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# ALUMINUM FROM CLAY

## Introduction

Light metals in large quantities are essential to winning the war. They may be expected to occupy an increasingly important position in the post-war picture. We have ceased to marvel at rapid travel by air to nearly any point on the earth's surface, but we fail, generally, to credit light metals and their alloys for their part in air-travel development. Aluminum is by far the most important of the light metals, and in years to come bids fair to become second only to steel among the metals in industrial importance.

Bauxite, essentially aluminum oxide and combined water, has been the ore from which aluminum has been reduced, except in Germany. There, because of pre-war deficiency in bauxite, some aluminum (reported to be approximately 50,000 tons a year) was made from clay.

High-grade bauxite, formerly used exclusively for domestic production of aluminum, contains 55 percent or more alumina (aluminum oxide) and 8 percent or less of silica. Clay, on the other hand, is composed essentially of aluminum silicates which contain a much lower percentage of alumina and very much higher percentage of silica which is chemically combined and must be separated. Therefore it is evident that bauxite is superior to clay as a source of metallic aluminum. Why then consider clays in competition with bauxite? The answer is that, measured by the present and potential demand for metallic aluminum, the United States is lacking in suitable bauxite reserves. It follows that the United States is dependent on foreign bauxite for its aluminum. This may be satisfactory in peace time, but it should not be necessary to emphasize the hazard of depending entirely on foreign sources of such a vital material. We have experienced the unpleasant results of our own negligence in establishing sufficient and safe supplies of such necessities as rubber, tin, and quinine.

## United States Bauxite Resources:

Government agencies in 1941 estimated that domestic high-grade bauxite reserves amounted to 9,343,000 long tons, and that low-grade bauxite having an average grade of 50 percent alumina and 17 percent silica totaled approximately 17,337,000 tons. By far the largest part of domestic bauxite - about 85 percent - occurs in Arkansas.

Since 1941 a considerable part of this reported reserve of high-grade bauxite has probably been used up. Pilot-plant work on utilization of low-grade bauxite has been done and some of this material is now being used. Probably most of our ore, however, is presently coming from Surinam and British Guiana, as the submarine hazard has considerably lessened.

## Foreign Bauxite Reserves

Foreign deposits of greatest importance to this country are those in British Guiana and Surinam (Netherlands Guiana). Large reserves are known and unprospected areas which are potentially important cover many square miles. Shipments of bauxite from both countries, mainly to Canada and the United States, have increased several times in volume during the past few years.

In Europe the best known bauxite deposits are in France, Hungary, Italy, and Yugoslavia, all of which production is controlled by Germany. Complete information on U.S.S.R. is not available, but a large aluminum industry has been built up.

Important deposits of bauxite occur in the Netherlands Indies, also in India, Northern China, and Indo-China. The Island of Bintan in the Netherlands East Indies has produced high-grade bauxite for many years. Most of the production went to Japan. At the present time Japan controls very large reserves in conquered areas and is reported to be exploiting the deposits as rapidly as possible.

Bauxite deposits have been developed in Southern Rhodesia, Brazil, and Australia, and occurrences are known in various other countries including Venezuela and Honduras.

## Clays

True clays are finely-divided aluminum silicates which contain water of combination. Commonly, clays are plastic when wet, but the term is also applied to compacted earthy rocks which have little or no plasticity. The principal clay minerals are kaolinite, dickite, nacrite, montmorillonite, beidellite, halloysite, allophane, and nontronite. Clay deposits contain varying percentages of impurities, and it follows that there is a wide range in the composition of clay deposits.

Next to stones for weapons, probably clay is the most ancient of man-used rocks or minerals. Down through the ages use of clay has been intimately connected with man's daily life - in houses, in household utensils ranging in type from the Latin American olla to the finest Dresden china, for refractories, for tiles of wide variety, for foundry materials, oil-well drilling mud, for filtering and bleaching mediums, for a wide variety of "fillers", for sanitary wares, sewer pipe, electrical porcelain, terra cotta, and abrasives. Finally, we come to the latest use and possibly that of greatest future importance - a source of metallic aluminum.

Clays may be classified according to use, mineral characteristics, geological occurrence, or burning qualities. If classified according to burning characteristics, in general high alumina clays are the best refractories.

