

EXAMINATION OF GIBBSITE SAMPLES
FOR DIVISION OF MINERAL RESOURCES

Minerals Research Laboratory July 1970 Progress Report

Lab. No. 3612-A to G - Book 262
by
Edwin H. Bentzen III

Abstract

Seven samples of material, collected by the State Mining Engineer, were examined for Al_2O_3 content, and the possible presence of gibbsite. Chemical analyses showed a variation in samples of between 13.5 and 23.4 percent Al_2O_3 . X-ray analyses indicated the presence of five to seven percent gibbsite in the sample with the highest Al_2O_3 content.

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Introduction

The State of North Carolina is concerned with recent interest expressed in deposits located in northwestern North Carolina. These deposits are said to contain significant quantities of Al_2O_3 mineralization. In an effort to inform, and protect the interests of, the people of North Carolina, the Minerals Research Laboratory is assisting the Division of Mineral Resources in determining the type and degree of Al_2O_3 mineralization of this area.

Objective

The objective of this work was to determine the amount of Al_2O_3 in each sample and, if possible, to determine the amount of gibbsite in each sample.

Procedure

The samples were brought to this Laboratory March 17 by Mr. Craig McKenzie, State Mining Engineer. They were identified as follows:

Site I, Murphy Mt., numbers 1 through 4

Site II, New Saddle Mt. Church, numbers 1 and 2

Site III, Doughton Park, number 1.

The samples were identified as Lab. No. 3612, A through G. The

samples, as received in plastic bags, were in a moist condition. To facilitate handling, they were dried overnight in an electric oven at $100^{\circ} \pm 5^{\circ}$ C. The dry samples were then cooled to room temperature. The cool, dry samples were crushed to pass a 1/4-inch screen and were then mixed well and split. A 20-gram portion of each sample was removed and analyzed. The results are shown in Table 1.

From the chemical analyses, it was decided to perform further testing on sample Site II, No. 2. This decision was based on the high Al_2O_3 content, high L.O.I., and lower SiO_2 content of this sample. Approximately 1000 grams of this material was scrubbed in a three-tier Wemco scrubber at 60 percent solids for ten minutes. The pulp was then completely deslimed at 200 mesh. The minus 200 mesh material was filtered to recover all the solids. This material amounted to 33.9 percent of the head feed, or starting material. After drying at $100^{\circ} \pm 5^{\circ}$ C., the material was broken up to pass a 100 mesh screen, mixed and split. A 10-gram sample was then analyzed. The results are shown in Table 2.

Upon making arrangements with the Department of Engineering Research, North Carolina State University, portions of the seven head samples, along with the minus 200 mesh product, were sent to Raleigh for X-ray diffraction analysis. The results are shown in Table 3. This work was carried out under the direction of Dr. Robert F. Stoops, Acting Director of the Department of Engineering Research, NCSU.

Results

Table 1

| <u>Chemical Analyses %</u> | <u>Al₂O₃</u> | <u>SiO₂</u> | <u>Na₂O</u> | <u>K₂O</u> | <u>CaO</u> | <u>MgO</u> | <u>Fe₂O₃</u> | <u>TiO₂</u> | <u>L.O.I.</u> |
|----------------------------|------------------------------------|------------------------|------------------------|-----------------------|------------|------------|------------------------------------|------------------------|---------------|
| Site I, No. 1 | 19.0 | 60.3 | 1.2 | 4.3 | 0.9 | 2.2 | 7.6 | 0.4 | 3.4 |
| No. 2 | 15.3 | 66.9 | 0.9 | 2.4 | 1.0 | 2.2 | 6.3 | 0.4 | 4.2 |
| No. 3 | 19.8 | 58.5 | 0.4 | 3.3 | 0.6 | 2.9 | 7.2 | 0.4 | 6.0 |
| No. 4 | 14.5 | 69.2 | 2.0 | 1.3 | 1.4 | 1.8 | 5.1 | 0.4 | 3.7 |
| Site II, No. 1 | 15.4 | 68.4 | 0.1 | 0.9 | 0.4 | 1.9 | 5.9 | 0.4 | 5.8 |
| No. 2 | 23.4 | 51.7 | 0.2 | 3.4 | 1.2 | 3.3 | 8.0 | 0.4 | 7.2 |
| Site III, No. 1 | 13.5 | 75.0 | 0.1 | 1.3 | 0.1 | 1.2 | 3.4 | 0.4 | 4.5 |

Table II

| <u>Chemical Analyses %</u> | <u>Al₂O₃</u> | <u>SiO₂</u> | <u>Na₂O</u> | <u>K₂O</u> | <u>CaO</u> | <u>MgO</u> | <u>Fe₂O₃</u> | <u>TiO₂</u> | <u>L.O.I.</u> |
|-----------------------------|------------------------------------|------------------------|------------------------|-----------------------|------------|------------|------------------------------------|------------------------|---------------|
| -200 Mesh Site II, No. 2 | 35.5 | 36.0 | 0.4 | 3.8 | 0.8 | 0.1 | 8.0 | 0.7 | 14.3 |

Table III

| <u>Sample Location</u> | <u>Analysis No.</u> | <u>Approximate Gibbsite Content</u> |
|-----------------------------|---------------------|-------------------------------------|
| Site I, No. 1 | 3-18-50 | Possible trace |
| No. 2 | 3-18-51 | Trace |
| No. 3 | 3-18-52 | Not detectable |
| No. 4 | 3-18-53 | Trace |
| Site II, No. 1 | 3-18-54 | 3 to 5% |
| No. 2 | 3-18-55 | 5 to 7% |
| Site III, No. 1 | 3-18-56 | 3 to 5% |
| Site II, No. 2 -200 Mesh | 3-18-57 | 15% |

"Trace" indicates about two percent, the minimum amount detectable by X-ray diffraction under these circumstances. The specific amounts given above are estimates and may be in error by a factor or two. However, the relative amounts should be accurate. For example, it is relatively certain that sample 3-18-57 contains more gibbsite than any other.

