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HYATT RANCH PEGMATITE, LARIMER COUNTY, COLO.

By M. M. Gilkey

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UNITED STATES DEPARTMENT OF THE INTERIOR

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UNITED STATES DEPARTMENT OF THE INTERIOR
Fred A. Seaton, Secretary

BUREAU OF MINES
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HYATT RANCH PEGMATITE, LARIMER COUNTY, COLO.[1]

by

M. M. Gilkey[2]

INTRODUCTION AND SUMMARY

Pegmatites in Colorado occur for 150 miles along the Front Range (easternmost range of the Rocky Mountains) from Larimer County on the north to Canon City on the south, and west into the Gunnison area. Many of the deposits have been classified. Minerals found in the various dikes include beryl, scrap and possibly punch mica, lithium-bearing minerals, columbite-tantalite, feldspar, and several rare minerals.

Pegmatites are abundant in the Crystal Mountain district in Larimer County. About 5 miles south of the Crystal Mountain district and often identified with that district is the Hyatt pegmatite area. The Hyatt Ranch deposit has attracted particular attention because of the comparatively high beryl content of the upper part exposed in opencut workings.

The Hyatt Ranch pegmatite, at an altitude of 8,100 feet, is in a heavily wooded region of rough terrain. Access to the property is by 4-1/2 miles of unsurfaced mountain road that branches from State Highway No. 262 near Drake, Colo. The climate in the vicinity of the property is characterized by pleasant summers and moderately severe winters.

The deposit was discovered in 1936 and was worked intermittently by several operators in 1936, 1942, 1943, and 1948. This work was confined to shallow opencut operations. Total recorded production from the deposit is about 50 tons of beryl, 30 tons of scrap mica, and 400 tons of potassium feldspar.

The geologic age of the pegmatite and of the enclosing schist and granite is Precambrian. The pegmatite strikes northeasterly and dips northwesterly. It is a roughly lenticular body 365 feet long and has a maximum width of 70 feet. Near its center, it appears to bottom about 200 feet vertically below its surface outcrop. Besides a discontinuous border zone, it is divided into four internal zones: A wall zone, outer intermediate zone, inner intermediate zone, and core zone. Most of the beryl is found in the inner intermediate and wall zones. Muscovite occurs principally in the inner intermediate zone.

1/ Work on manuscript completed January 1960.

2/ Mining engineer, Bureau of Mines, Denver, Colo.

Chemical and microscopic studies indicate that beryl and mica are the only potentially valuable minerals in the deposit. The potassium feldspar present is of low quality.

Information gained from exploratory diamond drilling done by the Federal Geological Survey and examination of the surface workings indicated that the Hyatt Ranch deposit might contain a substantial tonnage of beryl-bearing pegmatite of a grade sufficiently high to warrant beneficiation. The purpose of the Federal Bureau of Mines project at the Hyatt Ranch pegmatite was to investigate the following: (1) Extent, grade, and distribution of beryl and other economically important minerals, (2) possibilities for selective mining, (3) feasibility of hand sorting, and (4) amenability of the ore to metallurgical beneficiation.

Project work began September 18, 1950. During the one-year period ending Sept. 18, 1951, an adit 272 feet long was driven to explore the pegmatite from footwall to hanging wall, four diamond-drill holes (Appendix I) totaling 297.5 feet were completed to explore the deposit below the adit level, and a sorting plant was constructed and operated to investigate the feasibility of hand concentration of the beryl and mica. Ground conditions encountered in the granite and pegmatite were generally satisfactory, although the hardness of the rock slowed drilling. Core recovery (Appendix II) from the diamond-drill holes averaged 93 percent. The diamond drilling revealed that about one-half of the deposit lies below the adit level and that the underlying portion is similar in grade and mineral distribution to the middle portion penetrated by the adit. The grade is too low for economic operation at present prices, and selective mining offers no solution. Results of the attempt to concentrate the beryl and mica by hand sorting were disappointing. Although 60 percent of the mica in the ore was recovered by hand sorting, only 18 percent of the beryl was recovered by this method.

In June 1953, two 7-ton samples were taken from the adit level for metallurgical testing. One sample, taken in the inner intermediate zone, assayed 0.065 percent BeO (beryllium oxide). The other was taken from the wall zone and contained 0.022 percent BeO. The results of the metallurgical experiments were satisfactory for mica but were unfavorable for beryl. The highest grade beryl concentrate obtained by flotation assayed only 4.5 percent BeO, and the recovery of beryl was only 45 percent.

ACKNOWLEDGMENTS

Acknowledgment is made to the Federal Geological Survey for cooperation in supplying geologic information, and particularly to W. R. Thurston from whose data the description of the deposit and the maps included in this report were taken in part. For his continuous cooperation, acknowledgment is made also to Fred H. Hyatt, owner of the deposit.

LOCATION AND ACCESSIBILITY

The Hyatt Ranch pegmatite is in Larimer County, Colo., in the NE1/4NW1/4 sec. 28, T. 6 N., R. 71 W., sixth principal meridian (fig. 1). It is approximately 5 miles south of the Crystal Mountain pegmatite district and about 2

