

Geological Survey of Wyoming  
Mineral Report MR91-2

by  
W. Dan Hausel and Ben Edwards

Beryllium Resources of Wyoming

The element beryllium (Be) is not abundant in the Earth. Although it is found in over 90 different minerals, only 8 are currently considered to be of possible economic importance. The element has a small ionic radius and so does not fit well into the lattice of most crystal structures. Therefore, it often forms its own minerals when it is highly concentrated by natural processes. The only currently mined ores of beryllium are beryl ( $3\text{BeO} \bullet \text{Al}_2\text{O}_3 \bullet 6\text{SiO}_2$ ) and bertrandite ( $4\text{BeO} \bullet 2\text{SiO}_2 \bullet \text{H}_2\text{O}$ ). However, phenacite ( $\text{Be}_2\text{SiO}_4$ ), chrysoberyl ( $\text{BeAl}_2\text{O}_4$ ), eudidymite ( $\text{NaBeSi}_3\text{O}_7$ ), berylite ( $\text{Be}_2\text{BaSi}_2\text{O}_7$ ), herderite ( $\text{CaBe}(\text{F},\text{OH})\text{PO}_4$ ), and helvite ( $3(\text{Mn},\text{Fe})\text{BeSiO}_4 \bullet \text{MnS}$ ) all have economic potential (Soja and Sabin, 1988).

Although the element beryllium was discovered over 200 years ago (Petkof, 1985), its use did not become popular until after WWII. Its high strength, hardness, and thermal conductivity combined with its light weight and low density make it an important component in many modern metal alloys and space age products. Beryllium alloys are used in heat shields for spacecraft, aircraft brake discs, missile guidance systems, in ceramics used for electronics, and for lightweight aircraft frames. Its demand in high technology fields should continue to grow in the future (Schiller, 1985). The mineral beryl can sometimes be found as gem quality crystals.

Beryllium ores have been classified into 5 types of deposits (Smirnov, et al., 1983). (1) Pegmatitic occurrences containing beryl are numerous and perhaps the most common type of deposit. However, beryl is restricted to those pegmatites which have a heterogeneous composition. Often Be is a secondary product associated with mining of K-feldspar, mica, lithium bearing minerals, columbite, tantalite, and cassiterite. (2) The mineral berylite can be found in fenites, rocks which have been metasomatically altered by sodium-rich fluids. Often the host rocks are slates or porphyric

volcanic rocks. (3) Greisen deposits consist of altered K-feldspar and mica which have been converted to aggregates of quartz, tourmaline, topaz, and lepidolite by F-bearing hydrothermal fluids. They sometimes contain Be minerals associated with tantalum, tin, and tungsten. (4) Similar types of deposits occur in plutogenic, hydrothermally altered granites and syenites in which Be has been removed and redeposited along fractures and dikes in the intrusions and surrounding limestones. (5) In altered volcanic rocks bertrandite occurs as disseminated deposits and in veins, associated with chalcedony, adular, fluorite, calcite, ankerite, and hematite-specularite. The volcanic rocks, tuffs and rhyolites, sometimes contain blocks of surrounding country rock. The presence of fluorine, can be an important constituent in the formation nonpegmatitic beryllium deposits. It has been estimated that Be is associated with F in 75% of all nonpegmatitic deposits (Griffitts, 1978).

Brazil, China, and the USSR are the world's principle producers of beryl, which probably accounts for the majority of the unrefined beryllium ore in the world (Petkof, 1985). In many of these areas the beryl is concentrated by hand cobbing. Canada may soon enter the world beryllium market, though. At least 3 major nonpegmatitic deposits of Be-bearing minerals have been identified in Canada. Both at Seal Lake, Labrador, and Strange Lake, Quebec, potential Be resources have been identified. At Thor Lake, Northwest Territories, a large complex of metasomatized syenites and granites contains high abundances of rare-earth elements, and may soon be mined for phenacite (Schiller, 1985). Nonpegmatitic occurrences of potentially economic beryllium minerals also have been found in Coahuila and Ahuachili, Mexico.