Discussion

The largest consumer of alumina is the aluminum industry; therefore, a brief look at the production of alumina is warranted.

The Bayer process is the most widely used method for the production of alumina. This process produces commercially pure alumina by leaching crude bauxite, (usually a mixture of gibbsite, $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$, and boehmite, $\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$), with concentrated sodium hydroxide. Crude bauxite is dried and ground and then digested in an autoclave with strong NaOH solution under about 60 pounds pressure, for two to eight hours at about 150°C . The aluminum dissolves to form a sodium aluminate:



The iron, titanium, and silica remain behind in the form of "red mud". The iron oxide of the bauxite is insoluble in the sodium hydroxide solution and aside from increasing the bulk of the red mud, which must be filtered and thrown away, has little effect on the process. The silica content of the bauxite is, however, very important. Silica forms an insoluble sodium aluminum silicate, and each pound of silica in the bauxite ties up about a pound each of alumina and soda. This remains in the red mud.

To recover the alumina from red mud, The Aluminum Company of America has developed a soda-lime-sinter process. The red mud is mixed with soda ash (Na_2CO_3) and ground limestone and sintered in a rotary kiln at temperatures of 1800 to 2000° F. This breaks up the sodium aluminum silicate and forms an insoluble calcium silicate and sodium aluminate. The sinter is leached with water to recover the sodium aluminate, which is then treated as in the standard Bayer process.

The sodium aluminate solutions from both of the above processes are diluted, filtered, and sent to precipitation. Seeding with precipitated $\text{Al}(\text{OH})_3$ causes the reversal of the solution reaction. The alumina comes down as a precipitate of hydrate oxide:



The precipitated hydrate is filtered, dried, and calcined at 1000° C., yielding an oxide containing about 99.6 percent Al_2O_3 . The filtered solution is returned to the leaching process.

Bauxite that is used in this, and other consuming industries, differs considerably in specifications. To be suitable for the manufacture of metallic aluminum and aluminous abrasives, bauxite should contain less than 5 percent SiO_2 , and a range of 2.5 to 3 percent SiO_2 is preferred. The sinter process operating with the Bayer process does, under certain circumstances, permit the use of bauxite containing 12 to 15 percent SiO_2 . The iron oxide content is immaterial in bauxite used for metal manufacture and may be as high as 20 to 25 percent; if the alumina content is still reasonably high, 48 to 50 percent.

However, when it is to be used in the manufacture of aluminous chemicals and refractories, it is important that the bauxite contain as little iron oxide as possible. Bauxite for manufacture of aluminum sulfate should contain a maximum of 2.25 percent Fe_2O_3 ; for the manufacture of refractories the maximum is 1.75 percent Fe_2O_3 . For all purposes, it is important that the alumina content be as high as possible consistent with the price.

Examination of the samples collected by the State Mining Engineer shows the presence of gibbsite. However, in an ore containing seven percent gibbsite there is only 4.58 percent available Al_2O_3 . In order to be marketable in the aluminum industry, the product must contain at least ten times this amount. The silica content would also have to be lowered to less than 15 percent.

The limited test work undertaken indicates that the gibbsite mineralization occurs in the finer fractions, and it is possible that size separations at finer than 74 microns (200 mesh) could produce an even more enriched concentrate. But it is thought that losses could be high, and the ratio of concentration would be higher than ten to one.

Extensive processing of this type does not appear warranted, using generally recognized processes, especially when dealing with a low-priced product like alumina.

Conclusions

- 1) The aluminum industry is the largest consumer of alumina
- 2) Alumina is produced primarily by the Bayer process using bauxitic ores containing gibbsite

- 3) Iron is not critical contaminant in bauxitic ores for the Bayer process, but silica is very critical
- 4) The soda-lime-sinter process can take up to 15 percent silica
- 5) Bauxite for other uses must have a low iron content
- 6) The material sampled and tested contained gibbsite, but only in a small quantity
- 7) Processing this material by presently acknowledgeable technology would be very costly
- 8) Alumina is a low priced product, which is in plentiful supply.

Recommendations

If the company involved in attempting to process alumina ores continues to express confidence in their success, the State of North Carolina should undertake an extensive sampling program to determine the extent of mineralization. This work should be done in cooperation with the company. This should be in an effort to help, and not hinder, the company and the people of North Carolina.

It is possible that the company has knowledge of new processes, not known to this investigator or his colleagues, that could make deposits of this low grade profitable to process. But with a ratio of concentration as high as ten to one there would be ten tons of tailings to be disposed of for every ton of alumina produced. With the degree of reclamation now required by public opinion, returning this much land to suitable conditions would be a major added expense.