Pegmatite Investigations in Colorado Wyoming, and Utah 1942-1944

By JOHN B. HANLEY, E. WM. HEINRICH, *and* LINCOLN R. PAGE

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A report on resources of beryllium tantalum, and lithium minerals and of muscovite

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PEGMATITE INVESTIGATIONS IN COLORADO, WYOMING, AND UTAH, 1942-1944

By JOHN B. HANLEY, E. WM. HEINRICH, and LINCOLN R. PAGE

ABSTRACT

During 1942–44 the authors examined 114 pegmatites in Colorado, Wyoming, and Utah as part of the Geological Survey program for the appraisal of domestic resources of beryllium, tantalum, and lithium minerals and of muscovite. Many pegmatites were mapped and studied in detail, and the grades of a number of deposits were determined. Studies of a few deposits were made in cooperation with other Federal agencies interested in the production of strategic and critical minerals.

The pegmatites occur in pre-Cambrian schists, gneisses, and igneous rocks throughout the Rocky Mountains. Most are small tabular or lenticular bodies that in general are steeply dipping to vertical. Many are zoned pegmatites. These consist of structural and lithologic units of contrasting composition or texture, or both, which have the form of concentric shells. Zoned pegmatites commonly contain border, wall, and intermediate zones and a core. The intermediate zone, in which most beryllium and tantalum minerals are found, commonly is discontinuous, and it may occur only on one side or one end of a pegmatite. Lithia-bearing minerals commonly occur in the core. Many pegmatites contain a wall zone of plagioclase-quartz-microcline pegmatite, an intermediate zone of plagioclase-quartz-muscovite pegmatite, and a core of either microcline-quartz pegmatite or quartz pegmatite. Units of unknown origin have been found in the pegmatites, and these may have been formed by hydrothermal replacement either along fractures or along preexisting zones. Fractional crystallization in place under conditions resulting in incomplete reaction between crystals and residual liquid is suggested as the mode of origin of the zonal structure. This process may have been modified in some pegmatites by hydrothermal replacement, but evidence sufficient to determine the scale of replacement is not available.

Because the desired minerals occur most commonly in certain zones of the zoned pegmatites, a knowledge of zonal structure is of great assistance in the appraisal of a pegmatite. Studies of the structure and mineralogy have resulted in the successful prediction of the size, shape, and position of minable deposits in several pegmatites.

For economic purposes, the pegmatites are classified as beryllium, lithia, muscovite, columbium-tantalum, potash feldspar, or rare earth pegmatites, but one pegmatite body may contain deposits of more than one of these materials.

More beryllium pegmatites were examined than those of the other types, because the emphasis of the investigations during 1942–43 was placed on sources of beryllium. Beryl and chrysoberyl are the abundant beryllium minerals. Beryl occurs in the border, wall, and intermediate zones and in the cores of the pegmatites. However, the deposits of beryl recoverable by hand cobbing are most numerous in intermediate zones, and chrysoberyl is known to occur only in intermediate zones. The wall zones of certain pegmatites contain quantities of fine-grained beryl that can be recovered only by milling. In some pegmatites the beryl content of the intermediate zones is estimated to be as much as 2 percent, but the general content of minable deposits probably ranges from 0.5 to 1 percent. At least 450 tons of beryl has been produced from Colorado pegmatites up to 1945, and probably less than 3 tons has been produced from Wyoming and Utah pegmatites. The reserves of beryl in Colorado are estimated to be between 2,000 and 5,000 tons, much of which can be recovered only by milling.

Lithia pegmatites are abundant only in the Quartz Creek district, and few have been examined outside of this district. Lepidolite is the common lithia-bearing mineral, although spodumene and amblygonite have been found in a few pegmatites. Lepidolite occurs in deposits in intermediate zones and cores, but only core deposits are large enough to be mined. The lepidolite content of the core ranges from 15 to 75 percent. The lithia content of the mineral ranges from 1 to 5 percent in different pegmatites and also within the same pegmatite. Neither spodumene nor amblygonite has been found in minable quantities. At least 250 tons of lepidolite has been produced from the Colorado pegmatites, and the reserves are estimated to be several times the quantity produced.

The muscovite deposits fall into two groups, one consisting of deposits that can yield punch or sheet mica as well as scrap mica and the other consisting of deposits that can yield only scrap mica. Sheet mica-bearing pegmatites are abundant in one district in Colorado, and several small sheet mica-bearing pegmatites have been examined in Wyoming. Many other Colorado pegmatites, particularly the beryllium ones, contain minable concentrations of scrap mica. Sheet mica has been found in wall and intermediate zones and also is disseminated uniformly throughout the pegmatites in one prospect. Scrap mica has been found in intermediate zones and cores of many pegmatites. A total of about 1,000 pounds of mica of punch and sheet quality was produced in Colorado during 1943–44, and a total of about 28,000 tons of scrap mica was produced up to 1945. The reserves of punch and sheet mica in Colorado are probably small, but the reserves of scrap mica are at least equal to the past production.

Columbite-tantalite and microlite are the most abundant columbium and tantalum minerals. Columbite-tantalite commonly is found associated with beryl in beryllium pegmatites, and microlite occurs with lepidolite in the lithia pegmatites. Columbite-tantalite is most abundant in intermediate zones, and microlite is most common in cores. The production of columbium and tantalum minerals has been very small, and the reserves are also very small.

Potash feldspar pegmatites were examined only if they were reported to contain critical and strategic minerals. In many beryllium pegmatites the core forms a deposit of feldspar, and in several pegmatites feldspar is the most abundant mineral. In general, feldspar that can be recovered by hand cobbing is abundant only in the cores. The production of feldspar from

Colorado has been at least 250,000 long tons, and the reserves are estimated to be several times this quantity.

Rare earth pegmatites are not abundant in the three States. In the few deposits examined the rare earth minerals—cerite, euxenite, samarskite, monazite, and allanite—are distributed erratically throughout feldspar-rich cores in pegmatites that commonly contain only small quantities of muscovite. No rare earth minerals occur in deposits large enough to be mined for them, but a small quantity can be recovered as a byproduct of feldspar mining.

Most of the report is devoted to descriptions of the mines and prospects examined.

INTRODUCTION

Pegmatites have been found in the Rocky Mountains of Colorado and Wyoming throughout widely separated areas underlain by pre-Cambrian metamorphic and igneous rocks.

Pegmatites are most abundant in the Front Range, which extends through Colorado northward into Wyoming. The pegmatites in this range have been examined from Canon City, Colo., on the south to Laramie, Wyo., on the north. Additional pegmatites have been studied in the interior ranges of Colorado and in isolated areas of pre-Cambrian rock in Wyoming and Utah.

The most important pegmatite areas in Colorado are the Crystal Mountain district in Larimer County, the Left Hand Creek district in Boulder County, the South Platte district in Jefferson and Douglas Counties, the Devils Head district in Douglas County, the Saint Peters Dome district in El Paso County, the Eight Mile Park district in Fremont County, the Micanite district in Fremont and Park Counties, the Turret district in Chaffee County, and the Quartz Creek district in Gunnison County.

The most important pegmatite areas in Wyoming are the Copper Mountain district in Fremont County and the Haystack Range district in Goshen County. A few pegmatites have been examined outside of these main districts. Only one pegmatite area is known in Utah, the Granite Mountain area of the Dugway Range in Tooele County.

Pegmatite mining began in Colorado and Wyoming about 1880 as a search for tin. Shortly thereafter, from 1881 to 1907, several attempts were made to produce mica from the pegmatites in these two States. The most successful were the operations by the United States Mica Co. in the Micanite district, Fremont County, Colo. During this period many of the pegmatites of Wyoming were prospected, and those in the Haystack Range district of Goshen County were mined on a small scale. Interest in the pegmatites then lapsed until the early 1920's when a local market for scrap mica was established. About 1930 a market for potash feldspar was assured, and many of the larger operations were started. Extensive prospecting for beryl, tantalum minerals, and sheet mica took place between 1934 and 1944, but the increase in production during this period was small. In 1938 the pegmatites of Utah were first prospected.

Colorado pegmatites have yielded at least 250,000 long tons of feldspar, 28,000 short tons of scrap mica, 1,000 pounds of punch and sheet mica, 450 short tons of beryl, 250 short tons of lepidolite, about 1 ton of microlite, 1 ton of columbite-tantalite, and 200 tons of rose quartz. The Wyoming pegmatites have yielded at least 87,000 long tons of feldspar, 18 tons of scrap mica, 3,000 pounds of punch and sheet mica, 2 tons of beryl, and 335 pounds of columbite-tantalite. There has been no production from the Utah pegmatites.

The investigation by the Geological Survey of the pegmatites of Colorado, Wyoming, and Utah began in August 1942 and continued through 1944. It was part of the appraisal by the Geological Survey of the domestic resources of beryllium, tantalum, mica, lithia, and other materials commonly occurring in pegmatites. The increasing demand for these materials arising from war needs made such an appraisal necessary.

The pegmatite investigations were restricted in scope, and the emphasis was placed on minerals in critical and strategic demand at that time. Most of the field work was in Colorado, and only short periods were spent in the investigation of Wyoming and Utah pegmatites. During 1942 and 1943 the investigations were focused on the occurrence and reserves of beryllium and tantalum minerals. Later, in response to changing demand, they were expanded to include studies of deposits of quartz crystals, muscovite, and lithium minerals. Despite the fact that potash feldspar, which occurs in the vast majority of all granitic pegmatites, is a mineral of major economic importance to the pegmatite industry, only those potash feldspar pegmatites in which strategic minerals occurred were examined. Thus, in Colorado, only brief examinations were made in such well-known pegmatite districts as the Devils Head, and neither the fluorine pegmatites of the Saint Peters Dome district nor the feldspar pegmatites of the South Platte district were examined.

The investigations started in Wyoming during August 1942 when J. D. Love and J. B. Hanley examined the tantalum and beryl pegmatites of the Copper Mountain district in Fremont County. Subsequent work in this State, carried on at widely spaced intervals until the end of 1944, was under the direction of J. B. Hanley.

In September 1942 L. R. Page and J. B. Hanley examined the beryl and tantalum pegmatites of the Crystal Mountain district in Larimer County, Colo. Shortly thereafter E. Wm. Heinrich began a reconnaissance investigation, which continued until December 1942, in Fremont, Park, and Gunnison Counties. E. Wm. Heinrich made several independent examinations and had charge of the detailed investiga-

tion of many of the pegmatites in these counties during the first half of 1943. The investigations after June 15, 1943, were under the direction of J. B. Hanley, assisted for various periods of time by E. Wm. Heinrich, R. Miller III, J. H. Chivers, J. E. Husted, and A. F. Trites, Jr. Many of the mine descriptions in this report are the work of these men. Specific credit is given in the individual descriptions.

Most of the investigations included detailed mapping of individual pegmatites in order to determine the position, size, and shape of deposits of strategic or commercially valuable minerals. The maps were made at scales ranging from 1 inch to 10 feet to 1 inch to 100 feet. Mapping was done by transit-and-stadia, plane table-and-telescopic alidade, compass-and-tape, and compass-and-pace methods. Time did not permit detailed mineralogical or microscopical studies, but preliminary studies were made when they were needed to understand the geology of individual pegmatites.

Several of the investigations were made in cooperation with other Federal agencies: namely, the Colonial Mica Corporation, Metals Reserve Company, War Production Board, and Reconstruction Finance Corporation, whereas some pegmatites were examined jointly by geologists of the Geological Survey and engineers of the Federal Bureau of Mines. The mica pegmatites were examined in cooperation with the Colonial Mica Corporation. Much valuable geological information was gained by detailed studies of the development work financed by the Reconstruction Finance Corporation at the Hyatt beryl mine in Larimer County and the Brown Derby mine in Gunnison County, and by the Metals Reserve Company at the Devils Hole mine in Fremont County, all in Colorado.

The owners and operators of the properties examined assisted the Survey geologists by freely supplying needed information. The officials of the Western Feldspar Milling Co. and of the Colorado Feldspar Co. aided the investigation by contributing information as to the location, access, history, and possibilities of many pegmatites. The officials of the Hayden Mining Co. assisted studies of their properties materially.

R. H. Jahns, Ogden Tweto, and Doak Cox of the Geological Survey offered valuable suggestions during the course of the work.

The investigations in Colorado and Wyoming in 1942-44 resulted in concepts of pegmatite structure and of the distribution of the minerals within pegmatites that have been of great value in pegmatite appraisal. Informal discussions during these years and in 1945 with the men—particularly E. N. Cameron, R. H. Jahns, and L. R. Page—working in other pegmatite districts of the country have clarified and extended these concepts. The discussions have established a marked relationship between the pegmatites in the different parts of the country. As a result, a uniform nomenclature for pegmatite features and a classification of pegmatites have been established by joint effort. The system of map presentation and the symbols used on the maps and diagrams in this report are other results of the discussions, representing agreement between all the men occupied in domestic pegmatite investigations.

GEOLOGY

GENERAL FEATURES

The pegmatites examined in Colorado, Wyoming, and Utah are granitic in composition. They are scattered throughout many areas that are underlain by pre-Cambrian rocks, which are mostly high-grade metamorphosed sedimentary and igneous rocks that have been intruded by other igneous masses. In most areas pre-Cambrian granite crops out near the pegmatites, but in a few areas granite is not exposed. The pegmatites are found in both the metamorphic rocks and in the older igneous rocks. All three groups of rocks have been later intruded by basic dikes and sills, but in general the basic rocks are not abundant and occur only in a few of the pre-Cambrian areas. Few pegmatites have been intruded by basic rocks. Plate 1 shows the location of the pre-Cambrian areas in Colorado and also the locations of the pegmatites within the areas; in this paper, numbers in parentheses following the names of individual mines or prospects are the numbers assigned them on the map. Two pegmatite regions which were not examined, however, are known to be in Tertiary volcanic areas and are associated with rhyolite flows. Many of the pre-Cambrian areas have been described in bulletins, monographs, professional papers, and folios of the Geological Survey and in other publications.

The most extensive area of pre-Cambrian rocks containing pegmatites is a belt about 155 miles long and 40 miles wide that extends from the Canon City embayment in Fremont County north along the Front Range to the Cache la Poudre River in Larimer County, Colo. Smaller areas are known in the pre-Cambrian rocks along the slopes of the Continental Divide.

The pre-Cambrian areas in Wyoming that are known to contain pegmatites include the Medicine Bow Mountains, the Owl Creek Mountains, the Haystack Range in the Hartville uplift, and an unnamed district near the headwaters of Sage Hen Creek in Natrona County. All of these are small except the Medicine Bow area, which is a continuation of the Front Range in Colorado. Other pre-Cambrian areas, such as the Laramie Range, the Wind River Range, and the Big Horn Mountains, are reported to contain pegmatites, but they were not examined.

WALL ROCKS

In most of the districts the pegmatites occur chiefly in biotite schists that commonly contain sillimanite, but numerous pegmatites occur in amphibolites, biotite gneisses, granite gneisses, granites, and quartzites in different districts. None of the pegmatites examined occurs in garnet schist, and no pegmatites are known to occur in marble or other carbonate rocks. In several districts the wall rocks of the pegmatites are unconformably overlain by the Sawatch quartzite of Cambrian age and by younger sediments, so that the age of the wall rocks is known to be pre-Cambrian. The geographic distribution of the pre-Cambrian areas is wide, and a great diversity of metamorphic and igneous wall rocks has been found.

PEGMATITES

Except for the Tertiary rhyolitic pegmatites, most of the pegmatites in the three States are thought to be of pre-Cambrian origin. The age of some pegmatites has been determined by means of radioactive minerals, and the pre-Cambrian age of others has been demonstrated clearly by the overlap of Cambrian quartzite upon truncated and eroded pegmatites in the pre-Cambrian complex. The age of still other pegmatites has been established by correlation of the wall rocks with similar rocks in areas of known age.

The pegmatites are most abundant in pre-Cambrian rocks that are in the vicinity of granite intrusives, but a few that have been examined are in areas that are not known to contain granite masses. The largest granite mass in Colorado is the Pikes Peak batholith, around which pegmatites are particularly numerous. Smaller red granite masses, which probably are of the same age as the Pikes Peak granite, are exposed in many of the pegmatite districts. In the northern part of the Front Range several large intrusives of gray granite crop out in the pre-Cambrian areas. Pegmatites are not as abundant around the gray granite bodies as they are around the Pikes Peak and related granite masses. The distribution of these granite masses is shown in plate 1.

The pegmatites generally range from a few feet in length and width up to bodies about a mile in length and 500 to 600 feet in width; most of those examined are less than 500 feet long and 50 feet wide. In general the larger pegmatites are more likely to contain minable concentrations of commercially valuable minerals than the smaller ones.

Pegmatites range from tabular to lenticular or pipelike bodies. The tabular and lenticular bodies are most common. Many of the pegmatites examined are wider at one end than at the other and have surface exposures that are shaped like tadpoles. Some pegmatites are extremely irregular, having many offshoots and branches. These pegmatites commonly occur either as segregations in granite or as bodies in the high-grade schists and lit-par-lit gneisses. The more symmetrical pegmatite bodies are found in schists, gneisses, amphibolites, and other metamorphic rocks, and their shapes probably were controlled by the bedding or fracture systems in these rocks.

The attitudes of the pegmatites are different in each district. Most are nearly vertical or steeply dipping, but in the Quartz Creek and Micanite districts in Colorado, and in the Copper Mountain area of Wyoming, the pegmatites dip gently. In a few districts, particularly the Copper Mountain, the pegmatites have been emplaced in highly folded rocks, and their forms reflect the folded structures of the wall rock. In any one district the pegmatites may show considerable range of attitude because they are commonly controlled by the local structures along which the pegmatite is emplaced and not by the regional structure. In some districts, however, a strong regional structure has controlled pegmatite emplacement, and the pegmatites within such a district agree closely in attitude.

TEXTURE

The distinguishing features of pegmatites are coarseness and irregularity of grain. Some minerals commonly are much larger in size than those associated with them. Bastin [1] regarded the irregularity of grain as more distinctive than the coarseness, and this is true of the pegmatites examined in the present study.

The grain size of a pegmatite cannot be established accurately because many of the component minerals—mica, beryl, tourmaline, and spodumene—occur in crystals that are markedly elongate. Therefore, statements with regard to the grain size of a pegmatite indicate the general appearance in the exposures rather than the grain size that would be obtained by actual measurement of the component minerals.

Because pegmatites are so coarse-textured that all of them would fall into the coarse-grained division of the normal rock classification, the differences in grain size between pegmatites or the parts of one pegmatite cannot be expressed by the use of terms applied to normal rocks; hence for the purposes of this report special designations are used. Any pegmatite or pegmatite unit with an average grain size of 2 inches or less is called fine-grained; one with an average grain size of more than 2 inches and less than 1 foot is called medium-grained; and one with an average grain size of more than 1 foot is called coarse-grained.

In nearly all the pegmatites examined the size of grain is progressively greater from the walls of the

[1] Bastin, E. S., Geology of the pegmatites and associated rocks of Maine: U. S. Geol. Survey Bull. 445, p. 10, 1911.

body to the center. However, many pegmatite bodies contain no coarse-grained pegmatite but are entirely fine-grained or medium-grained. Those bodies that have produced commercially valuable minerals have a coarse-grained texture, in part or entirely. Those which have not been mined in the past are mostly fine- to medium-grained pegmatites and thus were not amenable to hand sorting, which has been the most common method of separating the commercially valuable minerals from the waste.

Potash feldspar, beryl, mica, tourmaline, and spodumene commonly occur in larger crystals than the associated minerals. Many pegmatites contain subhedral to euhedral crystals of the potash feldspar, microcline-perthite, 10 feet or more in size, and beryl crystals as much as 1 foot in diameter and 4 feet in length. Mica and tourmaline generally are not as large, but crystals more than 1 foot in size are numerous.

ZONAL STRUCTURE

GENERAL FEATURES

Most of the pegmatites examined are essentially uniform from wall to wall and commonly are similar to coarse-grained granite except for greater size of grain. They seldom contain minable concentrations of valuable minerals, and therefore none of them are described in detail in this report. Many of the pegmatites in Colorado and Wyoming, however, show a more or less distinct grouping of the component minerals into structural and lithologic units that can be distinguished on the basis of mineral composition or texture.

It is probable that two general types of structural and lithologic units are present in the pegmatites examined—replacement bodies and zones.

Replacement bodies are units formed by replacement of preexisting pegmatite. They can be of at least two types, both of which are controlled by the structure of the containing pegmatite. One type appears to have formed along preexisting fractures and the other along the zonal structure. Replacement bodies of the first type tend to obscure or confuse the zonal structure of the pegmatite. The formation of bodies of the second type may cause partial or even complete replacement of a zone. In some of the pegmatites examined there are units which may belong to this class, but evidence sufficient to establish the replacement origin of the units is not available.

Zones are successive shells, complete or incomplete, that commonly reflect the shape of the pegmatite body in greater or less degree. In ideal development the zones are successive shells concentric about the core, as shown in pegmatite *A* in figure 1. However, some concentric units are not zones, but may be replacement bodies. A zone normally is characterized by a specific mineral assemblage, but variations in mineral proportions within zones are found in many pegmatites. Zones are the most common type of unit in the pegmatites examined and are also economically the most important.

Four general types of zones, which are shown in pegmatite *A* in figure 1, have been recognized. They are:

1. Border zone. The fine-grained zone, commonly not more than a few inches thick, directly in contact with the wall rock.
2. Wall zone. The zone next inside the border zone.
3. Intermediate zone. Any zone between the wall zone and the innermost zone.
4. Core. The innermost zone of a pegmatite.

Commonly, however, some of the zones within any particular Colorado or Wyoming pegmatite are incomplete or discontinuous, as shown by the intermediate zone in pegmatite *C* in figure 1. A discontinuous intermediate zone occurs in the Devils Hole pegmatite (see pl. 7) in Fremont County, Colo. All gradations have been found between complete zones and those that are formed only at one end of a pegmatite body or along one side, as shown in pegmatite *D* in figure 1 and in the Mica Lode pegmatite (see pl. 4) in Fremont County. These incomplete zones show a variety of forms, of which lenses (pegmatite *C* in fig. 1) and layers are the most common.

In some pegmatites the core, or more rarely the core and an adjacent intermediate zone, occurs only as small disconnected lenses, termed "pods" in this report. Pods are shown in pegmatite *B* in figure 1 and have been found in the Meyers' mine pegmatite (see fig. 6) in Fremont County, Colo.

Most pegmatites contain only three or four zones, but a few contain two or more intermediate zones in addition to the border and wall zones and the core. In general the pegmatites that contain lithia-bearing minerals have the largest number of zones. The examples given in table 1 serve to illustrate the common zonal arrangement in Colorado and Wyoming pegmatites.

In some pegmatites two zones that are distinct and separate in one part of the pegmatite may merge to form a single zone in another part. In still other pegmatites minerals that typically occur in different zones are found mixed together within a single zone. Thus minerals of the wall zone may be mixed with minerals of the intermediate zone, or minerals of the intermediate zone may be mixed with minerals of the core so that it is not possible to distinguish the zones. This intermixing of zones is referred to as "telescoping," and the resulting zones are called "telescoped" zones.

In the main body of the Devils Hole pegmatite (p. 55) the intermediate zone is composed of muscovite-quartz-albite pegmatite, and the core is made up of a quartz pegmatite unit and a microcline pegmatite unit. However, in the western branch of this pegmatite pods (see

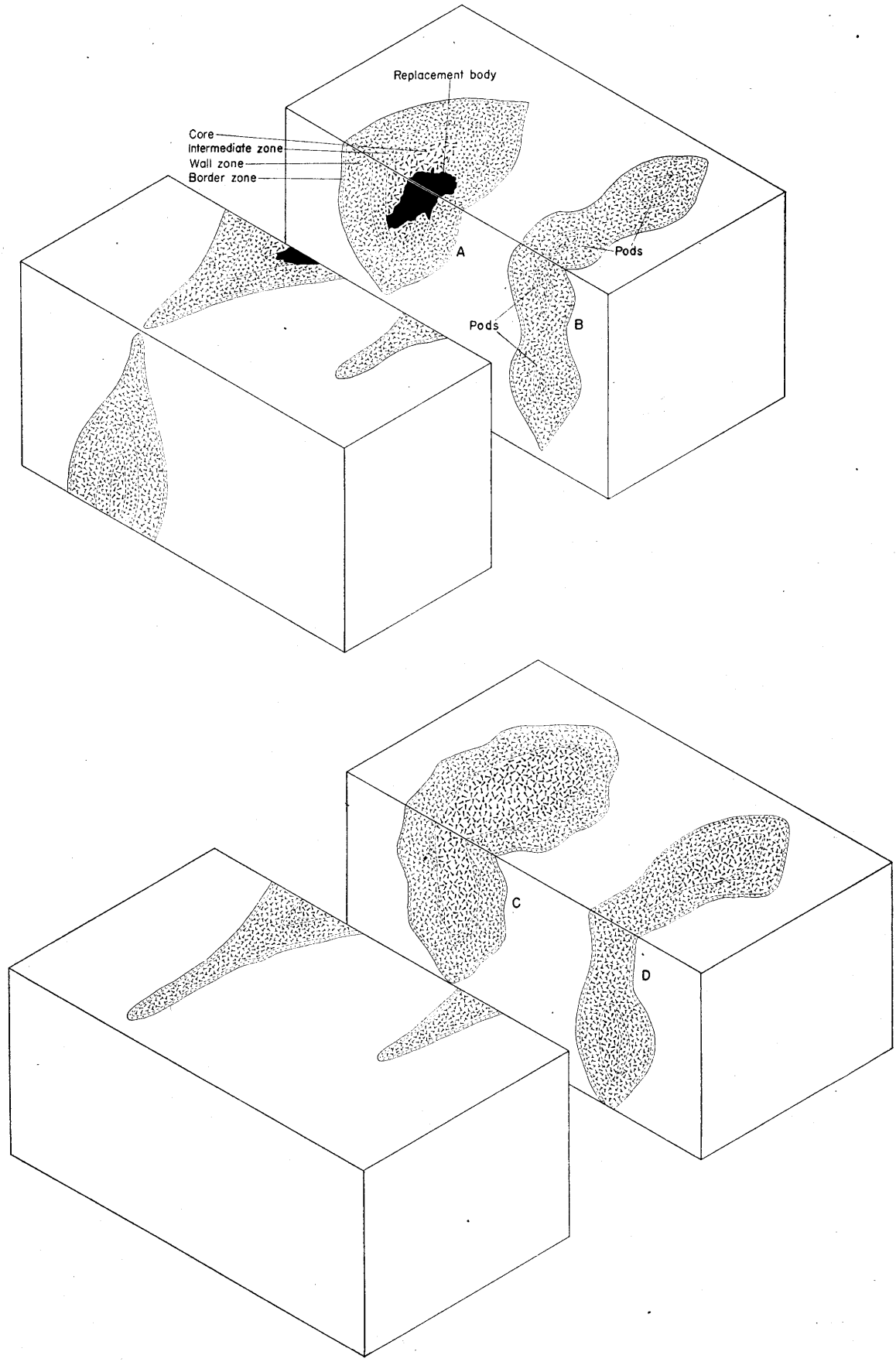

FIGURE 1.—Idealized diagrams of pegmatite units.

