MINES BRANCH

DEPARTMENT OF MINES

OTTAWA, CANADA

NOTES ON BERYLLIUM AND BERYL

Memorandum Series
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NOTES ON BERYLLIUM AND BERYL

By Hugh S. Spence

INTRODUCTORY

In view of the considerable publicity that has been given during the past year or two in the technical press to the subject of beryllium and its ores, it appears desirable to present a brief synopsis of some of the principal facts relating both to the progress made in developing industrial uses for the metal and to the market possibilities for the mineral beryl - the only present commercial ore of beryllium. Somewhat erroneous conclusions seem to have been drawn in some instances from published articles relating to the subject, and statements have appeared from which it might be inferred that there exist in Canada large known deposits of beryl of high commercial value and that a ready market exists for the mineral. Such inferences are not strictly in accordance with the facts, and it is probably due to the misapprehension obtaining that the Mines Branch has lately received numerous enquiries from foreign and domestic sources for information relating to the occurrence of beryl in Canada and to the market possibilities for the mineral.

BERYLLIUM - Properties, Uses, Etc.

Beryllium (somestimes also called glucinium) is a light metal, having nearly the same specific gravity (1.8) as magnesium (1.7). It is very hard,

brittle, non-ductile and takes a high polish: it cannot be worked in the cold. Its melting point is 1285°C. The electrical conductivity is reported to be comparatively low. The metal shows good resistance to atmospheric agencies and corrosion. Its coefficient of elasticity is almost equal to that of steel, and its coeffecient of thermal expansion approximately that of cast iron.

Although beryllium has been known for over a hundred years, means have only quite recently been found to isolate it in anything more than the most minute quantity. Previous to 1920, production of the metal was by the gram or ounce, and even then the product was not particularly pure.

During the last ten years, considerable research has been conducted both in Europe and the United States upon the development of industrial uses for beryllium and the perfecting of a commercial process for the production of the metal from its ores.

As far as known, there has been no attempt made to produce beryllium in Canada. In the United States, the Beryllium Corporation of America, of Cleveland, has produced a small amount of the metal and has also investigated the subject of alloys of beryllium with aluminium, gold and silver. In Great Britain, beryllium and beryllium-iron alloys have been studied at the National Physical Laboratory, under a committee of the Department of Scientific and Industrial Research, and attempts have been made to prepare the metal in a purer and more ductile form. Probably the greatest amount of research on beryllium has been conducted in Germany, where the Siemens-Halske Company has been particularly interested in studying the properties and possible industrial uses of the metal and its alloys with iron, copper and nickel. Most of the comparatively small quantity of beryl sold in recent years in the United States is believed to have been shipped to Germany for experimental purposes, and the only small shipment ever made from Canada, consisting of two tons in 1927, also went to Germany. This last was shipped from a deposit in Lyndoch township, Ont.

The chief obstacles encountered in the research on beryllium have been the difficulty of preparing the metal in sufficient quantity and in a pure enough state to enable its properties to be studied, and the prohibitive cost of the refined product. While progress has been slow, it appears that the main metallurgical difficulties have now been overcome, and a recent press report[1] indicates that a plant has lately been placed in operation in Austria which will produce beryllium of 98 to 99 per cent purity. It is understood that the process used involves the electrolysis of beryllium salts prepared by leaching sintered beryl. The plant is situated in the Kflacher district, in Steiermark, near the deposits from which the ore is obtained, and where there is ample hydro-electric power for the metallurgical process. The project involves concentration of the ore, which is effected by a preliminary rough-sorting, followed by crushing, classifying and flotation. The Company concerned is the Beryllium Company Dr. Kent Siedler Graz, which is understood to be associated with American interests.

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[1] London Mining Journal, Feb. 8, 1930, p. 114.

Beryllium is a hard and brittle metal, and for this reason, few important commercial uses for it alone have been found. Its principal field of application will probably be as an alloying metal, more especially with iron, copper and nickel, to all of which small additions of beryllium impart greatly-increased hardness and strength. Both the hardness and strength of the straight alloys are further increased by subsequent heat treatment, making beryllium-iron the equal of hardened steel and beryllium copper and beryllium-nickel superior to bronze. An additional advantage possessed by the two latter alloys is that they may be worked as desired before the final hardening heat-treatment, whereas bronze cannot be so worked.

