

*Information Circular No. 7*

IDAHO BUREAU OF MINES AND GEOLOGY

MOSCOW, IDAHO

NOVEMBER, 1960



# *Prospecting for Beryllium in Idaho*

BY

R. R. REID and RAOUL CHOATE

(PREPARED IN COOPERATION WITH U. S. BUREAU OF MINES)

*State of Idaho*

ROBERT E. SMYLLIE, Governor

*Idaho Bureau of Mines and Geology*

E. F. COOK, Director

Information Circular No. 7

November, 1960

PROSPECTING FOR BERYLLIUM IN IDAHO

by

Rolland R. Reid

and

Raoul Choate

Prepared in cooperation with the  
U. S. Bureau of Mines

IDAHO BUREAU OF MINES AND GEOLOGY

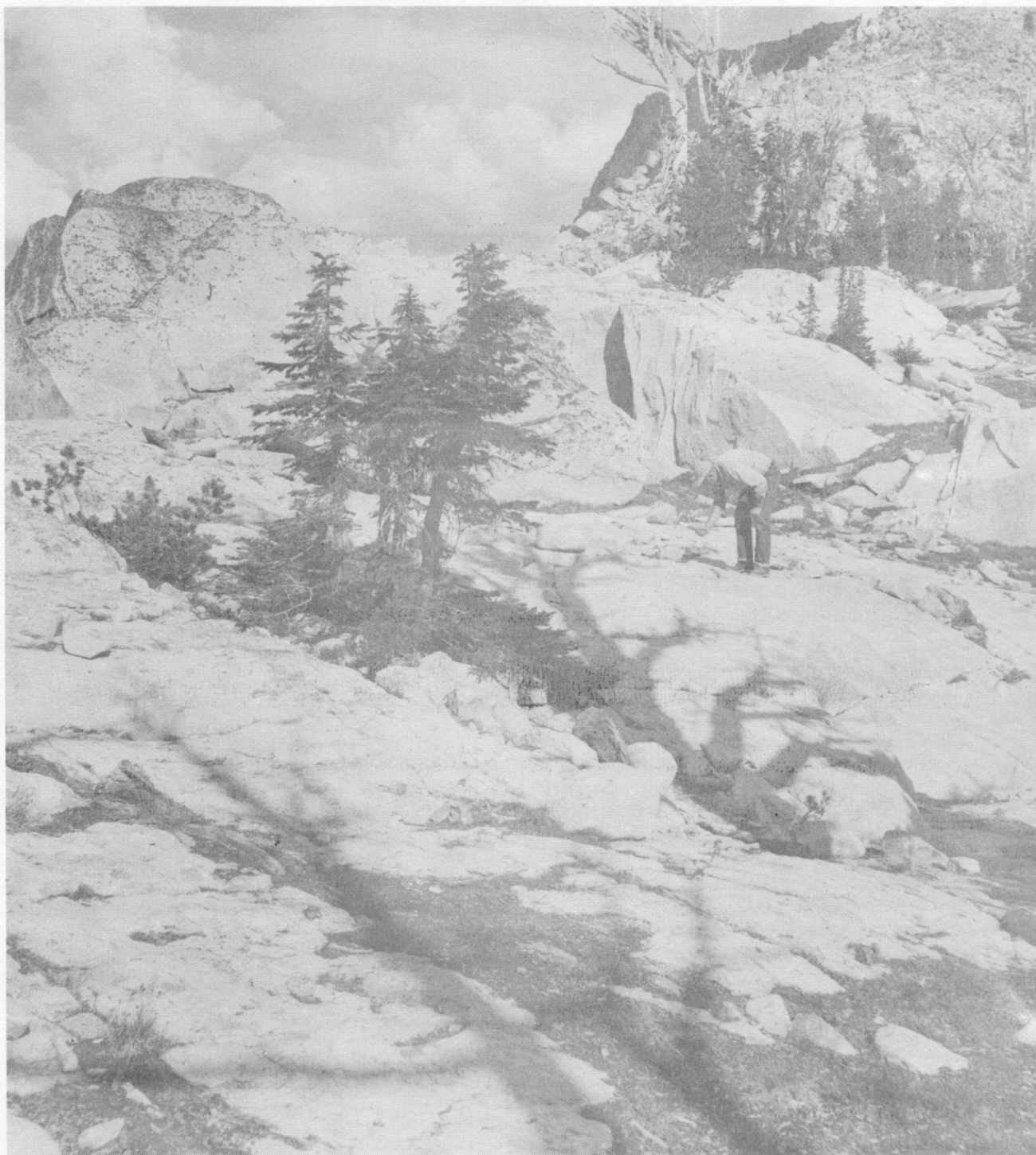
MOSCOW, IDAHO

## TABLE OF CONTENTS

	Page
Introduction.....	1
General remarks.....	1
Importance and uses of beryllium.....	2
Beryllium markets.....	2
Beryllium technology.....	4
Companies engaged in beryllium exploration.....	4
Mineralogy.....	6
Beryllium minerals.....	6
Minerals containing minor amounts of beryllium.....	7
General geology of beryllium occurrence.....	8
Beryl.....	8
Helvite.....	8
Bertrandite.....	9
Chrysoberyl and phenakite.....	9
Types of beryllium occurrence in Idaho.....	10
Pegmatitic and disseminated beryllium.....	10
Non-pegmatitic beryllium (high-temperature veins).....	11
Guides to prospecting.....	13
Possible beryllium indicators.....	13
Favorable localities to prospect in Idaho.....	13
Prospecting methods.....	15
The berylometer method.....	15
Chemical methods.....	15
Spectroscopic methods.....	17
Summary.....	18
Selected bibliography.....	19

## TABLE OF ILLUSTRATIONS

Photograph of the Glen's Peak deposit in the Sawtooth Mountains.....	Frontispiece
Map of the Sawtooth beryllium area.....	Follows p. 10



This light-colored granite (or alaskite) near Glens Peak in the Sawtooth Mountains contains disseminated aquamarine (beryl).



# PROSPECTING FOR BERYLLIUM IN IDAHO

by

Rolland R. Reid<sup>1/</sup> and Raoul Choate<sup>2/</sup>

## INTRODUCTION

### GENERAL REMARKS

During the summer of 1960, the U. S. Bureau of Mines and the Idaho Bureau of Mines and Geology, under the terms of a cooperative agreement, conducted the initial phase of an extensive reconnaissance exploration program for beryllium in Idaho. This program was instituted because of the ever-growing importance of beryllium for a wide range of industrial, research, and strategic uses. Certain special applications promise to use much larger amounts of beryllium metal than are yet available. Such applications, however, are obviously impossible unless large deposits of the metal are found.

