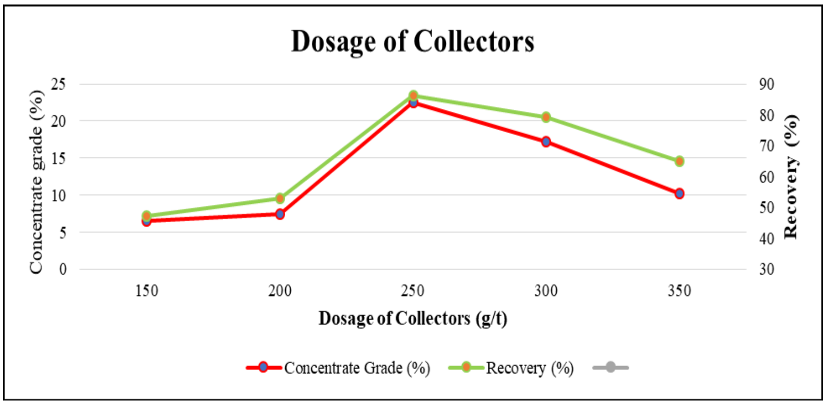


Figure 13. Effect of potassium amyl xanthate on grade and recovery of chalcopyrite ore.

4.2. Dosage of frother

Figure 14 shows that the recovery of chalcopyrite has increased in the presence of pine oil [11, 28]. Beyond that, the grade has been reduced; this may be due to its tendency to float gangue particles.

4.3. Dosage of depressant

The effect of the depressant (Na_2SiO_3) on the grade and recovery of copper ore is shown in Figure 15. The best results were achieved for the depressant dosage of 300 g/t, as shown in Figure 16. Another reason for the increase in the grade and recovery is that it alows functions as dispersant for the silicate minerals and quartz present in the pulp [29, 30]. The recovery slightly decreases beyond 300g/t, which might be due to the formation of brittle froth [27].

Table 4. Results of tests by varying dogase of frother.

Dosage of frother (g/t)		150	200	250	300	350
Avg. feed grade (%)	**f**	2.85	2.85	2.85	2.85	2.85
Feed weight (g)	**F**	1000	1000	1000	1000	1000
Concentrate grade (%)	**c**	6.45	7.5	22.5	17.2	10.2
Concentrate weight (g)	**C**	192.3	184.5	100.2	120.8	166.5
Tailings grade (%)	**T**	1.7	1.5	0.4	0.6	1.1
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Recovery = Cc/Ff*100 (%)		47.34	52.8	86.049	79.30	64.82

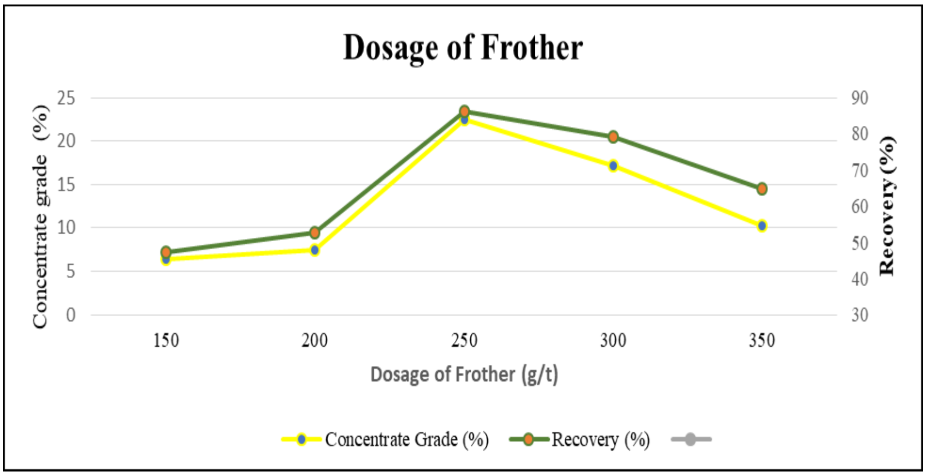

Figure 14. Effect of frother on grade and recovery.

