Separation of ulexite from colemanite by thermally assisted comminution and screening

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ABTRACT: Under beat treatment, some mİneralogical and structural changes take place in hydrated boron minerals Ulexite and colemanite lose their crystal water when they are subjected to heat treatment. Heat treatment significantly affects the grindability of ulexite and colemanite. Thermal treatment followed by semi-autogenous grinding and screening have been used for the separation of ulexite from colemanite. From an 1:1 artificial mixture of ulexite and colemanite calcined at 280°C, ulexite could be concentrated with 90,83 % recovery.

ÖZET: Isıl işlemler altında bazı bor mineralleri mineralojik ve yapısal değişikliğe uğrarlar. Uleksit ve kolemanit ısıtıldıklarında kristal sularını kaybederler. Isıl işlemler, uleksit ve kolemanitin ÖğütülebilirligİNi yakından etkilemektedir. Isıl İşlemler ve bunu takip eden yan-otojen öğütme ve eleme işlemleri uleksit *ve* kolemanitin birbirinden ayrılmasında kullanılmıştır. 1:1 oranında karıştırılan uleksit ve kolemanitin 280°C'de kalsinasyonlan sonucunda uleksit, %90,83 randımanlı kolemanitten ayrılabilmiştir.

1. INTRODUCTION

Al] hydrated boron minerals give of their water of crystallization on heating. The differential thermal analyses (D.T.A) of selected borates were studied by Allen (1957). He found that all the minerals investigated yielded distinctive endothernuc curves between 50°C and 650°C. Colemanite, whose endothermic reactions begins at 270°C, decrepitates violently between 350°C and 400°C, while in ulexite, endothermic reactions vary between 70°C and 200°C. Allen also studied artificial mixtures of colemanite and ulexite and he used DTA curves for practical semi-quantitative analysis of these minerals.

Şener (1997) found that thermal decomposition of ulexite has occurred within the temperature range of 60-500°C with two stage dehydration proceeded with two-stage dehydroxylation giving two endothermic DTA peakes at 151° and 180°C.

U.S. patent taken by Gnswold (1970) about calcination of colemanite in a fluidised bed furnace showed mat the feed should be charged to the furnace at 350°C for an efficient decrepitation. The powdered calcine could be recovered in cyclone with 80% recovery.

Industrial scale colemanite calcination is carried out in the U.S.A. The American Borate Company has used a rotary kiln to upgrade the $B2O3$ percent from 22 % to 36%, and the calcine is separated from the associated gangue by air cyclones. Lyday (1985).

The aim of this research was to use the calcination behaviour of boron minerals for their separation.

2. METHODS

2.1. Calcination Tests

The calcination tests were performed in the Heraeus brand muffle furnace equipped with time-proportioning temperature control system mat provided ±0.8 %/°C sensitivity from the setpoint of temperature.

Two NiCr-Ni thermocouples were used to measure temperatures within the furnace cell

In the procedure, the furnace was first set to the desired temperature with the empty crucible and then the experiment was started after immediately introducing the sample into the preheated crucible At the end of each experiment, the calcined samples were allowed to cool down to room temperature in a desiccator to avoid moisture pick up A ceramic crucible in cylindrical shape with the colume of 340 cm^3 was used throughout the tests In the calcination tests performed on ulexite, the crucible was used without a cover but in the case of colemamte it was covered with an aluminium sheet to prevent escaping of decrepitated colemamte powders from the crucible

2 2 Separation Method

The method for separating ulexite from colemamte has previously been studied by Şener (1991) and Şener and özbayoğlu (1995) According to this study, the ulexite sample calcined at 240°C for 1 hour, could be separated from colemamte by semi-autogenous grinding and screening to obtain ulexite as undersize with recovery over 90% In present research, the following procedure has been followed for the separation of ulexite from colemamte

As procedure, -1 168+0 600 mm sized thermally pretreated and then mixed (in 1 1 ratio by weight) ulexite and colemamte samples were ground in the ceramic will having dimensions of 190 mm in diameter and 190 mm in length The mill was rotated for 70 rpm The parameters such as calcination temperature and duration, grinding time, size and number of balls were tested and the optimum conditions were determined 200, 240 and 280°C as the calcination temperature and 60 minutes as the calcination duration were particularly chosen accordmg the data obtained from the gnndability studies 10, 20 and 30 minutes grinding time were applied The ground mixture was screened through the 0 600 and 0 500 mm sieves for 15 minutes screening time and +0 600, -0 600+0 500 and -0 500 mm sized fractions were weighed

The representative semples were then taken from each fraction for the chemical analyses The recovery of ulexite for each condition was evaluated on the basis of Na_20 content which is the only difference m the chemical compositions of ulexite and colemamte

2 3 Chemical Analyses and Chemicals

The chemical analyses for the B_z0_3 content were achieved by volumetric titration method based on the standard method of TSI2481

The chemical analyses for the Na_zO content were performed by Jenway PFP brand low temperature, single channel emission flame photometer All the reagents and chemicals used throughout the analyses were of analytical grade

