BENEFICIATION OF COLEMANITE TAILINGS

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ABSTRACT

Two different boron plant tailings, taken from classificator sands and tailing dam, were re-evaluated by scrubbing + screening and flotation tests. The effects of pulp density and scrubbing time were investigated in scrubbing + screening tests, while the effect of collector dosages was examined in flotation tests. Additionally, the influence of slime coatings on flotation behavior of colemanite samples was examined. Flotation method was found to be more effective for both samples. A concentrate with 46.24% B_2O_3 content was obtained with 66.9% recovery at the end of flotation of classificator sand. A concentrate containing 40.38% B_2O_3 was produced with 60.7% recovery under the optimum flotation conditions carried out on the sample taken from tailing dam.

INTRODUCTION

Boron minerals are generally concentrated by washing attritioning methods followed by screening and classification to remove clay minerals in industrial scale. Colemanite, which is one of the boron minerals, is calcium containing hydrated boron minerals ($Ca_2B_6O_{11}.5H_2O$) and Turkey is the world's major source of high-grade colemanite (Kistler and Helvacı-1994). Although Turkey has large deposits of boron minerals, such as colemanite, there are considerable amount of plant tailings containing 20-30% B_2O_3 (Kaytaz-1987). Thus, it is important to re-evaluate these tailings due to the difficulties involved in their stockpiling and the environmental pollution they create. Their evaluation will be economically beneficial since it will not require additional mining cost.

Colemanite can be beneficiated by using different methods, such as attritioning + classification, heat treatment, electrostatic separation and flotation (Kaytaz-1987, Arslan et. al. -1999, Çelik et.al. -1993, Akdağ et.al. -1996, Çelik et.al. -1998, Girgin et al.-2000, Yaşar et. al.-1994, Özkan and Veasey-1994). Flotation and electrokinetic properties of colemanite have been studied by several researchers (Çelik et al.-1998, Yaşar et.al.-1994, Özkan and Veasey-1994, Koca and Savaş-1998). According to these studies, colemanite could be readily floated either by anionic (sulphonates) or cationic (amines) collectors and exhibits an isoelectric point at high pH values, such as pH 10.5.

The aim of the present study was to investigate the beneficiation possibilities of colemanite tailings by using scrubbing + screening and flotation methods.

EXPERIMENTAL AND MATERIAL

Two different samples, taken from classificator sands and tailing dam of Eti Holding Bigadiç Colemanite Concentration Plant, Turkey, were subjected to this experimental study; According to the mineralogical examinations, it was found that both samples contain colemanite as the main mineral. Calcite, quartz and some clay minerals also exist in minor quantities. Chemical composition of samples is given in Table I and size distribution of samples is shown in Table II and III.

Table I. Chemical analyses of colemanite samples.

Element (%)	Sample (Classificator sand)	Sample (Tailing dam)
B_2O_3	31.27	22.68
SiO_2	8.20	14.12
Fe_2O_3	0.14	0.21
Al_2O_3	0.22	0.38
CaO	27.41	25.62

As it is seen from Table I the samples were taken from classificator sand and tailing dam contain 31.27% B_2O_3 and 22.68% B_2O_3, respectively.

Table II. Size distribution of sample taken from classificator sand.

Size Fraction (mm)	Weight (%)	Cumulative Oversize (%)	Cumulative Undersize (%)
+6	4.2	4.2	100.0
-6+2.83	23.0	27.2	95.8
-2.83+1	44.1	71.3	72.8
-1+0.5	14.8	86.1	28.7
-0.5+0.297	4.6	90.7	13.9
-0.297+0.210	2.0	92.7	9.3
-0.210+0.105	1.4	94.1	7.3
-0.105+0.074	0.3	94.4	5.9
-0.074	5.6	100.0	5.6
Total	100.0		

Table III. Size distribution of sample taken from tailing dam.

Size Fraction (mm)	Weight (%)	Cumulative Oversize (%)	Cumulative Undersize (%)
+1	6.1	6.1	100.0
-1+0.5	23.0	29.1	93.9
-0.5+0.297	21.7	50.8	70.9
-0.297+0.210	15.1	65.9	49.2
-0.210+0.149	6.7	72.6	34.1
-0.149+0.105	6.4	79.0	27.4
-0.105+0.074	3.3	82.3	21.0
-0.074	17.7	100.0	17.7
Total	100.0		

Screening tests indicated that the tailing dam sample has a finer size distribution than classificator sand and d_{80} particle size of tailing dam is 0.7 mm while it is 3.4 mm for classificator sand.