Several deposits of beryllium minerals, brought to the attention of the two Bureaus by prospectors, were examined in a preliminary fashion. Two general news releases concerning these discoveries produced widespread interest. This circular is intended principally to make pertinent information about beryllium more easily accessible to interested persons in Idaho.

Such information is available in a number of textbooks, periodicals, and Federal and scientific society publications (see the selected bibliography). Because this circular is general in nature, detailed citations to the literature have been held to a minimum. Yet, the reader must realize that most of the material compiled herein has been derived from the authors or publications listed in the bibliography<sup>3/</sup>.

In reading about beryllium, one must keep in mind an important reservation held by some workers in the field. Some believe that pegmatite beryl does not exist in sufficient amounts to satisfy prospective demands, and that, consequently, deposits of non-pegmatitic beryllium ore may have to be found if beryllium is to become generally available in large amounts. Moreover, such non-pegmatitic deposits should contain preferably some other mineral

---

<sup>1/</sup>Head, Department of Geology and Geography, University of Idaho; Geologist, Idaho Bureau of Mines and Geology.

<sup>2/</sup>Minerals Engineer, Idaho Bureau of Mines and Geology.

<sup>3/</sup>The authors are indebted to Eldon Pattee and R. N. Appling, Jr., of the U. S. Bureau of Mines, Spokane Office, of Mineral Resources, for critical reading of the manuscript and many helpful suggestions.

than beryl. Beryl is rather refractory in the refining process, and therefore expensive to refine; however, new processes are being developed which may reduce the cost of refining beryl. The new(?) mineral "vitroite" seems to promise a cheaply refinable source of beryllium.

### IMPORTANCE AND USES OF BERYLLIUM

Because of its light weight and other properties, the metal beryllium has come to have great strategic importance in the past decade. Besides its growing use in the conventional branches of industry, it is being used increasingly in the fields of nuclear engineering, rocketry, and space craft construction. Not only is the density of beryllium about three-fourths that of aluminum, but the metal is 45 percent more rigid than steel, has a melting point twice as high as that of magnesium or aluminum, has high thermal conductivity, has excellent neutron reflecting ability, and is more efficient than graphite in moderating the velocity of neutrons in nuclear devices.

Beryllium metal is used mostly in alloys with copper. Because of their strength, hardness, electrical conductivity, and non-sparking characteristics, beryllium copper alloys have many specialized applications, such as springs, bellows, electrical contacts, diaphragms, marine propellers, aircraft engine parts, bearings, rollers, gears, and miniature electrical and electronic components. Some beryllium is also used in alloys with nickel, zinc, aluminum, gold, and magnesium.

Pure beryllium metal will be used increasingly in nuclear reactors. The AEC placed orders with the two producers of beryllium in the United States for approximately 95 tons each of the metal to be delivered in the five-year period starting January 1, 1958. These orders were later reduced to smaller tonnages. Beryllium is also used for X-ray windows, and is being tested for various structural applications in aircraft, by both private and Government agencies. However, difficult problems related to its extreme brittleness must be solved before it can be used extensively in aircraft construction.

Beryllium oxide is used in such things as special glasses, radiation shields, crucibles, and refractory supports. Some beryl is used in the manufacture of special porcelains for spark plugs.

### BERYLLIUM MARKETS

At the present time beryl is the only beryllium mineral on the market. Beryl is purchased in three forms: (a) finely ground beryl for ceramic applications; (b) beryl for extraction of metallic beryllium; (c) beryl for government stockpiling. Most beryl is used for the extraction of metallic beryllium. Pure beryl contains about 14 percent beryllium oxide ( $\text{BeO}$ ) or about 5 percent beryllium.

Two United States firms now extract and process beryllium: The Beryllium Corporation, Reading and Hazleton, Pa., and the Brush

Beryllium Co., Elmore, Ohio. Five other consumers of beryl are: Beryl Ores Co., Arvada, Colorado (specialized ceramic materials); Glass Coating Materials Div., A. O. Smith Corp., Milwaukee, Wis. (groundcoat frit or glass for ceramics); Champion Spark Plug Co., Ceramic Div., Detroit, Mich. (beryl in special spark plugs); Lapp Insulator Co., LeRoy, New York (beryl in high-voltage electrical porcelain); and Delta Star Electric Division, H. K. Porter Co., Lisbon, Ohio (beryl in ceramic products). Most of the beryl used by the beryllium industry is imported, and a large part of it is purchased through brokers, such as Derby and Co., Inc., New York, New York.

General Services Administration has bought domestically produced hand-cobbed beryl on a government program for stockpiling since 1952. Government purchasing depots are at Custer, South Dakota, Spruce Pine, North Carolina, and Franklin, New Hampshire. These purchases will continue until June 30, 1962, or until 4500 short tons have been purchased, whichever occurs first; 2,306 tons of beryl had been purchased through June 30, 1959.

E. and M. J. Metal and Mineral Markets in July, 1959, listed domestic beryl (10 to 12 percent BeO) at \$46 to \$48 per short-ton unit of BeO, f.o.b. mine. Government unit prices paid under the stockpiling program are as follows: 8 to 8.9 percent BeO, \$40; 9 to 9.9 percent BeO, \$45; and 10 percent or more BeO, \$50.

Beryl is bought on the basis of short-ton units of contained BeO. One unit is 1 percent of a short ton (20 pounds). The price per ton of beryl is determined by multiplying the percentage of BeO by its corresponding unit value. For example, the price of a ton of beryl containing 9.5 percent BeO and having a unit value of \$45, would be \$427.50.

The Government will assist exploration for new beryl deposits by loaning 50 percent of the total allowable costs through the Office of Minerals Exploration. The nearest office is at South 157 Howard Street, Spokane, Washington.