3 RESULTS AND DISCUSSIONS

The structure of ulexite was changed under heat treatment When the ulexite was heated up to 280°C, the individual ulexite crystals had partially disappeared and many partings, microcracks and interstices were formed The structure became much more permeable, porous and exfoliated (Şener, 1997) This made the structure weak and easily grmdable On the other hand, colemamte has not undergone any structural change up to 335°C The differences in the gnndability of ulexite and colemamte when calcined up to 280°C was used for their separation

The mixture of ulexite and colemamte, calcined at 200, 240 and 280°C for 60 minutes were selectively ground in the semıautogenous gnndıng conditions with 10, 20 and 30 balls of 10 and 20 mm diameter for 5, 10, 20 and 30 minutes of grinding time and then were screened through the 0 600 and 0 500 mm sized sieves for 15 minutes producing an ulexite concentrate as undersize and a colemamte concentrate as oversize The Na20 grade and recovery of ulexite for each fraction was determined and the results were evaluated m graphs given m Figures 1 and 3

As seen in the figures, a general trend of gradual decrease m the grade curve and an increase in the recovery curve with increasing grinding time, was observed This trend was more pronounced with increasing size and number of the balls as well as temperature

Figure 1 indicates effects of size and number of the balls and grinding tune on the grade and recovery of ulexite calcined at 200°C for 60 minutes As indicated in the figure, the grade of the calcined ulexite at this temperature was determined as 9 25% Na_20 and reduced to 7 70, 6,81 and 6,79% Na_20 by using 10, 20 and 30 balls of 10 mm diameter, respectively

When using 10 and 20 balls of 20 mm diameter, it was significantly reduced to 5.97 and 5 74% NajO, respectively.

As also indicated in Figure 1 the recovery gradually increased to 57.06% and sharply increased to 81.85 and 85.44% for 30 minutes by using 10, 20 and 30 balls of 10 mm diameter. When using 10 and 20 balls of 20 mm diameter, it increased to 69.05 and 86.39 %, respectively.

The effect of calcination temperature on recovery • was also examined. As indicated in the figures, more pronounced effect was obtained by the increase in temperature. The ulexite concentrates with significantly higher recovery for the shorter grinding time, were produced from the calcined mixture.

Figure 2 shows effects of size and number of the balls and grinding time on the grade and recovery of ulexite at 240°C for 60 minutes. As indicated in me figure, the grade of the calcined ulexite at this temperature was determined as 9.69 % Na_20 and was reduced to 7.88, 7.02 and 6.81 % Na_20 by using 10, 20 and 30 balls of 10 mm diameter, respectively. When using 10 and 20 balls of 20 mm diameter, it was reduced to 6.45 and 6.05% Na20, respectively.

As also shown İn Figure 2, the recovery gradually increased to 58.86% and sharply increased to 84.01 and 89.94 % by using 10, 20 and 30 balls of 10 mm diameter for 30 minutes. When using 10 and 20 balls of 20 mm diameter, it increased to 73.65 and 88.34 %, respectively.

Figure 3 shows effects of size and number of the balls and grinding time on the grade and recovery of ulexite at 280°C for 60 minutes. As indicated in the figure, the grade of the calcined ulexite at this temperature was determined as 9.98 % Na20 and reduced to 7.92, 7.11 and 6.96 % Na_20 by using 10, 20 and 30 balls of 10 mm dimater, respectively. When using 10 and 20 balls of 20 mm diameter, it reduced to 6.71 and 6.17 % Na_20, respectively.

As also shown m Figure 3, the recovery gradually increased to 59.94 % and sharply increased to 85.53 and 90.83 % by using 10, 20 and 30 balls of 10 mm diameter for 30 minutes. When using 10 and 20 balls of 20 mm diameter, it increased to 75.42 and 89.98 %, respectively.

