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Application of Aeration to Complex Sulphide Ore and its Effects on Circuit Performance

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ABSTRACT: Clastic ore is one of the complex sulphide ores found in the Çayeli deposit. It is the most difficult ore to treat and is processed in separate campaigns. The copper concentrates produced contain 19-20% copper and 9-10% zinc. In order to improve copper concentrate quality, a decision was made to try aeration. Laboratory-scale aeration and flotation tests were carried out in order to optimise aeration conditions. Based on the laboratory tests, aeration was put into practice with existing aeration cells in the plant. In this study, the laboratory and plant results are presented, and the effect of aeration on the plant metallurgy is discussed.

1 INTRODUCTION

The Çayeli ore deposit is volcanogenic massive sulphide. Clastic ore is one of the ore types found in the Çayeli deposit and is characterized by an abundance of fine-grained (less than 50 u:m), generally anhedral, sulphide debris. The ore consists of rounded pyrite, chalcopyrite and sphalerite clasts İn a matrix of fine-grained sphalerite, pyrite, chalcopyrite and barite. The clast size varies from 5 mm to greater than 50 mm, but the sphalerite clasts are generally larger than the pyrite and chalcopyrite clasts. Fine complex intergrowths are common. Most of the pyrite is framboidal to colloform, and sometimes occurs in aggregates, but may also occur as fine (20-50 pm) subhedral/euhedral crystals. Typical grades of the clastic ore are 3% copper and 13% zinc. The ore is not only fine-grained, but also contains abundant fine mineral intergrowths and inclusions, and requires fine grinding.

Flotation collectors, modifiers and grinding medium can substantially lower the oxygen content of the pulp (Jones and Woodcock, 1984). A lack of oxygen in the pulp sometimes adversely affects the floatability of the minerals. Sometimes aeration of the pulp restores the oxygen concentration. Air acts as a flotation reagent when it is used before the conditioning step with reagents either improving or reducing mineral floatability. For example, flotation tests on chalcopyrite and galena from Black Mountain ore indicated that aeration of the pulp resulted İn improvement of copper metallurgy (Graham and Heathcote, 1982; Ross and Van Deventer, 1985). Pyrite depression is a typical example of the depressive effect of aeration (Konigsman, 1973; Kristall et al., 1994; Houot & Duhamel, 1990). Some successful plant applications of aeration have been reported for pyrite depression (Konigsman, 1973; Carlson & Muir, 1976; Spira & Rosenblum, 1978).

The clastic ore contained a significant amount of pyrite (>50%). Therefore, it was decided to apply aeration to the clastic ore in order to improve concentrate quality by enhancing pyrite depression. In order to test this hypothesis, laboratory flotation tests were carried out. In Üiis study, the laboratory tests and plant trial results are presented and the impact of the aeration on metallurgy is discussed.

2 METHOD

2.1. *Laboratory lests*

The clastic ore samples used in the experimental study were taken from primary ball mill feed in September 1999. The grade of the ore was 4.8% copper and 10.4% zinc. According to previous plant experience, processing such ores caused selectivity problems in the copper circuit.

The ore samples were ground in a laboratory rod mill and a Humbold Wedag-type laboratory flotation machine was used in the aeration and flotation stages.

Sodium metabisulphite (Na2S20s) was used in the laboratory tests as a sphalerite and pyrite depressant instead of the SO2 applied m the plant due to handling difficulties. Aerophine {Cytec 3418A) was used as a collector.

2.2. *Plant application*

Aeration was first applied in the December 1999 clastic campaign and continued in the year 2000 campaigns with the existing aeration unit in the plant. This unit consists of three 45-m^3 cells equipped with an original Dorr Oliver rotor stator mechanism. The maximum air rate to the aeration unit is 6000 m^3/h.

The plant data were evaluated so as to determine statistically significant differences in the metallurgy with aeration. Results for the copper rougher, zinc rougher, and overall circuit metallurgy were used İn these evaluations.

3 RESULTS

3.1 *Laboratory test results*

3.1.1. *Effects of aeration*

The test results showed that aeration improves copper and zinc grades and recoveries in the rougher stage (Table 1). Although zinc recovery increases with aeration, selectivity is better due to the increased copper recovery, especially at pH 11.5. As shown in Table 2, the main effect of aeration observed was the depression of pyrite particles, so the relative amount of sphalerite and chalcopyrite particles in the copper concentrate increased.