Scrubbing + screening and flotation tests were carried out for concentrating these samples, separately. Effect of pulp density and scrubbing time were investigated in scrubbing + screening tests. Scrubbing was followed by fine screening (0.074 mm). Fine clay minerals can pass readily below this size and over size is defined as concentrate according to chemical analyses.

Dosage of sulphonate types collectors namely R-801 and R-825 was determined in the flotation tests in which pine oil was used as frother. The flotation test samples were ground below 0.297 mm by using a ball mill. The effect of slimes was also investigated in the flotation tests with and without applying desliming process.

RESULTS AND DISCUSSION

In scrubbing + screening test with sample taken from classificator sand, pulp density was changed as 40, 50, 60 and 70% at 5 minutes constant scrubbing time. Figure 1 shows the effect of pulp density on classificator sand and pulp density was determined as 50% from the test results.

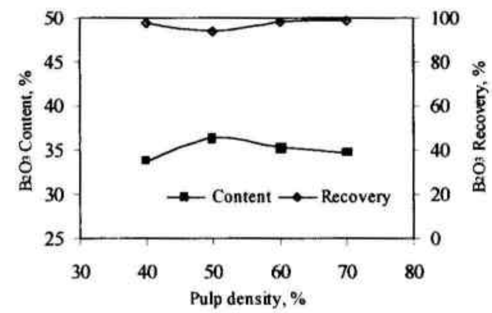

Figure 1. Effect of pulp density on scrubbing of classificator sand.

Scrubbing time was also changed as 5, 10, 20 and 30 minutes at the 50% of pulp density. Figure 2 illustrates the effect of scrubbing time on the sample taken from classificator sand.

50% pulp density and 30 minutes scrubbing time were chosen as the optimum conditions. Under this optimum conditions, a concentrate containing 38.92% B_2O_3 was produced with 82.8% recovery as a result of scrubbing + screening tests carried out with classificator sand.

In the scrubbing + screening tests conducted on the sample taken from the tailing dam, pulp density was taken as 40, 50 and 60% and scrubbing time was kept constant as 30 minutes.

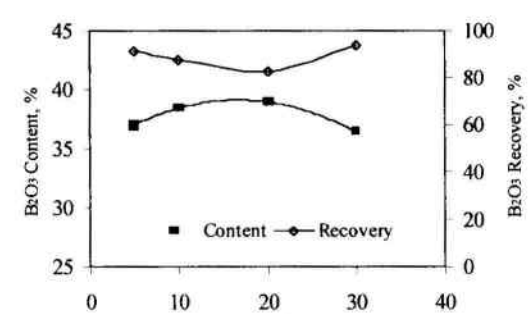

Figure 2. Effect of time on scrubbing of classificator sand.

The effect of pulp density is shown in Figure 3. As a result of these experiments, pulp density 50% was chosen as an optimum. Scrubbing tests were performed to examine the effect of time. 5, 15, 30 and 60 minutes of scrubbing time of were used at a constant pulp density (50%).

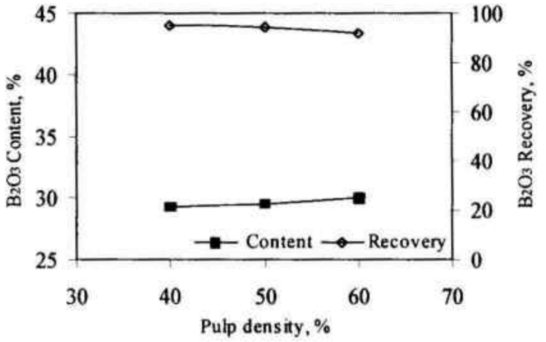

Figure 3. Effect of pulp density on scrubbing of tailing dam sample.

Figure 4 shows the effect of time on scrubbing of the sample taken from tailing dam and 30 minutes was determined as an optimum.

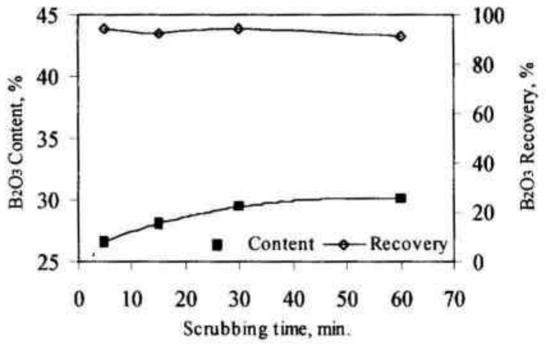

Figure 4. Effect of time on scrubbing of tailing dam sample.