Table 5. Results of tests by varying the dosage of depressant.

Dosage of depressant (g/t)		200	250	300	350	400
Avg. feed grade (%)	**f**	2.85	2.85	2.85	2.85	2.85
Feed weight (g)	**F**	1000	1000	1000	1000	1000
Concentrate grade (%)	**c**	6.45	7.5	22.5	17.2	10.2
Concentrate weight (g)	**C**	192.3	184.5	100.2	120.8	166.5
Tailings grade (%)	**T**	1.7	1.5	0.4	0.6	1.1
Tailing weight (g)	**T**	807.7	815.5	899.1	879.2	834.5
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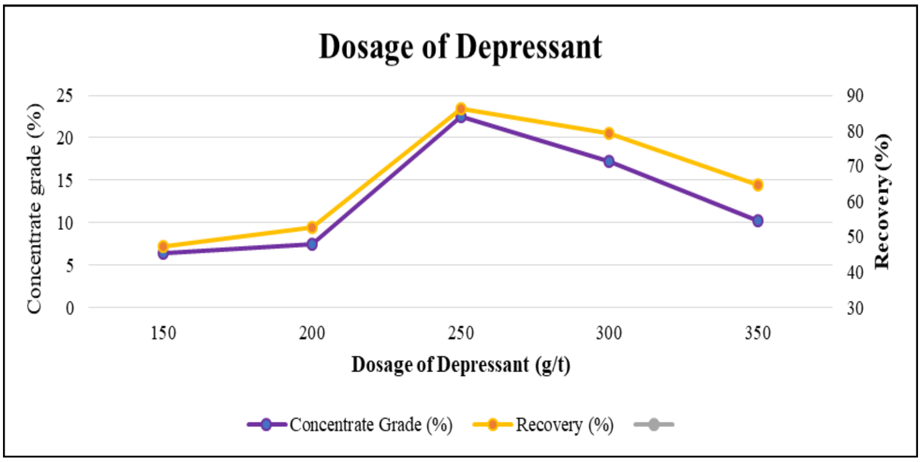

Figure 15. Effect of depressant on grade and recovery of copper.

4.4. Effect of change in conditioning time varaitons

Floatation of the metallic ores is often time-dependent, which plays a vital role in their high recovery and maximum grade [31]. Five tests were conducted for the conditioning time of collectors for 6-14 minutes. The graph obtained indicates that the conditioning time of 10 minutes is better regarding the grade and recovery of copper. Further increasing the conditioning time reduces the grade and recovery due to the dissolution of copper xanthate ions in the equilibrium system [12].

4.5. Effect of change in flotation time

Figure 17 shows the effect of change in the flotation time. This figure shows that the best value of flotation time for the flotation of Killa Saifullah chalcopyrite ore is 6 minutes regarding the grade and 12 minutes regarding the recovery of the mineral. The increase in recovery is at the cost of the decrease in grade of copper concentrate. This is due to some of the gangue mineral particles also included in the concentrate [32].

Table 6. Results of tests by varying conditioning time.

Flotation time		6	8	10	12	14
Avg. feed grade (%)	**f**	2.85	2.85	2.85	2.85	2.85
Feed weight (g)	**F**	1000	1000	1000	1000	1000
Concentrate grade (%)	**c**	18.8	20.9	23.9	16.9	13.8
Concentrate weight (g)	**C**	80.8	88.9	103	96.5	109.5
Tailings grade (%)	**T**	919.2	911.1	807	903.5	890.5
Tailing weight (g)	**T**	1.4	1.05	0.45	1.33	1.5
Recovery = Cc/Ff*100 (%)		53.3	65.2	86	57.2	53.02