TABLE 1.—*Zonal sequence in Colorado and Wyoming pegmatites*

Mineral assemblages	Pegmatite																	
	New York, Wyo.	Chicago, Wyo.	Ajax, Colo.	Crystal No. 8, Colo.	Skeleton No. 2, Colo.	Devils Hole, Colo.	Bigger, Colo.	Hyatt, Colo.	Mica Lode, Colo.	Meyers' Ranch, Colo.	Wisdom Ranch, Colo.	Whopper, Colo.	Crystal Silica, Colo.	Climax, Colo.	Buckhorn, Colo.	Brown Derby No. 1, Colo.	White Spar No. 1, Colo.	Bazooka, Colo.
1. Plagioclase-quartz-muscovite	×	×	×															
2. Plagioclase-quartz-microcline ± muscovite ± biotite				×	×	×	×	×	×	×	×	×	×	×	×	×	×	
3. Plagioclase-muscovite-quartz ± microcline						×	×	×	×	×	×		×	×	×××			
4. Cleavelandite-quartz																×		×
5. Spodumene-cleavelandite															×			×
6. Cleavelandite-lepidolite																×	×	
7. Microcline-quartz	×	×			×	×	×	×	×			×	×					
8. Quartz			×							×	×	×	×	×			×	×

pl. 7) of microcline-muscovite-albite-quartz pegmatite, in which the muscovite and albite occur only as accessory minerals, are found. These pods represent telescoped zones. The Grover pegmatite (p. 29) contains a wall zone of quartz-microcline-albite-biotite pegmatite and an intermediate zone of quartz-albite-muscovite pegmatite, both of which can be identified in parts of the pegmatite. However, in most parts the two zones are telescoped.

Zonal structure is an important feature of pegmatites, as a knowledge of the zoning and of other structural features can be used in predicting the position and size of minable concentrations of commercially valuable minerals. Inasmuch as the zonal structure of a pegmatite is related closely to the external structure, information regarding either group of features will assist in determining both the size and shape of the pegmatite, and of the zones within the pegmatite, in depth. During the present investigation the results of detailed studies were used successfully for this purpose.

CHARACTERISTICS OF ZONED PEGMATITES

Although zoned pegmatites show a great variety of mineralogical, textural, and structural characteristics, all have certain characteristics in common, and these characteristics are most significant in relation to the origin of the zonal structure. Briefly outlined, they are:

A. Zoned pegmatites consist of successive shells concentric about the core. The zones in a pegmatite commonly differ in composition, in texture, or in both.

B. Contacts between zones range from gradational to abrupt, but most are gradational.

C. Zoned pegmatites show definite sequences of lithologic types from the walls inward to the core. The general sequence of the dominant mineral assemblages, in order from the walls inward, appears to be:

1. Plagioclase-quartz-muscovite.
2. Plagioclase-quartz.
3. Plagioclase-quartz-microcline ± muscovite ± biotite.
   (a) Plagioclase-muscovite-quartz ± microcline.
4. Cleavelandite-quartz.
5. Spodumene-cleavelandite.
6. Cleavelandite-lepidolite.
7. Microcline-quartz.
8. Quartz.

D. Members in the last part (4 to 8) of the sequence correspond closely with the paragenetic sequence of the minerals in granite pegmatites as stated by Schaller.[2]

E. The first two assemblages are characterized by abundant plagioclase and some muscovite.

F. Replacement of one mineral by another within a zone may be indicated by the textural arrangement of the two minerals.

G. Assemblage 3a forms the intermediate zone in the 40 pegmatites examined that have a wall zone of assemblage 3 and a core of either assemblage 7 or assemblage 8. Beryl and columbite-tantalite are found most commonly in assemblage 3a.

ORIGIN OF ZONAL STRUCTURE

Three principal explanations of the origin of the zonal structure in pegmatites have been advanced.

One explanation is that the zonal structure has been formed by fractional crystallization in place under such conditions that the reaction between crystals and rest-liquid is incomplete, so that successive layers of contrasting composition are deposited. Formation of the zonal structure by this method requires that the pegmatite be of essentially the same composition as the magma from which it formed. This explanation has

[2] Schaller, W. T., Pegmatites: Ore deposits of the Western States (Lindgren volume), p. 150, New York, Am. Inst. Min. Met. Eng., 1933.

been advanced by Brögger,[3] Crosby and Fuller,[4] and Kemp [5] to explain the origin of pegmatites. In their papers the zonal structure of certain pegmatites is given as evidence for this mode of origin. In more recent years the explanation has been seriously considered by Johnston [6] and a group of men studying the New England pegmatites.[7]

The second explanation offered is that the zonal structure results when hydrothermal solutions deposit material against the walls of open channels, provided that the composition of the solution changes progressively, so that successive layers of contrasting composition are formed. This explanation has been supported by Hunt [8] and recently by Quirke and Kremers.[9]

The third hypothesis suggests that certain pegmatites, some of which are zoned, are formed in two stages: a magmatic stage in which pegmatite liquid is injected and crystallizes to form massive pegmatite that has essentially the same mineral assemblage as a potash-rich granite; and a hydrothermal stage in which solutions passing through the pegmatite cause it to be partly or completely replaced. This hypothesis is a modification and extension of the hypothesis proposed by Brögger [10] in 1890 and has been advanced more recently to explain the origin of certain pegmatites by Galpin,[11] Cook,[12] Hess,[13] Schaller,[14] Landes,[15] and Derry,[16] as well as by many other workers. In some pegmatites investigators have distinguished several successive stages of replacement controlled by renewals of fracturing. It is quite possible, if the hydrothermal solutions follow the walls, that successive shells around a core may result.

Whatever hypothesis is adopted must be checked against the essential characteristics of zoned pegmatites. If this is done, certain conclusions may be reached. Successive shells of contrasting composition or texture and either gradational or abrupt contacts could result from any one of the three modes of origin. Likewise, the textural relations observed could result either from incomplete reaction between crystals and rest-liquid or from hydrothermal replacement of preexisting minerals and therefore might develop as a byproduct of any of these modes of origin.

The agreement between the general paragenetic sequence of minerals and the observed sequence of zones from the walls inward can be explained by fractional crystallization in place or by deposition of material in open channels. This agreement probably would not exist if the zones formed by successive replacements of preexisting massive pegmatite. Concentric shells presumably would develop by peripheral replacement, so that the outer zones would be composed of younger material than the inner zones. This sequence is the reverse of that indicated by the relationships of zones to one another and by the mineral relationships from zone to zone given above.

The sequence of lithologic types from the walls to the core is consistent for all districts in Colorado and Wyoming. It is conceivable that this zonal sequence may be due to hydrothermal replacement of preexisting unzoned pegmatite, but the widespread uniformity of the sequence within a single district and also from one district to another district throughout the two States appears to be explained more easily by fractional crystallization in place. For example, the essentially uniform lithology and consistent sequential position of the plagioclase-muscovite-quartz assemblage in the many pegmatites composed of assemblages 3, 3a, and 7 or 8 (p. 7) throughout the wide geographic range of these pegmatites, many of which apparently came from different sources, make it unlikely that this assemblage has formed by hydrothermal replacement.

Because zoned pegmatites are mostly lenses, their formation by deposition of material in open channels appears improbable, particularly inasmuch as no connecting channels have been found in the few pegmatites that have been mined out so as to expose the walls or the border and wall zones completely around the pegmatite.

Therefore, it appears more likely that the zonal structure of the pegmatites examined has been formed by fractional crystallization in place than by either of the other two modes of origin.

However, replacement has played a part in the formation of these pegmatites even if, apparently, only on a small scale. Most of the replacement relationships observed appear explainable as due to reactions between

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[3] Brögger, W. C., Die Mineralien der Syenitpegmatitgänge der südnorwegischen Augit- und Nephelinsyenite: Zeitsch. Krystallographie u. Mineralogie, Band 16, pp. 212–235, 1890. See also translation by N. N. Evans, Canadian Rec. Sci., vol. 6, pp. 33–46, 61–71, 1894.

[4] Crosby, W. O., and Fuller, M. L., Origin of pegmatites: Am. Geologist, vol. 19, pp. 147–180, 1897.

[5] Kemp, J. F., The pegmatites: Econ. Geology, vol. 19, pp. 697–723, 1924.

[6] Johnston, W. D., Jr., Beryl-tantalite pegmatites of northeastern Brazil: Geol. Soc. America Bull. 56, pp. 1015–1070, 1945.

[7] Cameron, E. N., Larrabee, D. M., McNair, A. H., Page, J. J., Shainin, V. E., and Stewart, G. W., Structural and economic characteristics of New England mica deposits: Econ. Geology, vol. 40, pp. 369–393, 1945.

[8] Hunt, T. S., Notes on granitic rocks: Am. Jour. Sci., 3d ser., vol. 1, pp. 82–89, 182–191, 1871.

[9] Quirke, T. T., and Kremers, H. E. Pegmatite crystallization: Am. Mineralogist, vol. 28, pp. 571–580, 1943.

[10] Brögger, W. C., op. cit.

[11] Galpin, S. L., A preliminary report on the feldspar and mica deposits of Georgia: Georgia Geol. Survey Bull. 30, p. 27, 1915.

[12] Cook, C. W., Molybdenite deposit near New Ross, Nova Scotia: Econ. Geology, vol. 20, pp. 185–188, 1925.

[13] Hess, F. L., The natural history of pegmatites: Eng. and Min. Jour.-Press, vol. 120, no. 8, pp. 289–298, 1925.

[14] Schaller, W. T., The genesis of lithium pegmatites: Am. Jour. Sci., 5th ser., vol. 10, pp. 269–279, 1925; Pegmatites: Ore deposits of the Western States, pp. 144–151, New York, Am. Inst. Min. Met. Eng., 1933.

[15] Landes, K. K., The paragenesis of the granite pegmatites of central Maine: Am. Mineralogist, vol. 10, pp. 355–411, 1925; Origin and classification of pegmatites: Am. Mineralogist, vol. 18, pp. 33–56, 95–103, 1933.

[16] Derry, D. R., The genetic relationships of pegmatites, aplites, and tin veins: Geol. Mag., vol. 68, pp. 454–475, 1931.

earlier-formed minerals and rest-liquids. The field data suggest that changes in the degree of saturation of various elements in the rest-liquid have caused the resorption of part or the whole of preexisting zones and that this has been followed by the formation of new zones with compositions different from those of the older ones. This type of replacement appears to have occurred at the Brown Derby mine pegmatites (p. 70).

BERYLLIUM PEGMATITES

DISTRIBUTION

Beryllium-bearing pegmatites occur in all the pegmatite areas visited in Colorado, Wyoming, and Utah except the Trout Creek district in Chaffee County, the South Platte district in Jefferson and Douglas Counties, the Devils Head district in Douglas County, and the Saint Peters Dome district in El Paso County, Colo. The districts in which beryllium pegmatites are abundant and potentially most productive are the Crystal Mountain district in Larimer County and the Eight Mile Park district in Fremont County, Colo. The most promising pegmatites outside the limits of these districts appear to be the Hyatt pegmatite in Larimer County and the Devils Hole pegmatite in Fremont County. The beryllium pegmatites in the other districts, and in the isolated occurrences, are generally small or have a low beryllium content. Here follows a list of the beryllium pegmatites examined in these States:

Beryllium pegmatites examined

Colorado

Beryl:
- Boulder County:
  - New Girl prospect.
  - Beryl Lode mine.
  - Beryl No. 1 prospect.
- Chaffee County:
  - Combination prospect.
  - Last Chance Spar-Mica Dyke prospect.
  - Mica-Beryl mine.
  - Rock King prospect.
- Clear Creek County:
  - Grover mine.
  - Brandt prospect.
  - Santa Fe Mountain beryl prospect.
- Fremont County:
  - Mica Lode mine.
  - Meyers' mine.
  - School Section mine.
  - R. H. Magnuson prospect.
  - Phantom Canyon prospect.
  - Lower South mine.
  - Rowe's prospect.
  - Devils Hole mine.
- Gunnison County:
  - Opportunity No. 1 prospect.
  - Brown Derby mine.
  - Brown Derby Ridge prospect.
  - Brown Derby No. 5 prospect.
  - Brown Derby No. 4 prospect.
  - Buck Horn prospect.
  - White Spar No. 1 prospect.
  - White Spar No. 2 prospect.
  - New Anniversary prospect.
  - Comet prospects.
  - Black Canyon prospect.
- Jefferson County:
  - Bigger mine.
  - Roscoe prospect.
  - Centennial Cone prospect.
  - Cresman Gulch prospect.
- Larimer County:
  - Buckhorn mine.
  - Double Opening prospect.
  - Big Boulder prospect.
  - Crystal Silica mine.
  - Humphrey prospect.
  - Beryl No. 5 prospect.
  - Tantalum prospect.
  - Hyatt mine.
  - Lewis prospect.
  - Wisdom Ranch prospect.
  - Chaney-Sims prospects.
- Park County:
  - Beryllium Lode prospect.
  - Rose Dawn mine.
  - Meyers' Ranch mine.
- Summit County:
  - Monte Cristo prospects.

Chrysoberyl:
- Jefferson County:
  - Drew Hill prospect.
  - Ramstetter Ranch prospect.
  - Robinson Gulch prospect.
- Larimer County:
  - Wisdom Ranch prospect.

Wyoming

Beryl:
- Albany County:
  - Many Values prospect.
  - Ione prospect.
- Fremont County:
  - Whippet No. 1 prospect.
  - Whippet No. 8 prospect.
- Goshen County:
  - Crystal Palace prospect.
  - Denver prospect.
  - New York prospect.
  - Chicago prospect.
  - Ruth prospect.
  - Savage prospect.

Utah

Beryl:
- Tooele County:
  - Granite Mountain prospects.

TYPES OF DEPOSITS

All the beryllium deposits found in the pegmatites of the three States are in zoned pegmatites. According to the zone in which the beryllium mineral is con-

centrated, the deposits can be divided into four types. They are:

1. Border-zone deposit. This type of deposit characteristically contains anhedral to euhedral beryl crystals, commonly less than 3 millimeters in diameter, in a matrix of quartz-plagioclase-muscovite-microcline pegmatite. These deposits are not of major commercial importance because the border zone generally is thin, and they can be mined at a profit only if the wall zone also is beryl bearing. In all the pegmatites examined that contain a beryl-bearing border zone the wall zone also is beryl bearing. Examples of this type of deposit are found in the smaller beryl pegmatite at the Hyatt mine and in the Big Boulder pegmatite in Larimer County, Colo., where both the border and wall zones contain beryl deposits.

2. Wall-zone deposit. Wall-zone beryl deposits are of two kinds. One kind commonly contains anhedral to euhedral beryl crystals that are less than 13 millimeters in size. The matrix of these small beryl crystals commonly is quartz-microcline-muscovite-plagioclase pegmatite. This beryl can be recovered only by some method of milling, as it is too small to be separated by hand. The Hyatt pegmatite and the Big Boulder pegmatite in Larimer County, Colo., contain beryl deposits of this kind.

The second kind characteristically contains subhedral to euhedral beryl crystals that are as much as 6 inches in diameter, although larger crystals are found occasionally. The matrix of these beryl crystals is different in each pegmatite. Beryl can be recovered from this kind of deposit by hand. The Brown Derby No. 1 pegmatite in Gunnison County, Colo., and the Chicago pegmatite in Goshen County, Wyo., are excellent examples.

3. Intermediate-zone deposit. The intermediate-zone type of beryllium deposit is the most common and also the most productive type. Both beryl and chrysoberyl have been found in deposits in this zone. The beryl characteristically occurs in large crystals that range up to 2 feet or more in diameter. Chrysoberyl occurs also in crystals as much as 3 inches across. Because of the large average size of the crystals the beryl and chrysoberyl can be recovered from most deposits by hand cobbing. Both of these minerals are commonly associated with muscovite of scrap quality, albite, and quartz. Columbite-tantalite frequently is found with the beryl. Most commonly this type of deposit occurs around the outer edges of a quartz-microcline pegmatite or a quartz pegmatite core. Examples of beryl-bearing deposits of this type are found at the Devils Hole pegmatite and the Mica Lode pegmatite in Fremont County, the Bigger pegmatite in Jefferson County, and the Hyatt pegmatite in Larimer County, Colo. The Wisdom Ranch pegmatite in Larimer County contains both beryl and chrysoberyl in an intermediate-zone deposit. Most of the pegmatites that have produced beryl in Colorado are of this type.

4. Core deposit. The core type of beryl deposit commonly occurs only near the outer edges of a core composed of quartz pegmatite or quartz-microcline pegmatite and is related closely to the intermediate-zone type of beryl deposit. No core deposit is known in a pegmatite in which an intermediate-zone beryl deposit does not also occur. Examples of the core deposit are the Big Boulder pegmatite in Larimer County and the Bigger pegmatite in Jefferson County, Colo.

No true "disseminated" beryl deposits have been found in any of the pegmatites examined. In most pegmatites the beryl deposits that are referred to as "disseminated" are ones that are so indistinctly zoned that the zoning is not noted in a brief inspection, or else they are border- and wall-zone deposits of pegmatites in which the intermediate zone or core does not crop out.

In addition to beryl deposits in place, the dumps of many of the pegmatites examined contain an appreciable quantity of beryl that is easily recoverable. The dumps at the Mica Lode mine in Fremont County, Colo., are a low-grade but high-tonnage beryl deposit from which beryl can be recovered at relatively low cost. This mine and many others have been worked primarily for feldspar throughout most of the time that operations have gone on, and the beryl and other minerals removed in the feldspar mining have been discarded as waste.

MINERALOGY

Two beryllium minerals, beryl and chrysoberyl, have been found in the pegmatites investigated.

Beryl ($3BeO.Al_2O_3.6SiO_2$) has been found in the pegmatites in the three States in a variety of forms and in a variety of colors, of which bluish green is the most common. White and pale-pink beryl, which probably contain a high proportion of alkalies, have been found only in lithia-bearing pegmatites. Most of the beryl, particularly that in deposits in the intermediate zone, is subhedral to euhedral. Anhedral beryl is most common in the fine-grained wall-zone deposits. "Shell" beryl, in which a thin rim of beryl occurs around a core of quartz, muscovite, and albite, has been found in only the Double Opening pegmatite. Beryl most commonly is associated with albite, muscovite, and quartz, but the beryl in a few pegmatites occurs with microcline and not with albite. In lithia-bearing pegmatites beryl commonly is associated with lepidolite, cleavelandite, and quartz. The BeO content of the hand-cobbed beryl produced in 1943–44 was 11.04 to 12.62 percent, as shown by the following analyses of shipments:

	Percent BeO
Hyatt Mine	11.04
Bigger mine	12.19
Mica Lode mine	12.22
Brown Derby mine	12.62

The BeO content of composite samples taken from numerous beryl crystals from two mines was:

	Percent BeO
Mica Lode mine	12.68
Devils Hole mine	12.42

The indices of refraction of the ordinary ray of the beryl in the various pegmatites range from 1.567 to 1.596 ± 0.003. The indices of refraction provide a rapid method of determining the approximate BeO content of the beryl, because they change in reverse proportion to the BeO content of the mineral. Thus, the higher the index of refraction, the lower the BeO content.

Chrysoberyl ($BeO.Al_2O_3$) in the pegmatites examined occurs in thin yellowish-green to deep-green plates that are as much as 3 inches long and 0.5 inch thick. This beryllium mineral may contain as much as 19.7 percent BeO, and specimens containing 19.15 percent BeO are reported from the Drew Hill pegmatite.[17] It is commonly associated with quartz, muscovite, beryl, and albite. At the Wisdom Ranch prospect the chrysoberyl occurs in rounded aggregates of these minerals and also is found with massive brown garnet.

STRUCTURE

Most beryllium deposits either are zones rich in beryl or chrysoberyl, or both, or are concentrations of beryl or chrysoberyl within zones, and consequently their structures are closely related to those of the zones in which they occur. For this reason wall-zone deposits form shells of varying thicknesses which conform to the walls of the pegmatite. Where the total thickness of the pegmatite is the same as, or less than, the combined thickness of the footwall part and the hanging-wall part of the wall-zone deposit, the deposit will occupy the whole thickness of the pegmatite. Intermediate-zone deposits form shells or layers that generally are discontinuous. The outer contact of an intermediate-zone deposit is generally parallel to the walls of the pegmatite, but the inner contact is commonly subparallel. Core deposits are structurally more irregular than the other zone deposits. However, the pitch of the ends of a core deposit is commonly parallel to the pitch of the ends of the pegmatite body, and the general dip of the core deposit is parallel to the general dip of the pegmatite. Shoots of beryllium minerals within a zone are related to rolls in the contact of the pegmatite or to rolls and other minor structures, including the thickening or thinning of the host rock, in the containing zones. These shoots generally occur in the wider parts of the deposit beneath anticlinal rolls in pegmatite or zonal contacts, as in the Devils Hole pegmatite (p. 57), and rake parallel to the plunge of the ends of the pegmatite.

[17] Waldschmidt, W. A., and Gaines, R. V., Occurrence of chrysoberyl near Golden, Colo.: Am. Mineralogist, vol. 24, p. 268, 1939.

SIZE AND CONTENT

The size of a beryllium deposit is a function of the size of the pegmatite and the size of the zone which constitutes or contains the deposit. The deposits examined range from less than 5 feet to 500 feet in strike length and from about 5 feet to 80 feet in dip length. The common thickness is 5 to 7 feet, but the Mica Lode deposit is as thick as 25 feet in places. The beryl contents of most beryl deposits examined lie within the range of 0.5 to 1 percent; a few of the larger deposits have beryl contents as high as 2 percent. The grades of the deposits containing chrysoberyl appear to be lower than those of the deposits containing beryl, but because chrysoberyl contains more BeO than beryl, the BeO content of the two types of deposit is probably nearly equal.

PRODUCTION

The total known production of beryl from Colorado is at least 450 tons, of which 71.5 tons was produced between June 1943 and January 1945. Prior to 1943 the Devils Hole mine in Fremont County produced about 300 tons of beryl. The Hyatt mine was the largest producer during 1943–44 with a production of 34 tons, and the Mica Lode mine was the second largest with a production of 26.8 tons. The 1943–44 production came from 15 mines and prospects. The only chrysoberyl produced was included with shipments of beryl from the Wisdom Ranch pegmatite. No significant production of beryl from Wyoming and Utah is known.

RESERVES

The reserves of coarse-grained beryl in Colorado are estimated to be sufficient to maintain the 1943–44 production of hand-cobbed beryl for several years. The reserves of fine-grained beryl are much larger. If an economic method of milling the fine-grained beryl-bearing rock in the wall-zone deposits is developed, the production of beryl could be increased many times. The reserves of chrysoberyl are probably very small and of little commercial significance.

The beryl reserves in Wyoming and Utah are estimated to be very meager. In both States the beryl-bearing pegmatites are small and contain only low tonnages of beryl-bearing rock of which beryl makes up only a small part.

Estimates of the beryl reserves present in the pegmatites examined are based on detailed structural and mineralogical studies and on studies of grades as indi-

cated by sampling and mineral counts and such production data as are available. However, only the general magnitude of the reserves is known because exposures are not sufficient to permit full analysis of the geologic features that control the occurrence of the minerals and because production records needed for estimating grades are fragmentary.

Even for the best-exposed pegmatites the reserves cannot be estimated closely because:

1. Zonal structures beyond available exposures are uncertain.

2. The limits of the size range of the individual crystals of beryllium minerals are unknown. Some parts of intermediate-zone deposits contain the beryllium-bearing minerals in crystals too small to be recovered by hand cobbing; in other parts the crystals are larger and can be separated from waste by hand. For this reason, whereas estimates of total reserves may be possible for such a deposit, an estimate of beryl recoverable by present methods of mining is difficult.

3. Marked differences in grade are common between parts of beryllium deposits. In many pegmatites crystals of uncommonly large size have been found, and therefore the grade of the deposit is locally high. Conversely, the parts of the deposit near these large crystals commonly contain few or no beryllium minerals, and if only these parts are exposed, estimates of grade will be too low.

Unfortunately, many pegmatites are too poorly exposed or contain tonnages of rock too small to justify detailed examination. In such pegmatites the reserves can be estimated only by visual comparison with pegmatites that have been studied in detail.

The estimated reserves of beryllium minerals in the Colorado, Wyoming, and Utah pegmatites are given in table 2. They are listed by mine, district, county, or State.