The statement, often made in the press, that a great future is foreseen for beryllium or low beryllium-aluminium alloys in aircraft construction does not appear to be warranted at the present time since, so far as known, the properties of these materials make them entirely unsuitable for such a purpose. The close similarity, also, in many of the properties of beryllium and aluminum would indicate that no particular benefit is to be expected from alloying the two metals, though it is thought possible that high beryllium-aluminium alloys may have a field of usefulness, provided that certain technical difficulties in the casting of the metal can be overcome.

It has, however, been suggested that beryllium would be well adapted for the manufacture of aircraft motors, and it has been estimated that a 400 H.P. motor for such purpose would be light enough to be lifted by one man.

Minute plates of beryllium are sometimes used as windows in X-ray tubes, such windows being found to be seventeen times more permeable to the rays than aluminium plates of the same thickness. It has also been proposed to use the metal in the electrodes of neon signs.

Aside from straight metallurgical uses, the only other major field of usefulness for beryllium that appears to have been investigated is the substitution of the oxide for lime or magnesia in certain types of glass. This subject has been studied for some years past at the University of Pittsburgh, and the results are reported to be encouraging.

The possibility of employing the natural mineral beryl in ceramics has also been studied, and it has been found that the substitution of beryl for feldspar in porcelain mixtures results in high electrical resistance and low thermal expansion.

BERYLLIUM MINERALS

While over a dozen minerals are known that contain the element beryllithe only one known to occur in sufficient quantity to constitute a commercial or

of the metal is beryl. Most of the other beryllium minerals are complex silicates, which, while often containing a higher percentage of the element than beryl, are of such limited occurrence as to rank as rare minerals.

All of the known beryllium minerals, with the exception of the emerald variety of beryl, occur usually in or in close proximity to granite pegmatites, and they are often especially abundant in pegmatites carrying a large amount of lithium minerals, such as lepidolite, spodumene, amblygonite, etc. The latter association is not invariably the case, however, and beryl is also found in the ordinary type of pegmatite consisting mainly of feldspar and quartz, with or without muscovite mica and the common accessory minerals biotite, tourmaline, garnet, etc.

BERYL - Description

Beryl is a silicate of aluminium and beryllium, having the theoretical composition $3BeO.Al_2O_3.6SiO_2$. When pure, it contains 14 per cent beryllium oxide, corresponding to a content of 5.4 metallic beryllium, but usually some of the beryllium is replaced by other elements, such as sodium, lithium, caesium, etc. Beryl has been found that contained as much as 3.6 per cent of the oxide of the last-named rare element.

The usual colour is some shade of green, though blue, yellow, rose and even colourless beryl are sometimes found. Emerald is beryl coloured deep green (probably by chromium) and is one of the most highly-prized gem stones; it usually occurs in slates, shales or schist, and is believed to have been formed by solutions emanating from a near-by intrusive rock (pegmatite or granite). Occurrences of emerald are rare, and the world's supply is obtained chiefly from Russia and Columbia. Blue-green and clear, transparent beryl ranks as a precious stone (aquamarine), and the other colours, when clear and flawless, are also employed in jewellry.

The specific gravity of beryl ranges from 2.6 to 2.8, making it a little heavier than quartz. It is harder than quartz (7.5 to 8.0), and like

quartz, it has no distinct cleavage. It crystallizes in hexagonal prisms, rarely with pyramidal terminations, and the crystals are sometimes of immense size. A group of large beryl crystals recently found in a feldspar quarry in Maine contained individuals 4 feet across and 18 feet long, and yielded several hundred tons of clean mineral. Large crystals of almost comparable size have also been observed in a pegmatite dyke in the Black Hills, South Dakota, as well as in Namaqualand, South Africa.

While beryl is not exactly one of the common minerals, it is by no means as rare as is often supposed. It is often found as an accessory constituent of granite pegmatites, and many of the known occurrences owe their discovery to mining operations conducted on such pegmatites for their feldspar, mica or lithium minerals content. Hitherto, the beryl encountered during such operations has been considered of only minor importance as a commercial product, and quantities have doubtless found their way to the waste dumps. With the development of a sustained market for the mineral, closer attention to saving it by mica and feldspar producers may result in the recovery of an important aggregate tonnage as a by-product. As in the case of other previously disregarded minerals, also, which active prospecting, stimulated by demand, has revealed as existing in unsuspected amount, it may well be that closer examination of known pegmatites areas throughout the world will result in the discovery of beryl in commercial quantity.