Table I Effects of Aeration on Metallurgy

pH	Aeration (nun)	Cu%	Zn%	Cu recovery %	Zn recovery %
12.0	20	1075	1271	82.09	48.18
12.0	-	5.87	5.56	66.34	36.75
11.5	20	10.45	9.82	78.63	34 36
11.5	-	5.38	5.78	53.60	27.19

' Flotation Conditions; Rougher stage: $Na_2S_2O_s$ (1.5 kg/t), 3418A(90g/t), 10 min flotation.

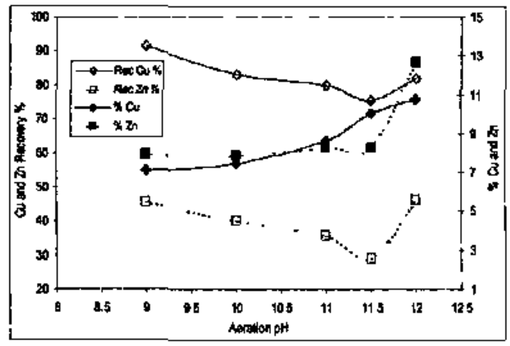
Table 2. Effects of Aeration on Pyrite Depression".

PH	Aeration (mm)	Cu recovery %	Zn recovery %	Fe recovery %
12.0	30	85 11	62.41	39 25
12.0		66.34	36.75	69.05

' Flotation Conditions; Rougher stage- $Na_2SïO_s$ (1.5 kg/t), 3418A(90g/t), 10 min flotation

3.1.2. *Effects ofpHduring aeration*

The effects of aeration pH on metallurgy are given in Figure 1. In these tests, the aeration pH was adjusted at the beginning of aeration with lime addition. An increase İn aeration pH resulted in a decrease in copper and zinc recoveries. The copper grade tended to increase with pH. At pH 11.5, the lowest level of zinc recovery was obtained.



Figure! Effect of Aeration pH on Metallurgy.

3.1.3. *Effects of aeration time*

The effects of the duration of aeration on copper and zinc recovery are given in Figure 2. Copper recovery was improved with aeration. Zinc recovery was also improved with aeration but to a lesser extent. Aeration times of over 20 min increased zinc recovery. However, zinc recovery did not increase at pH11.5.

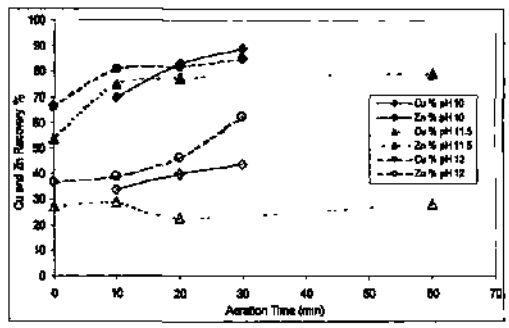


Figure 2. Effect of Aeration time on Metallurgy.

Based on the test results, aeration was put into practice using the procedure applied İn the laboratory (Figure 3).

3.2 *Plant results*

In the plant, grinding was performed without any chemical additions such as time or depressants. The secondary cyclone overflow was fed to the first aeration cell. Lime was added to the first cell and the pH was adjusted to 11.5. At the start of the plant trial, the total air rate was adjusted to 4500 m'/h and then decreased to 2700 m^3/h. It was observed that copper recovery in copper rougher deteriorated at high air rates probably due to oxidation of chalcopyrite. At the end of the aeration stage, the pH dropped to 10. After the aeration stage, the pulp was conditioned with SO2 (-1 kg/t), followed by collector addition. The flotation pH was 7-7.5.

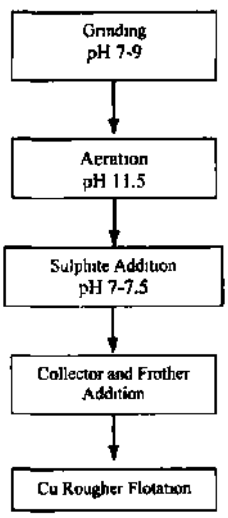


Figure 3. Experimental procedure.

