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ENHANCEMENT OF COLEMANITE FLOTATION BY ULTRASONIC PRE-TREATMENT

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Abstract. Ultrasonic treatment methods are widely used for surface cleaning purposes prior to application of flotation. In this study, enhancement possibility for colemanite recovery was investigated with use of an ultrasonic bath prior to flotation. Representative colemanite ore samples from Hisarcik and Espey open pit mines, located in Emet, Turkey were used for this purpose. Ultrasonic flotation experiments were carried out by using circularly shaped RK-106 model of ultrasonic bath with constant frequency and power, manufactured by Bandelin GmbH in Germany and Denver Sub-2A type flotation machine with an impeller speed of 1200 rpm and 1 cubic decimeter capacity. The reagent for colemanite flotation was Cytec-R825 with variable dosages during conventional and ultrasonic flotation experiments. The results showed that ultrasonic pre-treatment helps desliming and hence yields more borate recovery in floated part with lower borate content in tailing than under conventional flotation conditions by using similar reagent dosages.

keywords: colemanite flotation, ultrasound, ultrasonic pre-treatment, desliming, borates

1. Introduction

Froth flotation process can be influenced by a large number of material, chemical, equipment and operational variables. Changing one of these variables certainly affects the results of flotation, such as grade and recovery significantly. Ultrasound is one of the important treatment methods used to advance the flotation process (Stoev, 1992; Ozkan and Gungoren, 2010).

Chemical effects of ultrasonic treatment in a flotation system are characterized by cavitation and are accompanied by a local increase in pressure and temperature. As solid/liquid interactions are weaker than liquid cohesion forces, solid/liquid interfaces are more amenable to the formation of cavitation. The unsettled conditions occurred at a solid/liquid interface can modify the surface properties of minerals, leading to changes in the adsorption of collectors on minerals and accordingly in their flotation responses. However, dispersive effects occur when ultrasound is applied to a pulp containing a stabilizer such as a surfactant. This phenomenon ends with the formation of an emulsion. Ultrasonic treatment can improve the effectiveness of a reagent due to more uniform distribution in the suspension and also in enhancement of the activity of

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the chemicals used (Celik, 1987; Cilek, Ozgen, 2010, Letmahe et al., 2002; Mitome, 2003; Ozkan and Kuyumcu, 2006, 2007).

In this study colemanite flotation was optimized by conventional evaluation methods such as grade-recovery curves considering some of the material characterization tests, i.e. zeta potential measurements, and the results were compared with ultrasonic flotation data.

