

SOME NEW SOURCES OF ALUMINUM AND MAGNESIUM

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The sudden demand for light metals for the construction of airships in the national defense has put an enormous burden upon the producers of these metals. The responses have been startling. It has been stated that the present plans for the production of aluminum contemplate turning out from seven to ten times as much metal as was produced in the peak year before the war broke out. In like manner the capacity for the production of magnesium in 1942 was fifty times as great as the consumption in 1935, and in addition plans already announced for the present year contemplate the doubling of the 1942 capacity.

These meteoric developments have raised serious questions regarding our supply of raw material. Both of these metals have formerly been produced from a single source, and in both cases this natural material is limited in quantity. In both cases also we have abundant native compounds which we have never learned to employ for the production of the metal. As a consequence many serious problems have arisen as to possible methods for obtaining these metals from new sources, since these metals are vitally important in winning and maintaining air supremacy in the various battle fronts of the world conflict.

Aluminum was formerly obtained commercially from bauxite, a hydrated oxide which usually contains some iron and silica. The first step in winning the metal from this ore by the universally used Bayer method is digestion of the powdered bauxite with NaOH. This produces soluble NaAlO_2 , but the Fe_2O_3 is

not changed and is effectively removed by filtration. The aluminate is boiled and thoroughly aerated, resulting in the precipitation of $\text{Al}(\text{OH})_3$, which is filtered off and ignited to Al_2O_3 . This purified alumina is dissolved in a suitable solvent such as fused cryolite, and this solution upon electrolysis yields aluminum metal.

If the bauxite contains silica the alkaline digestion causes a reaction between the SiO_2 and the aluminum compounds producing aluminum silicates. These compounds are stable and the Bayer process does not recover the aluminum metal from them. As a consequence the presence of silica in the bauxite causes the "freezing" of the aluminum with a consequent reduction of the yield. To avoid as much as possible loss from this cause, only bauxite with less than about 7% SiO_2 has been considered suitable for use in the aluminum industry. Deposits of such high grade bauxite are not common and their exhaustion by the present frantic demand for aluminum is imminent. As a consequence there must be found new deposits of high grade bauxite, methods of removing the silica from the low grade bauxite, or practical methods for removing aluminum from the silicate tailings.

An effective washing method of processing bauxite ore for the removal of sand was announced by Alcoa in January 1943. If the process is successful it will do much to extend the production of aluminum because it will make available enormous deposits of low grade bauxite. So far prospectors have uncovered 6,000,-

000 tons of B grade ore, and the search is being continued.

For many years metallurgists have dreamed of the time when it would be possible to extract aluminum from silicate ores at moderate cost. When such a process is devised it will greatly extend our supply of this metal. The tailings of Bayer purification plants will furnish a large supply of material. The East St. Louis plant is said to have a 30-year accumulation of silicate tailings, which would be equivalent to a million tons of bauxite. A lime-soda sintering process has had some success, and it is now proposed to use this treatment for the recovery of aluminum from plants using high-silica bauxite.

Many attempts have been made to extract aluminum from clay and shale. Probably the most successful method so far proposed is the Pedersen process which consists of sintering the clay with limestone and then leaching with soda. Commercial trials of this method are under way. The great advantage which the method enjoys is the fact that it does not require the use of acids. The extraction of aluminum compounds from clay by means of acids has been in use for many years, but when these compounds are used for the production of aluminum metal, costs increase rapidly. But progress in this direction has been so rapid that Donald Nelson has been led to predict that after August 1943 the United States would be independent of foreign supplies of aluminum ores.

Alunite is a hydrated potassium aluminum sulfate which is found in great abundance in certain areas of the west. Near Marysvale, Utah, there are deposits which are capable of producing 30,000 tons of aluminum metal annually for ten years. Acid extraction of alunite seems to be most promising, and the presence of sulfur in the mineral is an advantage because it permits a plant to extract clay as well as alunite. Pilot plants are now in operation in Utah, at Wilson Dam as well as at other locations. It will be recalled that during World War I it was proposed to extract potash from alunite. If the present emergency results in reclaiming both potash and aluminum from alunite, there will be a great advantage because costs can be distributed between these two useful materials.