As a result of scrubbing + screening tests conducted on the sample taken from tailing dam, a concentrate with 29.45% B_2O_3 content was obtained with 94.5% recovery.

Flotation experiments were carried out with classificator sand and tailing dam sample. Flotation tests were conducted in Denver flotation machine at the constant conditions such as pH: 8-8.5, pine oil concentration: 120 g/l, conditioning time: 10 minutes, and flotation time: 5 minutes. R-801 and R-825 sulfonates types collectors were used together in the experiments, while ones dosage was changed and the others was kept constant. In the experiments to investigate the effect of collector dosage, the samples were deslimed prior to tests.

Figure 5 shows the effect of R-825 dosage on classificator sand sample and R-801 amount was kept constant as 0.5 kg/t.

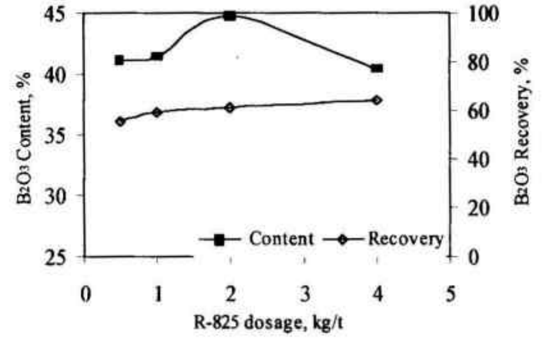

Figure 5. Effect of R-825 dosage on classificator sand.

Figure 6 indicates the effect of R-801 dosage on classificator sand and this time, R-825 dosage was kept constant as 2 kg/t.

Optimum collector dosages were found as 2 kg/t R-825 + 1 kg/t R-801 for classificator sand. A concentrate of 46.24% B_2O_3 content with 66.9% recovery was produced by flotation at the optimum conditions.

Figure 7 indicates the effect of R-825 dosage on tailing dam sample and the amount of R-801 was taken as 0.5 kg/t.

Figure 8 illustrates the effect of R-801 dosage on tailing dam sample and R-825 amount was kept constant at 1 kg/t.

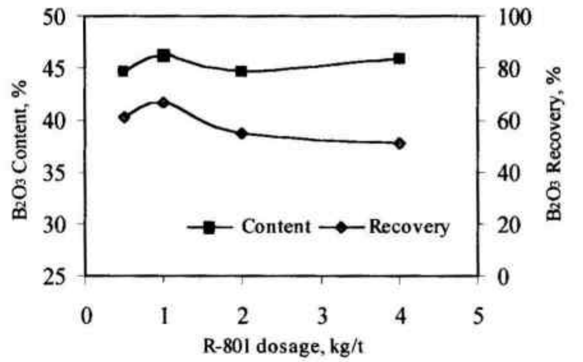

Figure 6. Effect of R-801 dosage on classificator sand.

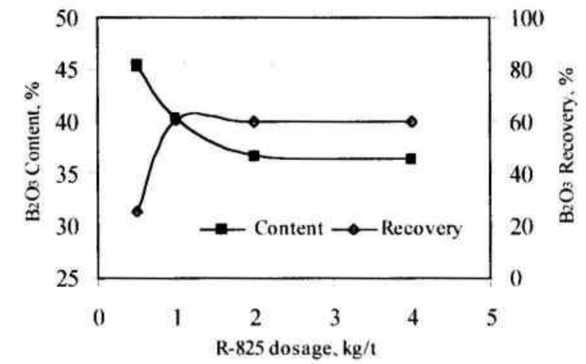

Figure 7. Effect of R-825 dosage on tailing dam sample.

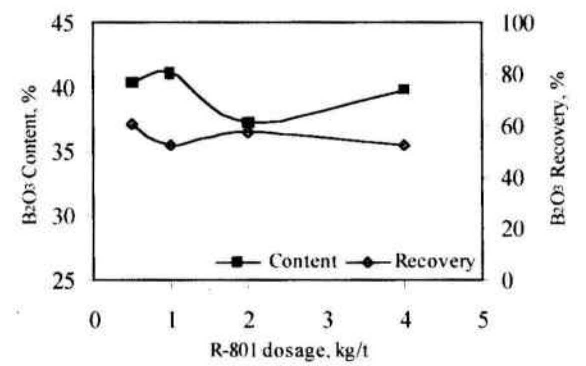

Figure 8. Effect of R-801 dosage on tailing dam sample.