## "Alumina from Clay" Project

In 1938 refractory clay deposits of western Oregon were described by Wilson and Treasher*, and this report was the basis of the clay exploration program in Oregon conducted by the U.S. Bureau of Mines and the U.S. Geological Survey. Two primary factors influenced the Federal bureaus in their selection of deposits to be explored. These factors were high alumina content and favorable indications for developing a large reserve in millions of tons. Deposits near Molalla in Clackamas County and at Hobart Butte in Lane County were selected for investigation. Extensive drilling and sampling has been done at both deposits with encouraging results, so that these deposits, together with a third at Castle Rock, Washington, are known to be satisfactory in quantity and quality for an "alumina from clay" project. Such a project has been set up by the Columbia Metals Company, Seattle, based on the ammonium-sulphate process as developed by the Chemical Construction Corp., a subsidiary of the American Cyanamid Co. The process has been examined and approved by the Alumina Committee of the National Academy of Sciences, and the War Production Board has authorized a semi-commercial plant, reportedly with a capacity of 50 tons of alumina a day. The crude clay requirement would be of the order of 200 tons a day. Possible sites for the plant have been investigated by a representative of the War Production Board and by engineers of the Chemical Construction Corp. but no decision has been announced. The latest report is that the matter is in abeyance, the reason given being manpower shortage in northwestern Oregon and Washington.

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* Bulletin No.6., Preliminary Report of Some of the Refractory Clays of Western Oregon by Hewitt Wilson and Ray C. Treasher, Oregon Dept. of Geology and Mineral Industries.

Aside from clay, the main raw materials required for the process are ammonium sulphate, sulphuric acid, oil or coal or both, and limestone. Ammonium acid sulphate is added to the calcined clay and the mixture digested. Aluminum goes into solution as ammonium aluminum sulphate, and may be separated from the solids - mainly silica, metallic oxides, and insoluble sulphates. The soluble sulphates are then subjected to a series of crystallizations and precipitations until pure aluminum hydroxide results. Alumina ($Al_2O_3$) is obtained from aluminum hydroxide ($Al_2(OH)_3$) by calcining.

It may be pointed out that the end product in the first step to obtain metallic aluminum is alumina, the oxide, whether the original material be bauxite, clay, alunite, or any other aluminous material. After the alumina is obtained the reduction to metallic aluminum by electrolysis in a cryolite bath is a standard process.

## Importance of Pilot Plant

Supplies of clay for the production of alumina are limited only by the "cut-off" point of percentage of available alumina contained. Naturally, physical characteristics of the deposit, location and transportation facilities, water supply, and availability of electric power and fuels have a direct bearing on the feasibility of any project. But generally speaking domestic reserves of high alumina clays are very large. However, they are of no value whatever as a source of alumina unless a workable process for treatment is developed in detail in a large pilot plant. Only a plant operating under actual working conditions on a scale large enough to simulate a commercial operation would provide the information required for design of a large commercial plant or plants. This is a matter for the government as it is of direct interest to all the people. The outcome of a future war might depend upon our ability to produce aluminum from domestic deposits. The large aluminum companies have sources of supply of bauxite in the Guianas, and do not have the necessary incentive now to build an "alumina from clay" plant which, so far as we now know, would be "high cost" compared to a plant using bauxite.

## Plant Location Should be in Northwest

According to present practice alumina is made in plants located at East St. Louis and Mobile. The required amount is then transported across the continent to reduction plants in the Northwest where ingot aluminum is produced. This is indeed an excessive amount of transportation. An alumina plant located in the Northwest, preferably on tidewater, would appear to be the logical answer.

Oregon high-alumina clays are relatively high-grade and occur in large quantities - of the order of many millions of tons in the two deposits partially explored. Other unexplored deposits in western Oregon are known. Particularly favorable conditions for an alumina plant prevail in northwestern Oregon due to the availability of Bonneville power, coal, nearness to ocean transportation, excellent working conditions, and proximity to established aluminum reduction plants at Vancouver, Troutdale, and Longview. No other part of the country has so many favorable conditions.

## Prices

Aluminum was first isolated in 1825. It remained more or less of a laboratory curiosity for many years. In 1855 the price was $113 a pound. In 1886 Hall in this country and Heroult in France simultaneously discovered that metallic aluminum could be produced electrolytically from a cryolite bath. This discovery gave birth to the aluminum industry. In 1890 the price was $2.38 a pound. By 1900 the price had been reduced to 23 cents a pound, and now the nominal quotation for ingot aluminum is 15 cents a pound. These successive reductions in price reflect the striking growth of the industry. As the scale of operations increased, unit costs were reduced. But reduction in costs was not due entirely to increased scale of operations. In no other industry has the skill and ingenuity of American metallurgists been more clearly evident.