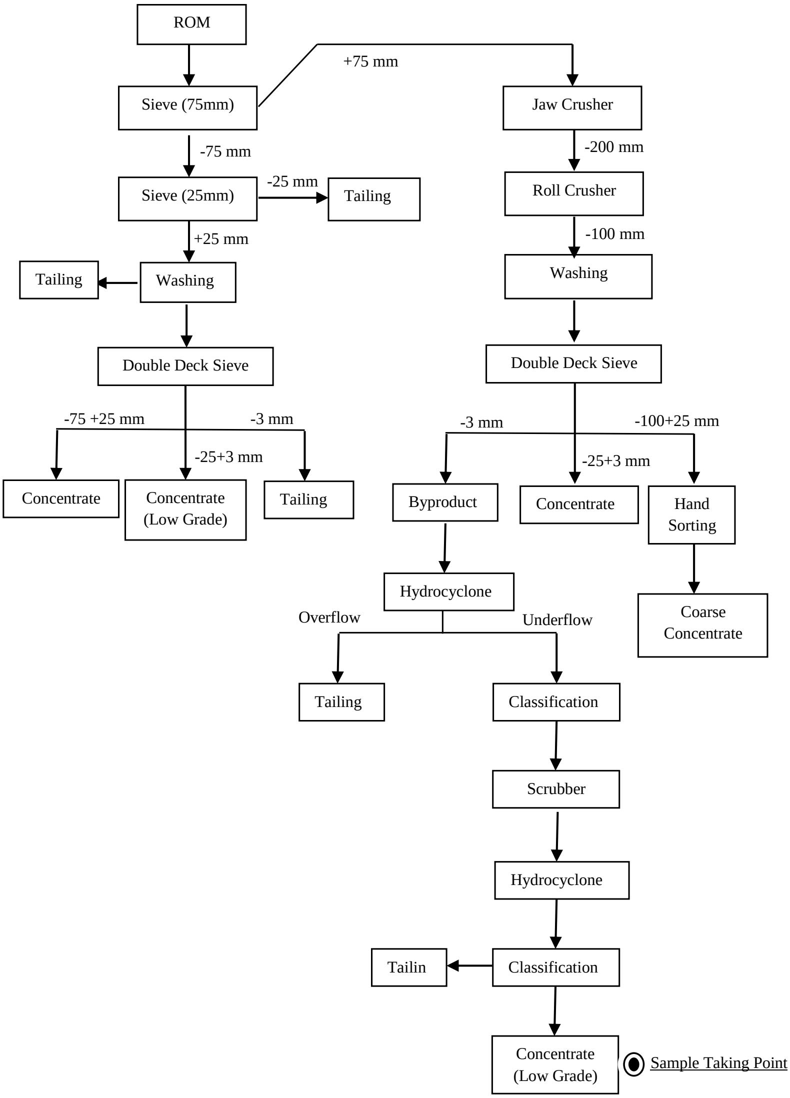

Fig. 1. Simplified processing flow-sheet of the Hisarcik colemanite concentrator (Arslan, 2007; Gungoren, 2009)