The United States is the world's major producer of beryllium products. Because of its importance in many metal alloys, the U.S. government has been stockpiling beryllium ore (as of 1987). Although the U.S. is a net exporter of beryllium products, until the mid-1970s most of the raw materials for beryllium production were imported to the U.S.. It has been projected that by the year 2000 the U.S. should be able to totally supply its own needs for beryllium ore (Petkof, 1985).

Small quantities of beryl have been extracted from pegmatites in New England, South Dakota, Colorado, Alaska, Nevada, and the Appalachians. But by far the largest source of beryllium ore in the U.S., and possibly even the world, is Spor Mountain, in Juab County, Utah. The main mining operation is run by Brush Wellman, which also happens to be the largest refining company of beryllium ore probably in the world (Soja and Sabin, 1986). Bertrandite is the ore mineral at Spor Mountain, and occurs with fluorite in

microcrystalline form in Tertiary rhyolites. The deposits occur as flourite nodules, in layers of breccia sandwiched between rhyolites and limestones. The ore zones range in thickness from 0 to 18 meters (60 ft.). Manganese oxides and uranophane are found associated with the bertrandite. This area was discovered in 1959, and production began in 1969. Since that time the deposits on the western and southwestern slopes of the mountain have become one of the world's largest source areas for beryllium. The cutoff grade for this large operation is 0.30% BeO (Davis, 1984). Similar types of bertrandite deposits have been found near Golden Hill, Utah, Honeycomb Hills, Utah, Seward Peninsula, Alaska, and in White Pine County, Nevada.

The only known occurrences of beryllium minerals in Wyoming are from pegmatites scattered throughout the state. However, at least one area may be a good prospect for nonpegmatitic deposits. The Bear Lodge Mountains in northeastern Wyoming consist of Tertiary alkaline intrusive bodies. These rocks contain unusual amounts of thorium and other rare-earth elements, similar to Thor Lake, Canada. Mironov et al., 1980, suggested that abnormally high concentrations of Th may be indicative of flourite-phenacite-bertrandite associations. The alkaline rocks intruded a sedimentary sequence which includes at least one major limestone layer. A study done in 1955 by W.C. Chenoweth determined that within the Pahasapa limestone were layers of flourite, ranging from 1 inch to 2 feet in thickness. Staatz, 1983, reported several areas where the sedimentary rocks were "replaced" by alkaline rocks. All of the above information suggests that this area might be a good place to prospect. Any areas with flourite associated with limestone or dolomite could contain significant amounts of beryllium bearing minerals. Topaz-bearing rhyolites are also likely localities for prospecting.

Several pegmatitic bodies have been discovered throughout Wyoming which contain varying amounts of beryl. These include areas of Anderson Ridge in the Wind River Mountains, along Hoodoo Creek on the south flank of Copper Mountain in the Owl Creek Mountains, throughout the Hartville Uplift, and on Casper Mountain (Hausel, 1986). Reported occurrences are given below.

## **ALBANY COUNTY**

### Laramie Range

**Big Chief Mica mine:** Located immediately north of the section line between sec. 9 and 16, T.25N., R.71W. The pegmatite is a quartz and potash feldspar granite pegmatite containing minor plagioclase and muscovite with

accessory tourmaline. A pit at the north end of the pegmatite produced a small amount of punch mica. Small (□1 inch) pale blue crystals of beryl occur near the pegmatite in fractures in the hanging-wall actinolite schist (Osterwald et al., 1966, p. 132). The footwall of the pegmatite is a hornblende schist.

**Sec. 2, T.15N., R.71W.:** A pegmatite which was periodically mined for feldspar and mica, has some beryl and euxenite. The pegmatite is 75 feet wide (Osterwald et al., 1966, p. 220).

**NE/4 NE/4 sec. 2, T.19N., R.72W.:** A northeast trending pegmatite on the Sheep Rock Quadrangle of the central Laramie Range consists of milky quartz, potash feldspar, muscovite, garnet and a few scattered (less than two inches in diameter) bluish-green euhedral beryl crystals. The pegmatite forms a narrow three-foot wide dike (Hausel, personal field notes, 1981).