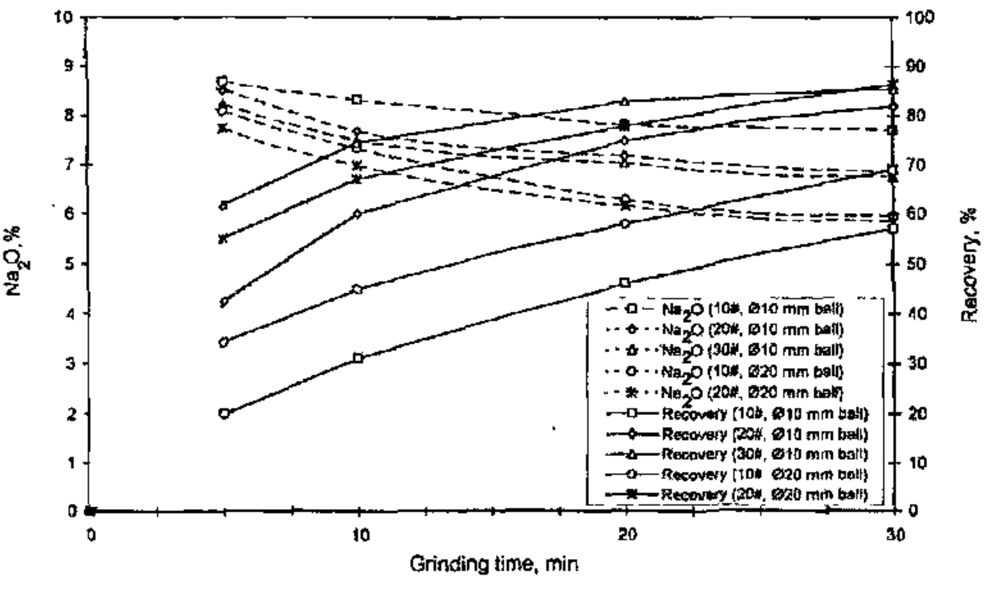

Fig. I The Effect of Grinding Parameters on Na_20 Grade and Recovery of Ulexite Calcined at 200°C

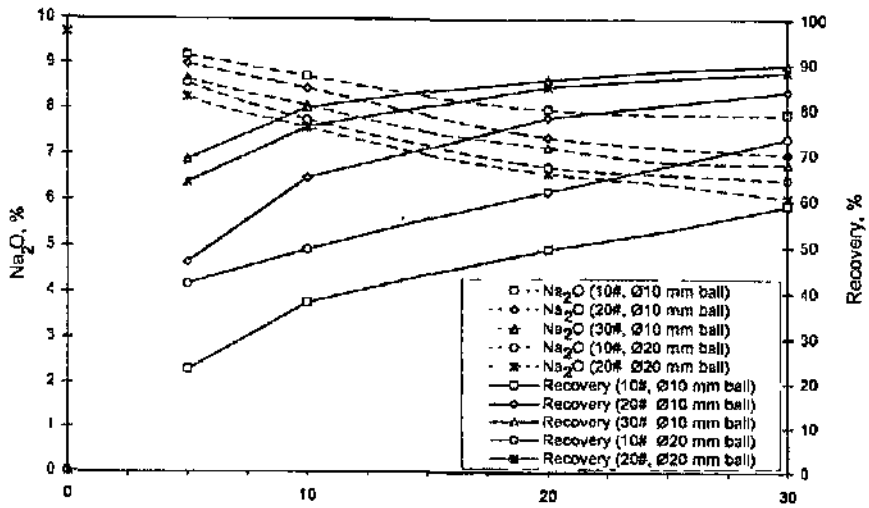

Fig.2 The Effect of Grinding Parameters on Na_20 Grade and Recovery of Ulexite Calcined at 240°C

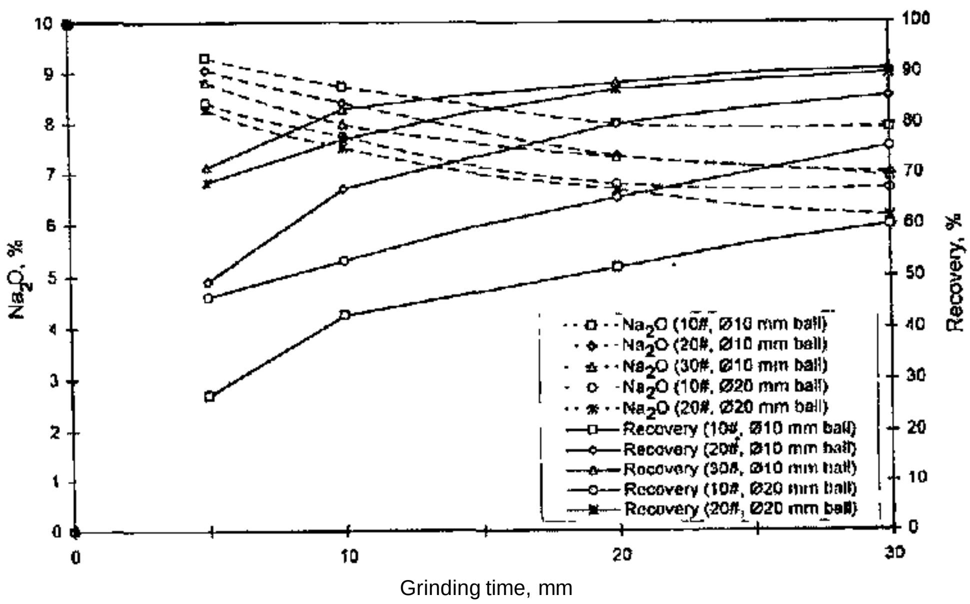

Fig.3 The Effect of Gnnding Parameters on Na_20 Grade and Recovery of Ulexite Calcined at 280°C

CONCLUSIONS

By calcination, colemamte and uiexite lose their water of crystallization while undergoing different nuneralogical and structural changes Then- different raineralogical and structural modifications due to heat treatment have affected to their grindabihty and could be used to separate them from each other The artificial mixture of colemamte and uiexite, calcined at 280°C was separated after semi-autogeneous grinding and screening Uiexite concentrate has been produced by 90,83 % recovery

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