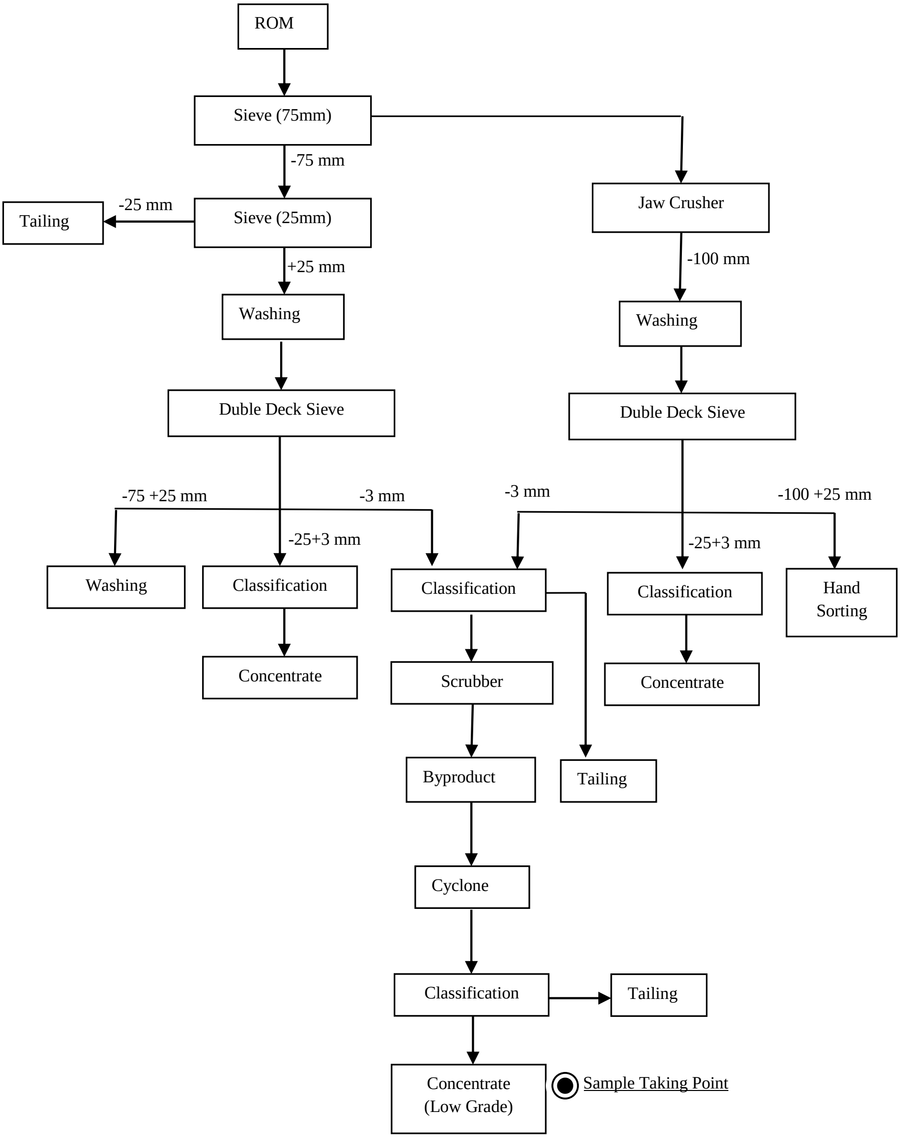

Fig. 2. Simplified processing flow-sheet of the Espey colemanite concentrator (Arslan, 2007; Gungoren, 2009)

2. Material and method

Current colemanite samples were taken from the product stockpiles insufficiently processed in terms of their borate contents by Eti Mines Inc. at Hisarcik and Espey open pit mines, situated in Emet, Kutahya, Turkey. The particle size fraction of the samples was -3 mm. They had insufficient B_2O_3% grades. Current colemanite processing flow-sheets of both concentrator plants operated by Eti Mines Inc. are shown in Figs. 1 and 2 (Arslan, 2007; Gungoren, 2009). The points of which the current samples were taken are illustrated on the process flowsheets.

The material characterization tests include grinding tests, particle size distrubition, complete chemical and mineralogical analyses as well as zeta potential measurements.

The mineralogical and mineral liberation observations were carried out by an optical binocular microscope. Besides the major colemanite mineral, some clays and arsenic minerals such as orpiment and realgar were observed as gangue minerals. It was also observed that colemanite liberates at minus 250 μm. Because of the possible neagative effects of slime coatings, material at minus 38 μm was decided to be removed before flotation.

Before flotation, grinding tests were performed by a laboratory scale rod mill. About 1 kg sample was ground for the periods of 5, 10 and 20 minutes. Cumulative under size curves of the ground material are shown in Fig. 3. Consequently, optimal grinding time was determined as 8 minutes.

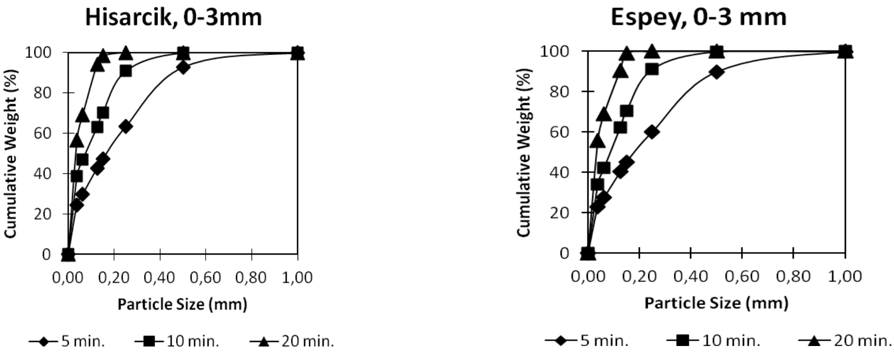

Fig. 3. Cumulative size distributions of the ground samples

The complete chemical analyses of the samples were performed at Eti Mines Inc.'s Emet Boron Works Laboratory and the results are shown in Table 1.

Zeta potentials of conventional and ultrasonically treated pure colemanite, which was previously hand-selected from the Emet deposits, were measured using a Nano Z (ZEN2500) model zeta meter supplied from Malvern Instruments. The device uses a combination of measurement techniques: Electrophoresis and Laser Doppler Velocimetry, called Laser Doppler Electrophoresis. This method is based on the velocity of particle movement in a liquid when electrical field is applied. Hand-selected pure colemanite crystals were ground with a mortar grinder, classified to minus 75 plus 38 micrometer particle size and used during the measurements. Suspensions at different pH values were prepared. Next, a small amount of the representative sample was transferred to the measurement cell. In Fig. 4, the zeta potential variation against various pH values can be seen. It explains the reasons for selection of an anionic type collector, sodium alkyl sulphonate (Cytec R825) for colemanite flotation.