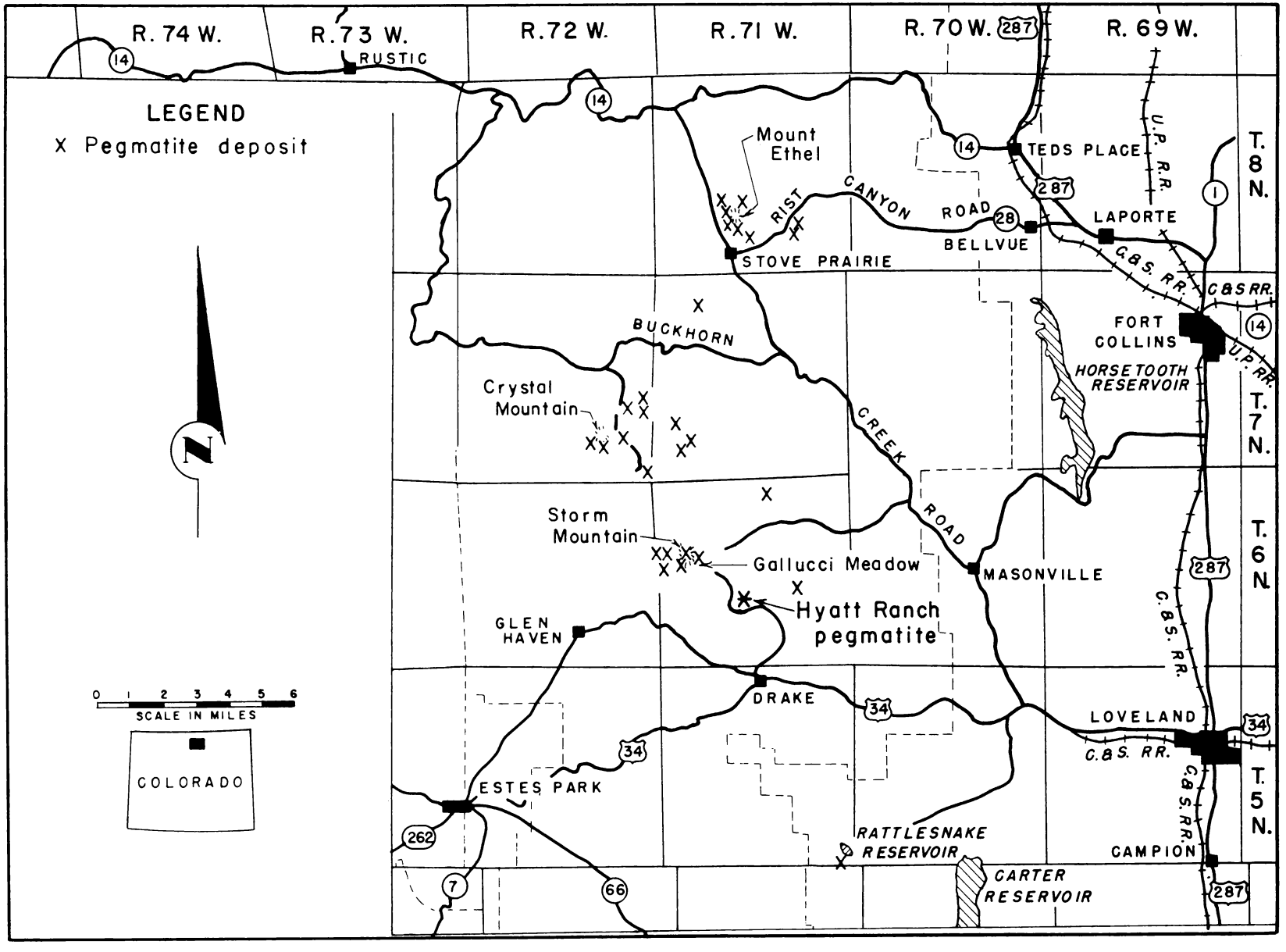

FIGURE 1. - Location Map, Hyatt Ranch Pegmatite, Larimer County, Colo.

miles north northwest of Drake, which is on U.S. Highway No. 34. U.S. Highway No. 34, which follows the canyon of the Big Thompson River, is surfaced and well maintained. The mine can be reached from Drake by driving 0.5 mile westward on State Highway No. 262, then 4.5 miles northward on an unsurfaced mountain road that passes through the Hyatt Ranch. The road to the ranch is rough and narrow and has steep grades and sharp curves.

The nearest shipping point is 13 miles east of Drake, where a spur of the Colorado and Southern Railroad crosses U.S. Highway No. 34. Loveland, a town of 10,000 population and the nearest commercial center, is 22 miles by road east of the mine and 56 miles north of Denver.

PHYSICAL FEATURES AND CLIMATE

The region adjacent to the mine is a rolling upland dissected by deep, precipitous canyons. The relief, which is very great near the Big Thompson River, necessitates circuitous routes for roads in the area. At the mine, the altitude is 8,100 feet, or nearly 2,000 feet higher than Drake. Storm Mountain, about 2 miles northwest from the mine, has an altitude of 9,915 feet.

Most of the nearby streams are intermittent; the nearest permanent stream is the North Fork Thompson River, about 1.5 miles to the southwest. A heavy growth of timber covers the area near the mine.

The climate is generally pleasant in late summer and early fall. At the altitude of the mine, moderate to heavy snowfall can be expected during the winter months.

HISTORY, OWNERSHIP, AND PRODUCTION

Mining in the Crystal Mountain district began in 1884 when the Buckhorn mica mine was discovered. This operation lasted only a few years, but activity was resumed in 1934 when it was learned that pegmatites in the district contained beryl. In 1941, the United Beryllium Ores and Metals Corp., Denver, Colo. bought the mineral rights on most of the land in the district to obtain control of nearly all the pegmatites.

The Hyatt Ranch pegmatite was located in 1936 by Roy Hyatt. In 1936, Hyatt shipped 1,500 pounds of beryl, of which 1,200 pounds was recovered from float. The deposit was next located by Fred H. Hyatt who, in September 1942, leased the property to the above-mentioned United Beryllium Ores and Metals Corp. The property was operated by this company intermittently in the fall of 1942 and, under a financial arrangement with the Reconstruction Finance Corporation, was worked continuously from June to December 1943. During the latter period, beryl shipped from the property amounted to 34 tons that averaged 11.04 percent BeO and was valued at $4,578.10.

In 1948, Fred H. Hyatt leased the property to Michael D. Lyons who mined about 400 tons of feldspar and 30 tons of scrap mica in that year. According to Lyons, the mica was of satisfactory quality, but the feldspar was of poor quality because it was mined nonselectively.

The Geological Survey made studies of the deposit during the period 1942-44, and the results are presented in Geological Survey Professional Paper 227. Thurston[3/] examined the property in 1947, and the Geological Survey explored the deposit in 1948 by core drilling.