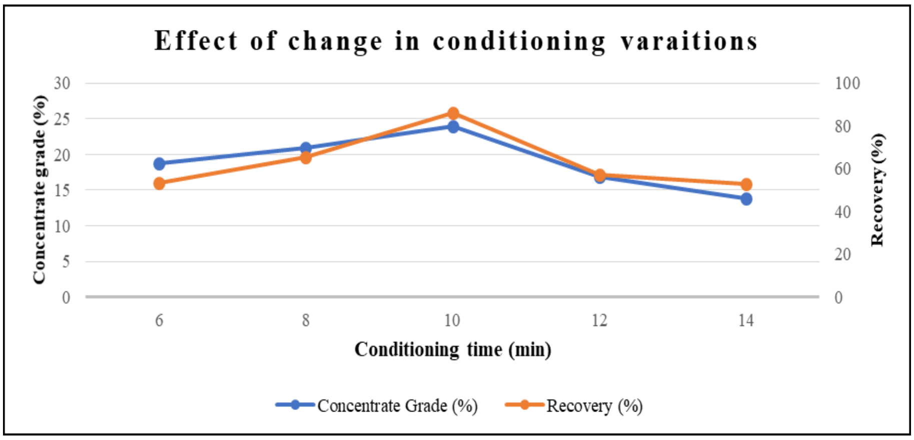

Figure 16. Effect of conditioning time on grade and recovery of copper.

Table 7. Results of tests by varying flotation time.

Flotation time		6	8	10	12	14
Avg. feed grade (%)	**f**	2.85	2.85	2.85	2.85	2.85
Feed weight (g)	**F**	1000	1000	1000	1000	1000
Concentrate grade (%)	**c**	23.8	21.3	18.2	16.7	15.1
Concentrate weight (g)	**C**	90.9	98.3	106.5	130.2	120
Tailings grade (%)	**T**	0.72	0.8	0.99	0.75	1.21
Tailing weight (g)	**T**	909.1	901.7	893.5	869.8	892.1
Recovery = Cc/Ff*100 (%)		75.9	73.4	68.01	76.3	63.6

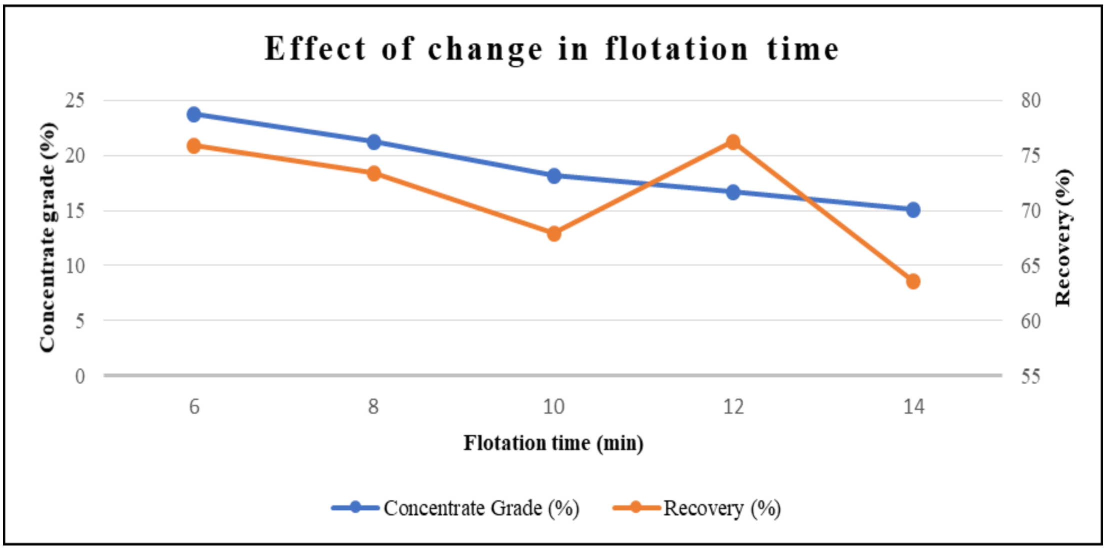

Figure 17. Effect of change in flotation time on grade and recovery of chalcopyarite.

4.6. Effect of variation in pH

In the earlier tests, the pH was kept at 9, and potassium hydroxide ions participated in the depression effect on pyrite by formation of mixed films of Fe (OH) and FeO (OH), so reducing the adsorption of xanthate on the Fe and gangue minerals (Kelly *et al*., 1982). It is evident from Figure 18 that pH of 10 gives the optimum grade and recovery [27]. However, beyond pH of 10, the grade and recovery were considerably decreased. This is due the deactivation of KOH on the copper minerals.