To reveal the effects of ultrasound applied before flotation, the tests were carried out on conventionally and ultrasonically pre-treated samples separately.

Table 1. Complete chemical analyses results of the investigated samples

Sample	B_2O_3 %	SiO_2 %	MgO %	CaO %	TiO_2 %	Al_2O_3 %	SrO %	K_2O %	Fe_2O_3 %	As ppm	LOI % 900 °C, 15 min
Hisarcik 0-3 mm	32.64	11.35	7.61	21.44	0.06	1.14	0.57	0.55	0.54	750	23.47
Espey 0-3 mm	39.28	8.72	2.68	22.10	0.15	2.28	1.41	0.83	1.24	350	21.04

A Denver Sub 2A flotation machine with one dm^3 cell volume was employed in the experiments. The agitation speed of 1200 rpm and 20% pulp to solid ratio were chosen during the tests. A five percent volumetric concentration of a sodium sulphonate type Cytec R825 collector and alcohol type Ekofol 440 frother were used. The collector was tested in four different dosages: 500, 1000, 1500 and 2000 g/Mg, whereas the frother quantity was kept at 100 g/Mg for all experiments.

A circular profile, 35 kHz single frequency and 120 W single power Bandelin RK106 model ultrasonic bath was used for ultrasonic pre-treatment. Colemanite samples with 20% pulp to solid ratio were sonicated for 10 minutes under above conditions.

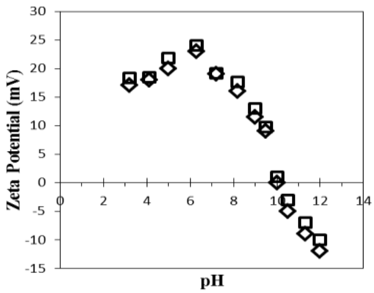

Fig. 4. Zeta potential variation of pure colemanite samples obtained from Emet deposits

3. Experimental results

Concentration tests can be categorized into conventional and ultrasonically pre-treated flotation with variable parameters for comparison and evaluation of the results. The purpose of these tests is to demonstrate and to clarify the grade and recovery differences between conventional and ultrasonicaly pre-treated flotation tests.

The grades and recoveries of flotation products are given in Figs. 5 and 6. B_2O_3 grade and recovery values regard flotation concentrates (floated) and tailings (sinked), whereas Fe_2O_3 % and As_2O_3 % values characterize the tailings (sinked).