Total recorded production from the Hyatt Ranch pegmatite was approximately 50 tons of beryl, 400 tons of feldspar, and 30 tons of scrap mica.

DESCRIPTION OF THE DEPOSIT

The following description of the deposit has been taken partly from Thurston.[4/]

In the vicinity of the Hyatt Ranch deposit, numerous pegmatite and gray-granite bodies intrude dark-gray schists that probably belong to the Precambrian Idaho Springs formation. In some exposures the granites are cut by the pegmatites and, hence, are older; both rocks are probably Precambrian in age. Few of the deposits are beryl bearing. The beryl-bearing Hyatt Ranch deposit is the only zoned pegmatite in the area.

The Hyatt Ranch pegmatite cuts across a small pluglike mass of gray biotite granite that crops out along the crest of a small anticline in quartz-mica schist (fig. 2). The main part of the deposit is in granite, but the northeast and southwest ends of the deposit project into schist. Between the granite and pegmatite, the contact is somewhat irregular and is locally gradational. In many places at the granite contact the pegmatite has no border zone. At the contact with the schist, the border zone is well developed, and the attitude is readily determinable.

The Hyatt Ranch pegmatite is 365 feet long and has a maximum width of 70 feet. It is a roughly lenticular, asymmetrical body whose long axis trends N. 60° E.; it has an average dip of 60° NW. The northeast end has a flat plunge to the southwest that steepens in the granite. The southwest end plunges about 42° northward, so the pegmatite has approximately the shape of half a lens tapering downward to the northwest. Near its center it appears to bottom about 200 feet vertically below its surface outcrop; however, the keel, or bottom edge of the body, is closer to the surface at its northeast and southwest ends.

Besides the discontinuous border zone, the Hyatt Ranch pegmatite is divided into the following four zones (figs. 2 and 3):

1. Wall zone: This zone ranges in width from 1 to 60 feet and averages about 25 feet. It constitutes the bulk of the pegmatite and its upper part consists of about 50 percent plagioclase and orthoclase, 25 percent perthite, and 25 percent quartz. In the lower part, the zone consists of 60 percent plagioclase and orthoclase and 40 percent quartz. The grains average slightly

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3/ Thurston, W. R., Pegmatites of the Crystal Mountain District, Larimer County, Colo.: Geol. Survey Bull. 1011, 1955, pp. 71-88.

4/ Work cited in footnote 3.