Optimum collector dosages were determined as 1 kg/t R-825 + 0.5 kg/t R-801 for the sample taken from tailing dam. A concentrate of 40.38% B_2O_3 was produced with 60.7% recovery as a result of flotation test carried out with the sample under the optimum conditions.

Flotation tests were found to be more successful than scrubbing + screening tests for both of samples. Although scrubbing method is more effective for removing clay minerals from colemanite concentrates, flotation is an effective method for removing all gangue minerals. Test results of clasificator sand were more satisfactory due to having fewer amounts of clay minerals.

Effect of slime on the flotation tests was investigated. Deslimed and undeslimed samples were floated under the same conditions. Table IV shows the effect of desliming for classificator sand. 2 kg/t R-825 + 2 kg/t R-801 collector additions were used.

Table IV. Desliming effect on the flotation of classificator sand.

Method	Products	Wt (%)	B_2O_3 (%)	Recovery (%)
Deslimed Sample	Concentrate	38.4	44.67	55.0
	Slimes	55.1	25.29	44.6
	Tailings	6.5	1.97	0.4
	Total	100.0	31.22	100.0
Undeslimed Sample	Concentrate	78.2	34.01	85.0
	Tailings	21.8	21.54	15.0
	Total	100.0	31.29	100.0

Results given in Table IV indicate that a concentrate assaying 44.67% B_2O_3 could be obtained with 55% recovery when the sample was deslimed. On the other hand, only a concentrate containing 34% B_2O_3 was produced without desliming process.

Table V presents the results of flotation tests with deslimed and undeslimed sample taken from tailing dam in which 1.0 kg/t R-825 +2 kg/t R-801 collectors were used.

Table V. Desliming effect on the flotation of tailing dam sample.

Method	Products	Wt (%)	B_2O_3 (%)	Recovery (%)
Deslimed Sample	Concentrate	35.0	37.02	57.3
	Slimes	54.1	17.47	41.8
	Tailings	10.9	1.94	0.9
	Total	100.0	22.62	100.0
Undeslimed Sample	Concentrate	50.6	26.03	58.4
	Tailings	49.4	19.00	41.6
	Total	100.0	22.56	100.0

A concentrate assaying 37.02% B_2O_3 was obtained with 57% recovery by applying desliming method while the concentrate containing 26% B_2O_3 was floated when undesliming sample was used.

Both Tables (IV and V) demonstrate that an effective colemanite flotation could not be achieved with undeslimed samples. In the flotation of deslimed sample, B_2O_3 content of concentrate increased, however recoveries decreased due to material loss. For the classificator sand sample; flotation recovery decreased by 30% when the sample was deslimed and for the tailing dam sample; it decreased only by %1 even if the content of slimes are almost the same in both samples (55% slimes in classificator sand and 54% in tailing dam sample). The reason for this is that the slimes of classificator sand includes more amount B_2O_3 than slimes of tailing dam sample.

CONCLUSION

As a result of investigations on the tailings taken from classificator sand (31.27% B_2O_3) and tailing dam (22.68% B_2O_3), the following results are obtained by applying scrubbing + screening and flotation tests:

A concentrate containing 38.92% B_2O_3 was produced with 82.8% recovery as a result of scrubbing + screening tests carried out on classificator sand. By flotation at the optimum conditions, a concentrate of 46.24% B_2O_3 content was produced with 66.9% recovery.

As a result of scrubbing + screening test conducted on the sample taken from the tailing dam, a concentrate with 29.45% B_2O_3 content was obtained with 94.5% recovery, while a concentrate assaying 40.38% B_2O_3 could be obtained with 60.7% recovery by flotation test carried out at the optimum conditions.

It was found that both samples can be floated more effectively by applying desliming process because of its preventing effect on slime coating.

For the classificator sand samples, both processes can be economically applied in industrial scale, since there is no cost for the ore production, crushing, and screening. Additionally, less amount of tailings will be collected in tailings dam.

For the tailing dam sample, again both processes could be used. But, If scrubbing tests are considered, the concentrate produced could marketted by mixing with rich concentrates. As a result of flotation tests, a marketable concentrates are produced. Similar advatages are also considered here.

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