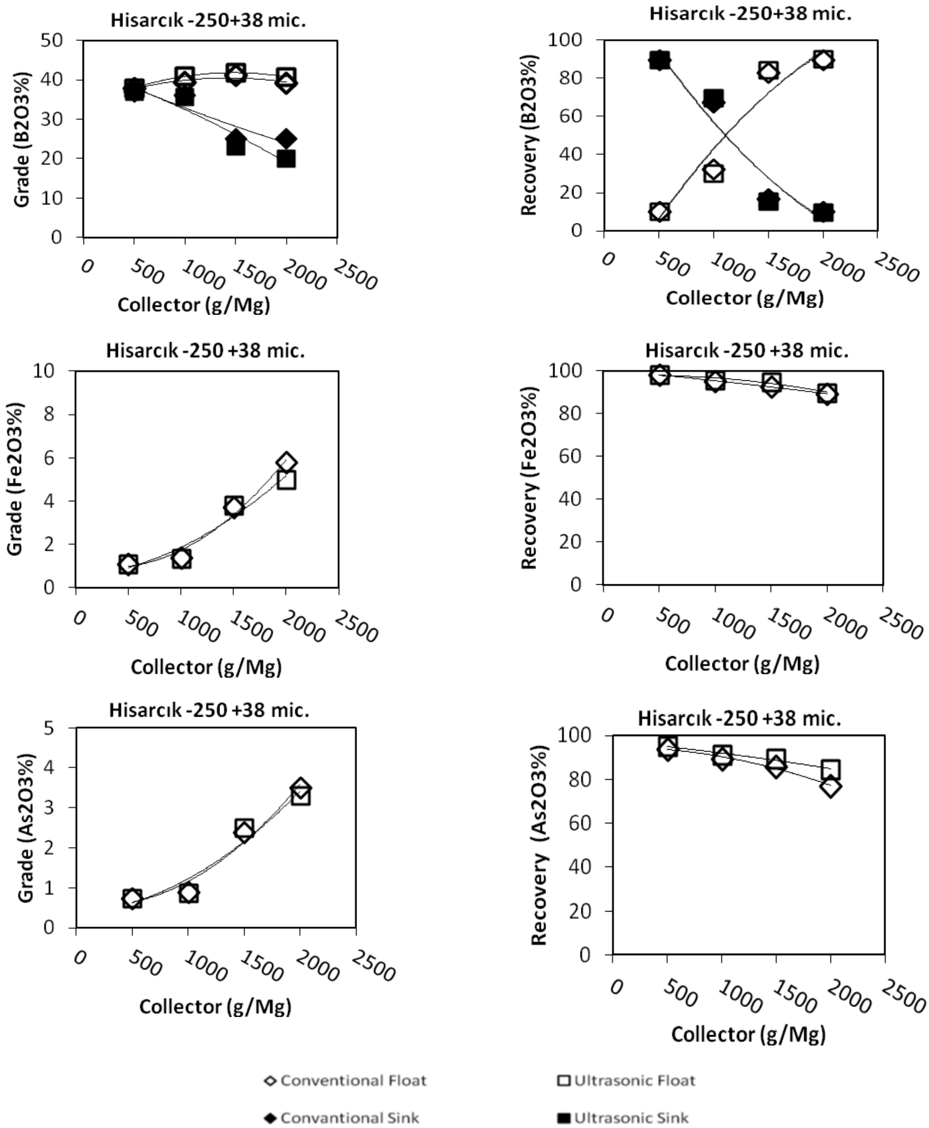

Fig. 5. Grade and recovery values of flotation products for the Hisarcik samples

Figures 5 and 6 show that the B_2O_3 content in the concentrates tends to rise with increasing the amount of collector until 1500 g/Mg for both the Hisarcik and Espey samples achieving recoveries up to 80%. The B_2O_3 grades of ultrasonically pre-treated samples are slightly greater than the conventional ones.

The Fe_2O_3 and As_2O_3 contents in the flotation tailings also go up with increasing collector dosage, though the recoveries decrease.