Engineering and Mining Journal (Sept. 1960) lists the following possible buyers of beryl:

Associated Metals & Minerals Corp.  
75 West Street  
New York, New York

Alfred D. Brown Associates Inc.  
24 Stone Street  
New York, New York

Beryllium Corp.  
Box 1462  
Reading, Pennsylvania

Brush Beryllium Company  
4301 Perkins Avenue  
Cleveland 3, Ohio

Beryl Ores Company  
Box 409, Route 1  
Arvada, Colorado

Continental Ore Corporation  
500 Fifth Avenue  
New York, New York

Derby and Company, Inc.  
285 Madison Avenue  
New York, New York

Pan American Trading Co.  
50 Broad Street  
New York, New York

Foote Mineral Co., Inc.  
18 W. Chelton Avenue  
Philadelphia 44, Pennsylvania

Phillip Bros. Inc.  
70 Pine Street  
New York, New York

E. A. Godoy and Co., Inc.  
25 Broadway  
New York, New York

Frank Samuel and Co., Inc.  
Lincoln Liberty Building  
Philadelphia 7, Pennsylvania

Lapp Insulator Co., Inc.  
Gilbert and Mill Streets  
Leroy, New York

J. A. Samuel and Co., Inc.  
220 Broadway  
New York, New York

Mercantile Import & Export Corp.  
21 E. 40 Street  
New York, New York

A. O. Smith Corporation  
3533 N. 27 Street  
Milwaukee 16, Wisconsin

Metallurg Inc.  
99 Park Avenue  
New York, New York

C. Tennant Sons and Company  
100 Park Avenue  
New York, New York

#### BERYLLIUM TECHNOLOGY

Beryl-bearing pegmatites are mined largely on a small-scale, highly selective basis, mostly by open-cut methods, partly by underground methods. The mining processes are similar to those used for other minerals.

For processing, beryl deposits fall into two classes: (a) deposits in which the beryl occurs in pieces large enough to be sorted out by hand; (b) deposits in which the beryl is so fine-grained that it could be recovered only by milling. Most of the world's beryl has been recovered by hand sorting methods from coarse-grained ores.

Fine-grained beryl is difficult to recover. Because beryl, quartz, and feldspar have nearly identical specific gravities, gravity concentration methods for beryl are ineffective. Research by the U. S. Bureau of Mines and others has shown that selective flotation will produce a good beryl concentrate with recoveries of 70 to 90 percent from ore containing more than 0.2 percent beryl, unless spodumene is present. Flotation methods, however, have not been used commercially, because it has been impossible to completely separate spodumene from beryl by flotation. Electrostatic methods of separation that have been tested show some promise. As further exploration brings new deposits of non-pegmatitic fine-grained beryllium minerals to light, flotation, chemical, and other modern concentration methods will become increasingly important.

#### COMPANIES ENGAGED IN BERYLLIUM EXPLORATION

Engineering and Mining Journal (Sept. 1960) reports that the following companies are engaged in exploration for beryllium, among



others: Vitro Minerals Corp., Beryllium Resources Inc., E. I. DuPont, U. S. Steel, Food Machinery and Chemical Corp., and Combined Metals Reduction Co. Mr. John Wood (oral communication) listed the following additional companies: Minerva Oil Company, Dow Chemicals, International Minerals, Phillips Petroleum, Union Carbide, and Kerr-McGee.

## MINERALOGY

### BERYLLIUM MINERALS

The following list--with certain deletions (rare beryllium minerals), additions, and modification--is taken from U. S. Geological Survey Professional Paper 318, Table 2, which concludes:

"Beryl, helvite, bertrandite, chrysoberyl, and phenakite are not only the most common minerals of beryllium, but actually account for nearly all mineralogical occurrences as well as all probable ores of beryllium. All can occur in deposits other than pegmatites."

Bertrandite.  $\text{Be}_4\text{Si}_2\text{O}_7(\text{OH})_2$ . 39.6 to 42.6 percent  $\text{BeO}$ . Orthorhombic, tabular, prismatic; vitreous; colorless, yellow. Insoluble. Cleavage perfect on 110. Two other distinct cleavages. Heart-shaped twins. Positive 2V,  $74^\circ$  (negative 2V,  $75^\circ$  according to Winchell and Dana). Hardness 6. Specific gravity 2.6. Fusibility 7.  $N_V$  1.61. Occurs in granitic pegmatites and feldspathic veins; widely distributed in small amounts.

Beryl.  $\text{Be}_3\text{Al}_2(\text{SiO}_3)_6$ . Ten to 14 percent  $\text{BeO}$ . Hexagonal, prismatic, vertically striated; vitreous; green (most common variety), blue-green (aquamarine), white, pink (morganite), yellow, colorless. Cleavage poor on 001. Insoluble. Hardness 7.5 to 8. Specific gravity 2.6 to 2.8.  $N_O$  1.57 to 1.60. Optical negative, by which means it may be readily distinguished from quartz in the petrographic microscope. Occurs in granitic pegmatites, high temperature veins, disseminated in granitic rocks; widely distributed. Alters to kaolinite.

Chrysoberyl.  $\text{BeAlO}_4$ . 16.9 to 19.7 percent  $\text{BeO}$ . Orthorhombic, tabular, twinned crystals; vitreous; green, yellow, brown, red; cleavage on 110. Hardness 8 to 9. Specific gravity 3.7. Fusibility 7.  $N_V$  1.75. Positive 2V widely varied. Uncommon, but occurs in granitic pegmatites, schists, and placer deposits.

Helvite.  $\text{Mn}_4\text{Be}_3\text{Si}_3\text{O}_{12}\cdot\text{S}$ . 10.5 to 15 percent  $\text{BeO}$ . Isometric, tetrahedrons, spherical masses; vitreous to resinous; yellow, red, brown; gels in  $\text{HCl}$ ; cleavage 111 (poor). Hardness 6. Specific gravity 3.2 to 3.4. Fusibility 3. Refractive index 1.73 to 1.75. Uncommon, but occurs in contact metasomatic (lime silicate--garnet, pyroxene, epidote, etc.) deposits, granitic and syenitic pegmatites.

Phenakite. (This mineral is also spelled "phenacite").  $\text{Be}_2\text{SiO}_4$ . 44.0 to 45.6 percent  $\text{BeO}$ . Trigonal, rhombohedral or prismatic; vitreous; colorless, yellow, rose, brown; insoluble; cleavage 1120. Hardness 7.5 to 8. Specific gravity 3.0. Fusibility 7.  $N_O$  1.654. Optical positive. Similar to quartz in appearance and optical sign, but, in thin section, has higher relief. Occurs in granitic pegmatites, high temperature veins. Rare.

## MINERALS CONTAINING MINOR AMOUNTS OF BERYLLIUM

Besides the beryllium minerals, certain other minerals may contain sufficient beryllium as an impurity to serve as a beryllium ore in the future. These include axinite (up to 0.1 percent BeO), allanite (up to 5.5 percent BeO), fergusonite (up to 0.74 percent BeO), garnet (grossularite, andradite, up to 0.2 percent BeO), vesuvianite (up to 4.0 percent BeO), samarskite (up to 0.3 percent BeO), thorite (up to 0.1 percent BeO), and zircon (up to 14(?) percent BeO). Deposits of these minerals should be tested for their beryllium content.

