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# Continuous Heavy Liquid Concentration of Brucite



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# Continuous Heavy Liquid Concentration of Brucite

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UNITED STATES DEPARTMENT OF THE INTERIOR
Rogers C. B. Morton, Secretary

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# CONTINUOUS HEAVY LIQUID CONCENTRATION OF BRUCITE

by

T. O. Llewellyn[1] and G. V. Sullivan[2]

## ABSTRACT

The Bureau of Mines investigated the use of a heavy liquid in combination with fluid cyclones to separate brucite from a Nevada ore on a continuous basis, using a mixture of dibromomethane and trichloroethylene having a density of 2.44 grams per cubic centimeter. Single-stage cyclone separation produced a concentrate that contained 84 percent of the total magnesia at a grade, on a calcined basis, of 95.6 percent MgO.

## INTRODUCTION

Brucite, $Mg(OH)_2$, theoretically contains 69.1 percent MgO and 30.9 percent $H_2O$. High-grade brucite is burned to produce caustic-calcined or refractory magnesia with a purity of 90 to 98 percent MgO (6).[3] The calcined material is generally used for the manufacture of magnesia compounds for use as fertilizer and ceramic products. Another potential use for brucite has resulted from research to establish methods to remove sulfur dioxide from stack gases. In this approach, $SO_2$-bearing gases are scrubbed with slurries of magnesium hydroxide (3, 9). With this technique, it is possible to use high-purity brucite directly without prior calcination.

The major domestic brucite deposit is located in Nevada and has been fully described by Callaghan (5). A coarse brucite concentrate is produced in a heavy-media unit at the Basic, Inc., plant in Gabbs, Nev. (6). Minus 3-mesh material, however, cannot be treated and is removed prior to sink-float concentration.

Heavy liquids have been used for a number of years as a laboratory tool for the separation of mineral mixtures (1-2, 4). In recent years the Bureau of Mines has conducted extensive studies to determine the feasibility of using heavy liquids in a practical mineral separation technique. Research has principally focused on using a heavy liquid in combination with fluid cyclones (10-12). The feasibility of using heavy liquid separation to concentrate

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[1]Metallurgist.
[2]Supervisory metallurgist.
[3]Underlined numbers in parentheses refer to items in the list of references at the end of this report.

brucite has been demonstrated by the Bureau on a batch basis in an earlier report (8). The purpose of this investigation was to determine if these results could be reproduced on a continuous basis. This report concludes the Bureau's study and presents the results of continuous heavy liquid cyclone separation tests.

## ACKNOWLEDGMENT

The authors wish to thank Basic Refractories, a division of Basic Incorporated, Gabbs, Nev., for furnishing the brucite sample used in this study.

## DESCRIPTION OF MATERIALS

A 5-ton sample of minus 1/2-inch brucite ore averaging 5.3 percent silica and 3.9 percent lime was crushed and ground dry to pass a 20-mesh screen. Most of the minus 200-mesh material was removed by screening and discarded. Earlier work (8) indicated that very fine particles of brucite did not respond readily to heavy liquid cyclone concentration, but they are marketable as an agricultural-grade magnesia.

Petrographic examination of a representative sample of the minus 20- plus 200-mesh material (table 1) showed that the principal minerals were brucite and dolomite, with minor amounts of hydromagnesite. Trace amounts of magnetite and hematite were present also. The hematite occurs as micro inclusions within the brucite. Brucite-dolomite locking was evident. Estimates, however, indicated that about 80 percent of the brucite was liberated at 20 mesh. Table 2 presents a sizing analysis of the ground material as well as chemical analyses of the sized fractions.

TABLE 1. - Petrographic analysis of brucite ore

| | Weight-percent[1] |
|---|---|
| Mineral: | |
| Brucite | 82 |
| Dolomite | 12 |
| Hydromagnesite | 2 |
| Other[2] | 4 |
| Total | 100 |

[1] By petrographic count of sized fraction and specific gravity correction.
[2] Includes quartz, magnetite, hematite, feldspar, serpentine or chlorite, and fosterite.