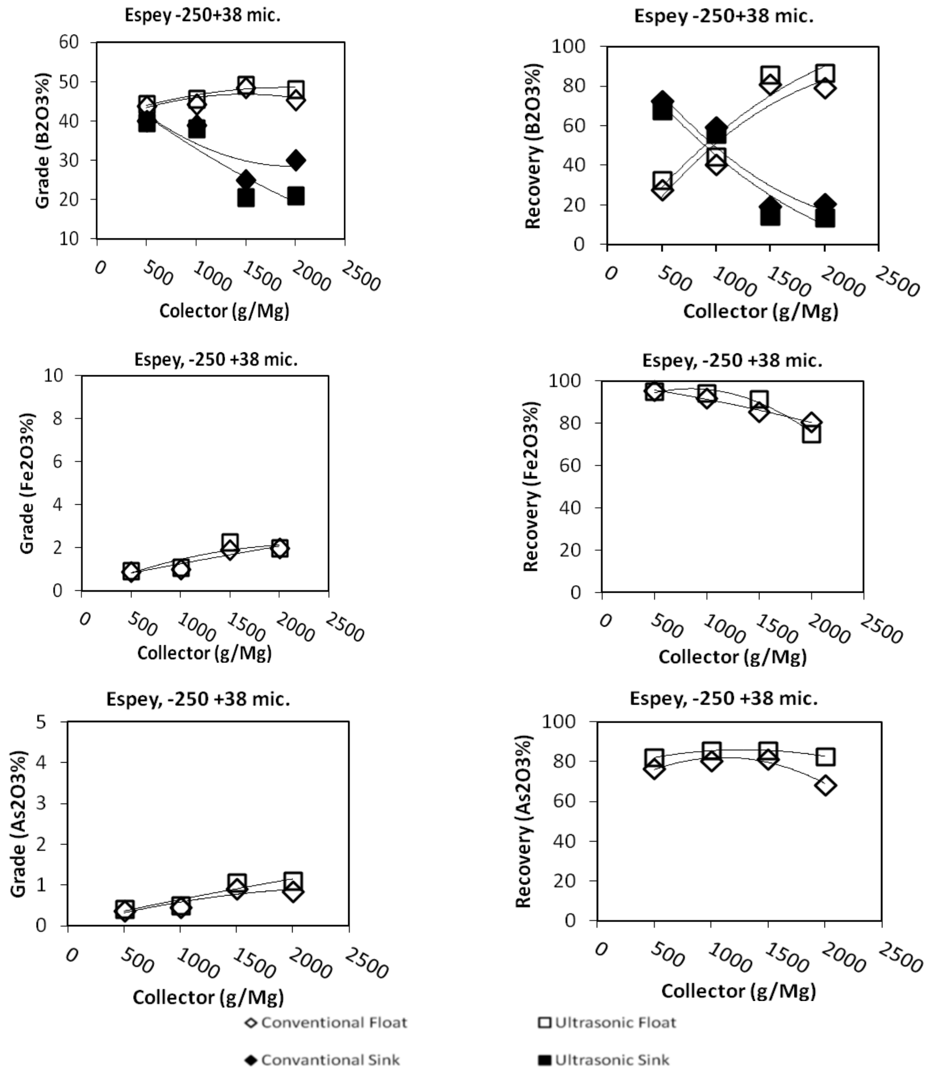

Fig. 6. Grade and recovery values of flotation products for the Espey samples

4. Discussion and conclusions

The results show that ultrasonic pre-treatment gives encouraging flotation results for both Hisarcik and Espey colemanite samples. However, it should be kept in mind that the samples used in this study are not run-of-mine ore. They are low grade concentrates which were tried to get suitable grades during this study. As seen from the B_2O_3 grade-recovery curves from the Figures 5 and 6 that increasing reagent dosages did not necesserally raise the grade and recovery values for the floated colemanite. Approximately 41% B_2O_3 grade value was reached by desliming only for both samples for particle size of -250+38 μm. In addition, the B_2O_3 % grade value could be increased upto 49% by ultrasonically pre-treated flotation with a recovery of above 80%. Besides, the B_2O_3 grade of the tailings was decreased to around 20% B_2O_3 agaisnt the feed grade B_2O_3 grade of 33% for Hisarcik and 39% for Espey respectively. The optimal results were reached with use of 1500 g/Mg collector dosage.

During flotation, the Fe_2O_3 and As_2O_3 contents of the samples were also investigated. As seen from the Fe_2O_3 and As_2O_3 grade-recovery curves in Figs. 5 and 6 the increasing reagent dosages did not significantly affect the grade and recovery values for sinked tailings. In the concentrates, 0.10% Fe_2O_3 grade could be reached when the feed grade was between 0.70-1.00 % while As_2O_3 grade could be decreased from 0.35% to 0.10%.

It is believed that better results in the ultrasonically pre-treated flotation, than in the conventional flotation, were caused by a cavitation effect of ultrasounds. It is also assumed that the high speed water jets at high pressure and temperature during the sonication remove the clay and slime coatings on the surface of colemanite which obstruct reagent adsorption. Due to the ultrasounds the reagents can absorb more effectively on the surface of colemanite and increase their hydrophobicity.

Acknowledgement

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