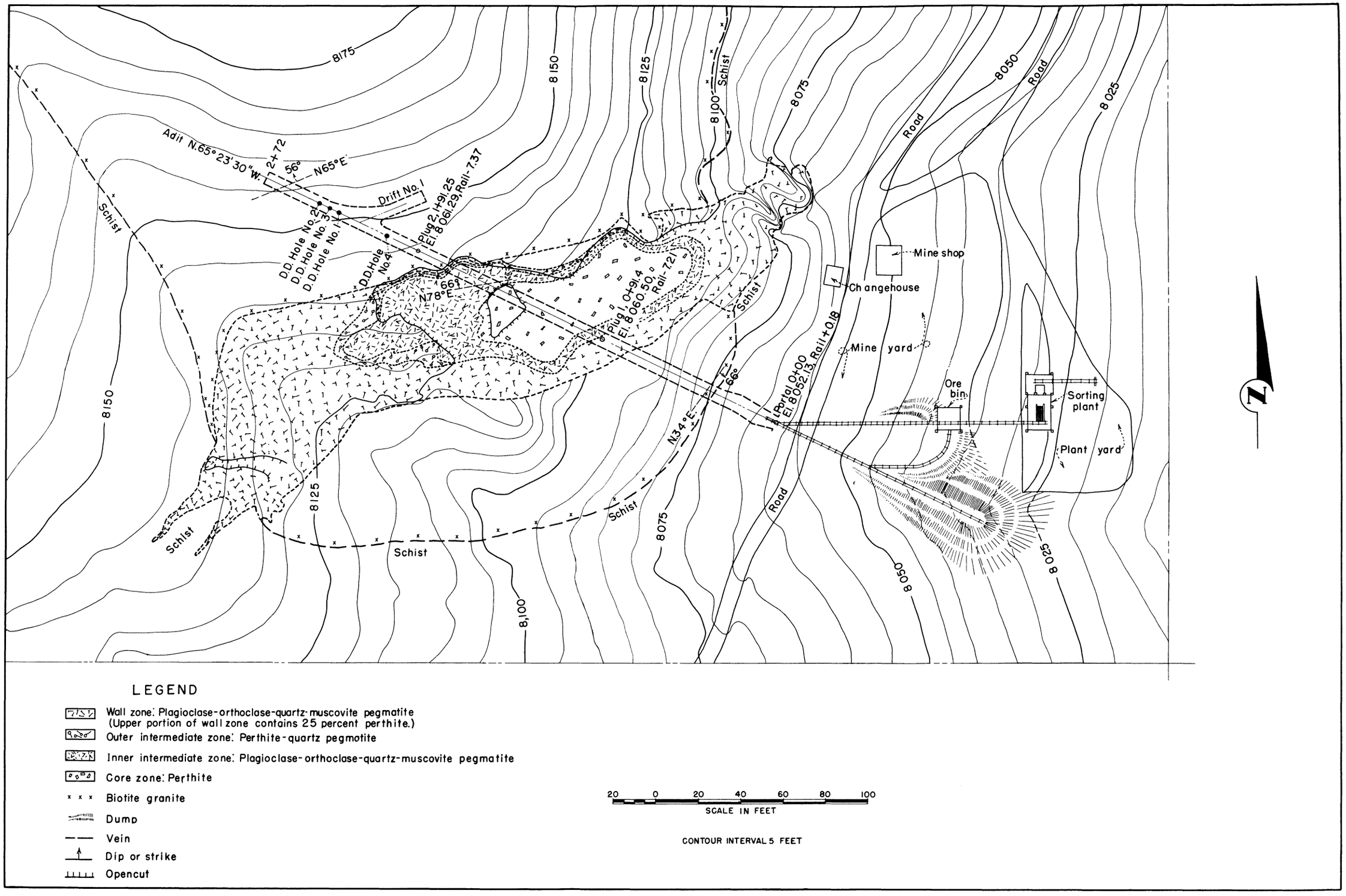
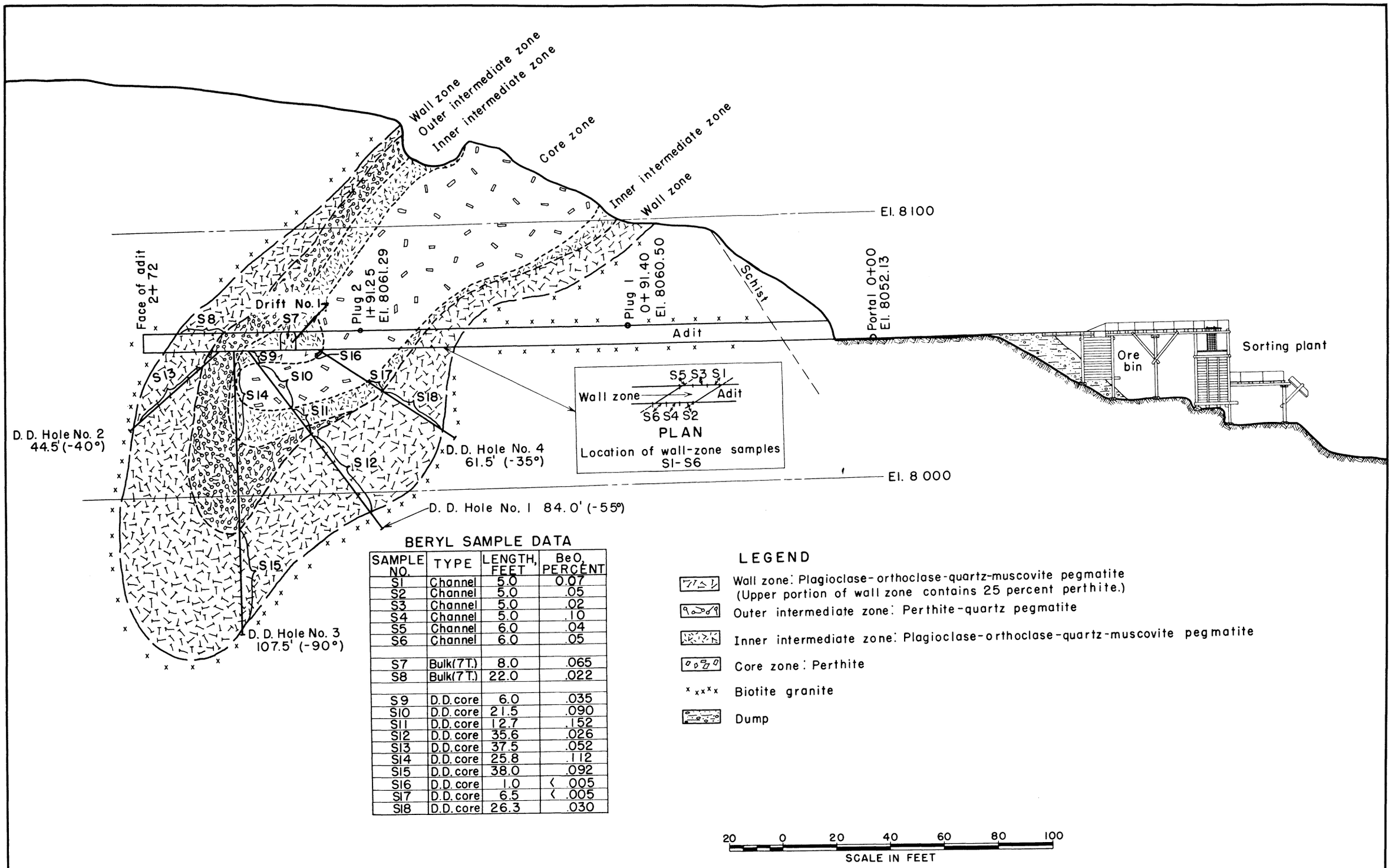


FIGURE 2. - Topographic Map, Showing Surface Geology and Mine Workings, Hyatt Ranch Pegmatite, Larimer County, Colo. Topography and Geology in Part by W. R. Thurston, U.S.G.S.



BERYL SAMPLE DATA

SAMPLE NO.	TYPE	LENGTH, FEET	BeO, PERCENT
S1	Channel	5.0	0.07
S2	Channel	5.0	.05
S3	Channel	5.0	.02
S4	Channel	5.0	.10
S5	Channel	6.0	.04
S6	Channel	6.0	.05
S7	Bulk(7T.)	8.0	.065
S8	Bulk(7T.)	22.0	.022
S9	D.D.core	6.0	.035
S10	D.D.core	21.5	.090
S11	D.D.core	12.7	.152
S12	D.D.core	35.6	.026
S13	D.D.core	37.5	.052
S14	D.D.core	25.8	.112
S15	D.D.core	38.0	.092
S16	D.D.core	1.0	< .005
S17	D.D.core	6.5	< .005
S18	D.D.core	26.3	.030

LEGEND

- Wall zone: Plagioclase-orthoclase-quartz-muscovite pegmatite (Upper portion of wall zone contains 25 percent perthite.)
- Outer intermediate zone: Perthite-quartz pegmatite
- Inner intermediate zone: Plagioclase-orthoclase-quartz-muscovite pegmatite
- Core zone: Perthite
- Biotite granite
- Dump

FIGURE 3. - Longitudinal Section Through Adit, Showing Zoning and Sample Locations, Hyatt Ranch Pegmatite, Larimer County, Colo. Geology in Part by W. R. Thurston, U.S.G.S.

less than 1 inch in diameter. Muscovite is a common accessory mineral and occurs in flakes and books from microscopic size to 2-1/2 inches long. Locally, the wall zone contains as much as 10 percent muscovite. Garnet and black tourmaline are minor accessory minerals in this zone.

