

The Elements of Cryolite and their Applications.*

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Near the settlement of Ivigtut, in West Greenland, in the high northern latitude of 61°, occurs the only workable deposit of cryolite of which we have at present any knowledge. Picturesque and somewhat lofty mountains whose bases are washed by the waters of the little bay upon which the small village is situated, are composed of granitic and gneissoid rocks, in whose bosom is entombed a remarkable vein, or rather deposit of the nearly pure mineral, which attains an average thickness of not less than eighty feet, and which appears to be coincident in direction with the general course or strike of the beds of gneissic rock. This occurrence of the mineral cryolite is wrought under the auspices of the Danish Government by an incorporated company, and supplies manufacturing establishments in England, France, Denmark and the United States, with a raw material upon which is based several important and rapidly extending industries.

The mineral occurs at this locality associated with several species, among which may be enumerated spathic iron (ferrous carbonate), galena (sulphide of lead), and copper pyrites (sulphides of iron and copper), though none of these have been found in quantities sufficient to render them of importance. In addition to these are two or three minerals of interest only to the collector, and which are of quite recent discovery. They are related to cryolite, and are probably the result of a secondary action on the main mineral.

On chemical analysis, cryolite is shown to be composed of the three elements, fluorine, aluminium and sodium, combined in the proportion of six atoms of the first or two of the second and three of the third, so arranged among themselves as to produce one equivalent of fluoride of aluminium and three equivalents of the fluoride of sodium, giving rise to the formula, $3 \text{ Na Fl} + \text{Al}_2 \text{ Fl}_3$. Its percentage composition, as deduced from this expression, is as follows: Fluorine (Fl), 54; Aluminium (Al), 13; Sodium (Na), 23. Each of these elements, as extracted from the cryolite, finds important applications in the arts.

And first of fluorine: In its elementary condition we know little, if any thing, of this substance. Its isolation has been attended with so many difficulties, that the labors of but few, if of any, of the many chemists who have undertaken it have been crowned with success. But two of its compounds—one with hydrogen and the other with silicon, called respectively fluo-hydric and fluo-silicic acids—have recently had their technical employment considerably extended, thanks to the labors of M. Tessie de Motay and others, and their production on an industrial scale formed, according to the report of our Commissioner, "a somewhat prominent feature of the development of the chemical arts, as brought by the Exposition of 1867." De Motay prepares them by mixing fluor spar (fluoride of calcium), silica and alumina in such proportions as to form a slag similar to that produced in a blast furnace; forms this mixture into a stiff paste, which is moulded into the form of bricks,

and then dried in an oven. These are thrown, with the addition of a sufficient quantity of coke, into a blast furnace of from thirty to forty feet in height, where, as they descend, they are decomposed into fluoride of silicon and silicates of lime and alumina—the two latter uniting in the production of a slag, the first passing off as a gas. Above the mouth of the furnace is arranged a series of five condensing chambers, constructed of wood, into which the gaseous fluoride of silicon is conducted, and where it is decomposed, by passage over Venetian glass plates moistened with water, into gelatinous silica and a solution of fluo-silicic acid.

This acid has, for some time, been used for liberating chloric acid from chlorate of potash, in order that it may be combined with other bases and be employed in pyrotechny. A recent application of it is for the production of the insoluble fluo-silicate of potassium, which is largely consumed in France as a substitute for borax in the manufacture of flint glass, and which it is proposed further to utilize by its conversion into caustic potassa. As the somewhat abundant chloride of potassium can be readily transformed into more useful salts of the same metal by the intervention of this fluo-silicic acid, both of these compounds assume a new importance in technical operations, for the question of the best and most economical method of extracting potash from minerals is forcing itself upon chemists all the world over.