TABLE 2.—*Beryl reserves in Colorado, Wyoming, and Utah*

Mine, district, county, or State	Estimated tonnages				
	1 to 50	51 to 100	101 to 500	501 to 1,000	1,001 to 5,000
Devils Hole mine, Colo.		×			
Mica Lode mine, Colo.			×		
Hyatt mine, Colo. (figures give minimum and maximum).					× (1, 100–2, 100)
Meyers' Ranch mine, Colo.		×	×		
Wisdom Ranch mine, Colo.	×				
Left Hand Creek district, Colo.	×				
Turret district, Colo.	×				
Eight Mile Park district, Colo. (also includes Mica Lode mine).			×		
Micanite district, Colo.	×				
Quartz Creek district, Colo.		×			
Crystal Mountain district, Colo. (figures give minimum and maximum).				× [1] (910)	× [2] (2, 400)
Clear Creek County, Colo.	×				
Jefferson County, Colo.		×			
Colorado (figures give minimum and maximum).					× (2, 000–5, 000)
Wyoming		×			
Utah	×				

[1] Mostly beryl separable by hand sorting. [2] Mostly beryl separable only by milling.

The Crystal Mountain district in Larimer County, Colo., appears to contain larger beryl reserves than any other because there are large numbers of pegmatites here that have been little prospected. It is possible that further prospecting will result in additions to the known reserves. However, a large part of the reserves found so far in this district consists of fine-grained beryl that can be recovered only by milling.

The Eight Mile Park district in Fremont, Colo., probably contains the largest reserve of beryl that can be recovered by hand sorting. Most of the beryl-bearing pegmatites in the district have been prospected, however, and the possibility of new discoveries is not great.

Although the known beryl reserves in Clear Creek and Jefferson Counties are not large, parts of this area promise the discovery of new beryl deposits. Beryl occurs in some quantity in most of the known pegmatites, and the zonal sequence shown by the pegmatites examined is the type with which beryl deposits appear to be commonly associated.

LITHIA PEGMATITES

DISTRIBUTION

Two varieties of lithia pegmatite are known in Colorado and Wyoming. In one variety the lithia is predominantly in the mineral lepidolite, a lithium mica, and in the other it is in the minerals spodumene and amblygonite.

The larger lithia pegmatites of Colorado are in the Quartz Creek district. The Bazooka and Tucker pegmatites in this district contain both spodumene and lepidolite, and at least nine other pegmatites are known to contain lepidolite. Two spodumene-bearing pegmatites have been found in the Crystal Mountain district, and one lepidolite-bearing pegmatite is known in the Eight Mile Park area.

In Wyoming lepidolite- and petalite-bearing pegmatites occur in the Copper Mountain district, and one spodumene pegmatite was examined in Natrona County.

The lithia pegmatites examined in Colorado and Wyoming are as follows:

Lithia pegmatites examined

Colorado

Lepidolite:
- Fremont County:
  - Meyers' mine.
- Gunnison County:
  - Opportunity No. 1 prospect.
  - Bazooka prospect.
  - Brown Derby mine.
  - Brown Derby No. 5 prospect.
  - White Spar No. 1 prospect.
  - White Spar No. 2 prospect.

Spodumene:
Gunnison County:
Bazooka prospect.
Larimer County:
Buckhorn mine.
Big Boulder prospect.

Wyoming

Lepidolite:
Fremont County:
Whippet No. 1 prospect.
Spodumene:
Natrona County:
Black Mountain prospect.
Petalite:
Fremont County:
Whippet No. 8 prospect.

TYPES OF DEPOSITS

Lithia minerals have been found in three types of deposits. They are:

1. Wall-zone deposit. Wall-zone deposits containing lepidolite but not spodumene occur only in one pegmatite, the Bazooka. This pegmatite has a low lepidolite content. In it the border zone also contains lepidolite.

2. Intermediate-zone deposit. The intermediate-zone deposits generally contain lepidolite but no spodumene. Known examples of this type of deposit contain a very high proportion of lepidolite. In the Brown Derby No. 5 and the Opportunity No. 1 pegmatites lepidolite appears to occur in intermediate zones. However, in all these pegmatites the zones are discontinuous and occur as layers and lenses.

3. Core deposits. The core deposit contains either lepidolite or spodumene. Spodumene deposits of this type are found in the Bazooka pegmatite in the Quartz Creek district and in the Buckhorn pegmatite in the Crystal Mountain district of Colorado. Lepidolite deposits of the same type occur in the Brown Derby No. 1 and the White Spar No. 1 and No. 2 pegmatites in the Quartz Creek district. The Meyers' mine pegmatite in the Eight Mile Park Area contains small lepidolite pegmatite pods that are segments of a discontinuous core.

MINERALOGY

Lepidolite ($3Li_2O.2K_2O.3Al_2O_3.8F.12SiO_2$) is the most common lithia mineral in the pegmatites of Colorado and Wyoming. It is a member of an isomorphous series of minerals that comprises pure lepidolite, pure muscovite, and other micas. The lithia content of the mineral is therefore variable. The lepidolite in the Brown Derby No. 1 deposit contains 5.05 percent lithia, but the lithia content of the lepidolite in the White Spar No. 1 deposit ranges from about 1 to 4 percent. In all the lepidolite deposits this mineral commonly is lilac or lavender in color; rarely, green lepidolite is found in the same deposit. Lepidolite commonly occurs as small flakes about 3 millimeters in size or as felted aggregates of these flakes, but also is found in books as large as 10 inches in length parallel to the cleavages. The common associated minerals are cleavelandite, quartz, topaz, lithia tourmaline, beryl, and microlite.

Spodumene ($Li_2O.Al_2O_3.4SiO_2$) is the second most common lithia mineral. It usually occurs in white to light-gray euhedral crystals many times as long as they are wide or thick. None of the spodumene deposits in Colorado and Wyoming contains large crystals, and the average crystal is less than 1 foot long. In many of the spodumene-bearing pegmatites the spodumene has been altered to a powdery, friable material and also to a lithia-bearing mica. It commonly occurs with quartz and cleavelandite; at the Tucker pegmatite it is associated with lepidolite.

Amblygonite ($Al_2O_3.P_2O_5.2LiF$) and petalite ($Li_2O.Al_2O_3.8SiO_2$) are the only other lithia-bearing minerals of economic interest. Small white nodules of amblygonite have been found at the Bazooka prospect, and small anhedral to subhedral crystals of fremonite [$(Na,Li)_2O.Al_2O_3.P_2O_5.H_2O$], a soda amblygonite, have been found in the Meyers' mine pegmatite. Petalite[18] occurs in fairly large subhedral crystals of grayish white at the Whippet No. 8 prospect in Fremont County, Wyo. None of these three minerals occurs in minable quantities in any of the pegmatites examined.

Amblygonite contains the highest lithia content, 8 to 10 percent, of the three minerals most commonly used as a source of lithia. Spodumene has the second highest content with 6 to 7 percent lithia, and lepidolite the lowest content with a maximum of 6 percent.

Assuming that the lithia-bearing zones in the pegmatites examined have been formed by fractional crystallization of liquid in place, with incomplete reaction between the crystals and the rest-liquid, the following discussion may possibly explain the different occurrences of lithia-bearing minerals found in this investigation:

Amblygonite appears to be the first lithia-bearing mineral to crystallize, provided that the liquid contains sufficient phosphorus. Possibly because the lithia concentration of the liquid is lowered by the crystallization of amblygonite and because phosphorus is used up, spodumene begins to crystallize next. In pegmatites low in potassium and fluorine, spodumene apparently continues to crystallize until all the lithia is used. In pegmatites rich in potassium and fluorine, lepidolite has formed instead of spodumene. Lepidolite apparently has formed instead of spodumene also in peg-

[18] McLaughlin, T. G., Pegmatite dikes of the Bridger Mountains, Wyo.: Am. Mineralogist, vol. 25, pp. 57–58, 1940.

matites low in lithia. Mineral sequences suggest that in some pegmatites the solutions became so depleted in potassium and fluorine by formation of lepidolite that in the final stage spodumene crystallized instead of lepidolite. Thus, if the original liquid did not have sufficient lithia to form spodumene and contained both potassium and fluorine, lepidolite was the only lithia mineral deposited, as at the Brown Derby mine. If both the potassium and fluorine were removed from a lithia-rich liquid by the crystallization of lepidolite, the residual liquid formed spodumene or amblygonite, depending on the quantity of phosphorus available. The Bazooka pegmatite may be an example of this sequence.

STRUCTURE, SIZE, AND CONTENT

The structures of the lithia deposits are related to the external structures of the pegmatite body as are the structures of the beryl deposits, but in all lithia pegmatites the effect of replacement obscures the zonal structure. It may be that this is a direct result of the unusual chemical composition of the liquids from which these pegmatites formed. The lepidolite-bearing pegmatites of the Quartz Creek district are rich in lithia, soda, tantalum, and fluorine. Relationships of the minerals suggest that the solutions from which these pegmatites formed became increasingly corrosive during crystallization. Structurally these pegmatites show peculiarities that do not exist in the non-lithia-bearing pegmatites, and it is possible that the original wall zone in many of the pegmatites was resorbed in part by a soda-lithia-tantalum-fluorine-rich liquid that later crystallized as a zone containing lithia minerals along the walls of the pegmatite, as at the Brown Derby mine (p. 70).

The size of a lithia deposit is a function of the size of the pegmatite and of the zone or zones in which the deposit occurs.

The largest lepidolite deposit known in these three States, the Brown Derby dike 1, has a surface length of 319 feet, ranges in width from 2 to 6 feet, and may extend down the dip as much as 170 feet.

The content of lepidolite is different in the various deposits, but the range probably is between 15 and 75 percent. The lithia content of the lepidolite may range from about 5 percent to about 1 percent in different deposits or within a single deposit. The average content of spodumene in the deposits studied is probably 15 percent, although the Black Mountain, Wyo., deposit has a spodumene content as high as 50 percent. The lithia content of the spodumene in the deposits is not known but is probably about 4 to 6 percent.

PRODUCTION

The recorded production of lepidolite in Colorado during 1942–44 was at least 250 tons. It was obtained from the Brown Derby mine and the Brown Derby No. 5 prospect. Lepidolite was produced also from the White Spar No. 2 prospect, but the exact production figures are not available. Probably the production equaled that from the Brown Derby properties. No lepidolite has been produced in Wyoming or Utah.

No spodumene or amblygonite has been produced in Colorado, Wyoming, or Utah.

RESERVES

The reserves of lepidolite in the Quartz Creek district, Gunnison County, Colo., are estimated to be sufficient for several years' supply at the 1942–44 rate of production. None of the other lepidolite deposits in Colorado and Wyoming appear to be large enough to be mined profitably. The known spodumene deposits in these States are probably too small to allow profitable operation.

MUSCOVITE PEGMATITES

DISTRIBUTION

In Colorado sheet mica-bearing pegmatites are most abundant in the Micanite district in Fremont and Park Counties. Outside this district four sheet mica-bearing pegmatites have been investigated: the Ajax pegmatite in Clear Creek County, the Bigger pegmatite in Jefferson County, the Meyers' Ranch pegmatite in Park County, and the Famous Lode, an unusual type of sheet mica-bearing pegmatite, in Park County. The sheet mica-bearing pegmatites of Wyoming are all in the Haystack Range district of Goshen County. Many other Colorado pegmatites contain scrap mica, but the rare earth pegmatites and the feldspar pegmatites usually contain very little muscovite. The muscovite pegmatites examined in Colorado and Wyoming are as follows:

Muscovite pegmatites examined

Colorado

Sheet mica-bearing:[1]
- Clear Creek County:
  - Ajax mine.
- Fremont County:
  - Climax mine.
  - Whopper mine.
- Jefferson County:
  - Bigger mine.
- Park County:
  - Famous Lode prospect.
  - Micanite district:
    - Rose Dawn mine.
    - Meyers' Ranch mine.

[1] These pegmatites contain scrap mica as well as punch and sheet mica.

Scrap mica-bearing:[2]
- Boulder County:
  - New Girl prospect.
  - Beryl Lode mine.
  - Elkhorn prospect.
  - Highline prospect.
- Chaffee County:
  - Last Chance Spar-Mica Dyke prospect.
  - Mica-Beryl mine.
  - Rock King prospect.
- Clear Creek County:
  - Grover mine.
- El Paso County:
  - Johnny mine.
- Fremont County:
  - Mica Lode mine.
  - Micanite district:
    - Rosemont mine.
    - Tickon prospect.
    - Lower South mine.
    - Upper South mine.
    - Rowe's North mine.
    - Rowe's No. 2 mine.
    - Rowe's South prospect.
  - Devils Hole mine.
- Gunnison County:
  - Buck Horn prospect.
  - New Anniversary prospect.
  - Last Chance mine.
- Larimer County:
  - Buckhorn mine.
  - Hyatt mine.
- Park County:
  - Copper King prospect.
  - Micanite district:
    - Beryllium Lode prospect.
    - Star Girl mine.

Wyoming

Sheet and scrap mica-bearing:
- Albany County:
  - Many Values prospect
- Goshen County:
  - Crystal Palace prospect.
  - Denver prospect.
  - New York prospect.
  - Chicago prospect.
  - Ruth prospect.
  - Savage prospect.
  - White Star prospect.
  - Haystack No. 1 prospect.
  - Haystack No. 2 prospect.

TYPES OF DEPOSITS

Some of the pegmatites examined contain sheet mica, whereas others contain only scrap mica. Sheet mica occurs in three different types of deposits, namely:

1. Disseminated deposit. The mica in a disseminated deposit is distributed uniformly throughout the pegmatite. The only deposits of this type examined are in the Famous Lode prospect. Here the pegmatites, only a few feet in length and depth, are not zoned.

2. Wall-zone deposit. The wall-zone type of deposit contains muscovite in large books near the inner edges of the wall zone. The muscovite commonly is flat, hard, ruby mica. The major defects are rippling, ruling, and in some books, partial films. Mineral inclusions are fairly common. The mica commonly is associated with quartz and albite. The only wall-zone mica deposit examined in Colorado was in the Ajax mica pegmatite, but most of the sheet mica deposits of the Haystack Range district in Wyoming are of this type.

3. Intermediate-zone deposit. Most of the sheet mica deposits in Colorado are in intermediate zones. Many of the better mica deposits occur in intermediate zones that surround quartz-rich cores, although a few have been found around microcline-quartz pegmatite cores. The muscovite in these deposits generally occurs in radially arranged aggregates of light-green, wedge-shaped books. The major defects are wedging, reeving, ruling, "A" structure, and brown and red stains and spots. The Climax and Rose Dawn pegmatites in the Micanite district, the Bigger pegmatite, and the Meyers' Ranch pegmatite are good examples of this type.

The scrap mica deposits are of three types, namely:

1. Intermediate-zone deposit. This type is similar to the intermediate-zone sheet mica deposit except that the muscovite books contain so many defects, particularly wedging and "A" structure, that no punch or sheet mica can be recovered. Beryl and columbite-tantalite are more commonly associated with this type of deposit than with the intermediate-zone type of sheet mica deposit. The Devils Hole pegmatite in Fremont County and the Mica-Beryl pegmatite in Chaffee County contain scrap mica deposits of this type.

2. Core deposit. Felted aggregates of muscovite flakes that are too small to yield punch or sheet mica commonly occur in the core of a pegmatite. This variety of muscovite aggregate locally is called "bull mica." In most physical properties this muscovite is identical with that in the other types of mica deposits. Albite and quartz are the main minerals associated with it. Scrap mica deposits in the core commonly are much smaller than mica deposits in other zones. Deposits of this type have been found at the Bigger mine, the Rose Dawn mine, and the Mica-Beryl mine.

3. Mica Lode type. The Mica Lode type of mica deposit (found in the Mica Lode mine) occurs in a unit that is not related to the zonal structure of the containing pegmatite. Although the origin of this type of mica deposit is not known definitely, the mica deposit probably was formed either by replacement or by assimilation of xenoliths. The muscovite commonly occurs in tabular bodies of felted aggregates of small

[2] The mica in these pegmatites is suitable only for scrap mica because of defects and small size.

flakes associated with quartz, plagioclase, and garnet. Deposits of this type contain a high percentage of muscovite, none of which is large enough to yield punch or sheet mica.

MINERALOGY

Muscovite ($K_2O.3Al_2O_3.6SiO_2.2H_2O$) usually occurs in both the sheet mica pegmatites and the scrap mica pegmatites as light-green to rum-colored flakes and books. The mica flakes are generally less than 2 inches in size, but the books may be as large as 27 inches in length, 12 inches in width, and 7 inches thick. The minerals commonly associated with the muscovite are albite and quartz. Beryl and columbite-tantalite commonly occur in the same deposit as the mica.

STRUCTURE, SIZE, AND CONTENT

The structure of a mica deposit is a function of the external structure of the pegmatite and of the zone in which it occurs. Concentrations of mica, such as mica shoots or layers, within the deposit are controlled either by rolls in the contact of the pegmatite or by the shape of the containing zone. The detailed structure of each mica shoot therefore is a feature of the particular pegmatite in which it occurs.

The size of the mica deposit is determined by the size of the pegmatite and the size of the zone in which it occurs. Most of the mica books are concentrated in the inner part of the containing zone. The deposits generally range in thickness from 2 to 7 feet.

Mica deposits differ in muscovite content in each pegmatite. As production figures are not available for most of the mica deposits, the muscovite content of a deposit can be estimated only on the basis of inspection. Most of the sheet mica deposits in the wall zones are visually estimated to contain 5 to 10 percent of muscovite, and most of the intermediate-zone deposits 5 to 15 percent. Samples collected at several of the sheet mica-bearing pegmatites yielded 5 to 10 percent punch- and sheet-quality mica by careful preparation. However, the samples were small and may not represent accurately the average yields of the deposits.

The qualification and grading of prepared sheet mica usually are based on standards adopted in 1938 by the American Society for Testing Materials (A. S. T. M. designation D351–38). The society declares that "natural mica shall be graded according to the area of the usable rectangle which can be cut from the specimen and the minimum dimensions of one side. The mica in the usable rectangle shall meet the quality requirements specified by the purchaser."

The standard A. S. T. M. chart to be "used for grading natural block mica and mica splitting according to size" agrees closely with the following "India grading scale," which has been in general use for many years:

Grade	*Area of rectangle (in square inches)*	*Minimum dimension of one side (in inches)*
Extra special	60 to 80	----
Special	48 to 60	----
A–1	36 to 48	4
1	24 to 36	3
2	15 to 24	2
3	10 to 15	2
4	6 to 10	1½
5	3 to 6	1
5½	2½ to 3	1
6	1 to 2½	¾

The A. S. T. M. classification of quality in mica may be stated as follows:

Classification	*Description*
Clear	Free of all mineral and vegetable inclusions, stains, air inclusions, waves, or buckles. Hard transparent sheets.
Clear and slightly stained	Free of all mineral and vegetable inclusions, cracks, waves, and buckles, but may contain slight stains and air inclusions.
Fair stained	Free of mineral and vegetable inclusions and cracks. Hard. Contains slight air inclusions and is slightly wavy.
Good stained	Free of mineral inclusions and cracks but contains air inclusions and some vegetable inclusions and may be somewhat wavy.
Stained	Free of mineral inclusions and cracks but may contain considerable clay and vegetable stains and may be more wavy and softer than the better qualities.
Heavy-stained	Free of mineral inclusions but contains more clay and vegetable stains than stained quality. Distinctly inferior as regards rigidity and toughness.
Black-stained and spotted	May contain some mineral inclusions consisting of magnetite (black), specularite (red), and hydrous iron oxide (yellow).

Some mica is sold, however, under the following domestic classification. The A. S. T. M. quality equivalents are given for comparison.

Domestic	*A. S. T. M.*
No. 1	Clear and slightly stained. / Fair stained.
No. 2	Good stained.
No. 2 inferior	Stained. / Heavy-stained.
No. 3	Black-stained and spotted.

In this report the quality figures given for the Colorado and Wyoming sheet mica were determined from test samples or from production figures and are based on the domestic classification.

Most of the scrap mica deposits in the intermediate zones are visually estimated to contain 20 to 60 percent muscovite, and most of the core deposits from 30 to 75 percent. None of the scrap mica deposits contain any punch- or sheet-quality mica.

PRODUCTION

The production of punch- and sheet-quality mica from Colorado during 1942–44 was 1,000 pounds. A few pounds of sheet mica was produced in Wyoming in 1944 when a few properties were sampled for quality and grade. The scrap mica production for Colorado and Wyoming up to 1945 has been at least 28,000 tons. The production from 1942 to 1944 averaged about 4,000 tons of scrap mica each year.

RESERVES

The reserves of punch- and sheet-quality mica in Colorado are probably rather small, although definite reserves cannot be determined from the available information. The reserves of punch and sheet mica in Wyoming are probably even smaller.

The reserves of scrap-quality mica are estimated to be sufficient for many years at the 1942–44 rate of production.

COLUMBIUM AND TANTALUM PEGMATITES

DISTRIBUTION

The columbium and tantalum minerals most abundant in the pegmatites of Colorado and Wyoming are columbite-tantalite and microlite. Euxenite, samarskite, betafite, and fergusonite have been found as minor accessory minerals in several pegmatites. Columbite-tantalite occurs in many of the beryl-bearing pegmatites in both States, and microlite occurs in the lepidolite pegmatites of the Quartz Creek district in Gunnison County, Colo. Here follows a list of the columbite-tantalite and microlite pegmatites examined in these States:

Columbium and tantalum pegmatites examined

Colorado

Columbite-tantalite:
- Boulder County:
  - New Girl prospect.
  - Beryl No. 1 prospect.
- Chaffee County:
  - Mica-Beryl mine.
  - Rock King prospect.
- Clear Creek County:
  - Grover mine.
- Fremont County:
  - Mica Lode mine.
  - Meyers' mine.
  - Phantom Canyon prospect.
  - Devils Hole mine.
- Gunnison County:
  - Opportunity No. 1 prospect.
  - Brown Derby mine.
  - White Spar No. 1 prospect.
- Jefferson County:
  - Bigger mine.
- Larimer County:
  - Buckhorn mine.
  - Crystal Silica mine.
  - Tantalum prospect.
- Park County:
  - Meyers' Ranch mine.

Microlite:
- Gunnison County:
  - Opportunity No. 1 prospect.
  - Bazooka prospect.
  - Brown Derby mine.
  - Brown Derby No. 5 prospect.
  - White Spar No. 1 prospect.

Wyoming

Columbite-tantalite:
- Albany County:
  - Many Values prospect.
  - Ione prospect.
- Fremont County:
  - Whippet No. 1 prospect.
  - Whippet No. 8 prospect.

TYPES OF DEPOSITS

Microlite has been found in the same types of deposits as lepidolite, and columbite-tantalite occurs in the same types as beryl, with the exception of the border-zone and wall-zone deposits. The available information indicates that the Ta_2O_5 content of the columbite-tantalite is higher the nearer it occurs to the center of the pegmatite and that columbite-tantalite in a core is likely to have an unusually high Ta_2O_5 content. One deposit in Colorado and one in Wyoming have been found that contained tantalite with 70 to 80 percent of Ta_2O_5. Most of the other deposits contain columbite-tantalite with either a low Ta_2O_5 and high Cb_2O_5 content or with nearly equal quantities of these oxides.

MINERALOGY

Columbite [(Fe, Mn) Cb_2O_6] is the columbium-rich mineral at one end of an isomorphous series, the other end of which is tantalite [(Fe, Mn) Ta_2O_6], a tantalum-rich mineral. All gradations in the ratio of Cb_2O_5: Ta_2O_5 occur between pure columbite and pure tantalite. The approximate percentage of Ta_2O_5 in a specimen of columbite-tantalite can be determined easily if the specific gravity of the specimen is known. The following tabulation shows the approximate Ta_2O_5 content (within 5 percent) in relation to the specific gravity.

Specific gravity	Approximate Ta_2O_5 content	Specific gravity	Approximate Ta_2O_5 content
6.0	30	6.7	55
6.1	35	6.8	60
6.3	40	7.0	65
6.4	45	7.2	70
6.5	50		

Both columbite and tantalite are iron black to brownish black in color with a dark-red to black streak. Columbite-tantalite occurs commonly in thin plates or equant crystals with metallic luster. Because of the color and luster, it is commonly confused with magnetite and ilmenite but can be distinguished readily from these minerals by differences in magnetism. Crystals and grains of columbite-tantalite generally are small. The common associated minerals are quartz, muscovite, albite, and beryl.

Microlite [$(Na, Ca)_2Ta_2O_6(O, OH, F)$] occurs in the lepidolite pegmatites of the Quartz Creek district as octahedrons and spherical masses that range in size from less than 1 millimeter to 13 millimeters. It commonly is dark brown, although honey-yellow crystals have been found. The resinous luster on the subconchoidal fracture surfaces is distinctive. The common associated minerals are lepidolite, cleavelandite, and quartz. Specimens of microlite from the Brown Derby mine contain 68.47 percent Ta_2O_5.

The lowest Ta_2O_5 content commercially acceptable in tantalite in June 1943 was 40 percent, and the SnO_2 and TiO_2 content could not be higher than 3 percent. The lowest Cb_2O_5 content acceptable in columbite was 50 percent, the TiO_2 content could not be more than 7.5 percent, and the SnO_2 content could not be more than 5 percent.

STRUCTURE, SIZE, AND CONTENT

Concentrations of columbite-tantalite have been found in the same zones as beryl and are of the same size and structure as the associated beryl deposits.

The microlite deposits, however, occur in pods and shoots within the lepidolite-bearing zones. The pods and shoots appear to be related to minor structures, such as rolls, instead of the major structures of the containing pegmatite. The deposits are generally small and commonly make up only small parts of the lepidolite-bearing zones in which they occur.