THE OCCURRENCE OF BERYL IN CANADA

Beryl is not an uncommon mineral in certain of the mica-bearing, granite pegmatites of eastern Canada, and its occurrence has been noted at a number of the quarries worked either for feldspar or mica in Ontario and Quebec. At none of such deposits, however, has it been found in sufficient amount to justify its being regarded as other than of purely mineralogical interest, its

occurrence being invariably as small individual crystals scattered here and there through the dyke-mass.

ONTARIO

The only recorded instance in eastern Canada of beryl occurring in quantity that can be considered as possibly commercial is a deposit situated on lot 23 of concession XV in the township of Lyndoch, Renfrew county, Ont. The occurrence of beryl at this spot was noted many years ago, and has been described by W. G. Miller (Ont. Bur. Min., VII An. Rep., 1897, pp. 234-7). The mineral association has also been described more recently by T. L. Walker (University of Toronto Studies, No. 24, 1927, pp. 12-14).

The deposit consists of a small pegmatite dyke, averaging about 10 feet wide, and exposed for a length of 150 feet. It is stated that the continuation of the dyke can be traced by small outcrops and float boulders for a considerably greater distance. There is no mica or feldspar of commercial grade present. The dyke-mass consists of a rather intimate mixture of pink or green (amazonite) microcline feldspar, soda feldspar (albite) and quartz, the latter white, smoky, and sometimes also rose-coloured. There is considerable black tourmaline and red garnet present in the form of large crystals, and magnetite is thickly disseminated through a large part of the dyke. Minor constituents are purple fluorite, columbite and lyndochite (a variety of euxenite).

Beryl is distributed rather thickly throughout the dyke, and occurs in the form of rather thin, well-developed, prismatic crystals, $\frac{1}{2}$ to 3 inches in diameter and 6 to 12 inches long. Occasionally, stouter individuals are found, the largest observed measuring about 20 by 5 inches. The crystals are seldom terminated, and are usually fractured, breaking up into short pieces when removed from the rock.

The colour of the mineral is a drab green and most of the material is cloudy, stained and flawed. The larger crystals sometimes contain small zones of clear, flawless beryl of gem quality, but the colour is generally greenish,

rather than the more highly-prized aquamarine shade.

An analysis of the beryl, made on selected material, is given in Walker's paper (loc. cit.), and is as follows:

SiO_2	64.40
Al_2O_3	18.08
Fe_2O_3	0.97
BeO	14.38
CaO	0,18
MgO	0.33
MnO	0.04
K_2O	0.18
Li_2O	0.18
Na_2O	0.35
H_2O	1.08
	100.17

The specific gravity of the analysed material was 2.726.

A little work has been done on the dyke from time to time over a period of years in order to secure mineral specimens, but the only mining for beryl was that performed under lease in 1926 by Mr. T. B. Caldwell, of Perth, Ontario. Mr. Caldwell worked for a few weeks and opened up the dyke for a length of 150 feet by a shallow pit 8 feet deep and 8 feet wide. About 3 tons of beryl are reported to have been obtained, most of which was shipped to Germany.

The deposit lies in a rather remote locality, being 20 miles over hilly roads from the nearest railroad station Killaloe, on the Ottawa-Parry Sound line of the Canadian National Railways. An alternative transportation route is by way of Palmer's Rapids, on the Madawaska river, 9 miles distant, and thence by scow 20 miles to Barry's Bay, on the above line of railroad. The

small village of Quadville, one mile distant, is the nearest settlement. The mining rights are owned by Mr. John Sullivan, of Quadville.

The deposit exhibits an interesting mineral association and is of a unique type among Canadian pegmatites. It is quite distinct in character from the dykes of the nearest productive feldspar district at Hybla, in Monteagle township, some 25 miles to the west.

Insufficient work has been done on the deposit to determine its importance as a potential producer of beryl on a commercial scale. The dyke at the surface is hardly wide enough to yield any important tonnage, and further exploration in depth will be necessary to determine its economic possibilities. Prospecting of the surrounding district for other larger bodies would also appear to be warranted.

Requests for further information on this property, samples of the beryl, etc., may be addressed to Mr. T. B. Caldwell, Perth, Ont.