Beryl occurs as irregularly disseminated euhedral to anhedral blue-green crystals. The beryl crystals are as much as 2 inches in length, but the average size is about one-quarter inch. A 300-pound surface sample of the wall zone assayed 0.6 percent beryl.

2. Outer intermediate zone: This zone extends about 130 feet along the hanging-wall side of the deposit. It ranges from less than an inch to a maximum of 25 feet in width, but probably averages about 7 feet. It is made up of 55 percent perthite and 45 percent quartz. The grains average between 4 and 12 inches in diameter; some are as much as 3 feet in diameter.

Although no beryl was observed in either the drill core or in opencuts, assays of the drill core showed small amounts of BeO.

3. Inner intermediate zone: The inner intermediate zone pinches and swells, and ranges from 2 to 12 feet in width. It consists of 50 percent plagioclase and orthoclase, 40 percent quartz, 7 percent muscovite, and 3 percent beryl and other accessory minerals including tourmaline, microcline, and garnet. The feldspar has a medium texture and a somewhat platy habit.

The beryl occurs typically in clusters of both large and small crystals. The beryl crystals range from 1 inch to 1 foot in diameter, and some are as much as 5 feet in length. A few small grains are scattered in the rock between clusters. Both euhedral and anhedral beryl are common. In the surface workings, the beryl recovered by sorting constituted about 2.3 percent of the material handled.

The zone also yielded scrap mica from surface shoots and streaks of fine- to very coarse-grained muscovite. The streaks are from 1 inch to 5 feet wide and from 1 to 30 feet long. The largest books are as much as 15 inches long and 6 inches thick, but no sheet mica has been obtained from them because the books are heavily ruled and wedged and have "A" structure and many mineral inclusions. The fine-grained mica consists of flakes and books that are oriented at random, range from microscopic to 3 inches in diameter, and are intimately intergrown with quartz, feldspar, tourmaline, and beryl.

4. Core zone: The core zone measures a maximum of 240 feet in length, 35 feet in width, and 150 feet down the plane of the dip. The core consists of about 96 percent perthite, 3 percent quartz, and 1 percent plagioclase, muscovite, tourmaline, and garnet. Some of the grains of perthite attain lengths of as much as 10 feet. Quartz occurs in coarse masses as much as 4 feet in dimension.

Beryl has been found along the margins of the core, but has not been observed in the interior.

WORK BY BUREAU OF MINES

Bureau of Mines work on the Hyatt Ranch pegmatite was done during two periods of operation. Most of the work was accomplished from September 18, 1950, to September 18, 1951. After a 21-month recess, a small amount of additional work (to obtain bulk samples) was done in the period June 7 through June 23, 1953.

Preparatory Work

Preparatory work starting on September 18, 1950, included the following: (1) The repairing of a 4.5-mile access road to the property, (2) removal of talus and dump material from the site of the adit portal, (3) excavation and leveling of ground near the portal for a mine yard and surface plant, (4) construction of detonator and explosive magazines and a miners' change house, and (5) installation of shop equipment, a 315-c.f.m. compressor, and a 500-gallon gasoline storage tank.

The Adit

From a conveniently situated portal site, an adit was driven N. 65° W., or obliquely to the strike, to explore the part of the deposit that directly underlies the best beryl showing in the surface pit (fig. 2). The elevation, determined from geologic information available at the time, was designed to place the adit just below the outer intermediate zone. At that elevation, it would have been driven through the deposit entirely in wall-zone pegmatite. However, as shown in figure 3, the adit as driven penetrated the pegmatite some 70 feet above the intended level.

In the vicinity of the portal (fig. 4), the adit is in badly fractured schist. At 37 feet from the portal it penetrates dense gray granite, and at 154 feet it intersects the footwall of the pegmatite. It intersects the hanging-wall contact of the pegmatite at 262 feet from the portal and ends in the granite hanging wall at 272 feet. Timber was required to support the loose ground near the portal, but no timber was needed beyond the first 20 feet. The cross section of the untimbered portion of the adit is 6 by 7 feet.

Because of the hardness of the granite and pegmatite, most of the blasthole drilling in the adit was done with a column-mounted drifting machine. A 30- to 35-hole, 6-foot, burn-cut round gave an average advance of 5 to 5-1/2 feet. The broken rock was mechanically loaded into 16-cubic-foot mine cars that were hand trammed to the surface. Time used in completing the cycle ranged from 10 to 16 hours. The project was operated on a one-shift basis. Miners were paid $1.35 per hour, and underground laborers were paid $1.29 per hour. The total direct cost averaged $16.41 per foot of advance.

Sampling on Adit Level

Six channel samples, Nos. 1 through 6, were cut from the 16 feet of wall-zone pegmatite exposed in the adit on the footwall side of the deposit. The locations of these samples and BeO assay results are given on figure 3. The

FIGURE 4. - View of Adit Portal and Adjacent Area.

six assays average 0.05 percent BeO, which is equivalent to about 0.45 percent beryl.

Also shown on figure 3 are the locations and assay results for two bulk samples, Nos. 7 and 8. These two samples, for metallurgical testing, were obtained in June 1953 when the project was reactivated for the purpose of additional sampling. Both were taken on the hanging-wall side of the deposit.

Sample No. 7 consisted of 7 tons of pegmatite from Drift No. 1, driven north-easterly in the inner intermediate zone. Every third car of the rock broken in 8 feet of advance was saved for the sample, which assayed 0.065 percent BeO. The drift was extended to a total distance of 28 feet from the adit to obtain further information regarding the composition of the zone. Inspection revealed that the part of the inner intermediate zone penetrated by the drift is highly irregular in composition.

Sample No. 8 assayed 0.022 percent BeO and consisted of 7 tons of pegmatite from the wall zone exposed on the north side of the adit. The excavation for the sample measured 2 by 7 by 22 feet and extended the full length of the wall-zone exposure. Approximately one-third of the broken material was saved for the sample. The wall zone (on both the hanging-wall and footwall sides of the deposit) is comparatively uniform in composition.