Axinite.  $H(Fe, Mn)Ca_2Al_2BSi_4O_{16}$ . Triclinic, wedge-shaped; vitreous; brown, blue, gray; insoluble; cleavage 112, 010, 130. Hardness 7. Specific gravity 3.3. Fusibility 2.  $N_V$  1.68 to 1.69. Negative 2V  $70^\circ$  to  $90^\circ$ . Occurs in contact metasomatic deposits and high temperature veins.

Allanite.  $(Ca, Ce)_2O \cdot Fe_2OH \cdot Al \cdot (Al, Si)_3O_9$ . Monoclinic, tabular or acicular, massive; submetallic; brown to black; conchoidal fracture with very bright vitreous luster on fracture surfaces; gels in HCl; commonly radioactive (thorium content). Hardness 6. Specific gravity 4. Fusibility 2.5 (swells).  $N_V$  1.65 to 1.78. Large negative 2V. Accessory in acidic igneous rocks, gneiss, schist, magnetite, or, as in the Lemhi region, Idaho, in hydrothermal veins. All beryllium material from granitic pegmatites.

Fergusonite.  $(Y, Er, Ce, Fe)(Cb, Te, Ti)O_4$ . Tetragonal, prismatic or pyramidal; submetallic; brown; soluble in  $H_2SO_4$ ; cleavage 111. Hardness 6. Specific gravity 5.8. Fusibility 7. Isotropic (metamict). Occurs in pegmatites. Rare.

Garnet. (grossularite, andradite).  $Ca_3(Al, Fe)_2Si_3O_{12}$ . Isometric, dodecahedral; vitreous; red, brown, yellow, green; no cleavage. Hardness 6.7. Specific gravity 3.1 to 3.4. Fusibility 3. Contact metasomatic deposits.

Vesuvianite.  $Ca_{19}(Al, Mg)_{13}Si_{18}(O, OH, F)_{76}$ . Tetragonal, prismatic; vitreous; brown, green blue; decomposed by HCl; poor cleavage on 110. Hardness 6.5. Specific gravity 3.4. Fusibility 3. Contact metasomatic deposits.

Samarskite.  $(Y, Er, Ce, U, Ca, Fe, Pb, Th)(Cb, Ta, Ti, Sn)_2O_6$ . Orthorhombic, prismatic or tabular, massive; black or brown; insoluble; cleavage 010. Hardness 5 to 6. Specific gravity 5.6 to 5.8. Fusibility 5. Commonly metamict. Occurs in granitic pegmatites. Rare.

Thorite.  $ThSiO_4$ . Tetragonal, prisms with pyramids; vitreous; brown; insoluble; cleavage 110. Hardness 5. Specific gravity 5.2 to 5.4. Fusibility 6. Commonly metamict. Occurs in pegmatites, syenites, or, as at several places in Idaho, in hydrothermal veins.

Zircon.  $ZrSiO_4$ . Tetragonal, prismatic. Adamantine; brown; cleavage 110 imperfect. Hardness 7.5. Specific gravity 4.7. Accessory mineral in igneous and metamorphic rocks. Beryllian variety (alvite) in granitic pegmatites; very rare.

## GENERAL GEOLOGY OF BERYLLIUM OCCURRENCE

### BERYL

Most of the world's beryl is in zoned granitic pegmatites. Homogeneous pegmatites have yielded little beryl. In zoned pegmatites, the beryl occurs preferentially in certain zones. Such enriched zones include zones of original crystallization, zones of filled fractures, and zones of replacement. In some places, beryl is found in shoots that lie within certain zones. Within all zoned pegmatites, larger beryl crystals are commonly near their cores and smaller crystals are near their contacts.

Thus far, most production has come from two of the many known varieties of pegmatites: muscovite-albite granitic pegmatites and lithium-bearing granitic pegmatites. Major producing areas include Brazil, Argentina, Mozambique, India, Belgian Congo, Southern Rhodesia, the United States, Madagascar, Southwest Africa, and the Union of South Africa. Within the United States, South Dakota is the main producing area, though beryl is or has been mined in Colorado, New England, Virginia, North Carolina, Arizona, New Mexico, and Idaho.

Beryl also occurs in granitic and syenitic intrusive rocks, and in nepheline syenites. But only greisenized granite (albitized, with addition of muscovite, topaz, quartz, and beryl) is known to be of potential industrial importance. Such deposits occur, for example, at Hillside, Arizona, and Shiprock, Utah. At Mount Antero, Colorado, and at Bagdad, Arizona, virtually complete gradation occurs from granite so rich in beryllium that it occurs as grains of aquamarine; through aquamarine-bearing schlieren, vugs and small veins; to conventional pegmatites.

Finally, beryl exists in quartz veins with such high temperature minerals as cassiterite, wolframite, and molybdenite. It appears to be more common in quartz-tungsten veins than in other kinds of veins. The only non-pegmatitic deposit from which beryllium minerals have been produced in significant quantities is at the Boomer mine, Lake George, Colorado. Beryl and bertrandite are associated with quartz and fluorite in a vein that cuts schist near a granite contact.

### HELVITE

Extractive processes have not been adapted to the use of helvite; hence, there is no market for it. However, should sufficiently large deposits be found, extractive processes to handle the ore would certainly be developed.

Contact metasomatic deposits contain helvite and other minerals containing traces of beryllium, such as vesuvianite, grossularite, and chlorite. Such occurrences are known in the Iron Mountain district of New Mexico, where some beryllium-bearing minerals occur in a layered variety of tactite, locally called "ribbon rock," and



some occur in strongly mineralized shear and breccia zones in earlier-formed massive tactite. Fluorite and magnetite are prominent constituents of the beryllium-bearing rock.

Helvite seldom occurs in Mn-Pb-Zn veins in association with such minerals as rhodonite, rhodochrosite, quartz, sphalerite, and galena, as at Butte, Montana. Helvite is the last mineral in the paragenesis.

#### BERTRANDITE

In some areas, bertrandite is found most commonly in pegmatites closely associated with beryl, in cavities formerly occupied by beryl crystals (rarely pseudomorphic after beryl). Bertrandite also occurs in high temperature veins with beryl and phenakite.

