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BERYLLIUM IN COLORADO

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Beryllium in Colorado

by Lincoln R. Page

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Beryl, the ore of beryllium, has been produced in Colorado as a by-product of feldspar and scrap-mica mining, but to date no single deposit has been mined solely for beryl. Under present economic conditions it is probable that this situation will continue; therefore, newly discovered deposits will have to be evaluated in terms of the abundance of the associated industrial minerals—feldspar, scrap- and sheet-mica, spodumene, lepidolite, columbite-tantalite, and microlite. At present there is no market for chrysoberyl, phenakite, and gadolinite, the only other beryllium minerals commonly found in Colorado pegmatite deposits.

Beryllium, one of the lightest weight metals known, has been used for many years in copper alloys. The addition of 2 percent of beryllium hardens and strengthens copper so that it can be fabricated into special springs, non-sparking tools, and other specialty items. The metal is used in making windows for X-ray tubes and in atomic energy apparatus. Beryllium oxide has had wide use in the past as a phosphor in fluorescent lamps and as a special refractory. The ground ore, beryl, is added, without refining, to certain ceramic mixtures, particularly glazes, to impart desirable properties to the finished product.

In 1947 _/ the total production of beryl in the United States

_/ Gustavson, S. A., Minor Metals, Minerals Yearbook; U. S. Bur. of Mines, p. 1250, 1947.

was 145 short tons, less than a third of the peak production of 1944. This production was mainly from mines in South Dakota and New Hampshire, with minor production coming from Colorado. The consumption of beryl in 1946 was 1,735 short tons, imports were 767 short tons, and world production was about 1,500 metric tons. Most of the world production was from Brazil with India and the United States being the only other major producerS. These figures clearly show that this country although by far the largest consumer of beryl produces only about one-tenth of its needs.

The demand for beryl during the war years stimulated the prospecting and study of beryllium-bearing rocks, and the introduction of new uses for the metal since then, together with the scarcity of the ore, has caused the price of beryl ore to increase to approximately 10 times the pre-war figures. The present-day price is sufficiently high to cause serious consideration of the feasibility of substituting mechanical methods for the recovery of beryl, in both Colorado and other states. In addition, other possible sources of beryllium are being given considerable attention. These include occurrences of helvite and other beryllium minerals that are found in contact metamorphic and other types of ore deposits and rocks. Such deposits may be considered potential beryllium reserves, but the metallurgical problems involved in the recovery and refining of beryllium from ores of this type are more difficult than those of the pegmatite ores.

Beryl-bearing pegmatite districts are scattered along the entire length of Colorado in the crystalline rock belt of the Rocky Mountains. The more productive districts are between Canyon City and the Wyoming line and Gunnison _/. The beryl occurs in the

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_/ Hanley, J. B., Pegmatites: Mineral Resources of Colorado, pp. 466-470, State of Colorado Mineral Resources Board, Denver 1947.

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pegmatites as crystals or masses as much as 10 tons or more in size. In South Dakota one mass, from which more than 100 tons was recovered, was mined in 1943-1944 at the Bob Ingersoll (Dike No. 1) mine at Keystone. A single crystal, found in Dike No. 2 at the same mine, is reported to have yielded 33 tons _/. Such masses and crystals have

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_/ Page, L. R. et. al., Pegmatite investigations 1942-1945, Black Hills, S. Dak.: U. S. Prof. Paper (in preparation).

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not been found in Colorado and are unusual. In most pegmatites crystals exceeding 12 inches in diameter are considered large. In general, less than half of the beryl in a deposit is recoverable by hand methods, indicating that in most deposits a large proportion of the beryl is less than 2 inches in diameter or breaks into small fragments in mining. In some deposits all the beryl is too small to recover by hand and its recovery would require flotation. The U. S. Bureau of Mines _/

_/ Kennedy, J. S. and O'Meara, H. G., Flotation of beryllium ores: U. S. Bur. of Mines, Rept. of Invest, 4166, January 1948.
Lamb, F. D., Beneficiation of New England beryllium ores: U.S. Bur. of Mines, Rept. of Invest. 4040, March 1947.

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has made some progress along these lines with their experimental work, but additional work probably will be necessary before commercial production can be attained.

Within the pegmatites the beryl crystals or masses are scattered irregularly through a matrix of feldspar, quartz, mica, tourmaline, and other minerals. Concentrations of beryl are restricted, nevertheless, to certain structural, mineralogical, or textural units, that form roughly concentric shells around a core. These are, for the most part, roughly parallel to the contact of the pegmatite and country rock. They are called zones and are to a large extent predictable as to their lateral and downward extensions _/. The zones are called,

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_/Cameron, E. N., et.al., The internal structure of granitic pegmatites: Econ. Geol., Mon. 2, 1949.

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in order from the outer edge of the pegmatite inward, border zone, wall zone, intermediate zone, and core. There is also reason to believe that the grade of these units remains essentially constant and that it can be predicted with reasonable accuracy, provided the original sample is representative _/.

_/ Page, L. R., Uranium in pegmatites: Econ. Geol., (in press).

The beryl concentrations or deposits within pegmatites can be divided into 5 main structural and mineralogical types.

but there are many pegmatites with reserves of this type that might be recovered by milling.