Domestic crude bauxite (not dried), 50 - 52 percent alumina, is quoted by the Engineering and Mining Journal as $5.00 per long ton (2240 pounds). Of course no comparison of the value of crude clay on the basis of alumina content may be made from this quotation because there is no present market for clay for production of aluminum. The only means available of arriving at a gross, potential value of clay suitable for production of aluminum is to multiply the aluminum content of the clay by the market price of aluminum. This gives a distorted figure, as the "alumina from clay" plant must sell its alumina to an established reduction plant at a price set by the reduction plant. This price has been reported to be $50 per ton plus freight.

It is of interest to compare this price for alumina with the gross value of metal contained. Alumina contains over 50 percent aluminum - say 1000 pounds to the ton. This means a gross value of $150 per ton for material costing $50 a ton. The difference is of course used up to a considerable extent in labor and cost of power and supplies required to produce aluminum from alumina, plus amortization of plant. Nevertheless the industry has been very profitable, and, as it is quite well known, it is largely controlled by a single corporation.

## Post-War Prospects

Of all the non-ferrous metals, aluminum is in the most favorable position for post-war business because of its increasing use as a structural material. The industries which are likely to expand most in the post-war world - those connected with transportation - will require large quantities of the metal. Compared to the copper industry, which is taking a beating in this war in depletion of ore reserves and in rigid price restrictions according to various quotas, the aluminum industry should go into the post-war period stronger than ever. There has been no price restriction on metallic aluminum except that established as economic by the industry itself. There has been depletion of domestic reserves of high-grade bauxite, but the known reserves of this grade have never been large. In recent years the industry has depended largely on the reserves in the Guianas. In point of contained metal these foreign deposits are very large, with additional large potential reserves in unexplored areas.

From a long range viewpoint the aluminum industry is youthful; it is still growing. On the other hand the domestic copper industry shows signs of age - premature age. Its output will shrink because of excessive depletion of reserves and burdensome taxes - conditions largely due to short-sighted policies of Washington bureaus. In normal times aluminum and copper are competitive in certain lines. Undoubtedly aluminum will be in a relatively favorable competitive position in seeking post-war business. Expansion in application of light metals and their alloys will continue, and domestic high-alumina clay deposits may, in the future, easily prove to be the backbone of the aluminum industry. It will be necessary to turn to them in time, and it would be the part of wisdom to work out the metallurgy on a commercial scale before another emergency strikes.

F.W.L.

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## NEW FORM FOR ACCESS ROAD APPLICATIONS

In order to standardize the original application for access road assistance, the Public Roads Administration has prepared Form PR-DA-3 to be used by applicants. These forms provide the minimum of information necessary to initiate a project of construction, improvement, or maintenance of access roads to sources of raw materials. Use of the new form does not change the procedure for obtaining assistance. Forms PR-DA-3, which should be filled out in duplicate, may be obtained at the Portland Office of the Department or from district offices of the Public Roads Administration.

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## "DOC"

### A Tale of the North Country*

I first met "Doc" in Dawson about 1898. He must have had more of a name than that, 'though I have never heard it. At that time he looked to be about 35 years old - a youngish man whose hair was prematurely graying at the edges. Doubtless one reason for his youthful appearance when I saw him recently was a splendid new set of teeth that he had just had made in Vancouver, B. C. He was so proud of them that he made the trip down to Portland so I could see them. During our visit Doc gave me the substance of the story that follows.

Doc is a placer miner and has a sizeable concession near the head of the Stewart river among the "Four-leaf Clover" lakes. Last winter he drifted a lot of old white channel stuff that proved pretty good; anyway he had between a ton-and-a-half and two tons of gold-dust and nuggets at the clean-up in May. That's a lot of gold in any man's country; too much to mush out with pack-sacks or sleds; and anyway there were'nt enough mules in the Yukon basin to handle it. So Doc started in a woods-made canoe, down the Stewart river for Selkirk in order to arrange for a couple of pontoon planes to come in from Carcross and take the gold out to the railroad.

Running the Stewart proved easy the first two days but on the third a land-slip decided to occupy a bend in the river at the same time that Doc and his Canadian "white water man" were shooting past in their canoe. Doc was the only survivor, - sans everything in the way of equipment save his Hudson's Bay knife and a waterproof match case, but minus his false teeth. He was about 175 miles due east "from the knowledge of Providence", in the west foothills of the Canadian Rockies and no eats. But Doc was resourceful - which goes without saying if a man sticks with the Yukon country for nearly half a century. He noticed bear signs along the bank of the river and so, there being an old spruce burn nearby with plenty of down logs, he rigged a deadfall where any inquisitive bear examining the fishing prospects would be sure to see it. He had no bait, but come dusk he ensconced himself in the machine as bait, taking the fifty-fifty chance that the bear would come from the right direction, which he did. When his bearship tripped the key-log he got his furry old back broken. Doc promptly finished the job with his Hudson's Bay knife - which tools are probably better than the legendary Toledo blades for edgeholding ability.