The columbite-tantalite deposits generally contain less than 1 percent of columbite-tantalite based on visual estimates. No production figures are available on which to base a more definite estimate of grade.

Microlite deposits contain less than 0.5 percent microlite according to production figures, sampling data, and visual estimates.

PRODUCTION

The production of columbium and tantalum minerals in Colorado and Wyoming has been very small. The total production of columbite-tantalite for both States up to 1945 is probably not more than 1,500 pounds. The production of microlite from 1942 to 1945 is not known exactly but is about 2,000 pounds of microlite concentrate.

RESERVES

The reserves of columbium and tantalum minerals in both States are small but are estimated to be several times the past production.

POTASH FELDSPAR PEGMATITES

Two kinds of potash feldspar pegmatites were found during the field work in Colorado. In both kinds feldspar is mined from cores of pegmatite bodies. Here follows a list of the potash feldspar pegmatites examined in 1943–44.

Potash feldspar pegmatites examined

Colorado

Feldspar pegmatites containing other mineral deposits:
- Fremont County:
  - Mica Lode mine.
  - Devils Hole mine.
- Jefferson County:
  - Bigger mine.
- Larimer County:
  - Hyatt mine.

Feldspar pegmatites containing chiefly feldspar deposits:
- Chaffee County:
  - Yard mine.
  - Crystal No. 8 mine.
  - Clora May mine.
- Douglas County:
  - Skeleton No. 2 mine.
  - Little Joe prospect.
  - Little Eddy prospect.
- El Paso County:
  - Johnny mine.
- Fremont County:
  - Meyers' mine.
  - School Section mine.
  - Border Feldspar No. 1 and No. 2 prospects.
  - Spikebuck mine.
  - Cotopaxi mine.
- Gunnison County:
  - Last Chance mine.
- Jefferson County:
  - Burroughs mine.

The first kind of feldspar pegmatite contains concentrations of other minerals—for example, beryl, muscovite, and columbite-tantalite—in the outer zones and large, minable concentrations of microcline or perthite in a quartz-microcline core. The Mica Lode mine and the Devils Hole mine in Fremont County and the Bigger mine in Jefferson County are excellent examples of this kind of potash feldspar-bearing pegmatite.

The second kind of feldspar pegmatite generally contains only a border zone, a wall zone, and a core. The minable feldspar deposit is the core. These pegmatites

generally have only a very small quantity of mica, and most commonly the mica is predominantly biotite. No beryl, columbite-tantalite, nor lithia minerals have been found in these pegmatites, but rare earth minerals have been found in several. In these pegmatites the core makes up the bulk of the pegmatite, and the border and wall zones together are relatively insignificant. In some pegmatites quartz occurs in the core as distinct units completely separated from the microcline and, in a few pegmatites, from albite, whereas in other pegmatites the quartz and microline occur together in a uniform mixture of subhedral crystals. Deposits of this second kind occur in the Yard pegmatite in Chaffee County, the Spikebuck pegmatite in Fremont County, and the Last Chance pegmatite in Gunnison County, Colo.

No detailed investigations of the second kind of feldspar deposit have been made, and the investigations of the first kind have been restricted, in a large degree, to the other mineral deposits in these pegmatites. Inasmuch as feldspar deposits are zones or parts of zones, their form is related closely to the structure of the containing pegmatite. Feldspar deposits range widely in size.

The quantity of commercially valuable feldspar in the pegmatites cannot be estimated satisfactorily because the suitability of the feldspar for commercial use is known for only a few deposits.

The production of microline-perthite from Colorado pegmatites up to 1945 has been at least 250,000 long tons. The feldspar reserves are estimated to be several times the past production.

RARE EARTH PEGMATITES

Rare earth minerals—cerite, euxenite, samarskite, monazite, and allanite—were found in several of the pegmatites examined in Colorado. Here is a list of the pegmatites examined that contained appreciable quantities of rare earth minerals:

Rare earth pegmatites examined

Colorado

Boulder County:
- Rusty Gold prospect.

Chaffee County:
- Yard mine.
- Crystal No. 8 mine.
- Clora May mine.

Fremont County:
- Cotopaxi prospect.
- Pine Ridge prospect.

In general the rare earth minerals are distributed erratically in the quartz-microcline pegmatite core of the containing pegmatite. They occur only in very small quantities. Rare earth minerals appear to occur most commonly in those pegmatites that contain only small quantities of muscovite.

Monazite [$(Ce, La, Di)PO_4$] is distributed most widely of all the rare earth minerals. It has been found in very small quantities at the Brown Derby mine in Gunnison County and at the Bigger mine and Centennial Cone prospect in Jefferson County as well as in the rare earth pegmatites listed.

Euxenite, samarskite, and allanite have been found in microcline and albite in the cores of five pegmatites. Cerite and other cerium-bearing minerals have been found in microcline in the core of the Rusty Gold pegmatite in Boulder County, Colo.

None of the rare earth minerals occur in sizable quantities in any of the pegmatites examined, but some of these minerals can be recovered as byproducts of feldspar mining.

COLORADO PEGMATITES

BOULDER COUNTY

LEFT HAND CREEK DISTRICT

LOCATION AND GENERAL FEATURES

Four small mica pegmatites—the New Girl prospect, the Beryl Lode mine, the Elkhorn prospect, and the Highline prospect—are in the Left Hand Creek district about 7 miles by air line north-northwest of Boulder, the nearest railroad shipping point. The district is in Boulder County and includes parts of sections 22 and 27, T. 2 N., R. 71 W., sixth principal meridian.

The pegmatites are reached from Boulder by Colorado State Highway 7 to Altona (8 miles) and then by the county road along Left Hand Creek. The New Girl prospect is on a mine road that branches from the county road 1.5 miles from Altona; the Elkhorn and Highline prospects are near an old road that branches from the county road 2.5 miles beyond the New Girl road; and the Beryl Lode mine is 150 feet west of the county road, 1 mile beyond the Elkhorn road. The New Girl prospect is on Spruce Gulch, a tributary to Left Hand Creek, about half a mile by air line north of the Beryl Lode mine. The Beryl Lode and the Elkhorn pegmatites are exposed on the steep valley walls of tributaries to Left Hand Creek, and the Highline pegmatite crops out on a gently sloping surface near the crest of the north wall of Left Hand Creek valley.

All four pegmatites are similar in structure, mode of occurrence, and mineralogy, except that beryl occurs in the Beryl Lode and the New Girl pegmatites but not in the others. The quantity of muscovite, potash feldspar, and beryl in the four deposits is so small that none of the deposits is of great economic significance. Some scrap mica is produced and is used mostly as house-insulation material by the Mica Pulp Co., owned by Freudenberg and Bruning, whose mill is near the

district. The pegmatites were examined on December 11 and 22, 1942, by J. B. Hanley.

NEW GIRL PROSPECT

The New Girl prospect (58) was first discovered by Robert L. Bruning in 1928 and was relocated on October 1, 1942, by Mrs. Nettie Bruning. About 240 tons of potash feldspar and 5 tons of low-grade scrap mica have been sold.

The mine workings include three tunnels and a glory hole connected by "groundhog" workings made in the removal of the potash feldspar.

The New Girl pegmatite occurs in highly folded schists of pre-Cambrian age and is about 400 feet long and 150 feet wide. It is unzoned. Potash feldspar, quartz, and a small quantity of muscovite of scrap quality are the chief constituents. Beryl and columbite occur as minor accessory minerals. The muscovite is wedged and generally is oriented at right angles to the walls or fractures in the pegmatite. All the mica occurs in small flakes intergrown with other minerals. No mica books were seen, and none are reported to have been found.

Two small crystals of beryl were found during the mining operations, the largest 6 inches across. The other was much smaller and, according to Mr. Bruning, contained about 10 pounds of beryl. Columbite, in large bladed crystals, is associated with small irregular concentrations of albite. The specific gravity of 5.42 determined by the Chemical Laboratory of the Geological Survey indicates that the columbite contains 4 percent Ta_2O_5 and 75 percent Cb_2O_5. The mineral associations and the poorly developed internal structure of the pegmatite suggest that no large quantities of beryl, columbite, muscovite, and potash feldspar occur.

BERYL LODE MINE

The Beryl Lode mine (3), formerly the Lehman mine, is the most westerly of the pegmatites. The present location notices claim the property for C. H. Conradson, R. M. Conradson, and Agnes Raybeck of Boulder, but no work has been done on the mine for several years. It is reported locally that some beryl was produced during World War I, but the ownership of the deposit has changed several times since 1919, and records of past production are not available.

One pit, about 80 feet long, N. 45° W., 50 feet wide, N. 79° W., and 30 feet deep at the face, has been made in the pegmatite. Several smaller pits and "ground hog" workings to the east expose the eastern part of the pegmatite and another small pegmatite. Three adits have been driven in the property. One adit, at an altitude 40 feet greater than that of the pit, was not examined because the portal was caved. The second adit, 30 feet lower on the hillside than the main pit, was driven along the footwall contact of the pegmatite. The third adit is entirely in wall rock.

Two pegmatites are exposed on the property. The larger pegmatite is about 70 feet wide and is exposed for a length of 300 feet up the hillside. The general trend is N. 63° W., and the dip on the footwall is 10° to 15° NE. The exposures of the contact are poor except on the southwest side where the pegmatite crops out as a small ridge. About 30 feet to the northeast is a smaller pegmatite, which is parallel to the larger pegmatite and may be a branch of it.

A fault plane with 3 inches of gouge is exposed in the pit wall. It strikes N. 66° W. and dips 75° SE.

The larger pegmatite is obscurely zoned. It contains a wall zone of quartz-potash feldspar-muscovite pegmatite, a discontinuous intermediate zone of muscovite-cleavelandite pegmatite, and a core of quartz pegmatite. Only the core is sharply defined, and the wall and intermediate zones are difficult to identify. The core is about 40 feet long and 10 feet wide and is exposed along the southwest side of the large pit. Near the outer edges the core contains beryl crystals and potash feldspar in masses 4 feet wide and 8 feet long. It is bordered by the intermediate zone, which contains cleavelandite masses as large as the potash feldspar masses in the core. The wall zone has an average grain size of 5 inches and is composed of milky-white quartz, light-pink to flesh-colored potash feldspar, and muscovite with accessory manganese garnet.

Pale greenish-white beryl occurs only in the core. The crystals are tapered, distorted, highly fractured, flattened, and commonly tabular. A few hexagonal crystals were observed. Eleven crystals were seen, but many of them were almost completely removed. The largest crystal measured 8 inches across and 4 feet long. The highly fractured condition of the beryl prohibits hand sorting. The quantity of beryl seen indicates a maximum ratio of beryl to pegmatite of 1:5,000.

The quantity of potash feldspar, muscovite, and beryl in the pegmatite is small.

ELKHORN PROSPECT

The Elkhorn prospect (33) is the most easterly of the pegmatites. It is on Elkhorn Gulch about three-quarters of a mile northeast of the Beryl Lode mine. Present location notices claim the property for Cliff Summer and Ben Vickery as the Tin Horn Lode claim, but no work has been done on the prospect for several years.

The pegmatite has been explored by means of an open pit about 50 feet square and 10 feet deep with two rooms, one below the footwall of the pegmatite and the other just below the hanging wall.

The pegmatite cuts across the dioritic wall rock and is about 100 feet long and 15 feet wide. It strikes N.

47° W. and dips 25° NE. The mineralogy is the same as at the Beryl Lode mine, except that beryl has not been found. The composition of the pegmatite is uniform throughout the exposures except for a slight increase in muscovite near the contacts.

The reserves of potash feldspar and muscovite, the only minerals of economic significance in this pegmatite, are probably very small.

HIGHLINE PROSPECT

The Highline prospect (37) is about halfway between the Beryl Lode mine and the Elkhorn prospect and a short distance north of a line connecting these two pegmatites. It is supposed to be owned by Ellery Cruthers of Jamestown but was not posted at the time of examination. The pegmatite, which is 10 feet wide, is explored by two small open pits and occurs in a coarse-grained reddish granite. The length of the pegmatite is not known, as it is covered by soil outside the pits. No beryl was observed in this pegmatite, but otherwise the mineralogy is the same as that of the Beryl Lode.

The small size of the pegmatite indicates that the reserves of commercially valuable minerals are probably small.

RUSTY GOLD CERITE PROSPECT

The Rusty Gold cerite prospect (75), in sec. 17, T. 2 N., R. 71 W., sixth principal meridian, Boulder County, is on Central Gulch, 2 miles by air line northeast of Jamestown and 9 miles by air line north-northwest of Boulder. It is owned by Edith E. White of Boulder and was examined on May 27, 1943, by J. B. Hanley and E. Wm. Heinrich. Other cerite-bearing pegmatites are known in the region and have been described by Goddard.[19]

The small cerite-bearing pegmatite is exposed in a shallow trench on the property. It trends N. 28° W. and dips 75° NE. The pegmatite is about 30 feet long, with a maximum width of 5 feet and a minimum width of 2 feet. It contains a unit of feldspar-biotite pegmatite along the footwall; a core of potash feldspar pegmatite, as much as 16 inches thick, containing cerite and associated minerals; and a unit of feldspar-biotite-muscovite pegmatite along the hanging wall. The two units are probably parts of the wall zone that differ slightly in composition, but the exposures do not show their relationship. Cerite and associated minerals occur in irregular grayish-brown masses composed of extremely fine grains. These masses are visually estimated to make up to 2 to 5 percent of the core.

[19] Goddard, E. N., and Glass, J. J., Deposits of radioactive cerite near Jamestown, Colo.: Am. Mineralogist, vol. 25, pp. 381–404, 1940.

BERYL NO. 1 AND NO. 2 PROSPECTS

The Beryl No. 1 and No. 2 prospects (4) are in secs. 5 and 6, T. 1 N., R. 71 W., sixth principal meridian, Boulder County. They are reportedly owned by H. J. Barakage of Boulder, Colo., but were first located March 1, 1942, by William D. Brough of Boulder. The prospects are 6.5 miles by air line northwest of Boulder and crop out along the crest of a ridge northwest of Sunshine, Colo. The workings are small discovery holes and shallow trenches a few hundred yards east of the Boulder-Gold Hill county highway and are reached by a mine road that joins the county highway at a sharp curve about 1.6 miles toward Gold Hill from the Sunshine road junction. The property was visited by J. B. Hanley on January 9, 1943, in the company of W. P. Huleatt of the Federal Bureau of Mines and was revisited on May 14, 1943.

The Beryl No. 1 pegmatite is about 400 feet long and has a maximum width of 55 feet. The trend is east, and the dip on the hanging wall is 45° N. The gneissic granite country rock is exposed only at the eastern end of the pegmatite. Most of the pegmatite is composed of quartz-microcline-muscovite-plagioclase-biotite pegmatite, which in general has a granitic texture, although some blocky masses of microcline are as much as 2 feet in size. In a few places, as in the discovery hole near the center of the pegmatite, small isolated pods of quartz-plagioclase pegmatite occur. These pods contain accessory bluish-green beryl and columbite-tantalite. No large beryl crystals were seen in place; the average size is about 2 inches in diameter. The maximum ratio of beryl to quartz-plagioclase pegmatite in the pods is estimated to be 1:1,000, and the average ratio is 1:5,000. No sizable concentrations of economic minerals occur in this pegmatite.

The Beryl No. 2 pegmatite is a mass, less than 10 feet in diameter, in coarse-grained granite wall rock. The pegmatite is not zoned, and no beryl was seen in the discovery hole or in the waste material on the dump.

CHAFFEE COUNTY

TROUT CREEK PASS REGION

The feldspar pegmatites that contain rare earth minerals crop out near Trout Creek Pass. The three mines in these pegmatites—the Yard, the Crystal No. 8, and the Clora May—have been operated in the past for feldspar but, when examined by J. B. Hanley and A. F. Trites, Jr., on August 26, 1944, had been inactive for several years.

YARD MINE

The Yard mine (89), in sec. 26, T. 13 S., R. 78 W., sixth principal meridian, is about 4 miles north of U. S. Highway 24 and 10 miles by road from Buena Vista, the nearest railroad shipping point. It is

slightly more than 4 miles by air line northeast of Buena Vista. The mine is reported to be owned by Robert Yard of Canon City.

The mine workings consist of an extremely irregular open-cut made up of a main cut about 15 feet wide, 75 feet long, and 20 feet deep with several smaller open-cuts branching from it.

The pegmatite strikes N. 43° E., with a very gentle dip to the southeast. On the surface it is about 200 feet long and 50 feet wide. The wall rock is coarse-grained granite, with which the pegmatite probably is genetically related. The main minerals are quartz, pink microcline, and highly sericitized plagioclase, with accessory biotite, muscovite, monazite, and euxenite. The average grain size of the main constituents is about 6 feet.

One of the rare earth minerals in the pegmatite has been tentatively identified as euxenite. Only small anhedral grains of it are exposed. Monazite occurs in subhedral to euhedral masses as much as 8 inches across. Euxenite masses of comparable size are reported to have been found when the mine was in operation. These rare earth minerals occur in only small quantities and are erratically distributed through the pegmatite.

The rare earth minerals can be recovered only as byproducts of feldspar mining.

CRYSTAL NO. 8 MINE

The Crystal No. 8 mine (28) is in sec. 17, T. 14 S., R. 77 W., sixth principal meridian, and is approximately 8 miles from Buena Vista and about half a mile south of U. S. Highway 24. It is 6 miles by air line east of Buena Vista and about 5 miles by air line southeast of the Yard mine. The pegmatite is owned by the M & S, Inc., of Denver.

The mine workings include an irregular, two-level open-cut, which has a total length of 80 feet, an average width of 10 feet, and a maximum width of 30 feet. Many small pits and crosscuts also prospect the pegmatite. One short, narrow adit has been driven from the north slope of the hill into the open-cut.

The pegmatite is an elongate lens that trends N. 85° E. and crops out at the top of a small knoll. The surface exposure is 300 feet long and 40 feet wide, but the pegmatite is a shallow body, as the footwall contact is exposed at several places in the workings. The detailed structure of the pegmatite cannot be determined from surface exposures, but at one place in the workings the dip of the footwall is 75° SE. The wall rock is a porphyritic granite, to which the pegmatite is probably related in genesis.

The pegmatite contains only two zones, of which the most evident is the quartz-microcline-plagioclase pegmatite of the core. The narrow border zone appears to be composed of the same minerals but contains a large quantity of dark-red garnet crystals, which commonly are surrounded by a black stain. The chief constituents of the core are white to pale-rose quartz, pink microcline, and highly sericitized plagioclase with accessory euxenite and allanite. Minor quantities of biotite occur in both zones, but the deposit contains little muscovite.

The rare earth minerals, euxenite and allanite, occur only in small quantities and are distributed sparsely throughout the core. No euxenite was seen in place when the mine was examined, but a few small fragments were found in the debris in the open-cut. Allanite occurs in long straight crystals, associated with microcline, that are as large as half an inch across and 6 inches long.

The rare earth minerals can be recovered only as byproducts of feldspar mining. The reserves of feldspar are estimated to be about a thousand tons or more.

CLORA MAY MINE

The Clora May mine (22), also owned by the M & S, Inc., of Denver, is in sec. 11, T. 14 S., R. 77 W., sixth principal meridian. It is 10 miles from Buena Vista on U. S. Highway 24 but is only 8 miles by air line east of Buena Vista. It is about half a mile south of U. S. Highway 24 and about 2 miles northeast of the Crystal No. 8 mine.

The mine workings consist of an open-cut 100 feet long, 40 feet wide, and 30 feet deep, in which the footwall contact is exposed in several places.

The pegmatite in plan is an oval with its long axis bearing N. 85° E. The dip of the pegmatite is probably very gentle, as the general dip of the contacts is 15° SE. At the surface the pegmatite is 175 feet long and as much as 70 feet wide, but it is not more than 30 feet thick. The wall rock is quartz-mica schist, which is poorly exposed in this region.

The pegmatite is similar in mineralogy and zoning to the Crystal No. 8 pegmatite. The minerals in the core are quartz, microcline, and altered plagioclase with accessory garnet, euxenite, allanite, and biotite. Biotite occurs in books 2 feet across and is most abundant at the outer edges of the core. The potash feldspar masses in the core are as large as 14 feet across. About 600 pounds of bismuth minerals has been produced from the pegmatite, but no bismuth nor rare earth minerals could be found in place when the mine was examined. The euxenite in this pegmatite is reported to occur in masses 8 to 10 inches in size.

The rare earth minerals and the bismuth minerals can be recovered only as byproducts of feldspar mining. The reserves of feldspar are estimated to be about a thousand tons or more.

TURRET DISTRICT

LOCATION AND HISTORY

The pegmatites of the Turret district are east of the town of Turret, about 7 miles by air line N. 10° E. of Salida. The district is in Chaffee County and includes most of T. 51 N., R. 9 E., and the first tier of sections in T. 50 N., R. 9 E., New Mexico principal meridian. It is reached from Salida by 12 miles of graded and unimproved dirt roads which lead to Turret and the numerous mines. Most of the pegmatites that have been prospected or mined are along Railroad Gulch, but some are as much as 2 miles away. Most of those examined are shown in figure 2.

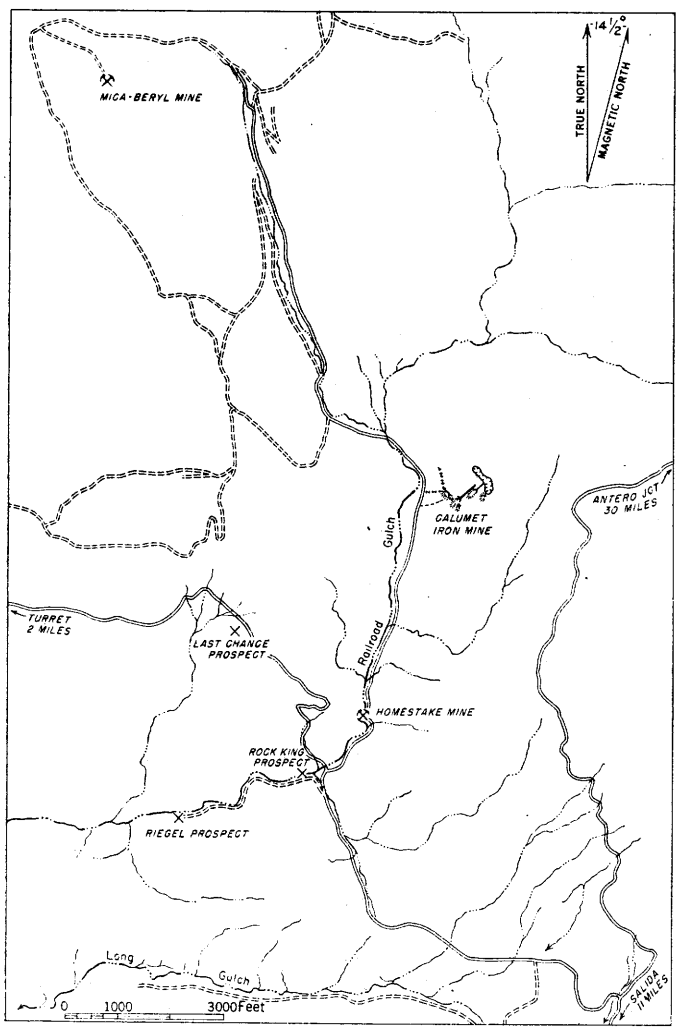

FIGURE 2.—Index map of Turret district, Chaffee County, Colo.

The district is one of moderate to high relief and has an average altitude of 8,000 feet. The main drainage systems are Railroad Gulch and Long Gulch. Normally the streams are intermittent, and the water supply is limited. In general, the area is lightly wooded with many natural clearings and park lands, but sufficient timber is available for small mining operations.

In the past many gold mines have been operated in the vicinity of the town of Turret, and the Calumet iron mine of the Colorado Fuel and Iron Co., on Railroad Gulch near the eastern edge of the district, was operated in the late 1800's. Marble has been mined recently about a mile north of the Calumet mine.

The mining operations in pegmatite are all recent and were encouraged by the increased prices for strategic minerals during 1942–45. Although most of the pegmatites contain sizable concentrations of potash feldspar and scrap mica, the low prices of these minerals and high transportation costs to the nearest markets had long prevented active mining. During the recent period of activity potash feldspar, scrap mica, and beryl were produced from several of the pegmatites.

The Combination, Homestake, Last Chance Spar-Mica Dyke, Mica-Beryl, and Riegel feldspar pegmatites were examined by E. Wm. Heinrich on November 13, 1942. The Mica-Beryl mine was mapped by plane table and telescopic alidade by J. B. Hanley and A. F. Trites, Jr., on August 24, the Homestake and Last Chance Spar-Mica Dyke were reexamined on August 22 and 24, and the Rock King pegmatite was examined on August 23, 1944. Other pegmatite claims reported in the district could not be found by the writers.

COMBINATION PROSPECT

The Combination prospect (23), located on November 10, 1942, by L. J. Doyle and J. H. Brookhart, is half a mile south of the abandoned Turret schoolhouse and 200 yards south of the Turret road.

The pegmatite has been prospected by a shallow shaft at the summit of a hill and by two shallow cuts on the western slope.

The pegmatite body is 150 feet long and as much as 30 feet wide and tapers abruptly at both ends. The pegmatite strikes east and is vertical. The only exposures are in the shaft and prospect cuts. In the shaft and lower cut the pegmatite is a coarse-grained mixture of small red and white mottled feldspar crystals, masses of quartz, biotite plates, garnet crystals, and graphic granite. A number of fine-grained gray schist inclusions are here exposed. The upper cut exposes pegmatite of the same composition, but the crystals of feldspar are larger. A few bright-blue crystals of beryl as much as 3 by 6 by 12 inches in size were observed in the pegmatite, but it is not rich enough in beryl or feldspar to be of commercial importance.