TABLE 2. - Chemical and size analysis of brucite test sample[1]

| Mesh | Weight-percent | Analysis, percent | | | | | Distribution, percent | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | MgO | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | CaO | MgO | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | CaO |
| Minus 20 plus 35 | 27.5 | 88.9 | 5.4 | 1.1 | 1.2 | 3.4 | 27.7 | 27.9 | 28.3 | 26.0 | 23.7 |
| Minus 35 plus 48 | 28.7 | 88.5 | 5.1 | 1.1 | 1.4 | 3.9 | 28.7 | 27.5 | 29.2 | 31.5 | 28.6 |
| Minus 48 plus 65 | 18.3 | 88.6 | 5.3 | 1.0 | 1.1 | 4.0 | 18.3 | 18.3 | 17.0 | 15.8 | 18.6 |
| Minus 65 plus 100 | 10.2 | 88.0 | 5.2 | 1.0 | 1.3 | 4.5 | 10.2 | 10.0 | 9.4 | 10.2 | 11.8 |
| Minus 100 plus 150 | 7.6 | 88.2 | 5.0 | 1.1 | 1.2 | 4.4 | 7.6 | 7.1 | 7.6 | 7.1 | 8.4 |
| Minus 150 plus 200 | 5.3 | 87.6 | 5.7 | 1.1 | 1.1 | 4.5 | 5.2 | 5.6 | 5.7 | 4.7 | 6.1 |
| Minus 200 | 2.4 | 83.9 | 7.8 | 1.3 | 2.5 | 4.5 | 2.3 | 3.6 | 2.8 | 4.7 | 2.8 |
| Composite | 100.0 | 88.3 | 5.3 | 1.1 | 1.3 | 3.9 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

[1] All chemical analysis in this report are based on calcination of samples at 1,000° C where brucite, $Mg(OH)_2$, is converted to MgO with a theoretical 31 percent loss in weight.

From the standpoint of availability and recoverability, a mixture of dibromomethane and trichloroethylene was chosen as the heavy liquid to be used in this research work. The important physical and chemical properties of these two heavy liquids are thoroughly described in the report on batch tests (8).

## FLOWSHEET

Figure 1 gives the general flowsheet used for continuous heavy liquid cyclone separation of brucite. In the test procedure used, a quantity of sized ore sufficient for about a 4-hour run was stored in an ore bin and withdrawn by a feeder to a conditioner at a rate of 150 pounds per hour. Heavy liquid, which was stored in 50-gallon stainless steel drums, was fed into the