#### Medicine Bow Mountains

**Many Values prospect:** SE/4 sec. 32, T.13N., R.78W. There are two open pits and two timbered shafts on the property. The pegmatite cuts Precambrian tourmalinized mica schist and gneiss, and strikes N50°E and dips 85° northwest, with 140 feet of exposures. The pegmatite averages 15 feet wide.

Seventy-five feet north of the main pegmatite body a quartz, potash-feldspar, mica, plagioclase pegmatite strikes north and is vertical; it is apparently not connected with the larger body, but cover prevents an accurate estimate of the extent of the pegmatite beyond the workings. Muscovite is abundant near the hanging wall in the larger pegmatite. Up to 1942, 36,600 pounds of scrap mica, 2,500 pounds of punch mica, and 500 pounds of rifted mica were produced from the mine, and two tons of beryl were shipped. The beryl crystals are corroded. Small tantalite crystals are rare but about 85 pounds were recovered prior to 1942. Minor accessory minerals include fergusonite, tourmaline, and pink euhedral garnets and orange subhedral garnets about 1/4 inch in diameter (Hanley and others, 1950).

**Muscovite claim:** W/2 SE/4 sec. 32, T.13N., R.78W. A granite pegmatite dike strikes N50°E and cuts Precambrian metadiabases, hornblende schists, and gneisses on the Muscovite claim for a distance of 600 feet. The maximum width of the dike is 70 feet and the average width is 40 feet.

Tantalite-columbite crystals are associated with green beryl along fractures in the wall rock (Osterwald and others, 1966, p. 132, 1933).

## **CARBON COUNTY**

Specimens of aquamarine beryl have been reported from the southeastern Seminoe Mountains (Aughey, 1886, p. 60). No other information was given.

**NW/4 sec. 27, T.27N., R.88W.:** Master (1977, p. 46) reported anomalous beryllium concentrations (200 ppm) in a pegmatite in the Ferris Mountains.

## **CONVERSE COUNTY**

### Laramie Range

#### Esterbrook District

**N/2 sec. 34, T.29N., R.71W.:** Two vertical beryl-bearing pegmatites strike parallel to the foliation of hornblende schists. The pegmatites vary from two to five feet wide and up to 300 feet in length. The pegmatites are zoned with a quartz-beryl core. Individual beryl crystals in the core vary from a quarter to three inches in diameter, and comprise less than one percent of the quartz core (Greeley, 1962).

#### Laprele District

### **Jasper mine**

#### Miscellaneous

**Schundler-Glenrock prospect:** A granite pegmatite intrudes schist south of Glenrock. The pegmatite carries some beryl with pink microcline. Some feldspar ore was shipped from the pegmatite to Custer, South Dakota (Hagner, 1942f).

## **FREMONT COUNTY**

### Owl Creek Mountains

#### Copper Mountain District

In the vicinity of Hoodoo Creek on the south flank of Copper Mountain, several simple and complex pegmatite swarms occur in potassium-rich

granite that intrudes Precambrian amphibolite, mica schist and quartzofeldspathic gneiss. The complex pegmatites contain a variety of minerals including beryl, columbite-tantalite, and lepidolite (lithium-bearing mica). Several complex pegmatites are located on the Whippet No. 1 and No. 8 claims. Between 1928 and 1940, small quantities of beryl and tantalite were produced from these deposits (Hanley and others, 1950).

**Whippet No. 1 prospect:** Located in the east-central part of sec. 28, T.40N., R.93W. The pegmatite dike trends N.65°E, dips 10° to 60° northwest, and can be traced for 320 feet. The pegmatite is very irregular but averages four to six feet wide with a maximum width of 60 feet. The northeastern portion is thinner and contains much coarse-grained potash feldspar, albite, and muscovite with some beryl and tantalite. The beryl-rich zone is estimated to have one part beryl in 250 parts pegmatite. The southwestern part is formed almost entirely of quartz. Directly north of this pegmatite is another pegmatite that trends parallel to the Whippet No. 1 pegmatite that contains numerous books of sheared mica, small pale-lavender flakes of lepidolite and some beryl and columbite (Hanley and others, 1950, p. 111).