HOMESTAKE MINE

The Homestake mine (38) is in a pegmatite that forms a sharp ridge jutting out into Railroad Gulch a few hundred yards northeast of the Turret road. (See fig. 2.) The mine is owned by the M & S, Inc., of Denver and was operated for soda feldspar in the

past. It was inactive when examined in 1944. About 3,500 tons of rock have been removed from an open-cut 60 feet long and 38 feet wide with a maximum depth of 20 feet.

The Homestake pegmatite trends N. 71° E. along the sharp ridge. The crest, north, and south slopes of the ridge are stripped contacts, and small patches of the gray quartzite and chlorite gneiss wall rock may be found above pegmatite on all slopes. The chlorite gneiss typically contains porphyroblasts of feldspar and has a radial arrangement of the chlorite plates.

The maximum length of the pegmatite is 240 feet, and it has a maximum width of 80 feet. The pegmatite pinches out toward the west and at the east end is bluntly forked. It probably plunges 10° to 15°, N. 71° E.

The pegmatite contains two zones. The outer zone, at least 6 feet in thickness, is composed of quartz-albite-muscovite-microcline pegmatite. The microcline commonly occurs in blocks up to 2 feet across in a matrix with an average grain size of 1.5 inches. The inner zone of the pegmatite is a fine-grained aplitic rock composed mainly of albite with minor quantities of quartz and apatite and other accessory minerals. The grain size of this rock is less than 1 millimeter.

The pegmatite appears to contain a large tonnage of soda feldspar, but the content of feldspar in the pegmatite and the quality of this feldspar are not known.

LAST CHANCE SPAR-MICA DYKE PROSPECT

The Last Chance Spar-Mica Dyke prospect (45), now known as the Old Glory claim, is owned by Walter Record of Turret. The pegmatite is 100 yards west of the road, 4 miles south of Turret, at the head of the steep grade of the Turret road just north of Railroad Gulch. (See fig. 2.)

Three small cuts have been made in the poorly exposed pegmatite. The largest is 25 feet long and 20 feet wide and averages 3 feet in depth. (See fig. 3.)

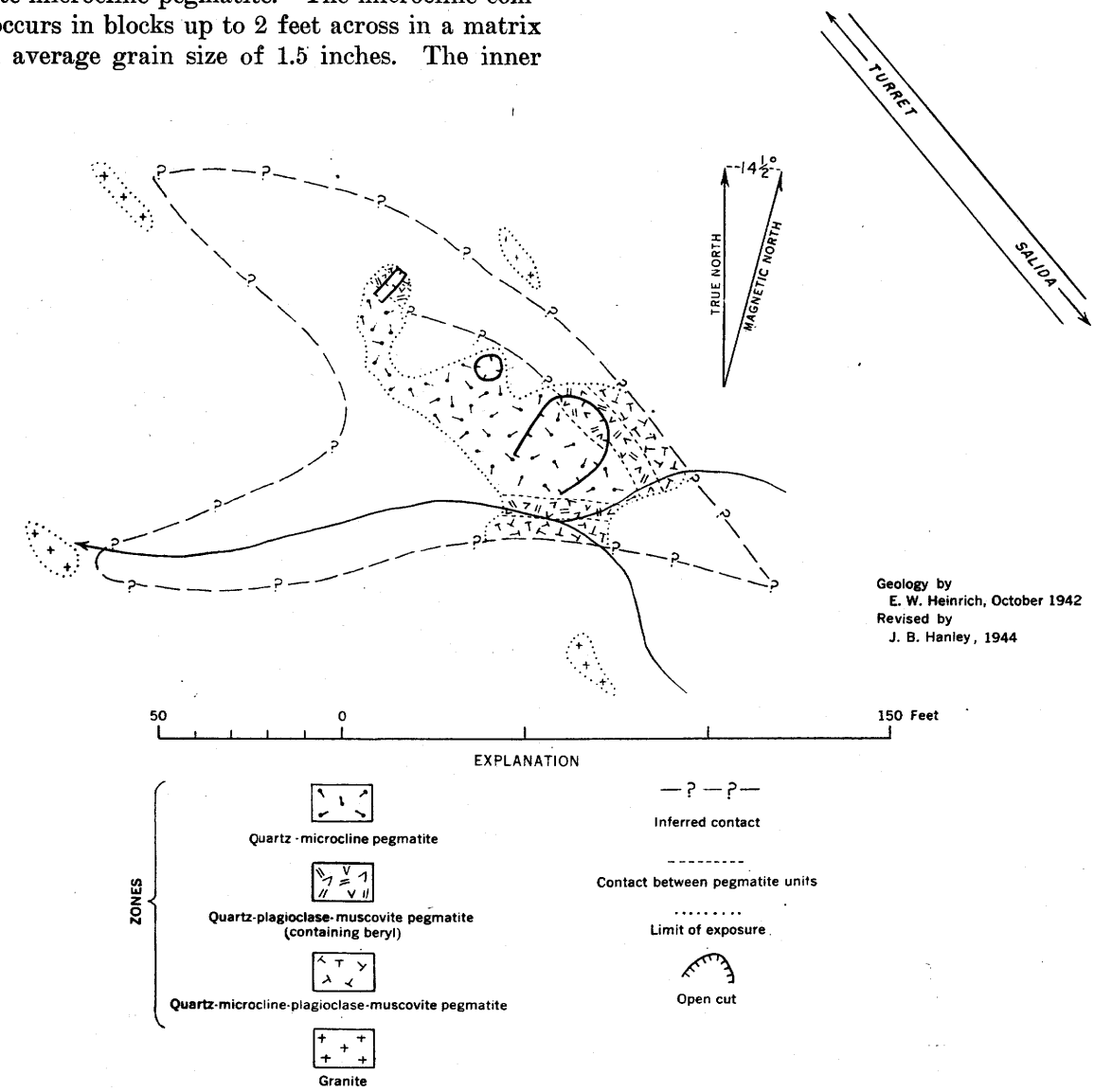

FIGURE 3.—Sketch map of Last Chance Spar-Mica Dyke prospect, Turret district, Chaffee County, Colo.

The pegmatite is rudely crescentic in shape. The main arm, about 200 feet long and 40 feet wide, strikes N. 55° W., and the other, about 105 feet long and as much as 35 feet wide, strikes S. 77° W.

The pegmatite occurs in gray, coarse-grained granite and contains three distinct zones in addition to a border zone. These zones are listed below in order from the walls to the center of the dike.

1. The wall zone is fine-grained quartz-potash feldspar-muscovite-plagioclase pegmatite. Dark-brown garnet is common.

2. The intermediate zone is quartz-plagioclase-muscovite pegmatite with accessory beryl. It is poorly exposed and appears to be discontinuous along its strike. Twenty beryl crystals, ranging from 0.5 inch to 1.5 inches in diameter, were exposed in the largest cut in 1942. Muscovite constitutes about 5 percent of the zone.

3. The core is quartz and white potash feldspar pegmatite. Quartz is visually estimated to form 75 percent and the feldspar 25 percent of this rock. Some of the feldspar masses are as much as 3 feet in length.

The gray-green muscovite of the intermediate zone would yield some sheet mica of No. 1 to No. 3 quality, but the total quantity of sheet recoverable is probably small. In 1944 very little muscovite was observed in the east pit, but in the westernmost pit a small quantity of sheet mica was exposed. No sheet mica is exposed between these pits. The quantity of scrap mica and feldspar also is small.

MICA-BERYL MINE

The Mica-Beryl mine (53), owned by Edgar and Edmond Riegel, Elbert Davidson, and Edgar Ingham, was located on December 1, 1941. In 1944 it was operated by a Mr. Strah of Salida, Colo. The claim is on a flat bench near the crest of the mountains that form the west wall of Railroad Gulch. (See fig. 2.) It is reported that intermittent operations produced a few hundred tons of feldspar, sold to the Colorado Feldspar Co. at Canon City, Colo.; about 100 tons of scrap mica, sold to the Western Non-Metallics Co. of Pueblo, Colo.; and at least 500 pounds of beryl, sold to the Metals Reserve Company depot at Salida, Colo. About 5 pounds of columbite-tantalite was recovered in the mining operations.

The core of the pegmatite has been mined by an elongate open-cut 160 feet long and up to 35 feet wide. The western part of the open-cut is 14 feet deep, but the eastern 50 feet is only 5 feet deep. (See fig. 4.)

Twenty to forty feet north of the pegmatite a series of five prospect pits has been dug on a quartz vein in the Sawatch quartzite and Manitou limestone in a search for gold. These pits range from 6 to 20 feet in depth. None have exposed pegmatite.

The pegmatite, about 450 feet long and as much as 50 feet wide, crops out on a nearly level surface. A thick soil cover obscures the structural relationship between the wall rock and the pegmatite. In addition, waste material dumped just outside the open-cut has hidden most of the pegmatite walls. The wall rock is a fine-grained dark-gray granite.

The pegmatite strikes N. 87° E. and probably is vertical. (See fig. 4.) It contains three distinct units, which are listed below in order from the wall to the core:

1. The wall zone is quartz-microcline-muscovite-plagioclase pegmatite with an average grain size of 1.5 inches. The thickness of this zone is not measurable, but it is probably 3 to 5 feet.

2. The intermediate zone contains muscovite and plagioclase with some beryl. It is 2 to 3 feet thick and completely surrounds the core. The percentage of muscovite is estimated to range from 10 to 90 percent, with an average of 40 percent.

3. The core is visually estimated to contain 80 percent microcline and 15 percent quartz. The western 60 feet of the core, only 6 to 8 feet wide, is predominantly massive white quartz, and microcline is a minor constituent. At the east end of this quartz-rich part of the core an irregular aggregate of fine-grained muscovite and plagioclase is exposed, but whether this aggregate is part of the core or a separate unit is uncertain. The walls of the cut delimit closely the position of the contact between the central core and the mica-beryl zone.

Greenish-blue subhedral to euhedral beryl crystals, practically free of mineral inclusions, occur with the muscovite. In 1944 no beryl was found in place because the walls of the open-cut had recently been cleaned of all visible beryl. Mr. Strah stated that the beryl had been recovered where the open-cut had penetrated the mica zone. The average size of the beryl crystals is not known, but one crystal seen in 1942 measured 6 by 10 by 12 inches. The beryl produced came from a small part of the beryl-bearing zone.

The small quantity of columbite-tantalite that has been recovered was probably from the intermediate mica-beryl zone, but none was found in place. Specimens of this mineral are massive and of large size. One fragment was 6 inches long and 3 inches wide.

The core of the pegmatite constitutes a sizable deposit of potash feldspar of high quality. This mass is about 110 feet long, averages 25 feet wide, and on the basis of visual estimates contains 80 percent microcline. The microcline occurs as large white to light cream-colored masses several feet in length and can be separated easily from waste by hand sorting.

Muscovite is estimated to make up 40 percent of the intermediate mica-beryl zone. This zone has an

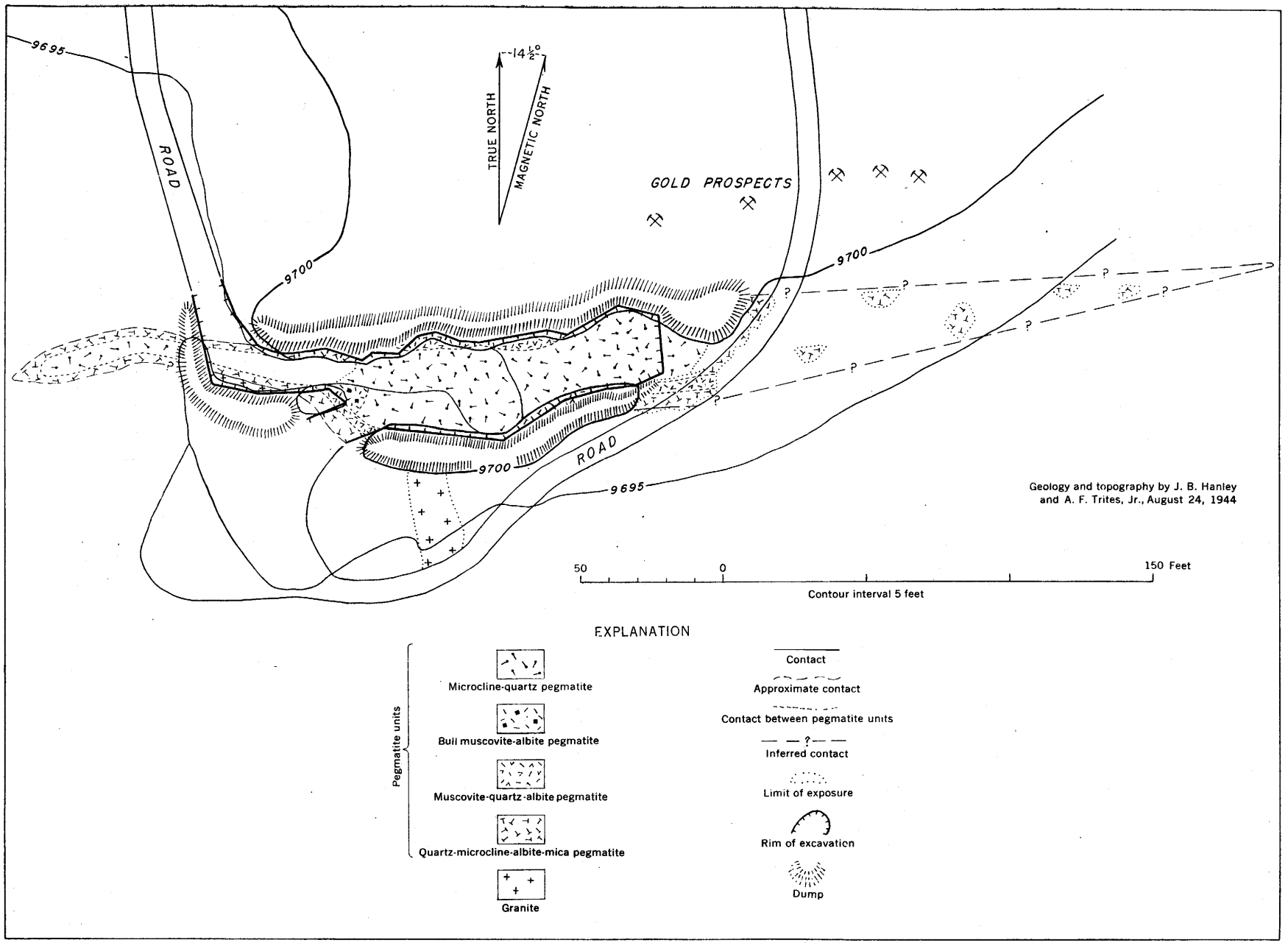

FIGURE 4.—Map of Mica-Beryl mine, Turret district, Chaffee County, Colo.

average thickness of 2.5 feet and, as closely as can be determined, has a total linear length, around the core, of approximately 300 feet. Muscovite occurs in spherical masses in which the individual books are as much as 2 feet in size. It is green, usually wedged, fishtailed, reeved, and has pronounced "A" structure, but some very heavily black-stained sheet mica of large size could be recovered. The intermediate zone is a possible source of scrap mica with some beryl as a byproduct.

RIEGEL FELDSPAR PROSPECT

The Riegel feldspar prospect (66) is on Railroad Gulch, a quarter of a mile west of the Turret road. (See fig. 2.) On this claim several vertical pegmatite dikes that strike southwest form the walls of the gulch. They have been explored by two cuts on its southeast side. Here mottled pink potash feldspar occurs in masses as much as 6 feet in length, associated with greenish-brown muscovite. The muscovite occurs both as books, as much as 4 inches in size, and as an intergrowth of fine-grained flakes.

ROCK KING PROSPECT

The Rock King prospect (68), located in 1937 by Harvey S. Moyer of Turret, is in a pegmatite that forms the north wall of Railroad Gulch just west of the Turret road. (See fig. 2.) During intermittent operation in 1943 and 1944, a total of 3,287 pounds of beryl was produced and sold to the Metals Reserve Company at Salida.

A shallow bench, about 75 feet long and 10 feet wide, at the foot of a cliff formed by pegmatite, constitutes the workings.

Three parallel dikes which strike east and dip vertically are exposed in the claim. The largest dike is 1,000 feet long, 50 feet wide, and forms a steep cliff about 80 feet high along the valley wall. The rock is a fine-grained, granitic quartz-potash feldspar-biotite-muscovite pegmatite with accessory garnet. No commercially valuable minerals were observed. South of the pegmatite and separated from it by a foot-thick septum of dark-gray quartzite is a beryl-bearing dike. The third pegmatite, north of the central pegmatite and separated from it by 30 feet of quartzite, also contains beryl.

The southern beryl-bearing pegmatite dike is from 8 to 10 feet wide and can be traced for at least 500 feet along the strike. The surface exposures are poor, as much of the dike is hidden beneath the debris of the largest pegmatite dike. It is composed mainly of fine-grained albite pegmatite containing subordinate quantities of microcline. Graphic granite is very common. Small irregular concentrations of massive white quartz occur abundantly throughout the rock.

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Beryl occurs in well-formed crystals ranging from a sixteenth of an inch up to 12 inches in diameter and as much as 8 feet in length. The ratio of beryl to rock was visually estimated as 1:1,000. A few pounds of columbite-tantalite in small grains was seen near the beryl. Beryl is distributed erratically, but on the selvages of the quartz bodies both beryl and columbite-tantalite occur in larger quantities than elsewhere in the dike. Although the pegmatite is rich in muscovite only scrap quality can be recovered because of the small size of the mica.

The second beryl-bearing dike, also about 500 feet in length and 10 feet in width, is similar to the southern dike, but its beryl content is estimated to be only 1:5,000, and no columbite-tantalite has been found. Less albite and more microcline were observed in this dike.

CLEAR CREEK COUNTY

AJAX MICA MINE

LOCATION AND HISTORY

The Ajax mica mine (1) is in sec. 34, T. 3 S., R. 72 W., sixth principal meridian, Clear Creek County, 5 miles by air line east of Idaho Springs and on the southern slope of the divide between the North Fork Clear Creek and the main stream. The mine workings are on the north side of Clear Creek Canyon at an altitude of 7,960 feet and about 760 feet above Clear Creek. They can be reached from Colorado State Highway 119 by 1½ miles of mine road with exceedingly steep grades.

The region around the mine is the headwater amphitheater of a tributary of Clear Creek and has a moderate to steep slope. The nearest water supply for mining purposes is Clear Creek.

The property is a mining claim owned by Ralph D. Naslund of Idaho Springs, Colo., and George Baer of Denver and leased to the Western States Mining Co. of Idaho Springs with Frank Witt as general manager. This company operated the property from June 22 to November 11, 1944. Previously, for a period of over 40 years, the mine was owned by Mrs. Catherine Wherry and her family. It was purchased by Ralph D. Naslund from Henry Tusing on February 3, 1942.

The mine was formerly known as the Floyd Hill mica mine and was referred to by J. A. Holmes [20] in 1899. Sterrett [21] refers to this older report in his bulletin but apparently did not visit the mine.

The mine was reportedly first operated in the 1890's for sheet mica, which was sold to stove manufacturers, but the old production records are not available. For a short period prior to June 1944, the mine was operated

[20] Holmes, J. A., Mica deposits in the United States: U. S. Geol. Survey 20th Ann. Rept., pt. 6, p. 707, 1899.

[21] Sterrett, D. B., Mica deposits of the United States: U. S. Geol. Survey Bull. 740, p. 49, 1923.

primarily for scrap mica that was sold to the Western Elaterite Roofing Co. of Denver, Colo. The production since the reopening of the mine by the Western States Mining Co., June 22, 1944, has been 50,900 pounds of scrap mica and 22,927 pounds of mine-run mica that contained 1,036 pounds of full-trimmed punch and sheet mica.

The mine was investigated by J. B. Hanley, A. F. Trites, Jr., and J. E. Husted from July 16 to 19, 1944, and was mapped by transit-and-stadia methods. Only part of the pegmatite was mapped, as no mica concentrations were observed east of the quartz core, the limits of which are shown on the map.

MINE WORKINGS

The old workings at the mine consist of a large shallow open-cut 123 feet long and 60 feet wide, a 32-foot adit, and an inclined shaft reportedly 40 feet deep but completely backfilled with muck. Most of the floor and the southern walls of the open-cut are hidden beneath waste rock.

The first development work by the Western States Mining Co. consisted of removing the waste rock from part of the open-cut and mining a small quantity of mica during this operation. When the property was mapped, the company was engaged in deepening a pit at the adit portal; when the mine was revisited in October 1944, the open-cut shown in plate 2 was filled completely by debris, and pegmatite was exposed only at the extreme eastern end.

GEOLOGY

The Ajax pegmatite is an irregular lens occurring in the Idaho Springs formation of pre-Cambrian age. In the vicinity of the mine the Idaho Springs formation is a series of beds of quartz-biotite-feldspar gneiss and quartz-muscovite-sillimanite schist. The schist beds are less competent than the gneiss beds and are highly folded into chevron folds. The general structure of the metamorphic sequence is a series of tight, overturned folds with an axial pitch of 45°, N. 10° E. Some beds in the formation are so highly iron-stained that their structure and lithology cannot be determined readily. The schistosity of the metamorphic rocks appears to be nearly parallel to the bedding.

The pegmatite is well exposed only in the mine workings, as the region is covered with heavy granitic float from the upper slopes of the hill. Outcrops are sparse and usually small except in areas underlain by the more resistant beds of the Idaho Springs formation. The old mining operations have effectively concealed much of the pegmatite beneath heavy dumps, particularly along the probable position of the hanging-wall contact.

The pegmatite is at least 175 feet long and 65 feet wide at the surface but is not more than 16 feet thick. It appears to be a lenticular pod, probably larger on the western end and narrowing to the east. The area east of the map limits is very poorly exposed, but the pegmatite is not more than 10 feet wide in its easternmost exposures.

The general strike of the pegmatite is east, and the dip is 30° S. The dike crops out on the hillside as shown in plate 2, but the structure indicates that it continues to the south under a thin veneer of wall rock.

The pegmatite cuts across the bedding and schistosity of the wall rock and has highly irregular contacts. The footwall contact is obscure, as the lower part of the dike is a mixture of schist inclusions and pegmatite. Large quantities of muscovite have been introduced into the hanging-wall schist, and the wall rock has been altered by the introduction of pegmatitic material. However, in the few places where it is exposed the hanging wall is sharply defined.

The dike is offset by a rotational fault, which is well exposed near the portal of the adit and which strikes N. 39° W. and dips 75° NE., although the dip varies locally. Linear elements on the fault plane pitch 38°, S. 55° E., and indicate a displacement in that direction. The displacement cannot be determined but from the relative displacement of the two parts of the quartz core appears to be about 20 feet.

The dike is distinctly zoned, as shown in plate 2. The most resistant, and consequently most evident, zone is the core of quartz with small quantities of albite and a few books of muscovite. The other zone includes the footwall and hanging-wall albite-muscovite pegmatite. This pegmatite contains large quantities of sheet mica, and the footwall part is much richer in sheet mica than the hanging-wall part. The former is 7.5 feet thick; the latter, 3 feet. Because of poor exposures the footwall part of this zone cannot be traced continuously around the core onto the hanging-wall side, but the similar mineral composition and the spatial relation suggest that the zone is continuous.

MINERALOGY

The main minerals of the Ajax pegmatite are quartz, albite, and muscovite with accessory black tourmaline and sericite. Quartz is visually estimated to make up 40 percent, albite 30 percent, and muscovite about 25 percent of the pegmatite. The remaining 5 percent is mostly black tourmaline and sericite.

Quartz is best exposed in the quartz pegmatite zone. It is white to pale rose, massive, and somewhat shattered. The quartz in the albite-muscovite pegmatite is grayish to white.

Albite occurs in small subhedral to anhedral masses throughout the albite-muscovite pegmatite and also as scattered anhedral masses in the quartz pegmatite. It is usually white, but throughout most of the pegmatite

it has been surficially stained by iron. Microscopic examination shows that the albite is highly sericitized. From a few relatively unaltered fragments it was determined that the N_m of the mineral was $1.530 \pm .003$, biaxial (+). It shows well-formed albite twinning. The composition of the albite therefore is about Ab_{94}.

Muscovite occurs in all the zones as plates ranging in size from half an inch to 10 inches. It is partly iron-stained but is mostly clear and transparent. It commonly shows alternating color stripes of clear and ruby, and some of it is rippled and ruled. Inclusions of tourmaline, quartz, and albite occur in some of the mica books. Some rifted sheets show partial films, but for the most part the mica is free of major defects. The N_m was determined as $1.603 \pm .003$, and under the microscope a small quantity of air staining was noted. The quality of this mica on the basis of sales to the Colonial Mica Corporation at Asheville, N.C., is about 30 percent No. 2 and the rest No. 2 inferior. The size pattern is about 90 percent 1 by 1 inch and 1¼ by 1¼ inches and the rest 1½ by 2 inches and larger.

A small quantity of bright-green muscovite was found in the bottom of the new workings, but the size of the plates is less than 1 square inch.

MICA DEPOSIT

Muscovite occurs throughout the albite-muscovite pegmatite and is most abundant immediately below the footwall of the quartz core. The concentration is about 2 feet thick and probably occurs along the full length of the core. Mica books from which sheet mica might be recovered are visually estimated to make up 3 to 5 percent of the concentration. A second concentration occurs adjacent to the hanging wall of the core, but the thickness and the quantity of mica are less than in the footwall concentration.

The muscovite in the footwall zone outside the concentration generally is small and contains many inclusions. It probably would yield only scrap-quality mica. The muscovite in the hanging-wall zone outside the concentration is slightly larger and contains fewer inclusions, but probably it would yield only a very small proportion of punch- and sheet-quality mica.

RESERVES

The Ajax mica deposit, to a depth of 20 feet down the dip below the present surface, is estimated to contain about 95 tons of rock, containing 3 to 5 percent of muscovite that would yield sheet mica.