Rainy River district - Small beryl crystals are reported[1] to occur in a pegmatite dyke on an island in Turtle lake. The beryl appears to have an irregular distribution in the dyke, and the observed crystals did not exceed two inches in length.

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[1] Summary Report, Geol. Surv. Can., 1925, Pt. C., p. 10.

QUEBEC

An occurrence of beryl was reported[2] about twenty years ago in the Abitibi region, on the west bank of the Kewagama river, 20 miles southwest of Amos, on the Canadian National Railways. The beryl was found during mining operations for molybdenite, and is stated to occur in crystals up to 4 inches across in a pegmatite dyke. No official reports on the amount of beryl present are available, and it is not believed that the deposit is of any commercial importance.

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[2] Report on Mining Operations in the Province of Quebec during 1910, pp. 192-5.

MANITOBA

Considerable publicity has been given during the last year or two to the occurrence of beryl in the Pointe du Bois district, between the Winnipeg and Bird rivers, about 100 miles northeast of Winnipeg, and it has been suggested that the occurrences constitute a valuable mineral resource for the Province. The existence of commercially important deposits, however, has not yet been established, and further work is required to determine whether beryl occurs in this district in paying quantity.

The discoveries have been made during operations for lithium minerals and for tin, the beryl being found in comparatively small amount as scattered crystals or small aggregates of crystals in pegmatite dykes. The crystals are mostly of small to medium size, and are usually of a greenish colour, though some of a cream to white shade have also been found. An analysis of the beryl from the Silver Leaf pegmatite showed 12.74 per cent beryllium oxide.

The following notes on the occurrence of beryl in this district have been furnished by J. F. Wright and C. H. Stockwell, of the Geological Survey, who have been engaged for several seasons in a geological examination of the region:

"Along the south shore of Shatford lake, several pegmatite bodies are exposed in prospect trenches. Two of these bodies contain areas in which beryl crystals up to 24 inches in length and 3 inches across are abundant. A number of other pegmatite masses in this area carry a few crystals of beryl.

"At the east end of Bernic lake, on the Buck mineral claim, a small mass of pegmatite-quartz contains a number of beryl crystals ranging from 2 to 10 inches in diameter. A few small beryl crystals are scattered through other portions of the same dyke and also through other dykes nearby.

"Beryl is also present on the Jack Nutt claims, at the northwest corner of Bernic lake; on the Rush group, west of Rush lake; on the Stannite group, north-

west of Rush lake; in the Silver Leaf pegmatite, one mile west of Greer lake; on the Captain claims, east of Greer lake; in several pegmatites at Cat lake, as well as at a few other localities.

"None of the beryl found is of gem quality, either because of its pale colour, minute fracturing or lack of transparency.

"By hand-sorting, a small amount of beryl could be mined from the above pegmatites, perhaps several tons in the case of the Shatford lake occurrences, but probably it would not be profitable to undertake to quarry and to market the beryl unless larger and higher grade deposits are found".

No attempt has yet been made in the district at beryl production, though it is reported that several small sample shipments have been made of crystals found during prospecting operations for tin or lithium minerals.

Requests for further information on the beryl of this region, samples, etc., may be addressed to the Manitoba Chamber of Mines, 203 Montreal Trust Building, Winnipeg, Man.

BRITISH COLUMBIA

Beryl crystals have been noted[1] in the mica-bearing pegmatites of the Tête Jaune district, but it is not believed that the mineral occurs in important quantity.

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[1] Ann. Rep., Geol. Surv. Can., Vol. XI, 1898, p. 39.

BERYL IN FOREIGN COUNTRIES

Although beryl is a mineral of fairly wide world distribution, and while occurrences are known in a number of countries, there are comparatively few known deposits that are likely to prove workable as a source of industrial beryl, per se. In some favoured instances, as, for example, in South Dakota, beryl, lithium minerals (amblygonite, lepidolite and spodumene), and feldspar can sometimes be won simultaneously, but such deposits are rare. In some cases,

also, beryl and mica might possibly be mined together, as in Madagascar, and Brazil; or feldspar and beryl, as at a number of feldspar mines in Maine, New Hampshire and New York.

At the present time, the most promising sources of industrial beryl are believed to be the following:

RUSSIA

Gem beryl, including emerald, has long been mined in the Ekaterinburg and Miask districts, in the Ural mountains, and there are said to be important beryl occurrences in the Kola peninsula and in Siberia. It has even been suggested that cheap beryl from Siberia may ultimately constitute the main supply of industrial beryl, at any rate, for Europe, and that the market price of the mineral will be largely regulated by the price of the Russian product.