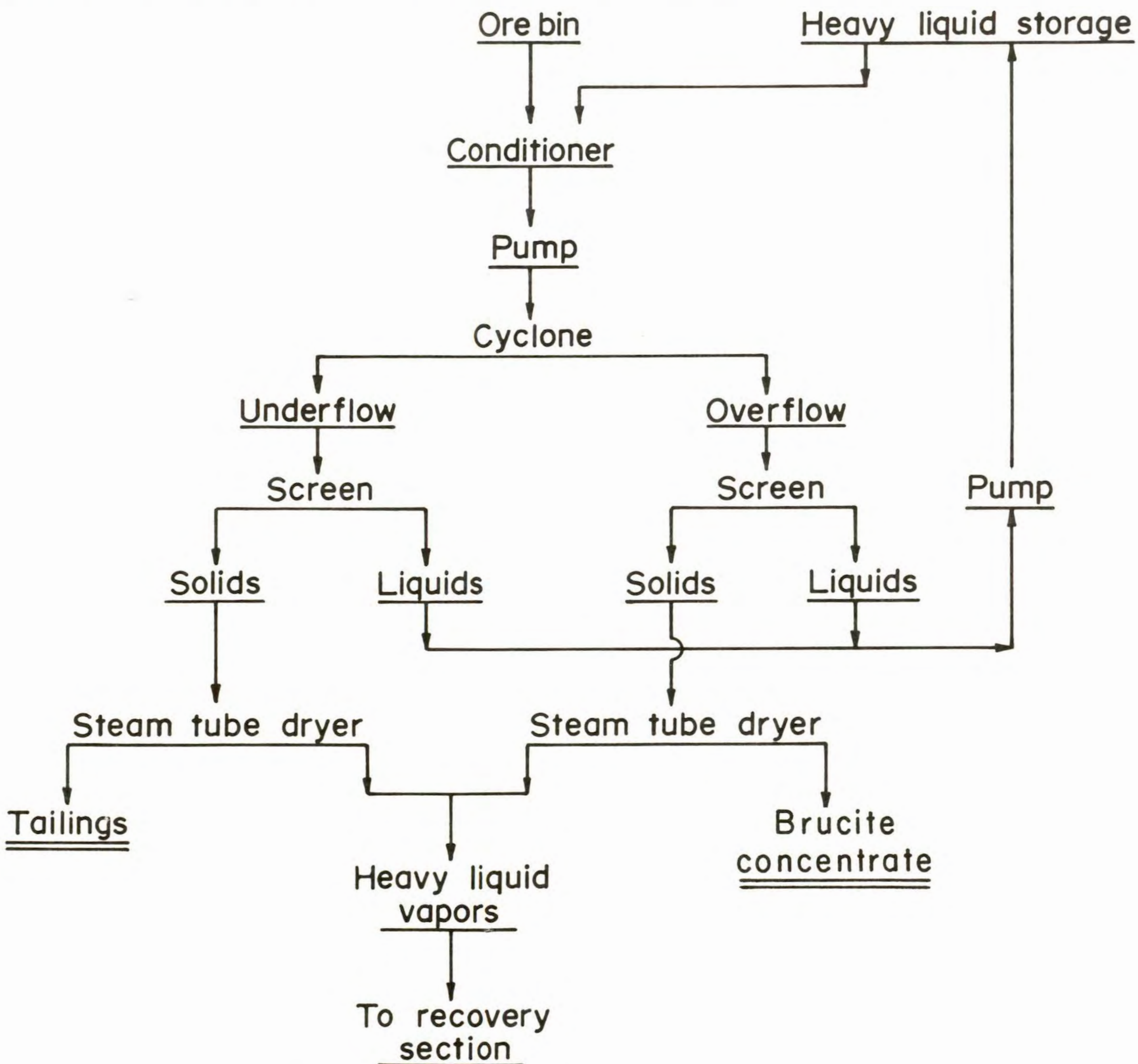


FIGURE 1. - Flowsheet for continuous separation of brucite.

conditioner by gravity flow at a rate required to obtain the desired pulp density. The pulp was then pumped to a 1-inch-diameter ceramic cyclone. Feed pressure to the cyclone was controlled by a positive displacement pump. The cyclone was fitted with a 1/3-inch-diameter vortex finder and a 1/4-inch-diameter apex opening. Cyclone feed density was maintained at 10 percent solids by weight and the feed pressure was set at 25-pounds-per-square-inch gage.

Minerals separated according to their specific gravities, the brucite reported in the float fraction (cyclone overflow), while the dolomite together with other impurities reported in the sink fraction (cyclone underflow). Separated fractions flowed by gravity onto 325-mesh stainless steel vibrating screens where approximately 95 percent of the heavy liquid from both the float and sink fractions was reclaimed.

Separated heavy liquid was pumped back to the heavy liquid storage tank. Separated minerals were fed to two rotary steam tube dryers maintained at 95° C. Heavy liquid vapors from the steam tube dryers passed to a recovery section. The vapor recovery section is described in detail in a Bureau of Mines report (7).

## EXPERIMENTAL RESULTS

Summarized results of three typical continuous tests are presented in table 3. Two of the runs were carried out at a liquid density of 2.42 (tests 6 and 7), and the third (test 9) at 2.44. For comparative purposes, batch results obtained under the same operating conditions in an earlier study (8) are also shown in table 3.