GROVER MINE

LOCATION AND OWNERSHIP

The Grover mine (36), at the common corner of secs. 9, 10, 15, and 16, T. 4 S., R. 72 W., sixth principal meridian, is on the top of a small ridge with an altitude of 8,750 feet on the north side of Beaver Brook valley. It is 4.5 miles by air line southeast of Idaho Springs and 12.5 miles by air line and 20 miles by road southwest of Golden, the nearest railroad shipping point. It can be reached from U. S. Highway 40 by taking the road up Beaver Brook at Elmgreen Ranch. The mine is owned by Joe Grover of Park City, Utah. It was examined briefly on June 13, 1943, by J. B. Hanley and was mapped in part by plane table and telescopic alidade by J. B. Hanley assisted at different times in October 1944 by A. F. Trites, Jr., and J. W. Adams.

Production records are not available.

MINE WORKINGS

The mine workings (see pl. 3) include a long, narrow open-cut, a 23-foot drift from this open-cut, and several small prospect holes, the largest of which is 18 feet long and 4 feet wide. The main open-cut is about 275 feet in length, as much as 23 feet in width, and as deep as 30 feet at the west face. It is at the eastern end of the pegmatite. Parts of the main cut have been worked at two levels, using timber staging that was partly collapsed when the mine was mapped.

GEOLOGY

The Grover pegmatite is an elongate, tabular body that in general appears to be concordant to the quartz-biotite schist and gneiss wall rock, which probably is part of the pre-Cambrian Idaho Springs formation. The metamorphic rocks are highly folded and crumpled, but their general strike appears to be parallel to the strike of the pegmatite. Away from the pegmatite the strike of the metamorphic rocks changes from N. 45° W. to N. 72° W., and the dip from 80° NE. to vertical.

The pegmatite is poorly exposed outside the main open-cut, but the size and shape can be determined roughly by soil differences and scattered outcrops. Adjacent to the main open-cut the contacts with the wall rock are hidden beneath waste material, and the width and the external structure of the pegmatite cannot be determined exactly.

The pegmatite is about 760 feet long and as much as 25 feet wide. The western 485 feet was not mapped. The pegmatite trends N. 88° E. and probably dips from 70° SE. to vertical. It is obscurely zoned, and the contacts between zones are gradational. The zones include a border zone and a wall zone of quartz-microcline-albite-biotite pegmatite, an intermediate zone of quartz-albite-muscovite pegmatite, and a core of quartz pegmatite. All four zones can be identified in the main open-cut, but only the wall zone and the core can be recognized beyond the limits of the open-cut. The zones overlap one another, and the zoning is telescoped.

The border zone has the same composition as the wall zone but differs from it in texture. The border zone is 0.5 inch thick at the only place where it is exposed. The wall zone of quartz-microcline-albite-biotite pegmatite is composed chiefly of grayish quartz, cream-colored to pink microcline, white albite, and biotite with accessory muscovite. The average grain size of this rock is about 1 inch, although some microcline crystals are as much as 8 inches and some biotite books 4 inches in size. The zone probably ranges in thickness from 1 to 2 feet. The western 280 feet of the pegmatite consists entirely of material of this zone.

The intermediate zone of quartz-albite-muscovite pegmatite is composed chiefly of milky-white to grayish quartz, white to cream-colored albite, and grayish-green muscovite. The accessory minerals are beryl, columbite, monazite, bertrandite, and a mineral tentatively identified as fluorite. The average grain size of this rock appears to be about 4 inches. Muscovite occurs in thick books as much as 6 inches in width and 10 inches in length. It is usually reeved, ruled, has "A" structure, and is very heavily black-stained. Because of these defects none of the mica found would yield mica of sheet quality, although some would yield flat pieces of acceptable size. Beryl occurs in light-green euhedral crystals that are as much as 8 inches in diameter and 2 feet in length. It is free of mineral impurities and probably has a high BeO content. Associated with the beryl are columbite in masses as large as 2 inches in thickness and 6 inches in length, monazite in small euhedral crystals, and bertrandite in very small, sharply defined crystals.

The quartz-albite-muscovite pegmatite of the intermediate zone grades imperceptibly into the quartz pegmatite of the core. The core is composed chiefly of milky-white quartz with minor quantities of microcline, albite, and muscovite. It is exposed in the main open-cut and on the surface for 320 feet and appears to occupy the full width of the pegmatite throughout this length. The eastern end of the core probably plunges vertically.

MINERAL DEPOSITS

The Grover pegmatite contains four minerals of economic significance. Microcline occurs in small quantities in the core, and muscovite, beryl, and columbite occur in the intermediate zone. Muscovite is visually estimated to make up 10 to 15 percent of the intermediate-zone pegmatite and probably would yield a good quality of scrap mica. Beryl is visually estimated to make up only 1 in 5,000 parts of the pegmatite, and the columbite is even less abundant than the beryl. However, these two minerals and some microcline could be recovered as byproducts of mica mining.

BRANDT BERYL-TOPAZ PROSPECT

The Brandt prospect (11), commonly known as the Beaver Brook pegmatite, in sec. 12, T. 4 S., R. 72 W., sixth principal meridian, Clear Creek County, was investigated by J. B. Hanley on October 14, 1944. The pegmatite crops out on the Brandt ranch on the south wall of Beaver Brook about opposite the Beaver Brook schoolhouse. It is less than half a mile from U. S. Highway 40.

The pegmatite is about 150 feet long and 6 feet thick. It trends N. 78° E. and dips 30° SE. It is roughly concordant to the structure of the wall rock, a biotite-rich granitic gneiss. The pegmatite is fairly well zoned, and well-formed beryl crystals as much as 6 inches in size are concentrated in the wall zone of the pegmatite along the footwall. Topaz, associated with the beryl, occurs in crystals as much as 4 inches in diameter. The core of the pegmatite is predominantly a pale amazon-stone variety of microcline.

The beryl content of the pegmatite is low. The distribution of the beryl is erratic, and the thickness of the beryl-bearing zone is less than 1 foot. The reserves of beryl in the pegmatite are consequently believed to be small.

SANTA FE MOUNTAIN BERYL PROSPECT

The Santa Fe Mountain beryl prospect (76) is near the top of a ridge that extends north from the main body of Santa Fe Mountain at an altitude of 9,200 feet. The pegmatite is about 3 miles by air line southeast of Idaho Springs in sec. 8, T. 4 N., R. 72 W., sixth principal meridian, Clear Creek County, and can be reached from U. S. Highway 40 by an abandoned logging road up Sawmill Gulch and a foot trail that switch-backs from the floor of the gulch to the pegmatite.

The prospect is owned by Frank W. Whitenack of Georgetown, Colo., and by George Frank and William Hollingsworth. It was formerly owned by W. J. Brampkamp, T. L. Camplin, and A. N. Moatz. F. W. Whitenack located the pegmatite on June 7, 1943, and in June and July 1943 produced 928 pounds of beryl that was sold to the Metals Reserve Company at Salida. The prospect was examined by J. B. Hanley on June 3, 1944.

The only opening in the pegmatite is an open pit with an average width of 5 feet, an average length of 12 feet, and a depth ranging from 2 inches to 11 feet. The average depth at the east end of the pegmatite is 6.5 feet.

The pegmatite is an irregular, roughly tabular body that cuts across the gneissic structure of the granite wall rock and crops out in a low area between two granite knobs. Small offshoots from the pegmatite are conformable to the structure of the wall rock, but

the main pegmatite appears to be controlled by a fracture system. The trend of the pegmatite is N. 80° W., and the dip appears to be nearly vertical. The surface exposure is about 100 feet in length and ranges from 5 to 20 feet in width with an average width of 10 feet. The only exposure in depth is in the pit.

A small rose quartz mass, which is 50 feet long and as much as 2 feet wide, occurs at the center of the dike west of the pit. No zoning was found other than this quartz concentration, and most of the pegmatite is a mixture of feldspar and quartz with an average grain size of 1 inch.

The chief minerals are white microcline in blocky masses 1 foot in size and grayish quartz in masses of comparable size. Smaller masses of cream-colored albite also are found. The most abundant mica is biotite, commonly highly altered by weathering. In general the pegmatite is mica-poor. Manganese garnet in crystals 1 inch in diameter and magnetite are distributed erratically throughout the pegmatite, although the garnet is most abundant in streaks that pass through the other minerals.

Blue or green beryl occurs in euhedral crystals associated chiefly with albite, although some crystals have been found in the grayish quartz. According to Mr. Whitenack 22 beryl crystals, ranging in size from 1 to 6 inches in diameter, were exposed in the pit at one time. These crystals were oriented at an angle of 30° inward from the walls and pitched 30° downward. When the prospect was examined, less than five small crystals 1 inch in diameter were seen in place. Many of the beryl crystals have corroded faces, and in all the crystals examined the corroding mineral is highly sericitized albite. All the beryl produced came from the open pit.

Although the prospect contains a high percentage of beryl, which made up 1.5 percent of the rock mined, no other minerals occur in minable concentrations. The prospect is difficult to reach, and the construction of a mine road would be extremely costly.

Two other small pegmatites in the vicinity of the Santa Fe Mountain beryl prospect were examined. The one about 100 feet south of the pit is a small circular pegmatite, about 5 feet in diameter, completely enclosed in granite wall rock, and the other, on the summit of the ridge, is a quartz-feldspar pegmatite that is 60 feet long and 16 inches wide on the surface. The latter strikes N. 85° W. and dips vertically. Neither of these pegmatites contains minable deposits of minerals.

DOUGLAS COUNTY

DEVILS HEAD REGION

Three prospects and one mine south of the Devils Head in Douglas County were examined by J. B. Hanley and A. F. Trites, Jr., on July 23, 1944. One prospect is a gem-mineral pegmatite, and the other three are feldspar pegmatites. All the prospects are at an altitude of about 7,500 feet and occur on the slopes of the Rampart Range.

DEVILS HEAD TOPAZ PROSPECT

The Devils Head topaz prospect (30) is in sec. 21, T. 9 S., R. 69 W., sixth principal meridian, Douglas County, about half a mile by air line southwest of the Devils Head and 36 miles by air line south-southwest of Denver. The prospect can be reached by taking the Rampart Range road to a point 2 miles beyond the Devils Head turn-off. From this point a wood road leads to the southeast into a small park. The pegmatite crops out on the top of a small ridge on the east side of this park. The ownership of the prospect is not known.

The only opening in the pegmatite is a shallow open-cut 70 feet long and about 10 feet wide. At the time of examination this cut was badly slumped and almost completely backfilled.

The pegmatite is about 80 feet long and probably about 10 feet wide; it trends N. 10° W. The contacts with the granite wall rock are hidden beneath the dumps and the slumped part of the open-cut.

The chief components of the pegmatite are quartz, microperthite, and cleavelandite with accessory topaz, biotite, and cassiterite. The minerals are usually heavily iron-stained, and field identification of the minerals is not always accurate. Some of the potash feldspar is of the amazon-stone variety, and graphic granite is common. The topaz and cassiterite occur in pockets filled with ferruginous mud and have been described by Peacock,[22] but none was found in place at the time of examination.

The Devils Head topaz prospect is of interest only as a gem and mineral locality.

SKELETON NO. 2 MINE

The Skeleton No. 2 mine (79) is in sec. 36, T. 9 S., R. 69 W., sixth principal meridian, Douglas County, about 3.5 miles by air line southeast of the Devils Head and about 37 miles by air line south of Denver. The mine can be reached by taking the Rampart Range road for 5.5 miles south of the Devils Head turn-off and then a mine road to the west. The mine is owned by the M & S, Inc., of Denver and has been worked for feldspar.

The mine workings are an open-cut, trending N. 15° E., 100 feet in length and 40 feet wide. The maximum depth is about 25 feet at the north face.

[22] Peacock, M. A., Topaz from Devil's Head, Colo.: Am. Mineralogist, vol. 20, pp. 354–363, 1935.

The pegmatite trends N. 45° W. and dips 25° SW. It is 500 feet long and as much as 100 feet wide. The wall rock is reddish granite, probably of the Pikes Peak type, and the pegmatite is probably closely related to this granite in origin. Three distinct zones occur in the pegmatite. They are a fine-grained border zone with an average grain size of 1 inch, an intermediate zone composed of microcline pegmatite, and a core of quartz pegmatite. The quartz pegmatite crops out near the eastern contact of the pegmatite. The microcline pegmatite is made up of large masses of microcline and contains only a few mineral impurities. The most abundant accessory mineral is white to pale-purple fluorite that occurs either as small crystals in the microcline or as bands sometimes 4 inches wide along the contact between the microcline masses and the quartz pegmatite. Well-shaped quartz crystals, mostly less than 1 inch in length, occur in the microcline pegmatite.

The Skeleton No. 2 pegmatite probably contains a large quantity of unmined feldspar, but the structure of the pegmatite is so little known that the reserves of feldspar cannot be estimated.

LITTLE JOE PROSPECT

The Little Joe prospect (48) is in sec. 1, T. 10 S., R. 69 W., sixth principal meridian, Douglas County, about 4.5 miles by air line southeast of the Devils Head. It can be reached by a mine road that branches to the west from the Rampart Range road 7 miles south of the Devils Head turn-off. It is owned by the M & S, Inc., of Denver.

The only opening in the pegmatite is a trench 60 feet long and 4 feet wide.

The pegmatite occurs in reddish granite and trends N. 32° E. The surface exposures are predominantly pink potash feldspar, but a quartz mass 100 feet long and 3 feet wide is exposed near the center of the outcrop.

The quantity of feldspar in this pegmatite is probably large.

LITTLE EDDY PROSPECT

The Little Eddy prospect (47) is in sec. 7, T. 10 S., R. 69 W., sixth principal meridian, Douglas County, about 5 miles by air line southeast of the Devils Head. It can be reached by a mine road that branches to the west from the Rampart Range road 7.5 miles south of the Devils Head road. It is owned by the M & S, Inc., of Denver.

The only opening in the pegmatite is a prospect trench about 30 feet long and 3 feet wide, with an average depth of 6 feet.

The pegmatite is exposed over a large surface area and appears to be composed chiefly of pink microcline. A quartz mass 100 feet long and 4 feet wide occurs in it. The structure of the pegmatite, however, is not known.

EL PASO COUNTY

JOHNNY FELDSPAR MINE

The Johnny feldspar mine (42), in sec. 10, T. 16 S., R. 67 W., sixth principal meridan, is about 15 miles by air line south-southwest of Colorado Springs and 33 miles by road northeast of Canon City, the nearest market. The pegmatite crops out as a low knob near the base of the north wall of the fourth gulch north of Little Turkey Creek. The mine can be reached from Canon City or Colorado Springs by following Colorado State Highway 115 to a dirt mine road that leaves the highway just south of Deadmans Canyon. This mine road, along the north side of the gulch, is half a mile in length. The pegmatite was located in 1940 by J. W. and D. A. Cosgrove of Colorado Springs and in 1942 was leased to the Colorado Feldspar Co. of Canon City. Only a few tons of feldspar had been produced when the mine was examined on September 30, 1942, by E. Wm. Heinrich. A pace-and-compass map was made as part of the examination.

The mine workings include an open-cut 30 feet long and 25 feet wide near the top of the knob and a smaller open-cut in the country rock 40 feet to the northeast. (See fig. 5.)

The Johnny pegmatite intrudes a light-red, medium-grained granite which contains quartz, light-red microcline, and biotite. Attenuated patches of jet-black biotite several feet long are common in this granite.

The pegmatite trends about east and is exposed for a length of about 350 feet and a maximum width of 95 feet. The footwall contact is exposed on the west and south sides of the knob at the west end of the pegmatite. On the south side of the knob the dip of the contact is about 60° N.; on the west side it is apparently 40° S. If these dips continue in depth, the shape of the pegmatite is probably that of a trough that is tipped toward the north. A north-south cross section of the pegmatite body would be V-shaped.

The pegmatite is extremely irregular. At the eastern end, about 320 feet east of the main cut, it is only 6 inches thick. The thickness gradually increases toward the west, and 200 feet west of the east end the pegmatite is 10 feet thick. As exposed at this place the pegmatite is made up of a unit of microcline 3 feet thick at the footwall, a unit of muscovite 1 foot thick, and a 6-foot-thick upper unit of white quartz at the hanging wall. Fifty feet west of this exposure the pegmatite swells abruptly into a bulbous mass about 80 feet square and 20 to 25 feet thick. In the bulbous part a 10-foot-thick mass of microcline pegmatite occurs at the center of the pegmatite. This is underlain by massive white quartz.

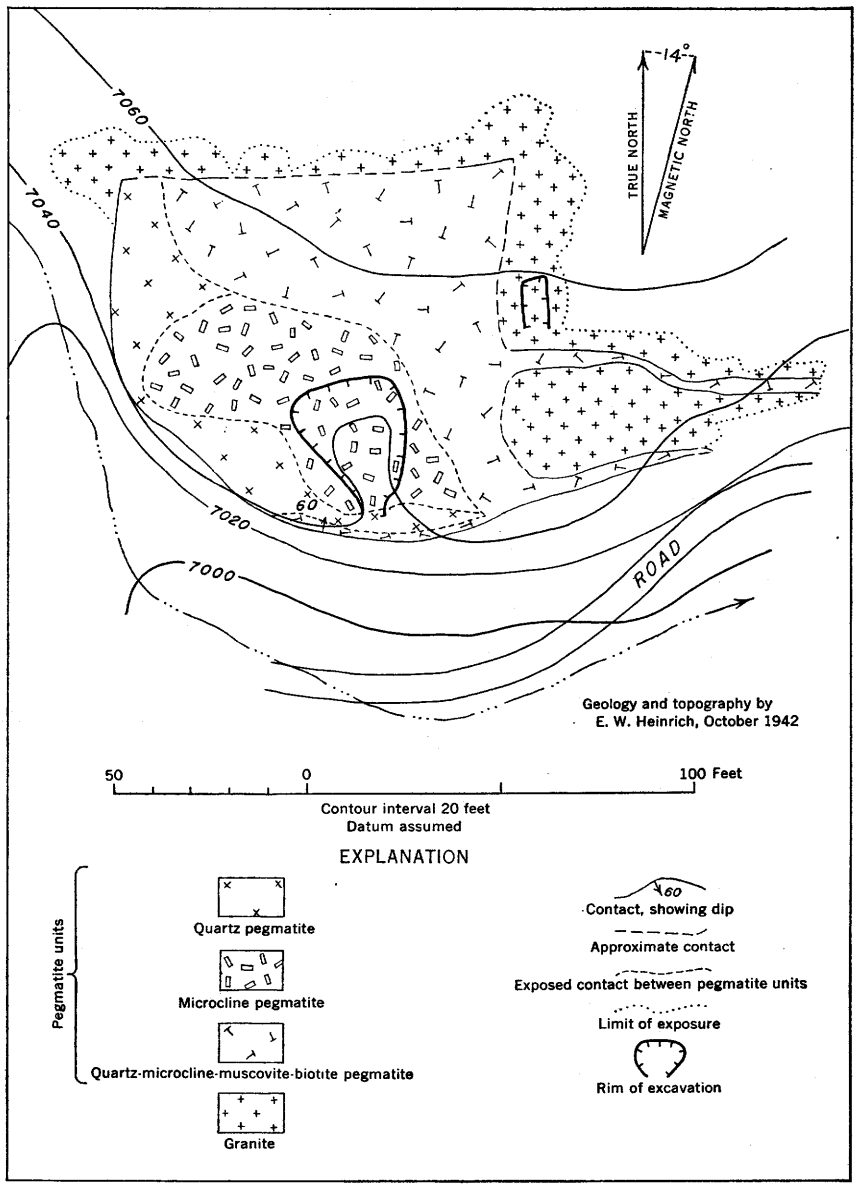

FIGURE 5.—Map of Johnny feldspar mine, El Paso County, Colo.

Below this quartz is a unit of feldspar and quartz-microcline-muscovite pegmatite, 5 feet thick, in contact with the granite. Toward the western end of the pegmatite the quartz-microcline-muscovite pegmatite pinches out, and the microcline pegmatite occurs at the footwall contact. On the west end of the pegmatite the quartz pegmatite occurs at the footwall contact.

The pegmatite contains massive white quartz, light-red microcline, grayish-green muscovite, biotite, and a little deep-green apatite. The quartz and feldspar occur either as large separate masses or in a coarse-grained intergrowth with muscovite. Books of muscovite are found in clusters within the feldspar and the quartz masses. Near the contact with the granite, biotite commonly occurs in flakes about 1 inch in size. Apatite and pale-green muscovite occur along the walls of quartz stringers that cut across feldspar crystals. The apatite probably has formed by replacement of the microcline.

The commercially valuable minerals of the pegmatite are feldspar and mica. The feldspar occurs in light-red crystals, as much as 4 feet long, which on the south side of the knob are grouped together to form a mass of nearly pure feldspar 80 feet long, 25 feet wide, and 10 feet thick. The quartz-microcline-muscovite pegmatite is estimated to contain 20 to 25 percent of recoverable microcline.

The mica occurs in the quartz-microcline-muscovite pegmatite and in large clusters in both the microcline pegmatite and the quartz pegmatite. These clusters may be as much as 2 feet in size. The muscovite is wedged, ruled, and fishtailed, and no mica of sheet or punch quality was observed.

The feldspar reserves in the Johnny pegmatite are estimated to be sufficiently large for the pegmatite to be profitably operated for that mineral. Scrap mica of good quality could be recovered as a byproduct.

FREMONT COUNTY

EIGHT MILE PARK DISTRICT

LOCATION AND GENERAL FEATURES

Eight Mile Park is 5 miles by air line northwest of Canon City and 8 miles by road. It embraces an area of about 10 square miles in T. 18 S., R. 71 W., sixth principal meridian, Fremont County, and is bounded on the north by U. S. Highway 50, on the east by the eastward-dipping hogback of Cambro-Ordovician sediments, on the south by the Royal Gorge of the Arkansas River, and on the west by westward-dipping Paleozoic sediments.

The northern part of the park is nearly level. Toward the south it changes to a gently rolling country and then into a series of deep valleys and ridges. These valleys and ridges have greater relief near the Royal Gorge. The position of the pegmatites has had an important influence on the topography of the southern part of the district. The trend of the ridges ranges from N. 70° E. to east in conformity with the general trend of the larger pegmatites.

GEOLOGY

IGNEOUS AND METAMORPHIC ROCKS

The district is underlain by pre-Cambrian igneous and metamorphic rocks that have been intruded by numerous pegmatites and a few mafic dikes. The pre-Cambrian rocks are overlain unconformably by a sedimentary sequence that begins with the Lower Ordovician Manitou limestones. The pegmatites do not intrude the sediments and are probably pre-Cambrian in age.

The igneous and metamorphic rocks are coarse porphyritic granite, fine-grained granite, aplitic granite, gneissic granite, quartz-mica gneisses, and quartz-mica schists. Gradations between these rocks and lithologic variations probably caused by granitic intrusions are common. The predominant granite is a reddish rock containing large phenocrysts of red microcline in a coarse-grained matrix of biotite, quartz, and microcline. This granite is similar to the Pikes Peak granite in texture and mineralogical composition and probably is of the same age and origin. Large, partly altered schist bodies exposed in it may represent either included blocks or roof pendants. The most abundant wall rock near the pegmatites is a granite gneiss containing biotite, quartz, and red microcline.

The intrusion of the granite was followed by the injection of the pegmatites and aplitic dikes. The pegmatites have profoundly altered the large gneiss inclusions but have affected the wall rocks only by emphasizing or crumpling the metamorphic structures locally. Both the schistosity and gneissic structure strike N. 80° E. and dip steeply to the northwest or the southeast. The youngest instrusives are mafic, aphanitic dikes.

PEGMATITES

Pegmatites are abundant in the southern part of Eight Mile Park. Because of their superior resistance to erosion, the pegmatites are well exposed; the outcrops of the wall rocks are relatively few and poor. The pegmatites range in size from lenses several feet long to roughly tabular bodies that are as much as three-quarters of a mile long and 500 feet wide. The larger pegmatites are irregular, pinching and swelling along their length. The wider parts usually are exposed as prominent knobs called "blow-outs" by the miners. The contacts with the wall rock are usually steep or vertical, but at one place in the School Section mine a horizontal contact was observed. The general strike of these pegmatites is N. 75° E.

The chief minerals are feldspar, quartz, and muscovite with accessory biotite, garnet, tourmaline, and beryl. Bismuth carbonate minerals, columbite-tantalite, and triplite commonly occur in these pegmatites. Graphic and granitic intergrowths of quartz and microcline constitute the largest part of the pegmatites, and a combination of subparallel muscovite flakes with quartz is abundant.

MICA LODE MINE

LOCATION AND HISTORY

The Mica Lode mine (54) has produced more feldspar than any other pegmatite in Colorado and also has been one of the largest scrap mica and beryl producers. It is in the NE¼SW¼ sec. 14, T. 18 S., R. 71 W., sixth principal meridian, where it forms a pronounced conical knob that is a distinct landmark in the south-central part of Eight Mile Park. The mine workings can be reached from U. S. Highway 50 by a dirt mine road 1 mile long.

The pegmatite was located in 1928 by J. E. Meyers of Canon City, who sold a half interest to B. O. Halstead in 1929. The deposit was purchased in 1930 and retained until 1939 by the M & S, Inc., of Denver, Colo. In 1944 it was owned by the Colorado Feldspar Co. of Canon City but leased to Robert A. Shipley of that city.