SOUTH AFRICA

Transvaal - In the Leydsdorp district of the eastern Transvaal[1], in the Murchison range, the Beryl Mining Company has lately been engaged in mining for gem beryl (emerald) and reports a production of about 300 pounds of crystals per week. The amount of inferior beryl discarded in securing the above is not stated. The mother rock of the beryl is a soft, decomposed mica schist, and a plant has been installed for breaking down the rock in a tube mill, followed by sizing of the lump beryl in a trommel and subsequent hand sorting of the more valuable material. The plant is designed to handle 200 tons of rock a day.

Namaqualand - What is said to be an important discovery of beryl was made in Namaqualand[2] in 1929, and the deposit is regarded as capable of producing on a large scale. Surface workings have disclosed single crystals weighing up to 15 tons, and the material is stated to run about 10 per cent of beryllium oxide, or 3.5 metallic beryllium. Float beryl has been found over a large area, and there is said to be an extensive development of beryl-bearing pegmatite in the district, much of which, from surface indications, is estimated

Most of the numerous other recorded occurrences of beryl in the United States are believed to be of more interest for the gem material (aquamarine, emerald and golden beryl) that they carry, than for any importance they may possess as potential tonnage producers of industrial beryl.

OTHER COUNTRIES

Small amounts of beryl are encountered during mica mining operations in Brazil, India, Madagascar, and possibly other parts of the world, but the deposits are not believed to be capable of supplying any large tonnage. Madagascar exports a small amount of gem beryl, including the rare rose-coloured variety. Practically all of the world's emerald hitherto has been mined in the Ural Mountains and Columbia. Some of the world's largest and finest aquamarine crystals have been obtained from the Minas Geraes district, in Brazil.

PRESENT MARKET OUTLOOK FOR BERYL

Despite the active interest in the possibilities of beryllium in recent years, progress in its metallurgy has been slow, and no active market for beryl has yet developed. Market quotations are not given in the technical press, and such sales as have been made/mostly have been in the nature of trial consignments for experimental purposes. The price paid for such material has probably been arrived at by bargaining in many instances, and cannot be taken as a criterion of what users may eventually find themselves disposed to pay for large-scale shipments.

It is believed that a price of between $60 and $70 per short ton f.o.b. New York has been the average paid for the occasional lots sold in the United States. During 1929, prices are stated to have ranged from $25 to $20 per ton at the mine, and exports are reported to have totalled several hundred tons, with an average content of 10 per cent beryllium oxide[1].

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[1] Eng. and Min. World, Feb. 1930, p. 83.

Rather fantastic figures have sometimes been quoted in the press for what producers may expect to obtain, with the result that the impression has gained ground that beryl is in the nature of a rare mineral, which will ultimately be saleable at a high price once the market is ready to absorb it in quantity. Such a belief would appear to be entirely at variance with the facts, and workers on the problem of producing beryllium on a commercial scale have emphasized that commercial beryllium will only become an actuality provided that cheap ore is obtainable.

Beryllium has proved extremely expensive to manufacture on a laboratory or semi-commercial scale. It is presently quoted in the United States at $200 per pound. It has been recently estimated that it could be prepared at not over $5 per pound, once the market is prepared to absorb 100 tons or over per annum. Another estimate for consumption on this scale suggests $12 per pound as the probable figure.

In considering the possible economic value of a beryl deposit, the fact that the beryllium content of beryl is distinctly variable, means that the mineral will have to be sold on analysis, which, therefore, in conjunction with transportation facilities, must prove an important factor in deciding whether any particular occurrence is likely to prove commercial.

Since beryl contains at best only about 5 per cent of beryllium, a very large quantity of material has to be treated to obtain a comparatively small amount of the metal, and consequently excessive freight charges have to be met unless manufacture takes place at or near the source of the raw material, as is being done at the recently-erected plant in Austria.

While, therefore, the usefulness of beryllium in the alloy field has been satisfactorily demonstrated, it appears that cheap beryl will be necessary if these alloys are to compete on a price basis with the bronzes and steels they are designed to supplant.

RECENT ARTICLES ON BERYLLIUM AND BERYL

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