Diamond Drilling

In August 1951, four diamond-drill holes totaling 297.5 feet were completed to determine the downward extent of the pegmatite, exposed for 108 feet in the diagonally driven adit, and to obtain samples of the pegmatite below the adit level (fig. 3). All four holes were drilled in the plane of the vertical section of the adit. The core from the holes provided information for the downward projection of the pegmatite zones, and samples for chemical assay and spectrographic analysis.

All core recovered from the inner intermediate and wall zones, as well as the core from the core zone of hole No. 1, was split; half was retained for Bureau of Mines core storage, and half was sent to the Bureau of Mines laboratory at Salt Lake City, Utah. Sample length was controlled by zoning. Locations of the individual samples and results of the chemical assays for BeO are given in figure 3. Results of the spectrographic analyses are given in Appendix III.

Chemical assays of the five inner intermediate-zone samples range from less than 0.005 percent BeO to 0.152 percent, and their weighted average is 0.097 percent BeO. Assays of the four wall-zone samples range from 0.026 percent BeO to 0.092 percent, and the average is 0.052 percent. The one core-zone sample assayed 0.090 percent BeO but was probably higher in grade than the core zone would average. The weighted average for all ten diamond-drill-core samples is 0.067 percent BeO.

Diamond drilling was done on a single-shift basis. Two drill stations were prepared by raising the back of the adit to a height of 11 feet above the track. Holes 1, 2, and 3 were drilled from station 1, and hole 4 was drilled from station 2. The drilling rate in the hard, relatively unfractured pegmatite and granite was slow, and bit wear was excessive. A total of 23 shifts was required to complete the four holes. The drilling rate during the 19-1/4 shifts spent in actual drilling operations averaged 15-1/2 feet per shift. Core recovery ranged from 90 to 96 percent for the individual holes and averaged 93 percent for the 297.5 feet of drilling.

Results of the diamond drilling show that in the vertical plane of the adit at least half of the pegmatite lies below the level of the adit. The keel of the pegmatite appears to be about 115 feet below that level. Examination of the drill core confirmed that the outer intermediate zone--easily recognized by its high quartz content--is almost entirely confined to the hanging-wall side of the deposit. The wall zone constitutes the bulk of the deposit, particularly below the adit level. The pegmatite is further characterized by gradation at its zonal contacts.

Sorting Plant

A sorting plant (fig. 5), constructed adjacent to the mine dump, was completed in July 1951. Only 31 tons of pegmatite was processed in the plant before the project work was suspended. The results were unfavorable.

FIGURE 5. - Sorting Plant.

The following data pertain to recovery of beryl and mica from the 31 tons processed by hand concentration in the sorting plant:

1. Material processed came from Drift No. 1, in the inner intermediate zone. The beryl crystals in this zone tend to be larger, therefore more amenable to cobbing than the beryl crystals in the other zones.

2. The freshly mined beryl crystals are solidly cemented to the feldspar-quartz gangue and are much less amenable to cobbing than those from the weathered zone.

3. It is assumed that the beryl content of the 31 tons was comparable to that of bulk sample No. 7, which assayed 0.065 percent BeO, (equivalent to 0.59 percent beryl). The mica (muscovite) content was estimated at 5 to 10 percent.

4. About seventy-five percent of the pegmatite mined from the zone was coarse enough for hand concentration.

5. In this coarse fraction, an estimated 30 percent of the beryl and 80 percent of the mica occurred as crystals sufficiently large for hand sorting.

6. Cobbing of the beryl to a clean product involved loss of about 20 percent of the average crystal. The larger books of mica, however, required little, if any, cobbing.

7. From the estimated percentage figures in items 4, 5, and 6, it is calculated that about 18 percent of the beryl and 60 percent of the mica in the 31 tons of inner intermediate-zone pegmatite were recovered in the sorting plant.

Although the tonnage processed was small, the results obtained in the sorting plant warranted the assumption that hand concentration of beryl and mica from pegmatite mined in the underground part of the deposit was not economically feasible.

Metallurgical Tests

At the Federal Bureau of Mines laboratory in Rolla, Mo., high-grade concentrates and high recoveries have been obtained from beryl ores containing as little as 0.35 percent BeO. Lower-grade concentrates, but fairly high percentage recoveries, have been obtained from ores containing less than this amount of BeO. The basic flotation procedure was essentially the same as that developed at the Bureau of Mines laboratory in Salt Lake City, Utah. The two 7-ton samples (Nos. 7 and 8) were sent to Salt Lake City for assaying and metallurgical testing.

Chemical and microscopic studies revealed that the two samples were similar in composition and contained about 35 percent quartz, 25 percent orthoclase (potassium feldspar), 25 percent plagioclase, and 10 percent muscovite. Tourmaline, apatite, hornblende, and other minor ferromagnesian minerals composed about 5 percent of the ores. The samples contained no columbite, tantalite, spodumene, or lepidolite. The studies showed that beryl and mica were the only potentially valuable minerals in the samples. The potassium feldspar was of little value because it was intergrown with both plagioclase feldspar and quartz. A spectrographic analysis revealed that the mica contained a minor amount of chemically combined lithium. As shown on figure 3, sample No. 7 assayed 0.065 percent BeO, and sample No. 8 assayed 0.022 percent BeO.

The ore-dressing tests performed on both samples included: (1) hand sorting of the crushed ores to obtain beryl concentrates, (2) stage crushing and screening to obtain mica concentrates, and (3) flotation to recover both beryl and mica.

A plus-90-percent mica concentrate was recovered as a byproduct by stage crushing and screening. Also effective for concentrating the mica was flotation of finely ground ore. However, the hand-sorting and flotation studies demonstrated that most of the beryl in the ores is finely crystalline and difficult to recover. Moreover, the beryl flotation concentrates assayed far below marketable grade. A description of the metallurgical tests made by Richard Havens[5/] and his discussion of the results are summarized as follows:

5/ Metallurgist, Bureau of Mines, Salt Lake City, Utah.