The fluorine of cryolite is used in this country for the production of semi-opaque white glasses, resembling in many respects, porcelain. They are formed by melting together, in the ordinary glass pots a mixture of sand, oxide of zinc and cryolite, and consist essentially of silicates of alumina, soda, and oxide of zinc with silico-fluoride of sodium to which latter the semi-opacity is most probably due.* The mineral, in this application, in addition to furnishing a peculiar product to the glass maker, also serves him as a cheap cheap source of soda, saving expensive and troublesome manipulation. And this brings us to another of the elements of cryolite—sodium.

The history of the production of soda compounds is one of the most interesting accounts of the methods in which chemical science has subserved and answered the demands of a thousand industries. The progress of business from the time when they were collected from the lakes of Egypt and elsewhere, up through the period of sea-weed burning for the production of kelp, varec or barilla, to the countless improvements on the original common salt process of Le Blanc, is the progress, in a great measure, of the important industrial operations of the glass and soap maker. The utilization of cryolite in the same direction, is still another important forward step which was first taken but a few years ago.

As practiced near Pittsburgh, Pennsylvania, the method of manufacturing soda from cryolite, consist in calcining the pulverized mineral with lime, which removes the fluorine from both the aluminium and the sodium, with the formation of fluoride of calcium, and alumina and soda. The lixiviation of this calcined mass dissolves the soda, and through it the alumina, and leaves the fluoride of calcium as an insoluble mass.

The passage of carbonic acid through the solution of soda and alumina results in the formation of carbonate of soda and the precipitation of alumina, and these two compounds are separated by filtration, the liquid being evaporated for obtaining the carbonate, which may subsequently be converted into caustic soda or into bicarbonate. Or the product of the first lixiviation may be evaporated to dryness, with the production of aluminate of soda, which finds employment as a mordant in dyeing, being reported to heighten greatly the color on certain woolen goods. Aluminate of soda is also prepared from the mineral *bauxite*, by boiling it with a concentrated solution of caustic soda, or by calcining it in a reverberatory furnace with soda ash.

The precipitated alumina from the operation of producing carbonate of soda from cryolite, is placed in a suitable leaden vessel, and agitated with sulphuric acid and water for the production of sulphate of alumina, a compound much used in dyeing, and to some extent in paper making, and which, as formed above, is free from iron and from any excess of acid. On account of these features and the trifling cost at which it can be produced, it is rapidly superseding alum in many operations.

When acetic acid is used as a solvent for precipitated alumina, the production is an acetate of that base, which was formerly, before the utilization of cryolite and *bauxite*, prepared by a process of double decomposition between sugar of lead and alum, and being decidedly more expensive, was much less used than it now is.

Very nearly five thousand tons of cryolite are annually consumed in this country for the production of soda and aluminous compounds, the only establishment using it being at Natrona, Pennsylvania. Its products are remarkable for their purity, and are in request by the manufacturers of the finer qualities of glass, as well as by dyers, paper makers and sugar refiners. In Europe, the cryolite is sometimes decomposed by long continued boiling with milk of lime, the change being essentially the same as when the process of calcination and subsequent lixiviation is employed. It has been proposed to fuse the mineral with twice its weight of wolfram, for the production of tungstate of soda, from which caustic soda can be recovered by the addition of lime, tungstate of lime being at the same time produced. A patent has been granted in this country for a method consisting in calcining cryolite with the mineral apatite or other native phosphates of lime, by which phosphate of soda is formed, which can be subsequently decomposed by lime, and the resulting phosphate of lime be employed as a fertilizer. It is, however, doubtful if any of the processes will take the place of the one first described, unless, indeed, some of their new secondary products become of greater importance, so that the caustic soda may come to be regarded as an incidental product.

The metal aluminium has also been extracted from cryolite by simple fusion with metallic sodium. There are, however, difficulties in the way of employing one mineral for this purpose, so that its use has been almost entirely replaced by the artificial double chloride of aluminium and sodium, readily and cheaply prepared from common salt and clay. The excessive cost of sodium

*From the Technologist.

*C. P. William's Jour., Franklin Institute, April, 1860.