The economic geology and mineralogy of the deposit have been briefly described by Sterrett,[23] and the para-

[23] Sterrett, D. B., Mica deposits of the United States: U. S. Geol. Survey Bull. 740, pp. 55–56, 1923.

genesis of the pegmatite has been discussed in two papers by Landes.[24]

According to J. E. Meyers the production prior to 1942 was 168,000 tons of feldspar, 25,000 tons of scrap mica, and about 30 tons of beryl. Since 1942 the Metals Reserve Company depot at Salida, Colo., has purchased at least 26.8 tons of beryl from this deposit, and 9,699 tons of scrap mica and 1,091 tons of feldspar have been produced. A mill on the property treats scrap mica-bearing rock.

In the course of the present investigation a preliminary map of the pegmatite was made by E. Wm. Heinrich in the winter of 1942. A more detailed investigation of the eastern 750 feet of the pegmatite was made during 3 days in September and 6 days in October 1944 by J. B. Hanley assisted at different times by A. F. Trites, Jr., and J. W. Adams. During this investigation the pegmatite was mapped by plane table and telescopic alidade.

MINE WORKINGS

The workings consist of four open-cuts near the east end of the pegmatite. The main open-cut (see pl. 4), which is on the south side of the pegmatite knob, is roughly triangular in shape with the apex toward the south. It is 215 feet long and 205 feet wide, with a depth of at least 131 feet at the north face. The deepest part of the pit was flooded to an altitude of 6,045 feet in 1944. A room 45 feet long, 22 feet wide, and about 25 feet high has been made in the north face of this open-cut at the water level. Another large open-cut, designated the "west" cut (see pl. 4), is west of and connects with the main open-cut at an altitude of 6,160 feet. This cut is 60 feet long and 55 feet wide, with a maximum depth of 18 feet. Two smaller cuts are on the east and north slopes of the pegmatite knob. The one labeled "east" cut in plate 4 is roughly L-shaped; it is 50 feet long and 18 feet wide and has an average depth of 4 feet. The other is the original discovery hole and is called the "north" cut. It is 59 feet long, 12 feet wide, and about 10 feet deep.

GEOLOGY

Wall rock.—The wall rock of the Mica Lode pegmatite is probably quartz-mica schist, although granite gneiss occurs near the extreme eastern end. The exposures are very sparse and poor in the vicinity of the pegmatite. In one outcrop on the northwest side of this pegmatite the schistosity strikes N. 68° E. and dips vertically. A body of mixed quartz-mica schist and pegmatite, 50 feet in length and as much as 7 feet in width, is exposed within the pegmatite body from 50 to 100 feet north of the west open-cut. This mixed rock contains schist patches of random orientation that have been reworked by the pegmatite and have lost many of the characteristic features of the original wall rock.

Pegmatite.—The Mica Lode pegmatite is an east-trending body that intrudes schists and granite gneisses. It is tadpole-shaped and at least 2,000 feet long. The eastern 650 feet is as much as 400 feet wide, whereas the western end is less than 100 feet wide. The wider part of the pegmatite is well zoned, but the intermediate zone and core are lacking in the narrower parts. The pegmatite contact with the wall rock, where exposed at two places along the north side of the dike, is sharply defined. The contact is not exposed on the south side, and only the approximate position can be mapped. The contacts of the mixed schist and pegmatite body are extremely vague, as would be expected if this body is an inclusion that has been partly assimilated.

The form of this pegmatite is unknown. The contact dips 60° NE. in the north open-cut and 85° SE. near the place where the dike narrows, but the attitude of the contact cannot be determined elsewhere. The zonal structure of the pegmatite is better known and suggests that the upper part of the pegmatite body may dip 20° to 25° N. but may rapidly steepen in depth, in which case the walls also may be expected to steepen in dip with depth. The surface distribution of the different types of pegmatite and the meager structural evidence suggest that the pegmatite body may be lenticular in section as well as in plan. (See pl. 4.)

A distinct brecciated zone, striking N. 52° E. and dipping 59° NW., is exposed for a length of 110 feet and a width of 8 feet in the southeast face of the main open-cut at the inner end of the old haulage cut at an altitude of 6,100 feet. This brecciated zone has passed through both the wall zone and core of the pegmatite without any displacement of the zonal contact.

The eastern end of the pegmatite (see pl. 4) is well zoned. The three zones, which have been mapped, are a wall zone of quartz-microcline-muscovite-biotite pegmatite, an intermediate zone of muscovite-quartz-albite pegmatite, containing beryl, and a core of microcline-quartz pegmatite. In addition, a unit of microcline-quartz-muscovite pegmatite cuts across the core into the wall zones and merges with the intermediate zone. No border zone was observed at the two places where the pegmatite contact with the wall rock is exposed.

The quartz-microcline-muscovite-biotite pegmatite of the wall zones is composed mainly of white to gray quartz, pink microcline, greenish-gray muscovite, and biotite with accessory black tourmaline, garnet, and apatite. A distinguishing characteristic of this zone is the occurrence of blades of muscovite and biotite that are only 2 or 3 inches wide at their outer ends but are more than 1 foot wide at their inner ends. Some of these blades are more than 10 feet long, and all of them

[24] Landes, K. K., Colorado pegmatites: Am. Mineralogist, vol. 20, pp. 328–329, 1935; Minerals from Eight Mile Park, Colo.: Am. Mineralogist, vol. 24, p. 188, 1939.

have grown at right angles to the pegmatite contact. The average grain size of this pegmatite is probably between 6 inches and 1 foot. This zone is 40 to 50 feet thick along the footwall and at least 18 feet thick along the hanging-wall contact. Where the dike narrows to less than 100 feet it is composed entirely of wall-zone material. The structure of this zone is probably controlled by the external structure of the pegmatite, and the contact of the wall zone with the core or intermediate zone is probably parallel to the walls of the pegmatite.

The muscovite-quartz-albite pegmatite of the intermediate zone is exposed only between the wall zone and the core in the south haulage cut and in the main open-cut. This zone appears to be a pod localized near the footwall at the thickest part of the pegmatite body. It is exposed for 90 feet along the strike, but the lateral extensions are hidden beneath dump material. The zone is 25 feet thick in the walls of the haulage cut. It is parallel in trend to the pegmatite body and dips 22° to 25° N. The exposures suggest that the zone pinches out in depth, but it may widen below the floor of the open-cut.

The zone is composed of grayish-green muscovite, white quartz, and pale-pink to light-lavender albite with accessory beryl, columbite-tantalite, triplite, and some bismuth carbonate minerals. Muscovite occurs chiefly as clusters of radiating blades but also as aggregates of small flakes and books. It is wedged, fishtailed, reeved, ruled, and has pronounced "A" structure. Because of these defects it can be used only as scrap mica. The albite occurs in large masses associated with the muscovite and is generally subplaty in habit. Beryl occurs in pale blue-green to yellow-green subhedral crystals that often are tapered. Many of the crystals are so fractured that they seem to be composed of separate fine grains. The crystals may be as much as 1 foot in diameter and 6 feet long, but the average size is about 2 inches by 1 foot. Triplite occurs in clove-brown masses and rough crystals as much as 1 foot in size; however, as this triplite has also been identified as thorite and allanite, it is probable that more than one of these minerals is present. Columbite-tantalite occurs as subhedral crystals in both albite and muscovite.

The microcline-quartz pegmatite of the core forms a large lens 415 feet long and 225 feet wide on the surface. Its apparent thickness is about 150 feet, but its true thickness may be much greater. It is composed of light-buff to pale-pink microcline and grayish-white quartz with accessory muscovite. The individual masses of microcline and quartz are as much as 35 feet long and 10 feet wide. Quartz generally occurs as isolated masses in a microcline matrix. In the face of the main open-cut these quartz masses are exposed as rough rods and teardrop-shaped bodies that are oriented at right angles to the upper contact of the core with the wall zone.

Muscovite occurs in the core as two types of radiating masses formed by wedge-shaped books, some of which are 3 feet in length. The mica books in one type appear to have grown outward from fracture planes, which are usually coated with small muscovite flakes parallel to the fracture plane. In the other type the books are clustered into spherical masses, commonly 10 feet in diameter, that are scattered through the core.

The microcline-quartz-muscovite pegmatite occurs in an irregularly shaped mass near the center of the pegmatite body. (See pl. 4.) The longer axis of the mass appears to be parallel to the strike of the pegmatite. This unit merges with the muscovite-quartz-albite pegmatite in depth, and although most of this unit occurs within the core, it also cuts across the contact between the core and the upper wall zone in the west cut. It contains the minerals of the zones that it transects, but also contains additional muscovite, albite, and garnet. The muscovite occurs typically as aggregates of flakes about 1 inch in size that are intergrown with light-lavender albite around a central mass of quartz and brownish-red garnet. The typical bodies have a tabular form and are as much as 20 to 30 feet in length and height but only 2 to 3 feet in width. They are usually oriented with the length parallel to the long axis of the main pegmatite body and the intermediate dimension vertical. Where this unit is contained within the core, about 40 to 50 percent of the rock consists of core minerals, and the mica masses make up the rest.

The muscovite and associated minerals in the mica masses may have been formed by replacement along concealed fractures or may have resulted from the assimilation of schist zenoliths, a possibility that is suggested by the large quantity of garnet in the central part of the masses. Comparison of the mica and plagioclase within the masses with the same minerals in the core and the intermediate zone might indicate the origin of the unit.

MINERAL DEPOSITS

The Mica Lode pegmatite has produced over 169,000 tons of potash feldspar, 34,700 tons of scrap mica, 57 tons of beryl, and 615 pounds of columbite-tantalite. The beryl and the columbite-tantalite are in the intermediate zone; the feldspar is in the core and the microline-quartz-muscovite unit; and the scrap muscovite is recovered from all the units except the wall zone. The extensions of these mineral deposits below the water level (6,045 feet altitude) cannot be predicted accurately; hence only the unmined parts above the water level are included in the following descriptions.

Feldspar.—The microcline in the core and in the microcline-quartz-muscovite unit is relatively free from impurities. The core prior to mining had a length of 415 feet, a width of 225 feet, and an apparent thickness of 150 feet. A part of it about 150 feet long, 120 feet wide, and from 55 to 85 feet deep has been mined out. The remaining part of the deposit above the water level is contained in three blocks: one to the east of the main open-cut, one to the west, and one to the north. The east block averages 130 feet in length, 65 feet in width, and a height above water level of 55 feet. The west block averages 110 feet in length, 37 feet in width, and a height above water level of 60 feet. The north block, the largest, has average dimensions of 280 feet in length, 85 feet in depth, and 30 feet in width.

The three blocks, however, contain an unknown quantity of the microcline-quartz-muscovite unit, and consequently the size and shape of the feldspar deposit is not completely known. Production figures indicate that the unit makes up about 15 percent of the core, but the unit was exposed over 37 percent of the west wall of the main open-cut when the pegmatite was mapped. In order to allow for the effect of the unit on the size and shape of the feldspar deposit, it has been assumed that 25 percent of the core is composed of the unit.

The feldspar content of the core is visually estimated at 50 to 60 percent. An estimated 5 to 10 percent of recoverable muscovite also is present. In addition to the feldspar in the core, the microcline-quartz-muscovite unit contains 17 to 20 percent of recoverable microcline.

Scrap muscovite.—Muscovite is recovered from the microcline-quartz-muscovite pegmatite unit, the microcline-quartz pegmatite of the core, and the muscovite-quartz-albite pegmatite of the intermediate zone. The mineral has two distinct habits: wedge-shaped books that are fishtailed, reeved, and ruled and have pronounced "A" structure; and small flakes, about 1 inch in size, mixed with albite and other minerals.

The size and shape of the microcline-quartz muscovite unit is not known beyond the present exposures. However, the block exposed in the west wall of the main open-cut, in the wall between the main open-cut and the west open-cut, and in the north wall of the west open-cut probably extends beyond the present exposures. It is very irregular in shape and size, with a maximum length of 185 feet, a maximum width of 140 feet, and a maximum depth of 115 feet. In estimating reserves, it is assumed to equal a rectangular body 130 feet long, 39 feet wide, and 45 feet high above the water level. In addition to this block, 25 percent of the quantity of rock in the three blocks of the core is assumed to be microcline-quartz-muscovite pegmatite.

The unit is visually estimated to contain 35 to 40 percent muscovite; 35 to 40 percent feldspar, at least 50 percent of which is albite; and 20 to 30 percent quartz and garnet.

Scrap muscovite makes up 5 to 10 percent of the three blocks of the core and 15 to 20 percent of the intermediate zone.

Beryl.—A composite chip sample representing most of the beryl crystals exposed in the main open-cut, analyzed by the Chemical Laboratory of the Geological Survey, had a BeO content of 12.68 percent. Two shipments of beryl sold to the Metals Reserve Company at Salida contained 12.01 percent and 12.44 percent BeO. Many of the beryl crystals are too small to be recovered by hand cobbing, but the beryl usually breaks free from the surrounding minerals, and the recovery can be kept high enough by careful handling to be profitable under 1944 prices.

The columbite-tantalite in the deposit occurs in subhedral crystals usually less than 2 inches in size. The Ta_2O_5 content of the mineral is not known, but it is probably low.

Beryl and columbite-tantalite occur only in the intermediate zone and appear to be distributed uniformly through it. The intermediate zone is 25 feet thick and is exposed in the main open-cut for at least 90 feet along the strike. It has an average depth of 60 feet down the dip. The ends of the zone at the surface are covered by dumps. About 53 percent of the exposed part of the zone has been mined out. On the basis of visual estimates and past-production figures the zone probably contains 1 to 2 percent beryl. It is estimated to contain also 15 to 20 percent muscovite. The content of columbite-tantalite is not known.

Additional reserves are contained in the two dumps to the east of the mill buildings. (See pl. 4.) These are stock piles consisting of about 8,000 tons of crude rock that contains beryl and scrap mica. The dumps are visually estimated to contain between 0.25 and 0.5 percent beryl and 20 to 30 percent muscovite.

RESERVES

The reserves, above water level, of commercially valuable minerals in the Mica Lode pegmatite can be calculated only approximately. It is estimated that an aggregate of about 55,000 tons of feldspar separable by hand, 35,000 tons of scrap mica, and about 110 tons of beryl still remains unmined in the pegmatite. It is probable that the actual reserve of these minerals is two or three times the estimated total.

MEYERS' MINE

LOCATION AND HISTORY

Meyers' mine (51), in sec. 14, T. 18 S., R. 71 W., sixth principal meridian, is east of the Mica Lode mine.

The mine workings are 1,500 feet east of the Mica Lode open-cut and 1.5 miles south of U. S. Highway 50. Although the ends of the two pegmatites are within 200 feet of each other, they are not connected on the surface and probably are not connected in depth, for the two pegmatites have fundamental differences in mineralogy.

The pegmatite was discovered by J. E. Meyers in 1929 and has been operated intermittently by the Colorado Feldspar Co. According to J. E. Meyers the past production has been several thousand tons of feldspar, 200 tons of mica, and about a ton of beryl.

The pegmatite was investigated by E. Wm. Heinrich in the winter of 1942 and was mapped by a combination of plane table-and-telescopic alidade and compass-and-pace methods.

MINE WORKINGS

Two large open-cuts and numerous small exploratory trenches constitute the workings. The eastern and larger open-cut is 120 feet long, 100 feet wide, and 40 feet deep at the face. The western cut is 120 feet in length, ranges from 10 to 70 feet in width, and is 50 feet deep.

GEOLOGY

Both of the two large pegmatites that crop out on the property (see fig. 6) are lenticular, with tapering ends and several offshoots. The northern pegmatite ranges from 100 to 200 feet in width and has been mapped along the trend for a distance of 1,000 feet. The total length of this pegmatite is nearly half a mile. All the outcrops are composed of a granitic intergrowth of minerals, and the pegmatite probably has little value as a source of hand-separable feldspar, scrap mica, or other pegmatite products.

Meyers' mine is in the southern pegmatite, which is more irregular and ranges from 200 to nearly 500 feet in width. It has been mapped along the trend for a distance of 1,500 feet, and it probably continues for an additional 1,200 feet. The pegmatite has a general strike of N. 70° E. and appears to be vertical. The contacts are usually conformable to the metamorphic structures of the wall rock but locally cut across the schistosity. Several large, highly altered schist inclusions have been seen in the pegmatite.

The Meyers' mine pegmatite is poorly zoned. The pegmatite consists mainly of two facies of microcline-muscovite pegmatite: a quartz-muscovite intergrowth in which the mica displays a subparallel arrangement of the flakes and a graphic to granitic intergrowth of quartz and microcline. Masses of these two pegmatite facies are interspersed with transecting bodies of massive quartz, blocks of microcline, and large blades of intergrown biotite and muscovite. A few crystals of beryl are exposed.

The western end of the pegmatite contains two types of pegmatite: the microcline-muscovite pegmatite described above and cleavelandite-lepidolite pegmatite that occurs as patches within the microcline-muscovite pegmatite. Seven patches, the largest of which is exposed for 50 feet in length and 30 feet in width, were mapped.

The microcline-muscovite pegmatite contains quartz, microcline, muscovite, biotite, black tourmaline, garnet, and beryl. The beryl is pale green to dull blue, earthy to chalky, and crumbles upon exposure to weathering.

Muscovite, in flat books as much as 6 inches in width, occurs in minor quantities, and some of it is sufficiently free from imperfections to yield punch mica and small sizes of sheet mica, but much of it is heavily stained with iron oxide. This mica is too sparsely distributed to be recovered profitably under 1942–44 conditions in those parts of the pegmatite in which it is the only mineral of commercial value. Masses of scrap mica are rare in the Meyers' mine pegmatite.

The minerals of the cleavelandite-lepidolite pegmatite are buff to light-red cleavelandite, lepidolite, quartz, muscovite, beryl, and several varieties of tourmaline. Columbite and amblygonite are reported from these patches, but neither was found in place.

The cleavelandite occurs in radiating masses in which the plates are as much as 6 inches long. Lepidolite occurs in two forms: fine- to medium-grained, lilac to deep-purple lepidolite and platy, pale-lilac lepidolite. Much of the silvery-green muscovite has an outer rim of pale lepidolite.

Beryl occurs in large lemon-yellow euhedral crystals and in smaller subhedral crystals surrounded by fine-grained lepidolite. It differs from beryl in the microcline-muscovite pegmatite by having a porcelanous texture, a much brighter yellow color, distinct secondary parting, and no tendency to disintegrate upon exposure.

Columbite is reported to occur with red, green, and black tourmaline in masses that weigh as much as 600 pounds. An analysis given by Headden [25] showed a Cb_2O_5 content of 56.48 percent, a Ta_2O_5 content of 22.12 percent, and a density of 5.6608.

The amblygonite reported from this locality is fremontite in which sodium has replaced part of the lithium and hydroxyl part of the fluorine.

MINERAL DEPOSITS

In the microcline-muscovite pegmatite, which makes up 99 percent of the pegmatite body, the beryl and mica content is too low to permit profitable extraction of these minerals, but locally the rock can be mined for feldspar.

The feldspar generally occurs in small, isolated blocks, and much of it contains a high percentage of

[25] Headden, W. P., Mineralogic notes: No. 11: Colorado Sci. Soc. Proc. 8, pp. 57–58, 1904–07.

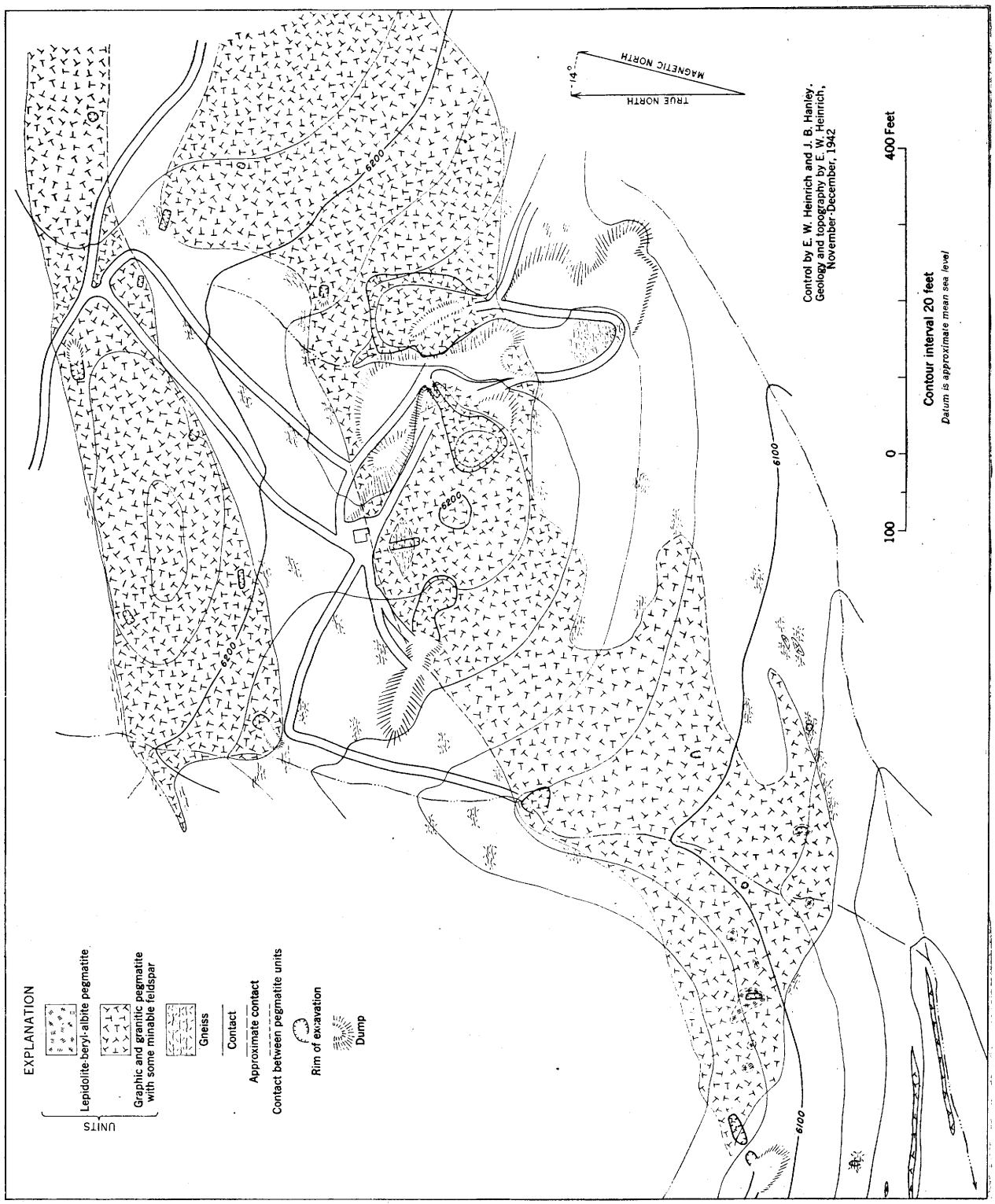

FIGURE 6.—Map of Meyers' mine, Eight Mile Park, Fremont County, Colo.

iron oxide. The north wall of the western open-cut was estimated to contain 25 percent graphic granite, 25 percent quartz-muscovite intergrowths, 30 percent quartz, 5 percent muscovite, and 15 percent recoverable feldspar. The main face contained less than 10 percent recoverable feldspar, and most of this was the variety high in iron. One small beryl crystal was seen in the entire cut.

The past-production figures indicate that the beryl content of the microcline-muscovite pegmatite is about 1:13,000.

The cleavelandite-lepidolite pods have an aggregate surface area of about 1,600 square feet. These pods are estimated to contain 70 percent cleavelandite, 20 percent quartz, 7 percent muscovite and tourmaline, 2 percent lepidolite, and 1 percent beryl. Although the beryl occurs in crystals as much as 2 feet in diameter, the secondary fractures and the occurrence of much small subhedral beryl necessitate milling. Lepidolite, scrap mica, feldspar, and probably amblygonite and columbite could be recovered as well as the beryl.

SCHOOL SECTION MINE

The School Section mine (78), in the southwestern part of Eight Mile Park, is in lots 1 and 2 of sec. 16, T. 18 S., R. 71 W., sixth principal meridian, Fremont County, and is 1 mile south of U. S. Highway 50. The Royal Gorge highway passes within a quarter of a mile of the main cut. The land on which the pegmatite crops out belongs to the State of Colorado.

The property was first leased by Robert A. Shipley, who began mining in 1929 and continued until 1931. For the next 4 years it was leased to the M & S, Inc., of Denver. The mine was inactive from 1936 until 1939, when it was leased and operated by the Colorado Feldspar Co. The total production to 1942 is several thousand tons of feldspar, 150 tons of scrap mica, and probably less than a ton of beryl.

The property was examined by E. Wm. Heinrich in the winter of 1942 and was mapped by pace and compass.

Seven open-cuts (see pl. 5) and three prospect pits, the largest 600 feet in length and as much as 200 feet wide, have been made in the pegmatite.

The School Section pegmatite is an irregular, pipelike intrusive that in most places cuts across the wall rocks. To the northwest of the central pipe are at least two narrow, branching offshoots. These offshoots and the central pipe have vertical contacts, but a southeastern offshoot is flat lying, and the horizontal basal contact was observed at one place. The central pipe is about 500 feet in diameter. (See pl. 5.)

The minerals of the pegmatite are quartz, microcline, muscovite, biotite, black tourmaline, apatite, beryl, garnet, bismuth carbonate, and a mineral that has been identified both as triplite and thorite.

According to R. A. Shipley, the largest open-cut was made in a rich feldspar concentration, but the exposures at the time of field examination showed little evidence of zonal structure. The main part of the pegmatite is a mixture of quartz-muscovite intergrowths and graphic to granitic quartz-microcline intergrowths. Blades of intergrown muscovite and biotite as much as 6 feet long, fine-grained apatite, clusters of large, radiating, black tourmaline crystals, and masses of fine-grained muscovite are found. The rarer minerals—beryl, bismuth carbonate, and triplite or thorite—are associated with the masses of fine-grained mica.