The total expenditure scheduled for new aluminum plants in the United States from January 1, 1940 to July, 1943, is estimated at approximately \$600,000,000.

Before the outbreak of the present war the sole producer of magnesium in the United States was the Dow Chemical Company, who prepared the metal by electrolysis of fused $MgCl_2$ which was obtained from deep well brines. When it became evident that this source of material could not yield an adequate supply of magnesium, a large plant was built at Freeport, Texas to reclaim $MgCl_2$ from sea water. Later plants were built to use $MgCl_2$ which is prepared by the action of HCl upon magnesite ($MgCO_3$), dolomite ($MgCO_3 \cdot CaCO_3$) or brucite ($Mg(OH)_2$). These later methods are expensive because of the quantity of acid required and the inevitable loss which accompanies its recovery.

Since most of the ores of magnesium are carbonates or hydroxides, they are converted to oxides without too great difficulty. Some method of winning magnesium from the oxide seems to be highly desirable. Apparently little effort has been made in this country to obtain magnesium by electrolysis of a solution of the oxide in a fused halide bath. This method has been the favorite one in Germany, which has produced about half of the pre-war magnesium. In the United States and Canada many efforts have been made to produce magnesium by the thermal reduction of MgO .

Prominent among these methods is the Hansgrig process, now being operated by Henry Keiser in a huge plant near San Francisco which has a capacity of 66,000,000 pounds per year. Brucite or magnesite is ignited to the oxide and reduction is accomplished by heating at a high temperature with carbon. The magnesium produced under these conditions is in the vapor phase and must be chilled suddenly to prevent a reverse action. Chilling is accomplished by flooding the chamber with intensely cold hydrogen, natural gas, or fuel oil. This method has encountered some unfortunate handicaps, but now seems to be in successful operation.

The Pidgeon process has been developed under the Canadian National Research Council. As raw material, dolomite may be used. The ore is calcined to

the oxide, and then reduced by ferrosilicon in a vacuum. Dicalcium silicate is formed and pure magnesium condenses without difficulty. This method is said to operate smoothly, to be safe, to require inexpensive equipment and to give excellent metal at low cost.

Another process which looks promising has been devised by Professor Doener of Washington State College. It operates upon low grade magnesite or dolomite, which is first concentrated by a flotation process and then treated by somewhat the same reduction method as is used by the Hansgrig process. The metal is cooled with fuel oil and purified by distillation.

A new magnesium plant near Spokane uses an electric-thermic reduction process which is a modification developed by the U. S. Bureau of Mines. It uses as raw material the magnesite from Stevens County, Washington, and power from the Grand Coulee dam.

Other plants are now in operation or are being completed at Las Vegas, Nevada; Austin, Texas; Lake Charles, Louisiana, and Painesville, Ohio. It is expected that the total capacity for 1942 will reach 100,000 tons annually, and present plans contemplate the doubling of this capacity within the near future.

Because both aluminum and magnesium are relatively new as engineering

metals and because they are both light in weight and form strong alloys, it is natural to regard these metals as rivals. It is by no means certain that they will become serious competitors for favor among engineering designers, since each plays a particular part in the design of airplanes. But a comparison of the two metals is interesting.

The electrolytic production of one pound of aluminum requires 12 kilowatt-hours of electrical energy, while a pound of magnesium uses 9.15 kilowatt-hours. Aluminum has a density (2.70) which is a third more than that of magnesium (1.74). Both metals are now selling for the lowest price in history—aluminum pig at 15 cents a pound and magnesium is still quoted at 27 cents a pound although it seems certain that this price may be greatly reduced. These prices seem high for the extensive use of an engineering material, but if the cost per cubic foot is computed it is discovered that aluminum and magnesium by the cubic foot are the cheapest of all our metals with the single exception of iron. The enormous growth of the light metal industries, together with the distinct advantages in their use, make it seem safe to predict that the post-war period will see a great expanse in their use for civilian purposes.