**Whippet No. 8 prospect:** Located in the south-central part of sec. 22, T.40N., R.93W. Two tantalite and beryl-bearing pegmatites separated by a small area of alluvium intrude amphibolite. The northeastern body crops out for 400 feet and has a maximum width of 30 feet. It is separated from the southwestern pegmatite by a valley partly filled with alluvium. These two bodies may represent one continuous pegmatite. The pegmatites contain coarse white quartz along the margins with coarsely crystalline white potash feldspar. Large beryl crystals occur near the hanging wall contact and fine-grained beryl near the footwall. The pegmatite contains the largest amount of tantalite of any prospect in the region. The northeastern portion of the pegmatite may contain 11,500 tons of tantalite-bearing rock to a depth of 20 feet below the surface. The southwestern portion of the pegmatite is 180 feet long with an average thickness of ten feet and is estimated to have about 2,250 tons of tantalite-bearing rock. About 250 pounds of tantalite and some beryl have been sold in the past (Hanley and others, 1950, p. 109-111).

## Wind River Mountains

### South Pass-Atlantic City District

**Anderson Ridge pegmatites:** NW/4 sec. 29 and sec. 31, T.29N., R.101W. Pegmatites west of South Pass City are quartz, feldspar, mica, garnet granites. Some of the pegmatites have accessory beryl and tourmaline (El-

Etr, 1963; Proctor and El-Etr, 1968). The scattered beryl crystals are generally greenish and less than one inch across. One large aquamarine beryl crystal, six to eight inches across, was recovered from a pegmatite in the area (Elmer Winters, personal communication, 1983).

#### Miscellaneous

**Helt claims:** Sec. 3 and 10, T.41N., R.108W. Beryl, scheelite, and unidentified radioactive minerals occur in pegmatite adjacent to the Warm Springs fault zone (Osterwald and others, 1966, p. 21).

### GOSHEN COUNTY

#### Hartville Uplift

##### Haystack Range District

The Haystack Range district is located ten miles northeast of Guernsey and covers several square miles. Pegmatites in the district occur in at least four sections and are concordant lenses in the Precambrian Whalen schists and gneisses. The pegmatites have a general trend of N60°E with steep dips to the northwest. Some of the pegmatites have been exposed at depth, and those show narrowing with depth. The bodies are mainly potash feldspar, quartz, muscovite pegmatites, with accessory plagioclase, apatite, black tourmaline, and beryl (Hanley and others, 1950, p. 112-113).

**Chicago prospect:** Sec. 35, T.28N., R.65W. This pegmatite is about 215 feet long, averages eight feet wide with a maximum width of 23 feet. It trends N72°E and dips steeply. The wall zone of the pegmatite contains quartz, muscovite, plagioclase, and black tourmaline, with a core of quartz and microcline. Beryl is found in the wall zone, and single euhedral crystals are up to four inches wide. Muscovite may form five to ten percent of the wall rock zone and beryl less than one percent (Hanley and others, 1950, p. 116).

**New York prospect:** Sec. 35, T.28N., R.65W. This pegmatite is tad-pole shaped, and is 85 feet long and 35 feet wide at its broadest point. It is zoned with a border zone that is six inches thick; a mica- and tourmaline-bearing wall zone two to three feet thick; and a core of quartz-microcline pegmatite with microcline crystals as large as four feet in length. The pegmatite strikes N72°W and dips 50° to 85°NE. A small quantity of whitish-green beryl occurs in the mica-tourmaline zone and in the core (Hanley and others, 1950, p. 115-116).

**Ruth prospect:** Sec. 35, T.28N., R.65W. The Ruth prospect is an oval shaped pegmatite about 155 by 80 feet. The pegmatite has a narrow border zone, and irregular wall zone of graphic granite, and a thin discontinuous intermediate zone of quartz muscovite pegmatite with beryl. Accessory minerals include black tourmaline, apatite, beryl and columbite. Beryl is estimated to form less than 1/2 percent of the intermediate zone, although some parts contain as much as two percent (Hanley and others, 1950, p. 116).

**Savage claim:** S/2 sec. 26, T.28N., R.65W. The Savage pegmatite trends N80°E and dips 75°NW. This pegmatite is 220 feet long by 20 feet wide and narrows to five feet near the eastern and western ends. Two faults occur in the pegmatite. On the southwest, the pegmatite has 12.5 feet of horizontal displacement and is thought to have a rotational component. The second fault is parallel to the pegmatite and dips 75°NW.