4.7. Effect of type of collector

Two different types of collectors, namely potassium amyl xanthate and potassium ethyl xanthate were used. The results obtained are shown in Figure 19, which indicate that potassium amyl xanthate is a more suitable collector for Killa Saifullah copper ore for the flotation process regarding the grade and recovery.

Table 8. Results of tests by varying pH of pulp.

Value of pulp pH		4	8	9	10	11	12
Avg. feed grade (%)	f	2.85	2.85	2.85	2.85	2.85	2.85
Feed weight (g)	F	1000	1000	1000	1000	1000	1000
Concentrate grade (%)	c	6.3	7.5	12.1	21.5	17.4	12.5
Concentrate weight (g)	C	180	170.5	160.5	113.2	135.5	158.2
Tailings grade (%)	T	1.8	1.6	0.8	0.2	0.3	0.75
Tailing weight (g)	T	820	829.5	839.5	886.8	864.5	841.8
Recovery = Cc/Ff*100 (%)		43.00	48.00	74.12	92.89	89.9	75.47

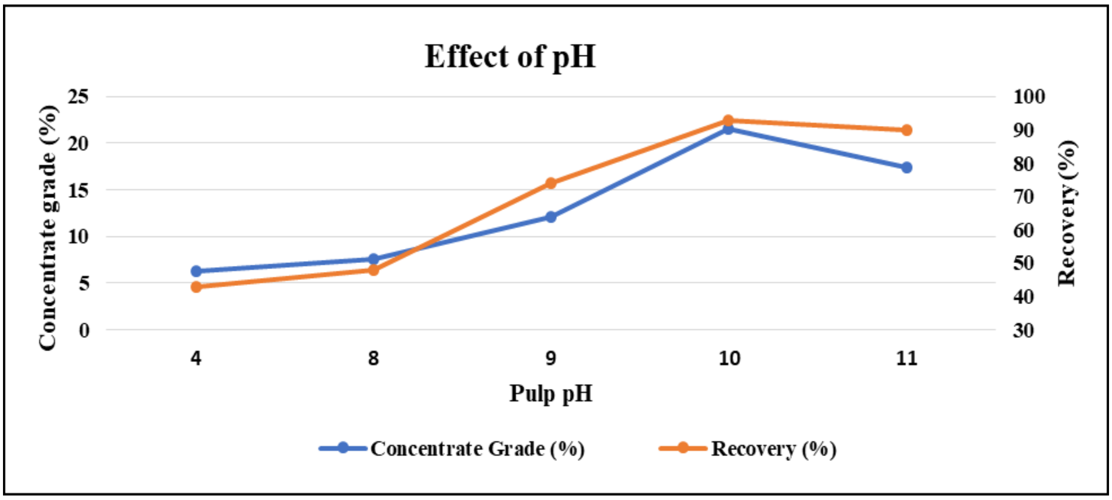

Figure 18. Effect of pH on grade and recovery of chalcopyrite ore.

Table 9. Results of tests by varying type of collector.

Types of collector		Potassium amyl xanthane	Potassium ethyl xanthane
Avg. feed grade (%)	**F**	2.85	2.85
Feed weight (g)	**F**	1000	1000
Concentrate grade (%)	**C**	22.0	14.0
Concentrate weight (g)	**C**	111.0	144.0
Tailings grade (%)	**T**	0.2	0.7
Tailing weight (g)	**T**	889.0	854.0
Recovery = Cc/Ff*100 (%)		93.2	76.9