3.2.1. *Rougher copper and zinc concentrate*

The effects of aeration on copper rougher and zinc rougher are given in Table 3. In this table, iron grade was used as an indication of pyrite content.

The results were analyzed using F and t-test statistics at a confidence level of 95% (Underhill & Bradfield, 1994). Statistical analysis showed that the zinc and iron grades were not significantly different. However, the increase in the copper grade in the application of aeration was statistically significant. The copper, zinc and iron recoveries were lower than those with the previous processing method and the decreases in recoveries were also statistically significant. Sphalerite and pyrite rejection improved with aeration, but chalcopyrite recovery dropped 4%.

The rougher zinc concantrate was affected positively by aeration. Both zinc grade and recovery improved, and these improvements were statistically significant. This was due to better zinc rejection in the copper rougher circuit and efficient pynte depression.

Another indication of pyrite rejection was the reduced tonnage recovered in the rougher copper and zinc concantrate. The reduction in the copper rougher and zinc rougher concentrate tonnages were 5.7% and 4.7%, respectively.

Table 3. Copper Rougher and Zinc Rougher Performances with Aeration.

Rougher Copper	Concentrate Grade %			Recovery %		
	Cu	Zn	Fe	Cu	Zn	Fe
Aeration	15.0	9 8	28.2	74.0	18 3	22.6
Previous	135	J 0.4	29.0	78 1	23.3	28.6

Zinc Rougher	Concentrate Grade %			Recovery %		
	Cu	Zn	Fe	Cu	Zn	Fe
Aeration	2 84	30.7	18 9	21.6	78.5	20.7
Previous	2.44	27.1	21 8	177	73.3	26.7

3.2.2. *Overall circuit metallurgy*

The effects of aeration on overall copper and zinc circuit metallurgy are given in Table 4. The decreases in the copper grade, and copper, zinc and iron recoveries in the final copper concentrate were significant. Although a higher copper grade was not obtained, (he zinc and iron rejections increased with aeration.

Table 4. Copper and Zinc Circuit Performances with Aeration.

Final Cu Concentrate	Concentrate Grade %			Recovery %		
	Cu	Zn	Fe	Cu	Zn	Fe
Aeration	19.3	9.1	28 3	62 9	9.9	13 6
Previous	20.4	9.4	28.3	68 4	11.3	150

Final Zn Concentrate	Concentrate Grade %			Recovery %		
	Cu	Zn	Fe	Cu	Zn	Fe
Aeration	3.0	510	75	13.3	75.8	5.0
Previous	3.1	49.1	9.4	13.6	73.3	6.4

The decreases in copper grade and recovery in the final copper concentrate could be due to:

j. lower copper feed grades (3.77+0.17 in aeration and 4.16±0.23 in previous campaigns without aeration, at a confidence level of 95%);

iL Difficulties of circuit adjustments during short clastic campaigns;

Hi. Lack of operator experience with the aeration scheme.

Another important feature observed in the application was the sensitivity of the copper rougher tail to air rate in the aeration cells. The increase in rougher tail resulted in a decrease in rougher recovery and copper circuit recovery. As mentioned above, clastic ore contains abundant fine mineral intergrowths and inclusions. As a result, chalcopyrite-pyrite locked particles might be depressed by oxidation due to its pyrite content and lost in the rougher tail.

The most pronounced effect of aeration was obtained in the zinc circuit. Both zinc grade and recovery increased significantly. The zinc concentrate quality was improved, zinc grade increased and the iron content of the concentrate decreased due to pyrite rejection. Zinc recovery in the final zinc concentrate also increased. Lower zinc recovery in the copper rougher improved zinc recovery in the zinc circuit. In addition, depressed pyrite particles in the copper rougher did not float in die zinc rougher and were rejected in the zinc rougher tail. Thus, the amount of pyrite particles recovered in the rougher zinc concentrate decreased and resulted in improved final zinc concentrate quality.

4 CONCLUSIONS

The zinc circuit metallurgy improved with aeration. Improvement in copper metallurgy was not obtained as expected with better zinc and pyrite rejection in the circuit. Due to the limited durations of the clastic campaigns and the ore variability, CBI intends to use aeration to investigate whether improvements in copper metallurgy can also be achieved with operating experience and circuit tuning.

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