This fault exhibits silicification, and the apparent movement indicates that the north side moved down. The pegmatite contains potash feldspar, quartz, and muscovite with accessory plagioclase, black tourmaline and beryl. The beryl is white to light-green and averages one inch in diameter with some crystals as large as five inches in diameter. Some enriched areas of the pegmatite contain 1.5 percent beryl, although the average content of the pegmatite is only about 0.5 percent (Hanley and others, 1950, p. 119).

**Torrington No. 1 prospect:** Also known as the Denver prospect. Located in sec. 35, T.28N., R.65W. This pegmatite is approximately 400 feet long and 30 feet wide, and trends N65°E and dips 60°NW. It is concordant to the host Whalen schists. The pegmatite is coarse-grained near its center and fine-grained along its margin. It is composed of quartz, microcline, muscovite, and albite with minor tourmaline and beryl (Hanley and others, 1950, p. 115).

**NW/4 sec. 14, T.27N., R.65W.:** About 150 pounds of beryl were recovered from a pegmatite at this location (Millgate, 1965a).

**Sec. 1, T.27N., R.65W:** A beryl- and mica-containing pegmatite, 275 feet long and 90 feet wide, trends N85°E with a dip of 80°N at this location. Beryl occurs in yellowish-green crystals 1/4 to one inch in diameter, and does not make up more than one percent of the pegmatite. Muscovite comprises 20 percent of the pegmatite and occurs in small books averaging two to three inches broad. Accessory minerals include tourmaline, apatite, and titanite (Wilson, W.H., 1951d).



## NATRONA COUNTY

**Catherine no. 1 mine:** W/2 SW/4 sec. 17, T.32N., R.79W. This pegmatite contains relatively large amounts of euhedral, light-green beryl. In 1956, two tons of beryl were mined from the property as a by-product of feldspar. From 1953 to 1977, 12,400 tons of feldspar were also produced from this pegmatite (Hausel and Glass, 1980).

## NIOBRARA COUNTY

### Hartville Uplift

#### Rawhide Buttes Area

A pegmatite swarm trending north-south to north-northwest intrudes hornblende and mica schist in the vicinity of Rawhide Buttes (T.31N., R.64W.). The pegmatites carry euhedral beryl with microcline, plagioclase, quartz, muscovite, and accessory garnet and tourmaline (Millgate, 1964).

**SE/4 sec. 3, T.31N., R.64W.:** Beryl crystals up to two inches in diameter and six inches long occur in a 300 by 20 foot pegmatite. The pegmatite strikes N8°W and dips 78°NE and consists of quartz, sodic plagioclase, with minor amounts of microcline, muscovite, garnet, tourmaline, and beryl (Osterwald and others, 1966, p. 21).

**Section line between secs. 2 and 3, T.31N., R.64W.:** Beryl crystals up to six inches in diameter occur in the south end of a pegmatite. The pegmatite is 400 feet long and 90 feet wide (Osterwald and others, 1966, p. 21).

**NW/4 sec. 14, T.31N., R.64W.:** A concordant pegmatite in biotite schist strikes N5°E and dips 80°SE. The pegmatite is approximately 120 feet long by fifteen feet wide. Beryl crystals which are more abundant in the outer portion of the pegmatite, range up to two inches in diameter and one foot in length (Osterwald and others, 1966, p. 22).

**SE/4 sec. 34, T.32N., R.64W.:** Beryl crystals, three inches and less in diameter, occur sparsely in a pegmatite hosted by mica schist. The pegmatite is concordant to the foliation of the schist, and strikes N15°W. The surface exposure is about 100 feet by 60 feet (Osterwald and others, 1966, p. 22).

## PARK COUNTY

### Beartooth Mountains

Gardner Lake area: T.58W., R.105W. Coarse-grained quartz and microcline pegmatites occur as dikes and conformable lenses. Minor minerals include albite, biotite, muscovite and accessory ilmenite and beryl. Beryl crystals up to 10 inches in length have been identified (Casella, 1969).

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