Bertrandite and a possibly new beryllium mineral, provisionally called "vitroite" by geologists of Vitro Minerals Corp. who discovered it, occur in the Topaz Mountain area in Utah. Engineering and Mining Journal, Sept., 1960, reports that: "Beryllium minerals in the Topaz Mountain non-pegmatitic deposit are disseminated in a volcanic tuff, overlain by rhyolite. Mineralization is regarded as hydrothermal." Fluorite is abundant in this general area and is intimately associated with "vitroite." Mr. Ben Dickerson, geologist for Vitro Corporation (personal communication) has contributed further information on the Topaz Mountain area:

"Host rock for beryllium in the Topaz-Spor Mountain area is a rhyolite tuff, which is generally highly altered in the mineralized areas. Montmorillonite and other clays are abundant. A typical rock sequence is as follows:

Topaz-beryl bearing rhyolite (top)  
Mineralized rhyolite tuff  
Dolomite (bottom)

"The beryllium mineral is not yet positively identified, but is certainly a silicate, possibly related to bertrandite. This mineral is closely associated with fluorite and manganese oxides.

"The adjacent fluorspar pipes contain traces of beryllium.

"Very large tonnages of the tuff contain more than 0.10% BeO. Some samples contain as much as 4% BeO, but a typical sample would be much lower.

"The beryllium can be extracted by conventional acid-leach procedures and further chemical processing can produce a marketable product."

#### CHRYSOBERYL AND PHENAKITE

Chrysoberyl and phenakite are mainly in pegmatites as accessory minerals with beryl. A few places are known where chrysoberyl is the main beryllium mineral in pegmatite. In the Seward Peninsula, Alaska, phenakite and chrysoberyl are found together in fluorite veins in limestone.

## TYPES OF BERYLLIUM OCCURRENCE IN IDAHO

In this section known beryllium occurrences in Idaho are described on the basis of their origin. So far, little other than pegmatitic beryllium has been found.

### PEGMATITIC AND DISSEMINATED BERYLLIUM

Cooperative work in the Sawtooth Range by the Idaho Bureau of Mines and Geology and the U. S. Bureau of Mines was initiated upon information received from Mr. Kenneth Liddiard of Atlanta, Idaho, concerning the occurrence of aquamarine in a pegmatite dike. This effort resulted in the discovery of disseminated aquamarine in granite over an area of several square miles in the vicinity of Glens Peak at the head of the Middle Fork of the Boise River (Fig. 1). Preliminary work has not yet completely delimited the extent of the aquamarine occurrence or of the granite that contains it. Based on visual examination, none of the deposits discovered thus far seems to be of commercial value.

Within this granite, which was given a field name of "pink granite," aquamarine exists as widely disseminated grains. The granite is a peculiar sort, "micropegmatitic," "micromiarolitic," and alaskitic throughout, with local zones or areas of fine-grained aplite or "rhyolite." J. W. Adams (U. S. Geol. Survey Bull. 982-D) described a similar rock in the Mount Antero region of Colorado. Xenoliths of granodiorite were noted in the Glens Peak granite near its southern margin, and one xenolith of porphyry was seen in the granite. Porphyry dikes cut the granite.

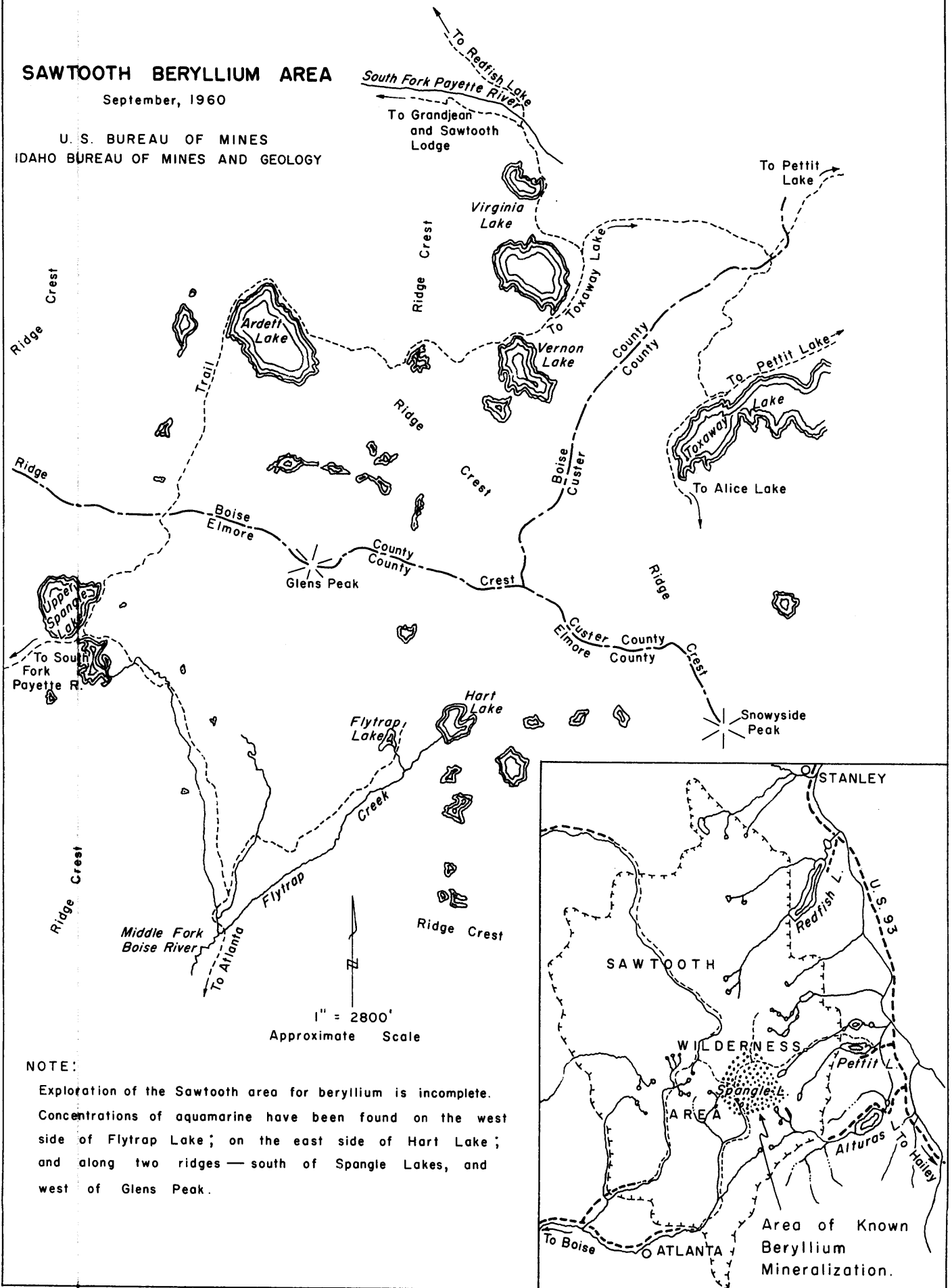
Where certain zones in the granite contain "aquamarine balls," blue spheres in which aquamarine forms 10 percent or more of the groundmass, the effect is definitely blue. In some places, the aquamarine is very fine grained. Some spheres are as much as a foot in diameter. Randomly scattered in certain zones are lenticular grain clusters of aquamarine in the groundmass of the rock or in small "micromiarolitic" cavities. All gradations exist from these to lenticular grain clusters of aquamarine localized in joints. One float boulder observed contained a half-inch thick seam of solid aquamarine. Grain clusters along joints grade into "sheet" pegmatites, localized mostly along low-angle joints. The "sheet" pegmatites, most of which are less than two inches thick, contain random clusters of aquamarine crystals spaced several feet apart. Such an exposure may cover several hundreds of square feet. There are some small vugs, lined with clear to smoky quartz crystals, in such "sheet" pegmatites.