Doc built a fire, cut off a hunk of bear-meat and roasted it, but the bear was no spring chicken and had evidently had a hard winter. Doc says "Multiply the toughest steak you ever saw by about 2,000, subtract the gravy and you have some idea." He simply couldn't "gum" that bear-meat, and that was a finality. But resourceful Yukoner that Doc was, he wasn't going to be stuck. He whittled down an unsplittable Yukon birch, cut some pieces off and by dint of taking some clay impressions of his jaws and faithfully copying them he soon had the groundwork of a set of teeth. Next, he took the bear's jaws over to a convenient rock-pile, knocked out an assortment of teeth, bored holes with the knife point in his wooden frames, mounted the teeth therein and proceeded to eat that bear with the bear's own teeth.

Next he shouldered a large hunk of meat and a piece of hide to sleep under, and made the distance to the Yukon opposite Fort Selkirk in less than a week. He shortly spotted a couple of chaps in a boat and by signaling them induced them to come close enough for a good look. They would come no farther, because Doc was wearing his handicraft, had two weeks of grizzled beard, and his bearskin over his shoulders.

Those boatmen beat it across to the CNWMP station at the fort and shortly afterwards three brave "mounties" armed with rifles came and rescued Doc. They knew him and from then on his troubles were over, except that he had to come out and get some teeth that fitted better because the ones he made so fortuitously made his gums somewhat sore.

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*This story was related by Geo. F. McDougall, consulting engineer and patent expert and good friend of the Dept. "Mack", who made the Klondike rush and stayed there some years because it seemed like a good idea, has a fund of stories and his own way of telling them. He does not vouch for the accuracy of North Country stories beyond his own ken. Would you?

## COAL UTILIZATION

The following is taken from the July, 1943 issue of Oregon Purchasing News, published by the Purchasing Agents' Association of Oregon. The item is timely in that both transportation and fuel supplies are so critical.

The British program which expects to obtain 30% greater energy from coal utilization and also obtain a more direct production of coal by-products (British Coal Utilization Research Association) might well be given more attention in this country. For the most part we are primitive in our coal utilization. Coal will absorb about 25% of water, and common practice is to ship water-soaked coal. Not only is it wasteful in transportation to ship raw coal, but it is wasteful to have to drive off the contained moisture in burning. Dried and briquetted coal gives high efficiency, burns regularly and evenly, permits use of lower grades, gives off less smoke. Introduction of the chemical by-product plants at the mine mouth also provides better utilization of all grades of the coal, furnishes the moisture-proofing material for the briquettes, and would diversify industrial jobs in districts now hampered by single-industry stagnation. In this country some research has been along the lines of mixing powdered coal with fuel oil for burning under industrial boilers (U. S. Bureau of Mines). As much as 40% powdered coal is mixed with the oil. Results of the efficiency tests have not yet been published.

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## BULLETIN PRICE REDUCED

The price of Department Bulletin No. 4 by H. C. Schuette issued in 1938, has been reduced from $1.15 to 50 cents. A survey of quicksilver deposits of the state is being made for the Department by Francis Frederick, consulting geologist of San Francisco, and results will be published as a bulletin sometime this fall. This report will not, however, duplicate discussions of the economics of the industry and metallurgy given in Bulletin No.4.

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## BERYL SALABLE AT METALS RESERVE DEPOTS

Metals Reserve Company will purchase clean beryl crystals delivered in sacks or other suitable containers at Purchase Depots under the following schedule:

Specifications: For beryl ore to be acceptable, the BeO content must be 8% or more and in the form of clean crystals, cobbed free of waste.

Price and Quantity: Large Lots (in excess of 2000 pounds), payment will be made after weighing, sampling and analysis (this includes moisture determination) on the basis of $120 per dry short ton for 10% BeO grade ore, with an increase of $12 per dry short ton for each one percent (1%) of BeO in excess of 10%, and a decrease of $12 per dry short ton for each one percent (1%) of BeO below 10% to a minimum of 8% BeO. Fractions prorated.

Small Lots (200 to 2000 pounds), which do not warrant the expense of sampling and analysis will be purchased, after weighing, on sight inspection by the Agent on the basis of $120 per dry short ton for 10% BeO grade ore. To be acceptable on sight inspection, that is, without sampling and analysis, the beryl crystals must be clean and all waste material cobbed off and free of inclusions of feldspar, mica or other deleterious material. This procedure of purchasing small lots of beryl ore will from time to time be revised as to price if analysis of composite samples of such lots at any Purchase Depot necessitates it.

(From Metals Reserve Company circular July 26, 1943)

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