Laboratory Hand Sorting

Separate 1000-pound portions of each of the two samples were crushed to minus-3-inch size and then screened into plus-1-1/2- , plus-3/4- , plus-1/4- , and minus-1/4-inch fractions. Each of the plus-1/4-inch fractions was carefully hand sorted for beryl. The results of assaying the products are presented in table 1.

TABLE 1. - Results of laboratory hand sorting

Product	Sample No. 7			Sample No. 8		
	Weight, percent	Analysis, percent BeO	Distribution, percent BeO	Weight, percent	Analysis, percent BeO	Distribution, percent BeO
Sorted beryl..	0.15	4.71	10.5	0.03	1.90	2.4
Sorted rejects	56.35	0.036	29.8	62.10	0.021	57.8
Primary minus-1/4-in.	43.50	.09	59.7	37.87	.024	39.8
Calculated heads.....	100.00	0.067	100.0	100.00	0.022	100.0

The data given in table 1 show that only 10.5 percent of the beryl in sample No. 7 and 2.4 percent of the beryl in sample No. 8 were recovered in hand-sorted concentrates assaying 4.71 percent BeO and 1.90 percent BeO, respectively. The unexpected low recovery of beryl obtained by sorting remains unexplained; after the sorted rejects were recrushed, microscopic examination revealed that no significant amount of beryl was overlooked during sorting.

The pegmatite in both samples was unusually friable; crushing to minus-3-inch size reduced approximately 40 percent of the weight of each sample to minus-1/4-inch. The minus-1/4-inch fractions contained 59.7 percent of the beryl in sample No. 7 and 39.8 percent of the beryl in sample No. 8. These facts indicate that a major portion of the beryllium occurs either as undetected minute crystals of beryl or as a constituent of one or more of the other minerals.

Stage Crushing and Screening

The sorted-reject products, crushed to minus-1/4-inch size, were combined with the primary minus-1/4-inch fraction. After dry screening to remove a clean mica product of plus-3-mesh size, the undersize was successively reduced to 6- , 10- , and 14-mesh fractions by stage crushing in rolls. Additional mica was recovered by screening the crushed ore prior to each reduction to the next finer size. By these means, approximately 70 percent of the mica was recovered in concentrates estimated to contain 90 percent mica.

Flotation

Satisfactory mica concentrates from both samples were obtained by flotation, but flotation of beryl from the two ores proved difficult. From the higher grade sample (No. 7, containing 0.065 percent BeO), only 45 percent of

the beryl was recovered in a cleaned concentrate that assayed 4.5 percent BeO. Sample No. 8 (containing 0.022 percent BeO) proved even more difficult to concentrate; only 35 percent of the beryl was recovered in a concentrate assaying 0.65 percent BeO.

Chemical and microscopic studies of flotation, middling, and tailing products indicated that the low recovery of beryl resulted mainly from loss in the large amount of untreatable slime formed by grinding the ore to flotation size. The low grade of the beryl concentrate is attributed to the difficulty in effectively separating the beryl from the tourmaline and apatite that tend to float with the beryl. The very low grade of the two ore samples also contributed to the difficulty in obtaining high-grade beryl concentrates with high recovery.

MARKETING OF BERYL, MICA, AND FELDSPAR

The principal purchaser of beryl in the Rocky Mountain region is (in October 1959) the Government depot at Custer, S. Dak. To be acceptable, the product must be in the form of clean beryl crystals cobbed free of waste and must have a BeO content of not less than 8 percent. Beryl purchases under the Government buying program are based on a short-ton unit (1 percent, or 20 pounds) of contained BeO. The price generally ranges from $40 to $50 per unit.

A limited market for beryl produced in the region is provided by the Beryl Ores Co. of Arvada, Colo. The price for beryl sold to this company is based on the price of imported material and, consequently, is variable.

According to information received from mine operators in the region, the average 1958 price for scrap mica was $25 per short ton f.o.b. Pueblo, Colo.; and for either potassium feldspar or a mixture of potassium and plagioclase feldspars, the 1958 price was $6.13 per long ton f.o.b. Denver, Colo. However, in the last half of 1958, the Pueblo and Denver mills stopped purchasing scrap mica and crude feldspar, and at present there is no market for these commodities within an economic shipping distance.

APPENDIX I

Summary of diamond-drill-hole data

Hole	Distance from portal, feet	Elevation of collar, feet	Bearing	Inclination	Total depth, feet	Depth to granite, feet	Size of hole, interval, feet
1....	233.55	8,054.13	S 65° E	-55°	84.0	75.8	NX-- 0 - 2.2 BX-- 2.2- 11.0 AX--11.0- 84.0
2....	243.50	8,054.18	N 65° W	-40°	44.5	42.8	BX-- 0 - 44.5
3....	238.25	8,054.16	Vertical	-90°	107.5	105.8	NX-- 0 - 3.0 BX-- 3.0- 10.0 AX--10.0-107.5
4....	207.75	8,054.00	S 65° E	-35°	61.5	55.1	BX-- 0 - 3.0 AX-- 3.0- 61.5