Thicker pegmatite dikes, standing at high angles, are developed in all sizes from a thin sheet or small lenticular pod to a few feet thick, whether lens-like or tabular. Vugs are rather common in such pegmatites, and range from very small to perhaps a foot in diameter. Minerals identified megascopically in such pegmatites include clear to smoky quartz, potassium feldspar, biotite, garnet, magnetite, and columbite(?).

# SAWTOOTH BERYLLIUM AREA

September, 1960

U. S. BUREAU OF MINES  
IDAHO BUREAU OF MINES AND GEOLOGY



**NOTE:**

Exploration of the Sawtooth area for beryllium is incomplete. Concentrations of aquamarine have been found on the west side of Flytrap Lake; on the east side of Hart Lake; and along two ridges — south of Spangle Lakes, and west of Glens Peak.

Area of Known Beryllium Mineralization.

Aquamarine is the latest mineral in vugs lined with smoky quartz and potassium feldspar. Well-developed crystals were collected from half a dozen vugs; however, most vugs seen are empty of aquamarine. If aquamarine was formerly present in such vugs, it has weathered out. Some evidence exists to indicate that aquamarine has perhaps weathered out of many vugs. In every vug from which aquamarine crystals were removed, the crystals were in a clay matrix. Many crystals were so strongly weathered and altered to clay that they fell to pieces upon being removed. If the clay alteration is not hydrothermal, but caused by surface weathering, then such vugs may contain more aquamarine in depth than would seem to be the case from surface exposures.

A discovery of widespread beryllium mineralization was made in the Yellow Jacket Mountains as a result of the cooperative work by the two Bureaus. Reconnaissance teams had no previous knowledge of beryl in the area, although claims had been staked in portions of the area for uranium and thorium minerals. The occurrence is on National Forest land along the Cathedral Rock road, 15 miles west of Cobalt, Idaho.

Green beryl and aquamarine occur over an area of a few square miles in porphyritic granite. The mineral is predominately in pegmatite stringers and lenses but is also found in vugs, as well as in disseminated crystals or clusters of crystals. Width of the pegmatite stringers is generally less than one-half inch. In general, the diameter of the beryl crystals is less than one-half inch. Based on visual examination, no commercial concentrations were found; however, only a limited examination was made of the area.

Near Deary, in Latah County, beryl was for many years produced as a byproduct of mica mining at the Muscovite mine. Beryl is also reported in limited amounts in small pegmatites at nine other mines in the district.

Three pegmatite bodies, cutting mica schist near the contact of the Thatuna batholith, occur at the Muscovite mine. The central pegmatite is the largest. It has a zoned structure: an albite (75%)-quartz (25%) core and wall zones of quartz, albite, and muscovite, in which the beryl occurs. Small amounts of microcline, black tourmaline, apatite, and garnet are also present. Some beryl occurs in altered (hornfelsed) schist near the pegmatite-schist contacts.

#### NON-PEGMATITIC BERYLLIUM (HIGH-TEMPERATURE VEINS)

Several high-temperature quartz-aquamarine veins and veinlets have been bound in the Sheep Creek area, five miles east of the Middle Fork of the Boise River. Beryl-bearing pegmatites also occur in the area. The deposits were discovered by Mr. George Ogden of Boise.

Beryllium is present as pale blue aquamarine with minor quartz in thin veinlets up to one-half inch thick and as pale green beryl subordinate to quartz in veins ranging from one inch to two feet



thick. The steeply dipping, roughly parallel veins have a general N 70° E strike. Hydrothermal alteration along most of the beryl-containing veins has produced grayish-black, silicified and sericitized zones extending several inches from vein walls into surrounding granodiorite.

Beryl in the quartz veins seems to be most abundant in veins from 3 to 6 inches thick. Beryl is primarily in grain clusters and needles along vein walls and, subordinately, in single crystals and small pods disseminated through the quartz. Much of the beryl is altered to kaolinite. Enriched beryl shoots occur along intersections of aquamarine veinlets and quartz-beryl veins.

Mica and feldspar are almost absent in beryl-containing veins but are plentiful in accompanying thin pegmatite dikes.

No other deposits primarily of non-pegmatitic beryllium in Idaho are known to us at the time of this writing; however, non-pegmatitic disseminated beryl occurs in the Sawtooth Range and in the Yellowjacket area.

## GUIDES TO PROSPECTING

### POSSIBLE BERYLLIUM INDICATORS

The geology of a particular area may provide an initial clue to possible occurrences of beryllium minerals. Intrusive granitic rocks are the source of beryllium minerals, either in pegmatitic zones, in contact metasomatic zones in adjacent limy rocks, in high-temperature veins either in the granitic rocks or in adjacent rocks. Sedimentary and metamorphic rocks have not yet produced beryllium minerals.

The mineralogy of particular deposits may also provide clues to possible presence of beryllium minerals. The association of beryllium and fluorine is the best example. Fluorite occurs in two-thirds of all the beryl-bearing quartz veins so far reported in the world. Further, it occurs in most of the helvite-bearing veins and contact metasomatic deposits. Certain other elements, such as tin, tungsten, and, less commonly, molybdenum, also associate with beryllium, although not universally so. Thus, minerals of these elements may provide a clue to possible beryllium deposits.

Fluorine-rich minerals, such as vesuvianite (which may or may not contain fluorine), may be a clue to the presence of beryllium minerals. Any minerals with minor beryllium content, such as zircon, allanite, and others, might also provide a clue to the occurrence of beryllium minerals.