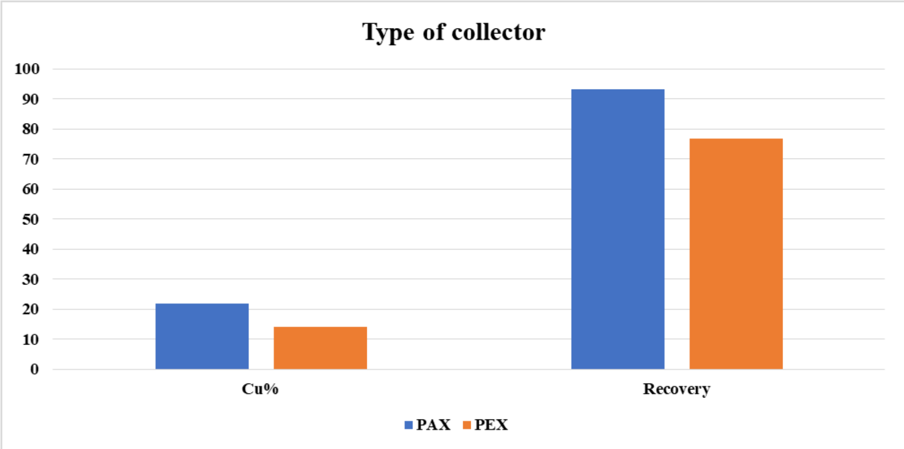

Figure 19. Effect of type of collctor on the grade and recovery of chalcopyrite ore

5. Conclusions

Durring this research work, the chalcopyrite copper ore from the Qilla Saifullah region of Balochistan in Pakistan was used to examine the most sutaible conditions for the recovery of copper by the froth flotation technique. In consideration of the experimental results, the following conclusions could be drawn:

1. Chalcopyrite (CuFeS2) was the main copper mineral in the test sample.
2. Other minerals occurred as common ions were Fe and SiO2.
3. The results of the flotation tests showed that sulfide copper ore of Qilla Saifullah region was acquiescent to be concentrated by flotation. The copper concentrate with a higher grade and recovery could be obtained using potassium amyl xanthate as the collector. Using potassium amyl xanthate as the collector, a copper concentrate having 22% Cu was obtained with 93.2% copper recovery, with conditioning and flotation of 10 and 6 minutes, respectively.
4. The optimum conditions for froth flotation were 30 minutes grinding with an optimum liberation size of 149 μm.
5. The maximum recovery was 92.89% for pH 10.
6. The best collector dosage was 300 g/t for a maximum copper recovery of 86.049%.
7. The optimum dosage of depressant and frother were, respectively, 300g/t and 300g/t for the maximum recovery of copper.

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بهینه سازی پارامترهای فرآیند برای برانگیختن عیار بالای سنگ معدن قیله سیف الله با استفاده از تکنیک فولیتاسیون کف

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چکیده:

در این کار، بر روی حد بالای عیار سنگ معدن مس قیلا سیف الله در پاکستان با استفاده از تکنیک فولیتاسیون کف تمرکز شده است. آنالیز شیمیایی نمونه سنگ معدن مس نشان دهنده وجود ۲/۸۵٪ مس، ۲۲٪ Fe_2O_3، SiO_2 ۵۲/۹٪ و سایر کانیهای جزئی است. زمان بهینه آسیاب و اندازه خردایش سنگ مس به ترتیب ۳۰ دقیقه و۱۰۵ تا ۱۴۹ میکرومتر برای پردازش بیشتر تعیین شده است. معرفهای شیمیایی به منظور به دست آوردن حداکثر درجه و بازیابی سنگ معدن بهینه شده‌اند. پس از مقایسه و تجزیه و تحلیل نتایج بدست آمده، می‌توان نتیجه گرفت که حداکثر عیار و بازیابی سنگ مس در دوز (g/t) ۳۰۰جمع کننده پتاسیم آمیل گزانتات ($C_6H_{11}KOS_2$)، (g/t) ۲۵۰روغن کاج، (g/t) ۲۵۰گرم بر تن ماده تنش‌زا (Na_2SiO_3)، زمان تهویه ۱۰ دقیقه برای کلکتور، زمان فولتاسیون ۶ و ۱۰ دقیقه و pH ۱۰ با استفاده از تکنیک شناورسازی کف به دست می‌آید.

کلمات کلیدی: کالکوپیریت، فولیتاسیون کف، سنگ معدن، اکسید آهن، سنگ معدن قیله سیف الله.