Most of the beryl produced in Colorado has come from deposits of the intermediate zone type. They lie inside and parallel to the wall zone and may be continuous shells or a discontinuous series of lenses in the same structural position as the shells. The largest production of beryl has come from deposits of types 2e and 2f, primarily because these deposits are mined for feldspar and the beryl is recovered as a by product. One of the largest beryl deposits—at the Devils Hole mine, Fremont County--is in an intermediate zone rich in muscovite (type 2a) and beryl has been produced at the Brown Derby mine, Gunnison County, from intermediate zones at the outer edge of a lepidolite-bearing zone (type 2d). Although beryl occurs at the Buckhorn mica mine, Larimer County, at the outer edge of a spodumene-bearing zone, the deposit has not been worked extensively. Beryl deposits associated with amblygonite, although this type has been very productive in the Black Hills of South Dakota, never have been productive in Colorado.

The intermediate zones commonly are composed of coarser-grained minerals than the wall zones, consequently they offer the best chance for an economical operation where hand sorting methods are employed. The beryl is in euhedral, subhedral, or anhedral crystals that are green to yellowish green or blue in feldspar- and mica-pegmatites and white to pale pink or blue in lithium-bearing deposits. The large crystals and masses of beryl are commonly associated with individual crystals of feldspar, as much as 10 feet in maximum dimension, that are sufficiently abundant to pay the cost of mining. Aggregates of muscovite books, not uncommonly 3 or more feet in size, may occur in the same deposit and can be readily recovered. Similarly, aggregates of lepidolite and the tantalum minerals may also help defray the expense of producing beryl.

Beryl deposits of the core type are less commonly a source of beryl, but have been productive in some of the mines of Jefferson County.

The average grade of a good beryl deposit in the United States, and also Colorado, is between 0.5 and 1.0 percent beryl of which only part is recoverable. The amount actually recovered varies widely depending on the size of the crystals and where it is possible to mine crystals individually may be in the order of 90 percent. The total expectable production from a single deposit is small compared to metal mines and any that has a reserve of over 500 tons of beryl is considered to be large. Consideration of the average grade, size, and the expectable recovery makes it readily apparent that mining for beryl alone will probably be unprofitable, consequently the value of a beryl deposit depends on the abundance and quality of associated industrial minerals.

The beryl ore shipped from Colorado has averaged between 11 and 13 percent BeO, but the beryllium content of beryl may vary widely, either within different zones of an individual pegmatite, between pegmatites of a district, or between districts. This variation in composition depends upon the content of lithium, sodium, and caesium, and is reflected by a variation in the index of refraction. Consequently, the approximate percent of BeO in beryl can be determined optically. It seems possible that these variations in composition will have a decided effect upon the beneficiation of mixed ores by flotation processes. In Colorado, however, many of the pegmatites in districts, such as the Crystal Mountain district, contain beryl of similar composition and consequently probably could be recovered by the same reagents.

In addition to the beryllium reserves in Colorado pegmatites there are other potential reserves in veins and other types of rocks. Because less is known about their size, grade, and mode of occurrence, prospectors have not given this group of deposits as much attention as the pegmatites.

Small quantities of beryl are known to occur with molybdenum and other minerals in a quartz vein at the head of Brown's Creek, on Mt. Antero, Chaffee County. Granitic rocks in this area also contain visible beryl in pegmatitic segregations and streaks, but in addition group samples indicate that there is as much as 0.01 percent BeO in the non-pegmatitic parts of the granitic mass _/. Such relationships

_/ Adams, J. W., Beryl deposits of the Mt. Antero district, Chaffee County, Colorado (in preparation).

suggest the possibility that beryllium is more widely scattered in this area than have previously been suspected.

1. Wall- and border-zone deposits.

2. Intermediate-zone deposits

   a) Inner edge of a mica-bearing zone.
   b) Amblygonite-bearing zone.
   c) Outer edge of a spodumene-bearing zone.
   d) Outer edge of a lepidolite-bearing zone.
   e) Outer edge of a perthite- and quartz-bearing zone.
   f) Outer edge of a quartz-bearing zone.

3. Core deposit.

4. Fracture-filling deposit.

5. Replacement deposit.

Types (4) and (5) are relatively unproductive as sources of beryl and type (5) is almost unknown in Colorado. Small, but commonly rich, deposits of type (4) are abundant in the Crystal Mountain district, Larimer County, Colorado. These are rarely over 100 feet long and 3 feet thick.

Wall- and border-zone beryl deposits form a continuous shell at the outer edge of many pegmatites in all the Colorado pegmatite districts. Beryl occurs with muscovite, albite, quartz, and tourmaline as pale yellowish green to bluish green, euhedral to subhedral crystals, commonly too small to warrant hand cobbing. Where muscovite is abundant the beryl may form skeletal crystals or shells. At the inner edge of the wall zone the individual crystals are larger than at the outer edge and crystals that start their growth near the schist contact may increase in diameter toward the center of the pegmatite. Practically none of the beryl produced in Colorado has come from such deposits, but there are many pegmatites with reserves of this type that might be recovered by milling.

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Helvite is known to occur in lead-bearing rhodonite veins of the San Juan area _/ and represents another potential source of

_/ Burbank, W. S., The manganese minerals of the Sunnyside veins, Eureka Gulch, Colorado: Am. Mineralogist, vol. 18, no. 12, pp. 521-522, December 1933.

beryllium. Its use as an ore probably will be dependent upon finding a use for the associated rhodonite. This occurrence of beryllium minerals with metallic ore deposits suggests the possibility of finding it in other veins of this type.

Recently the Geological Survey has been investigating the occurrence of small quantities of beryl in various types of rocks and some of the unusual and alkalic rocks of Colorado appear to contain more beryllium than the more normal igneous rocks. This beryllium, however, is probably tied up in feldspar or other common mineral molecules and consequently is not amenable to concentration by normal beneficiation processes. The ultimate value of these beryllium occurrences in rocks and ores other than pegmatites is problematical, but should not be disregarded in prospecting.