Scheelite is nearly as important an indicator mineral as fluorite for helvite in contact metasomatic (tactite) zones.

### FAVORABLE LOCALITIES TO PROSPECT IN IDAHO

The Idaho batholith, a very large pluton, is obviously the most favorable place in Idaho to prospect for beryllium. Certain places within the batholith, and in its environs, are more favorable than others. As a result of work done in the summer of 1960, we now believe the Sawtooths to be favorable for prospecting or exploration. Very little work has been done in large parts of the batholith, especially in its northern part, though one can hear rumors of both beryl and emerald deposits in the upper Clearwater River drainages.

A zone containing swarms of thin pegmatite dikes extends along much or all of the western margin of the Idaho batholith. Although very little beryl has been discovered in this zone to date it has probably not yet been sufficiently explored. Areas in the southern Seven Devils Range, near Iron Mountain and near Cuprum, contain small contact metasomatic deposits that should be examined further for beryllium, although preliminary examination was not favorable.

Mineralized areas containing tungsten minerals, especially scheelite, are potentially favorable--such areas as the Yellowpine district, Wildhorse Creek-Trail Creek area, Deadwood Reservoir area, the Mackay area, and the Stanley Basin area. Also, areas containing iron minerals (magnetite, specularite) are favorable--such

areas as Meyers Cove, the northern Lemhi Mountains, and parts of the Beaverhead Range, as near Agency Creek.

Large parts of the rocks bounding the entire southeastern part of the Idaho batholith may contain beryllium of the non-pegmatitic type. Favorable places exist wherever contact metasomatic deposits (garnet, pyroxene, epidote) have developed in or near limestone. Thick limestone formations crop out over much of the area.

Parts of the Challis formation (early to mid-Tertiary volcanic rocks) that have undergone more or less extensive fluorite mineralization--the Stanley Basin area, the Yankee Fork-Red Mountain area, and the upper Middle Fork of the Salmon River area--are also favorable. The geology and mineralization of the Challis are very similar to the geology and mineralization of the recently discovered non-pegmatitic beryllium deposits of Utah and Nevada. Some companies currently exploring for beryllium are concentrating on tuffs and rhyolites, especially where they contain fluorite.

## PROSPECTING METHODS

### THE BERYLOMETER METHOD

The beryllometer is a portable field instrument for detection of beryllium in rock. Instruments of this sort were devised at about the same time by persons working independently in England and Canada. The operation of the instrument is based on neutron emission by beryllium upon excitation by gamma rays. The gamma ray source generally used is  $Sb^{124}$ . Appropriate neutron counting devices are built into the machine. In the United States, such an instrument, manufactured by the Isotopes Specialties Co., of Burbank, California, and weighing about 11 pounds, sells for approximately \$2500. A laboratory instrument, manufactured by Boulder Scientific Co., of Boulder, Colorado, sells for approximately \$2600.

In use, the instrument is placed directly against the rock surface to be tested, which must be as flat as possible. The principles that govern the operation of the beryllometer limit its effective working distance. The inverse square law of radiation intensity is doubly invoked in the use of the beryllometer. It governs both the gamma rays emanating from the source and the neutrons released by any beryllium that is present. Further, gamma rays penetrate only the outer  $1\frac{1}{2}$  inches of rock. In general, stationary tests of  $\frac{1}{4}$  to  $\frac{1}{2}$  minute are made at each spot. Beryllium content down to 0.5%  $BeO$  is readily detected. Lower grades may be detected by longer tests--1 to 2 minutes for 0.1%  $BeO$ , and, under good conditions, up to 15 minutes for rock as low as 0.05%  $BeO$ .

$Sb^{124}$  is highly radioactive and therefore subject to Federal and State regulations regarding use and disposal of radioactive materials. Suppliers can release radioactive materials only to companies or persons licensed by the U. S. Atomic Energy Commission.

### CHEMICAL METHODS

Chemical field tests for beryllium are of two kinds: (a) colorimetric and (b) fluorimetric.

A colorimetric analysis for trace amounts of beryllium in soils, used in geochemical prospecting, is described in the Bulletin of the Institution of Mining and Metallurgy, April, 1960. The synopsis is as follows:

"A new method is described for the determination of beryllium in soils; the procedure is rapid and sensitive, and is sufficiently accurate for prospecting purposes. The beryllium is selectively extracted by dilute nitric acid after fusion of the sample with ammonium fluoride. Interfering ions are sequestered with ethylenediaminetetraacetic acid and N,N-di(2-hydroxyethyl) glycine, and the beryllium is estimated by visual comparison of colours after the addition of sodium hydroxide and berillon. Soils containing beryllium from 0.5 to 50 ppm can be analyzed without preliminary separation. . ."

Fluorimetric analysis may be made using different chemicals. The most reliable test appears to be that using quinizarin (1-4-dihydroxyanthraquinone). As little as 0.013 percent beryllium (0.26 percent beryl) can be detected by this method. This method is described in U. S. Bur. Mines Inf. Circ. 7946, available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for 15 cents:

"A small portion of the pulverized rock is fused with sodium carbonate-sodium hydroxide flux in a wire loop. The fused mass is dissolved in water, a few drops of quinizarin solution are added, and the solution is viewed under ultraviolet light. A pink-to-orange fluorescence reveals the presence of beryllium. . ."

Eldon Pattee of the U. S. Bureau of Mines found that sulfides commonly give positive quinizarin results, even when Be is apparently absent.

Another excellent test is that using morin, described in U. S. Bur. Mines Rept. of Investigations 5620:

". . .duplicate samples are fluxed--one with potassium bifluoride and one with potassium bisulfate-- followed by dissolution of salts in water, conversion of the solution to an alkalic condition, addition of morin, and examination of the solution for fluorescence under short-wave ultraviolet light. This method provides a fast dependable field test for beryllium minerals containing as little as 0.2 percent beryl or its equivalent."

Several other kinds of tests have been devised, but they do not appear to be as good as those described above.

Apart from all of these, certain staining and spot tests may be useful, chiefly because of their simplicity. The following material on staining and spot tests is taken directly from U. S. Geol. Survey Bull. 945-C by Jahns and Glass:

"Helvite dissolves slowly in boiling 1:1 hydrochloric acid, releasing hydrogen sulfide and forming a silica gel, whereas garnet is very difficultly soluble, does not yield hydrogen sulfide, and does not gelatinize.