The batch cyclone tests, made by using heavy liquids at specific gravities of 2.42 and 2.44, recovered 78.5 to 81.3 percent of the MgO at grades of 95.5 and 95.2 percent, respectively.

In continuous tests at a liquid density of 2.42, the average MgO grade was about 96.0 percent with a recovery of between 77 and 80 percent. At a density of 2.44, the grade was virtually the same but the recovery increased to almost 84 percent.

TABLE 3. - Summarized results of heavy liquid cyclone separation of brucite test sample

| Specific gravity | Test number | Product | Weight-percent | Analysis,[1] percent | | | | | Distribution, percent | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MgO | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | CaO | MgO | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | CaO |
| CONTINUOUS TESTS | | | | | | | | | | | | | |
| 2.42 | 6 | Overflow..... | 74.4 | 95.7 | 1.8 | 0.9 | 0.6 | 1.0 | 80.1 | 26.3 | 65.0 | 41.1 | 19.0 |
| | | Underflow.... | 25.6 | 69.1 | 14.8 | 1.4 | 2.6 | 12.0 | 19.1 | 73.7 | 35.0 | 58.9 | 81.0 |
| | | Head...... | 100.0 | 88.8 | 5.1 | 1.0 | 1.1 | 3.8 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 2.42 | 7 | Overflow..... | 71.0 | 96.0 | 1.7 | .9 | .5 | .9 | 77.3 | 21.8 | 62.7 | 31.6 | 15.5 |
| | | Underflow.... | 29.0 | 68.9 | 15.0 | 1.3 | 2.7 | 12.0 | 22.7 | 78.2 | 37.3 | 68.4 | 84.5 |
| | | Head...... | 100.0 | 88.1 | 5.5 | 1.0 | 1.1 | 4.1 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 2.44 | 9 | Overflow..... | 77.6 | 95.6 | 2.1 | .8 | .5 | .8 | 83.8 | 31.3 | 67.0 | 34.5 | 15.5 |
| | | Underflow.... | 22.4 | 64.2 | 16.0 | 1.4 | 3.3 | 15.1 | 16.2 | 68.7 | 33.0 | 65.5 | 84.5 |
| | | Head...... | 100.0 | 88.6 | 5.2 | .9 | 1.1 | 4.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| BATCH TESTS | | | | | | | | | | | | | |
| 2.42 | - | Overflow..... | 72.5 | 95.5 | 1.8 | 1.1 | 0.6 | 1.0 | 78.5 | 24.2 | 74.5 | 34.1 | 18.5 |
| | | Underflow.... | 27.5 | 69.2 | 14.7 | 1.0 | 3.1 | 12.0 | 21.5 | 75.8 | 25.5 | 65.9 | 81.5 |
| | | Head...... | 100.0 | 88.2 | 5.3 | 1.1 | 1.3 | 4.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 2.44 | - | Overflow..... | 75.3 | 95.2 | 2.4 | .9 | .5 | .9 | 81.3 | 31.8 | 68.6 | 31.5 | 17.7 |
| | | Underflow.... | 24.7 | 66.7 | 15.8 | 1.3 | 3.6 | 12.6 | 18.7 | 68.2 | 31.4 | 68.5 | 82.3 |
| | | Head...... | 100.0 | 88.2 | 5.7 | 1.0 | 1.3 | 3.8 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

[1] Chemical analysis based on calcined sample with brucite, $Mg(OH)_2$, converted to MgO. Theoretical weight loss is 31 percent.

## CONCLUSIONS

The investigation revealed that it is technically feasible to concentrate brucite by heavy liquid cyclone separation on a continuous basis. Brucite concentrates containing 95.6 percent MgO (on a calcined basis) with recoveries of 83.8 percent of the total magnesia were obtained at a separation gravity of 2.44. The continuous tests produced concentrates that were equivalent or better in recovery and MgO grade to those obtained in batch cyclone tests under similar conditions.

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