APPENDIX II

Diamond drilling, footage, and percent recovery

Hole	Footage From-	Footage To-	Drilled, feet	Recovered Feet	Recovered Percent
1...	0	1.5	1.5	1.0	67
	1.5	2.2	0.7	0.6	86
	2.2	4.0	1.8	1.6	89
	4.0	6.0	2.0	2.0	100
	6.0	10.0	4.0	3.9	98
	10.0	11.0	1.0	1.0	100
	11.0	19.5	8.5	8.4	99
	19.5	21.0	1.5	1.5	100
	21.0	23.5	2.5	2.5	100
	23.5	31.0	7.5	7.3	97
	31.0	35.0	4.0	3.2	80
	35.0	39.5	4.5	4.3	96
	39.5	53.5	14.0	14.0	100
	53.5	64.0	10.5	9.8	93
	64.0	74.0	10.0	9.8	98
	74.0	84.0	10.0	10.0	100
	Total...		84.0	80.9	96
2...	0	4.0	4.0	2.6	65
	4.0	12.0	8.0	6.7	84
	12.0	14.5	2.5	2.5	100
	14.5	24.5	10.0	9.5	95
	24.5	28.5	4.0	3.7	93
	28.5	32.0	3.5	3.5	100
	32.0	34.5	2.5	2.5	100
	34.5	44.5	10.0	10.0	100
	Total...		44.5	41.0	92
3...	0	3.0	3.0	2.8	93
	3.0	3.7	.7	.7	100
	3.7	6.0	2.3	2.3	100
	6.0	8.0	2.0	1.9	95
	8.0	10.0	2.0	1.8	90
	10.0	16.0	6.0	5.2	87
	16.0	26.0	10.0	10.0	100
	26.0	33.0	7.0	6.6	94
	33.0	37.5	4.5	3.8	84
	37.5	40.5	3.0	3.0	100
	40.5	42.0	1.5	1.5	100
	42.0	45.0	3.0	1.3	43
	45.0	49.0	4.0	2.9	73
	49.0	53.0	4.0	2.7	68
	53.0	58.5	5.5	3.9	71
	58.5	65.0	6.5	6.5	100
	65.0	68.0	3.0	2.6	87
	68.0	71.5	3.5	3.2	91
	71.5	78.5	7.0	5.5	79
	78.5	88.5	10.0	10.0	100
	88.5	97.5	9.0	9.0	100
	97.5	107.5	10.0	10.0	100
	Total....		107.5	97.2	90
4...	0	3.0	3.0	2.9	97
	3.0	8.0	5.0	4.3	86
	8.0	10.0	2.0	2.0	100
	10.0	15.0	5.0	4.6	92
	15.0	21.5	6.5	6.2	95
	21.5	23.5	2.0	1.9	95
	23.5	28.5	5.0	4.7	94
	28.5	33.8	5.3	5.3	100
	33.8	40.0	6.2	6.0	97
	40.0	42.0	2.0	2.0	100
	42.0	45.3	3.3	3.3	100
	45.3	53.0	7.7	7.7	100
	53.0	61.5	8.5	7.9	93
	Total....		61.5	58.8	96

APPENDIX III

REPORT OF SPECTROGRAPHIC ANALYSIS, DIAMOND-DRILL-CORE SAMPLES

Sample No.	Elements																		
	Ag	Al	As	Au	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga	Ge	Hf
S 9.....	-	A	-	-	-	D	D	-	B	-	-	-	E	D	E	B	E	-	-
S 10.....	-	A	-	-	E	E	D	E	B	-	-	-	F	D	E	B	E	-	-
S 11.....	-	A	-	-	D	E	D	-	D	-	-	-	E	D	E	B	E	-	-
S 12.....	-	A	-	-	E	E	D	-	B	-	-	-	F	E	E	B	E	-	-
S 13.....	-	A	-	-	E	E	D	-	B	-	-	-	F	D	E	B	E	-	-
S 14.....	-	A	-	-	E	D	D	-	B	-	-	-	F	D	E	B	E	-	-
S 15.....	-	A	-	-	E	D	D	-	B	-	-	-	F	E	E	B	E	-	-
S 16.....	-	A	-	-	E	D	E	D	B	-	-	-	F	D	E	B	E	-	-
S 17.....	-	A	-	-	E	E	E	-	B	-	-	-	F	E	E	B	E	-	-
S 18.....	-	A	-	-	E	E	D	-	B	-	-	-	F	E	E	B	E	-	-

	Elements																		
	Hg	In	Ir	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	Os	P	Pb	Pd	Pt	Rb	Re
S 9.....	-	-	-	B	-	C	C	C	-	B	E	-	-	-	E	-	-	D	-
S 10.....	-	-	-	B	-	D	C	C	-	B	-	-	-	-	E	-	-	D	-
S 11.....	-	-	-	B	-	D	C	C	-	B	-	-	-	-	E	-	-	D	-
S 12.....	-	-	-	B	-	D	C	C	-	B	-	-	-	-	E	-	-	E	-
S 13.....	-	-	-	B	-	C	C	C	-	B	-	-	-	-	E	-	-	D	-
S 14.....	-	-	-	B	-	D	C	C	-	B	-	-	-	-	E	-	-	D	-
S 15.....	-	-	-	B	-	D	C	C	-	B	-	-	-	-	E	-	-	D	-
S 16.....	-	-	-	A	-	C	C	D	-	B	-	-	-	-	E	-	-	D	-
S 17.....	-	-	-	B	-	D	C	D	-	B	-	-	-	-	E	-	-	D	-
S 18.....	-	-	-	B	-	D	C	D	-	B	-	-	-	-	E	-	-	E	-

	Elements																	
	Rh	Ru	Sb	Sc	Si	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y	Zn	Zr
S 9.....	-	-	-	-	A	-	D	-	-	-	D	-	-	-	-	-	-	D
S 10.....	-	-	-	-	A	-	D	-	-	-	D	-	-	-	-	-	-	E
S 11.....	-	-	-	-	A	-	D	-	-	-	D	-	-	-	-	-	-	E
S 12.....	-	-	-	-	A	-	D	-	-	-	E	-	-	-	-	-	-	E
S 13.....	-	-	-	-	A	-	D	-	-	-	D	-	-	-	-	-	-	E
S 14.....	-	-	-	-	A	-	C	-	-	-	D	-	-	-	-	-	-	E
S 15.....	-	-	-	-	A	-	C	-	-	-	D	-	-	-	-	-	-	E
S 16.....	-	-	-	E	A	-	C	-	-	-	D	-	-	-	-	-	-	E
S 17.....	-	-	-	-	A	-	E	-	-	-	D	-	-	-	-	-	-	E
S 18.....	-	-	-	-	A	-	D	-	-	-	D	-	-	-	-	-	-	E

- Not detected.
A Probably >10 percent.
B Probably 1 - 10 percent.
C Probably 0.1 - 1 percent.
D Probably 0.01 - 0.1 percent.
E Probably 0.001 - 0.01 percent.
F Probably 0.0001 - 0.001 percent.

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