"A very satisfactory selective staining method for the recognition of helvite has been developed by the research staff of Continental Machines, Inc., of Minneapolis, Minn. The procedure begins with the crushing of a small sample of the material to be tested and its immersion in dilute (1:5) sulfuric acid. A small amount of arsenic trioxide is added, and the solution is then boiled for one to two minutes. The acid is then decanted and the sample washed with water. Any helvite present will be covered with an easily recognized canary yellow stain of arsenic sulfide. . ."

"A spot test for detecting beryllium oxide . . . has been used by chemists and geologists of the Brush Beryllium Co. . . and gives excellent results on helvite-bearing material. . .

"Crush a piece of the sample to a coarse powder and grind this powder in a mortar to a fineness of about 200 mesh. Melt 1.5 grams of NaOH by heating to a dark cherry red in a 30-ml. nickel crucible, then add 0.08 to 0.10 gram of the finely powdered sample. Heat to a dark cherry red for five minutes. Allow the melt to cool, stirring briskly as it solidifies. Place the bottom of the crucible in cold water and put into it 10 ml. of cold water. Leaving the crucible thus partly immersed, stir the water inside continually until the melt is completely dissolved.

"With a stirring rod, put a large drop of paranitrobenzineazo-orcinol solution on a double thickness of filter paper. On the spot thus made, put a similar drop of 25 percent KCN; then put a small drop of the unknown solution in the center of the large spot. A pink ring will develop within five minutes if the original sample contained 1 percent or more of BeO.

"To make up 100 ml. of the paranitrobenzineazo-orcinol solution, dissolve 0.025 grams of the reagent in 100 ml. of normal (4 percent) NaOH solution."

It is not feasible in a publication of this sort to reproduce all the details of the various chemical tests that are used, complete with lists of chemicals. Those persons wishing to perform such tests may acquire the publications listed, where such detailed information is already in print.

#### SPECTROSCOPIC METHODS

In spectroscopic analysis, a tiny amount of sample material is burned in a carbon arc. The light emitted during burning has certain wave lengths characteristic of the element(s) present. After the light is passed through a prism and broken into its different colors, study of the light against a properly calibrated scale enables a trained person to determine the element(s) present in the sample.

Such an instrument is generally found only in larger scientific laboratories. However, the U. S. Bur. of Mines office at Spokane has constructed a portable spectroscope, which has been used in the beryllium reconnaissance program. Their portable laboratory has also facilities for radiometric and field chemical analyses.

For accurate laboratory work, the spectrograph, a device to photograph the light spectrum produced by the spectroscope, is generally employed. The spectrograph seems to be the most reliable instrument for quantitative determination of small amounts of beryllium. Accurate spectrographic determination may be made of rock

whose beryllium content is in the range 0.005 to 0.0001 percent BeO. Complex and expensive equipment is required, and the results must be interpreted by trained technicians.

#### SUMMARY

Samples of rocks suspected of containing beryllium should be subjected either to a beryllometer, chemical, or spectrographic test. Large numbers of random samples need to be taken. Otherwise fine-grained beryl, phenakite, and bertrandite may be overlooked entirely, or casually dismissed as fine-grained quartz or feldspar, whether in vein deposits or elsewhere. Similarly, fine-grained disseminated aquamarine in "aquamarine balls" in the Sawtooths may in many places be overlooked until one has "trained" his eyes. Fine-grained helvite intergrown with garnet is not easily distinguished visually from grossularite-andradite garnet. It would be wise to take samples of many rocks in areas of tungsten or fluorite mineralization--especially in and near veins of such deposits. Geochemical methods employing soil testing may very well be used in certain areas suspected to contain beryllium.

Rocks suspected of containing beryllium may be sent either to the U. S. Bureau of Mines, 1201 N. Division, Spokane, Washington, or to the Idaho Bureau of Mines and Geology at Moscow, Idaho. Either agency will perform a free qualitative test for the presence of beryllium. In order for maximum scientific value to be derived from such sample analysis, as complete information as possible should be given by each individual regarding (1) geographic location and (2) geologic features of each occurrence. Such information will be held in confidence. Moreover, personnel of both Bureaus will, upon request, so far as time and finances permit, attempt to visit all beryllium localities.

SELECTED BIBLIOGRAPHY

- Adams, J. W., 1953, Beryllium deposits of the Mount Antero region, Chaffee County, Colorado: U. S. Geol. Survey Bull. 982-D.
- Bulletin of the Institution of Mining and Metallurgy, April, 1960, no. 641.
- Dana, E. S., and Ford, W. E., 1955, A Textbook of Mineralogy, 4th ed: John Wiley and Sons, Inc.
- Dressel, W. M., and Ritchey, R. A., 1960, Field test for beryllium (quinizarin test): U. S. Bur. Mines, Inf. Circ. 7946.
- Engineering and Mining Journal, v. 161, no. 2 (Feb.) and no. 9 (Sept), 1960. (Articles on beryllium).
- Gary, G. L., 1940, Notes on beryl with a qualitative analysis for beryllium: California Jour. Mines & Geol. v. 36, no. 1, p. 86.
- Jahns, R. H., and Glass, J. J., 1944, Beryllium and tungsten deposits of the Iron Mountain district, Sierra and Socorro Counties, New Mexico, with a section on the beryllium minerals: U. S. Geol. Survey Bull. 945-C.
- Marks, G. W., and Jones, B. M., 1948, Method for the spectrochemical determination of beryllium, cadmium, zinc, and indium in ore samples: U. S. Bur. Mines, Rept. of Inv. 4363.
- McVay, T. N., 1960, Field test for beryllium minerals: The morin fluorescence method: U. S. Bur. Mines, Rept. of Inv. 5620.
- Mineral Facts and Problems, 1960, U. S. Bur. Mines Bull. 585.
- Moyd, Louis, and Moyd, Pauline, 1960, The gamma ray-neutron beryllium detector as a reconnaissance tool: Society of Min. Engr. of the Am. Inst. of Min., Met., and Petr. Eng., Preprint no. 60H95.
- Vaughn, W. W., Wilson, E. E., and Ohm, J. M., 1960, A field instrument for quantitative determination of beryllium by activation analysis: U. S. Geol. Survey Circ. 427.
- Warner, L. A., Holser, W. T., Wilmarth, V. R., and Cameron, E. N., 1959, Occurrence of non-pegmatitic beryllium in the United States: U. S. Geol. Survey Prof. Paper 318.
- Winchell, A. N., and Winchell, Horace, 1951, Elements of Optical Mineralogy, 4th ed: John Wiley and Sons, Inc.