The exposures are visually estimated to contain not more than 10 percent recoverable feldspar. The past-production figures indicate that the beryl content of the pegmatite is about 1:50,000. However, small parts of the pegmatite are much richer in beryl and probably contain as much as 0.1 percent beryl. These concentrations are small, and their positions are unpredictable. Unless beryl occurs with minable quantities of feldspar or mica, it is not recoverable at a profit. Small quantities of flat mica of punch size are scattered throughout the pegmatite, but recovery of this mica is likewise unprofitable except where it occurs with minable quantities of feldspar.

R. H. MAGNUSON PROSPECT

The R. H. Magnuson prospect (64), in sec. 14, T. 18 S., R. 71 W., sixth principal meridian, is half a mile by air line south of the Mica Lode mine on a homestead owned by R. H. Magnuson. It was examined by E. Wm. Heinrich in 1942.

The pegmatite crops out on the south side of an east-trending ridge that lies immediately north of the former Priest Canyon road. The pegmatite strikes east and has been crosscut by a 125-foot adit driven at right angles to the strike. The first 70 feet in from the adit portal is in pegmatite; the last 55 feet, in a fine-grained red granite. A single beryl crystal 2 feet in diameter and 3.5 feet in length is exposed in the east wall of the adit near the portal, and fragments of yellow beryl are numerous in the float below the pegmatite. The exposures in the adit are visually estimated to contain 70 percent graphic granite, 10 percent recoverable feldspar, and 20 percent quartz.

BORDER FELDSPAR NO. 1 AND NO. 2 PROSPECTS

The Border Feldspar No. 1 and No. 2 prospects (10), in secs. 21 and 22, T. 18 S., R. 71 W., sixth principal meridian, are in Royal Gorge Park, which is owned by Canon City. These prospects are claimed by Robert A. Shipley. They were examined by E. Wm. Heinrich in 1942.

The Border Feldspar No. 1 prospect is 0.75 mile by air line south of the School Section mine. The pegma-

tite crops out on the west end and top of a long east-trending ridge. It trends north and is probably vertical. On the north slope of the ridge it has a depth of 40 feet and an average width of 100 feet. Its total length is not known, but the exposed length is 50 feet. Quartz, feldspar, and muscovite are the chief constituents. Graphic granite occurs in many of the surface exposures. The eastern half of the outcrop is visually estimated to contain 40 percent recoverable feldspar. Muscovite is visually estimated to form 1 percent of the pegmatite.

The Border Feldspar No. 2 prospect is on the east end of the same ridge, several hundred yards southwest of the Royal Gorge highway. The pegmatite is at least 200 feet wide and strikes east along the ridge. It is composed chiefly of quartz and graphic granite with a little muscovite and numerous crystals of black tourmaline. Minable concentrations of feldspar and mica are not exposed.

PHANTOM CANYON BERYL PROSPECT

The Phantom Canyon beryl prospect (62) is about 19 miles from Canon City. It can be reached by a difficult trail, about 2 miles long, that leaves Colorado State Highway 67 two miles south of Adelaide, a former station on the Florence & Cripple Creek Railroad. In 1943 the trail could be reached only from Victor, Colo., as the highway had washed out between Canon City and the trail. The prospect was discovered in 1938 by Mr. Bartlett and Mr. Deeds of Canon City. It was operated in 1939, and the reported production was 12 carloads of feldspar and 2 carloads of scrap mica. The prospect was examined by E. Wm. Heinrich on May 30, 1943.

The workings in the pegmatite include an open-cut that is 50 feet long and has a maximum depth of 30 feet. It widens from 10 feet at the mouth to 50 feet at the face.

The pegmatite strikes N. 45° E. and is vertical. It is at least half a mile long and ranges from 65 to 200 feet in width. It has been deeply eroded by a steep valley at right angles to the strike of the dike and forms a conspicuous topographic ridge all the way to the summits on both sides of the valley. The contacts with the pink granite wall rock are gradational. The pegmatite is essentially granitic and is composed of a coarse granitic to graphic intergrowth of quartz and red microcline with small quantities of muscovite and garnet. In the open-cut most of the rock exposed is a fine-grained quartz-muscovite intergrowth together with graphic granite. Recoverable feldspar is estimated to make up less than 10 percent of the exposures. Ten yellow-green beryl crystals, the largest 3 inches in diameter and 6 inches in length, are exposed in the face of the open-cut, and four more beryl crystals, the largest 6 inches in diameter, were seen in the small discovery hole adjoining the open-cut. A few small crystals of columbite occur in the dark-red feldspar adjacent to the beryl crystals.

The Phantom Canyon pegmatite probably does not contain enough beryl to warrant operations for that mineral.

OAK CREEK GRADE PROSPECT

The Oak Creek Grade prospect (59) is in sec. 8, T. 20 S., R. 70 W., sixth principal meridian, Fremont County, about 300 feet west of Colorado State Highway 143. It is owned by the Colorado Feldspar Co. of Canon City and was visited by E. Wm. Heinrich in 1942.

A branching pegmatite containing numerous granitic inclusions has intruded the gray granite wall rock. This pegmatite contains clusters of biotite sheets as much as 12 feet in diameter and is probably iron-rich. The feldspar is a dark-red microcline that contains many quartz stringers.

SPIKEBUCK MINE

The Spikebuck feldspar mine (80), in secs. 27 and 28, T. 18 S., R. 72 W., sixth principal meridian, Fremont County, is 5 miles west of the mouth of McIntyre Gulch and 3½ miles in an air line S. 38° W. of Parkdale, Colo. The mine is in a semiarid area of moderate relief. It is reached over a steep, unimproved mine road up McIntyre Gulch from Colorado State Highway 9, two miles south of Parkdale. The deposit is owned by the M & S, Inc., of Denver.

The mine workings consist of a large open-cut 250 feet long, 69 feet wide, and 125 feet in maximum depth. Three benches at different levels have been made in this open-cut.

The pegmatite is over 800 feet long, ranges in width from 40 to 110 feet, and crosscuts green amphibolite composing the wall rock. The pegmatite is irregular in shape. It strikes in general nearly east and is vertical. At the west edge of the open-cut the pegmatite splits into four branches, the largest of which is 50 feet thick and tapers upward into a blunt nose. The other three branches thin out into elongate stringers. On the south wall of the open-cut at the lowest level a 3-foot diabase dike striking N. 53° W. and dipping 50° SW. cuts across the pegmatite and splits upward around an inclusion of pegmatite. Large zones of finely broken feldspar and quartz in the pegmatite indicate that faulting occurred after these minerals had crystallized.

The pegmatite is roughly segregated into two zones: an outer zone of quartz-microcline-muscovite pegmatite and a core of microcline and quartz.

Coarse-grained, blocky microcline feldspar is estimated to compose 40 percent of the pegmatite, and quartz makes up 25 percent. Muscovite occurs as "bull" mica and in wedge-shaped blades arranged in comb structure. The accessory minerals—black tourmaline, biotite, and garnet—are abundant in the outer border zone of the pegmatite near the septa between the four branches. Reddish-brown jasper occurs in small pods along fracture planes in feldspar and is associated with white chalcedony and opal.

The pegmatite contains an excellent deposit of potash feldspar of commercial grade, and scrap mica can be obtained as a byproduct.

MICANITE DISTRICT

LOCATION AND HISTORY

The Micanite pegmatite district embraces an area of about 4 square miles in T. 15 S., R. 72 W., sixth principal meridian, Park County, and T. 16 S., R. 72 W., sixth principal meridian, Fremont County. It is 5 miles by air line S. 32° E. from the town of Guffey and about 27 miles by road from Canon City, the nearest market and railroad shipping point. The pegmatites lie along Mac Gulch, a tributary to Currant Creek. Colorado State Highway 9 passes through the district, and ranch and mine roads lead to a few of the deposits.

The topography is moderately steep with a maximum relief of 1,000 feet and an average altitude of 8,500 feet. Mac Gulch, a permanent stream, is the nearest source of water for mining. In general, the country is only slightly wooded, but the northernmost pegmatites crop out, in part, within a good stand of pines that could furnish all the timber needed in mining.

The deposits described in this report, with the exception of the Beryllium Lode, have been separated into two geographic groups—the northern and the southern. The northern group includes the Star Girl, Rose Dawn, Rosemont, Tickon, Climax, and Whopper pegmatites (see fig. 7), which are near or on the top of the divide between Mac Gulch and the eastern tributary joining it at the Rowe ranch. The Star Girl, Rose Dawn, and Tickon pegmatites crop out along the southern edge, the Rosemont pegmatite along the eastern edge and the Climax and Whopper pegmatites at the heads of minor gulches in the gently rolling plateau at the summit of this divide.

The southern group includes the Lower and Upper South, Rowe's North, Rowe's No. 2, Rowe's South, and three small pegmatites, all of them cropping out along the steep slopes of the eastern wall of Mac Gulch. The Lower South mine and the Rowe prospects are in the valley, and the other deposits are high on the valley wall.

In 1902 and 1903 the United States Mica Co. located the northern group and the Lower South and Upper South pegmatites. A great deal of development work and mining was done by this company from 1904 to 1907, when operations ceased. The company operated a fabrication mill about 350 feet north of

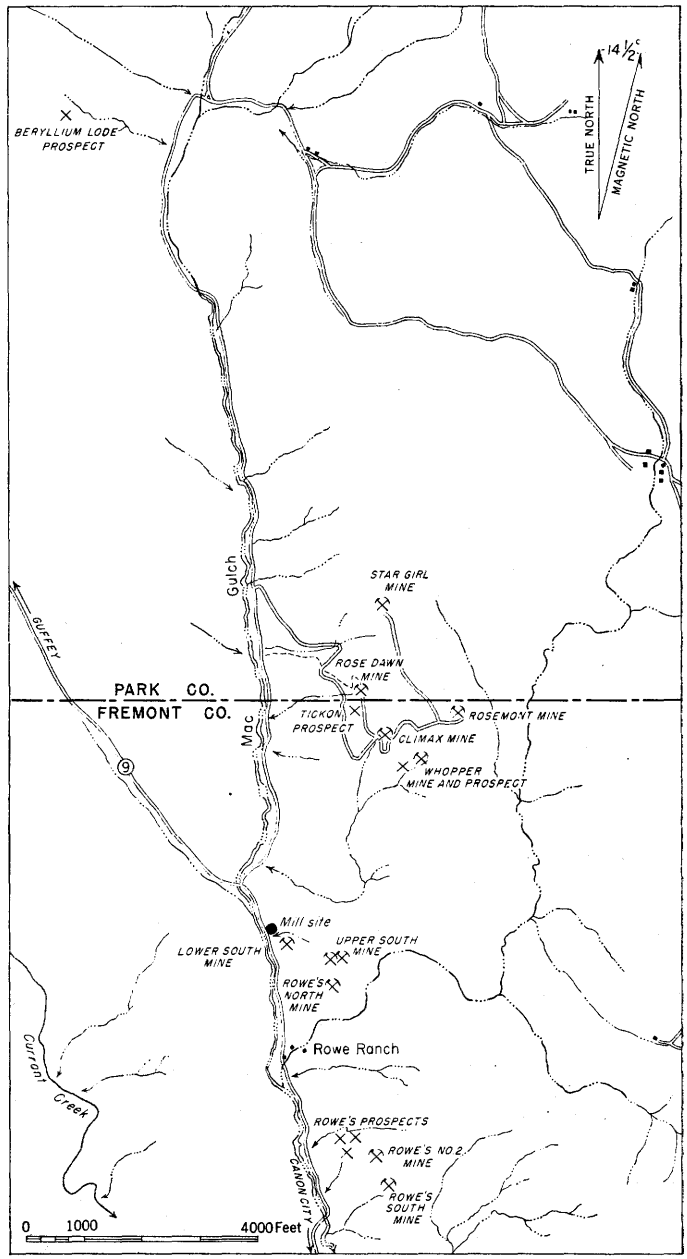

FIGURE 7.—Index map of Micanite district, Fremont and Park Counties, Colo.

the Lower South mine, but there is no available record of the products made in this plant. Imperfect mica disks and washers ranging from 0.6 inch to 2 inches in diameter were found in the reject pile at the mill site. The district remained inactive from 1907 to 1934, when these deposits became the property of the Colorado Feldspar Co. of Canon City, Colo. From 1934 to 1942

this company produced about 2,000 tons of feldspar and 175 tons of scrap mica.

The Rowe pegmatites were located in 1902 by Frank L. Rowe of Micanite. The present ownership of the deposits in the southern group is not known.

The mica pegmatites of the Micanite district were examined by Sterrett in 1908 and 1913, and he described in his report [26] the Climax; the North, now known as the Rose Dawn; the East, now called the Rosemont; the South, now named the Upper South; and Rowe's North mines.

The mines and prospects in the northern group, the Beryllium Lode prospect, and the Lower South mine were examined briefly by E. Wm. Heinrich in October and November 1942, and a preliminary map of the Climax mica mine was made by E. Wm. Heinrich and J. B. Hanley on November 17, 1942.

All the pegmatites were investigated again by J. B. Hanley and A. F. Trites, Jr., between September 15 and 25, 1944. The Climax and Rose Dawn pegmatites were mapped by telescopic alidade and plane table. The Whopper pegmatite was mapped by a combination of compass-and-tape and compass-and-pace methods, and the workings of the Lower South mine were mapped by compass and tape. The Star Girl, Rosemont, Upper South, and Beryllium Lode pegmatites were only briefly examined.

GEOLOGY

The Micanite district is in a region underlain by pre-Cambrian schists and gneisses. No Pikes Peak granite crops out in the district, but a large body of this granite is known to occur a few miles to the east. The pre-Cambrian metamorphic rocks are surrounded on the east, north, and west by Tertiary volcanic rocks, which are also exposed 2 miles to the southeast.

The metamorphic rocks are quartz-feldspar-biotite gneiss and quartz-sillimanite schist. The wall rock of most of the pegmatites is an older, dark-gray granite gneiss containing porphyroblasts of pink or red feldspar and abundant biotite. Quartz-sillimanite-biotite schist is the wall rock of the Rose Dawn, Climax, and Whopper pegmatites, and this schist is probably the wall rock of the Tickon pegmatite.

In general, the pegmatites of this district are similar in internal structure and mineralogy. The surface exposures are poor, and structure, zoning, lithology, and grade can be determined only in the mine workings. However, it is possible to delimit rather accurately the surface shape and extent of the pegmatites by means of float and marked differences in the soils formed from pegmatites and wall rocks. The accuracy with which the contacts can be determined is less where the slopes are steep.

If the pegmatite is well zoned, as is the Climax pegmatite, it contains a very fine grained border zone ranging from one-eighth of an inch to 2 inches in thickness, a wall zone of quartz-microcline-muscovite-plagioclase-biotite pegmatite, an intermediate zone of quartz-muscovite-plagioclase pegmatite, containing sheet mica, and a core of quartz-microcline pegmatite. During the formation of most of the pegmatites conditions were not suitable for the formation of the intermediate zone, and in these pegmatites only scrap mica is found. The core in the well-zoned pegmatites such as the Climax, Rose Dawn, and Beryllium Lode is predominantly quartz with microcline in minor quantities. In the other pegmatites quartz and microcline occur in the core in nearly equal quantities. However, the Whopper pegmatite has a quartz core on the surface, whereas in depth the microcline increases in abundance until the rock is similar in composition to the less well zoned pegmatites of the district.

Three minerals of commercial value occur in the pegmatites in the Micanite district. Two of them, muscovite and microcline, are found in concentrations large enough to be mined profitably, and the third, beryl, occurs in small quantities in a few of the deposits.

The descriptions of individual mica deposits in the northern and southern groups are arranged in the order of their importance as potential producers. The northern-group pegmatites are more likely to be productive than those in the southern group and consequently are described first. However, it is probable that the first two pegmatites described in the southern group might produce more than the Tickon pegmatite, which is described in the northern group.

NORTHERN GROUP

The Climax mine in the northern group, which is about 3,700 feet northeast of the mill site, is used as the main reference point in describing the location of the other deposits in this group.

CLIMAX MICA MINE

The Climax mica mine (21) is about 800 feet southeast of the Rose Dawn mine and 3,700 feet northeast of the former town of Micanite. (See fig. 7.)

No record of the mica produced during the United States Mica Co.'s operations is available, but it is reported that many tons of mine-run mica was obtained. Intermittent operations by the Colorado Feldspar Co. yielded about 500 tons of feldspar and 50 tons of scrap mica.

Mine workings.—The Climax pegmatite has been explored by eight open-cuts (see pl. 6), three of which were made by the Colorado Feldspar Co.; an inclined

[26] Sterrett, D. B., Mica deposits of the United States: U. S. Geol. Survey Bull. 740, pp. 51–55, 1923.

raise 16 feet long between pits 7 and 4; a 9-foot drift from the lower part of pit 5; and a series of underground workings at the southeast side of pit 7. This series of underground workings consists of a room, from which an 11-foot drift leads west to the foot of a backfilled shaft, and a 6-foot drift to the south, which connects with a short inclined shaft.

All the United States Mica Co.'s workings described by Sterrett [27] except the "lower tunnel" were still accessible in 1944. The probable position and extent of the lower tunnel can be determined accurately from Sterrett's sketch [28] and the position of the caved workings as shown in plate 6. Pit 7 was enlarged during the feldspar mining, and the size and extent of the former mica workings in the present pit cannot be determined.

Geology.—The Climax pegmatite is poorly exposed, but the shape and the extent of the pegmatite can be determined fairly well from the distribution of pegmatite material in float and soil. The only good outcrops are of quartz pegmatite. (See pl. 6.) The contact between the pegmatite and the deeply weathered quartz-sillimanite schist wall rock is exposed only in three places, all within the mine workings.

The pegmatite is a shallow, crosscutting body shaped like an irregular star. The surface exposure is 455 feet long, trending N. 32° E. Two major branches or arms extend to the northwest and to the southeast from the center of the main body. The dip of the walls and the internal structures can be determined only in a few places within the mine workings. However, the available information and Sterrett's sketch of the north face of the lower tunnel suggest that the pegmatite probably does not extend more than 30 feet below the surface.

Section *A–A′*, plate 6, shows both the probable shape in depth and the internal structure of the pegmatite. The general dip of the pegmatite appears to be nearly parallel to the present erosion surface. Part of the upper half of the pegmatite has been eroded so that the core is now well exposed, and it seems probable that the present surface of the quartz pegmatite core is approximately at the contact between the core and either the intermediate or wall zone. A veneer of wall-zone pegmatite 3 to 4 feet thick is actually exposed immediately above the quartz core between pits 7 and 4.

The effect of erosion, combined with the three major and two minor synclinal rolls (see pl. 6) and their complementary anticlinal structures, probably is responsible for the irregular starlike outcrop plan of the pegmatite. The axes of these synclinal structures converge in pit 7. This convergence may have been the controlling factor in the localization of a very rich mica concentration that has been extensively mined.

[27] Sterrett, D. B., op. cit. p. 52.
[28] Sterrett, D. B., op. cit. p. 53.

Four distinct zones are exposed in the pegmatite. They are a narrow border zone, a wall zone of quartz-microcline-albite-muscovite-biotite pegmatite, an intermediate zone of quartz-albite-muscovite pegmatite, and a core of quartz pegmatite. Small isolated patches of quartz-muscovite pegmatite, exposed at the outer edges of the core in pits 4, 5, and 6, may possibly constitute a fifth zone.

The quartz-microcline-albite-muscovite-biotite pegmatite of the wall zone is composed of quartz, reddish microcline, pale-pink to white albite, greenish-gray muscovite, and biotite. The average grain size is about 4 inches, although masses of quartz and microcline 2 feet in size are not uncommon. Large books of tanglesheet muscovite and blades of biotite 6 inches wide are exposed in pit 3. Quartz and microcline commonly are graphically intergrown. In the few places where this zone is fully exposed the thickness is 2.5 feet, but the zone is probably thicker in other parts of the pegmatite body.

The border zone is composed of the same minerals as the wall zone but is much finer grained. This zone ranges from a quarter of an inch to 2 inches in thickness.

The quartz-albite-muscovite pegmatite of the intermediate zone is composed of white quartz, white to very pale pink albite in masses about 6 inches in size, and greenish-gray muscovite. This zone is discontinuous and is well exposed only in the underground workings and in the west wall of the lower part of pit 5. At the surface it is exposed only in a few outcrops, and throughout the main outcrop area of the pegmatite no trace of it can be found.

Muscovite commonly occurs in spherical masses made up of wedge-shaped books that are radially arranged. Several of these masses are as much as 4 feet in diameter, but the average size is about 2 feet. Single books of muscovite exposed in the northeast face of the shaft are 27 inches long, 12 inches wide, and 7 inches thick.

The quartz pegmatite contains white to pale-pink quartz with accessory cream-colored microcline, which occurs mostly in isolated subhedral to euhedral masses as much as 4 feet in size. Quartz commonly forms at least 90 percent of the rock, but in the underground workings the rock contains as much as 40 percent microcline, which here is in masses as much as 8 feet in size. Crystals of cordierite, 2 feet wide and as much as 8 feet long, extend across the intermediate zone into the core. The crystals are almost completely altered to muscovite.

The quartz pegmatite adjacent to the intermediate zone commonly contains isolated masses of muscovite similar in mode of occurrence to those of the intermediate zone. In general the distribution of these masses is controlled by the structure of the main pegmatite, but the exposure in pit 6 indicates that this quartz-

muscovite pegmatite may occur also where the intermediate zone is poorly developed or completely lacking. The intermediate zone is not exposed in the extreme western part of the pegmatite, and the quartz-muscovite pegmatite takes its place in the zonal sequence.

Mica deposits.—The major mica deposits are along the outer edge of the quartz pegmatite core, either in the quartz-albite-muscovite pegmatite zone or the quartz-muscovite pegmatite. These units are not continuous, and the distribution of mica within them appears to be erratic. The size of the mica-bearing body cannot, therefore, be accurately determined. However, the quartz-albite-muscovite zone ranges from 1.2 to 5 feet in thickness, and the muscovite masses in the quartz-muscovite pegmatite adjacent to the intermediate zone have been found for a distance of 4 feet away from the contact of these two zones. The maximum thickness of mica-bearing body formed by these zones is 9 feet, the minimum thickness about 1 foot, and the average thickness 3 feet. The perimeter of the quartz pegmatite core at the surface is about 450 feet, exclusive of that part of the core exposed in pit 7 and the two small patches north of the main quartz mass.

The average grade of the quartz-albite-muscovite pegmatite zone is visually estimated to be 5 to 10 percent muscovite, although locally the grade is as high as 50 percent. The average grade of the quartz-muscovite pegmatite is visually estimated to be 2 to 5 percent muscovite, and the average grade of the mica deposit formed by these two zones is 5 percent muscovite. The recovery of sheet mica from a single 19-pound lot was 10 percent by weight. The sample was small, however, and was taken from a single book exposed in the north wall of pit 7; probably it does not indicate either the recovery or quality of sheet mica that would be obtained in mining.

The muscovite is commonly black-stained and spotted, although clear, flat, hard sheets can be found in most books. Ruling and ribboning, as well as "A" structure, are major defects in this mica. Sheets of light- and dark-stained mica as large as 5 by 10 inches have been rifted from books found in two small stock piles at the mine.

The 19-pound sample already mentioned was prepared by Mrs. Merle Thompson and qualified by G. A. Purcell, vice president of the Colonial Mica Corporation. The results of qualification are as follows:

Quality	Percent by weight	Quality	Percent by weight
No. 1	5	No. 2 inf	28
No. 2	17	No. 3	50

The size patterns for the four qualities as determined by the Colonial Mica Corporation at Custer, S. Dak., are given in table 3.

TABLE 3.—*Size patterns of qualities of mica from Climax mine, Micanite district, Fremont County, Colo.*

Size	No. 1	No. 2	No. 2 inf.	No. 3
Inches	*Percent by pieces*	*Percent by weight*	*Percent by weight*	*Percent by weight*
1 x 1	36	11	13	25
1¼ x 1¼	40	22	17	----
1½ x 2	14	11	23	25
2 x 2	10	17	26	----
2 x 3	2	28	----	50
3 x 3	----	11	26	----

Electrical tests by the National Bureau of Standards on part of this sample gave the results shown in table 4.

TABLE 4.—*Electrical tests on mica from Climax mine, Micanite district, Fremont County, Colo.*

Specimen No.	Thickness, in millimeters	Area between electrodes	Power factor, in percent	
			At 100 kilocycles per second	At 1,000 kilocycles per second
C11 [1]	0.09	No visible defects	0.04	0.04
C12	.11	do	.03	.03
C13	.11	Few small red-brown stains, broken films.	.04	.03
C14	.13	Number of red-brown stains	.41	.15
C21	.09	No visible defects	.03	.03
C22	.09	do	.04	.03
C23	.08	Few small red and black stains	.15	.11
C24	.08	Large black spot, large red spots	.08	.07
C31	.04	No visible defects	.14	.11
C32	.11	Number of large black and red-brown spots and stains.	.23	.10
C33	.06	Red-brown stains	.93	.55
C34	.08	Dark and black stains	.42	.31
C111	.08	No visible defects	.18	.09
C112	.09	Broken film	.02	.02
C113	.06	Black spots, one red-brown spot, and long streak.	.24	.14
C114	.07	Four dark spots	.02	.03

[1] The numbers C11 to C14, C21 to C24, C31 to C34, and C111 to C114 were applied by the National Bureau of Standards to test specimens from No. 1, No. 2, No. 3, and No. 2 inf. classifications, respectively.

Reserves.—The indicated reserves of crude mica, calculated on the basis of a continuous 3-foot-thick zone around the core to a depth of 15 feet, the maximum depth of the workings, below the present surface, are 94 tons of muscovite in 1,880 tons of rock.

The total inferred mica reserve in the pegmatite is probably about three times the indicated reserve. A few hundred tons of microcline might be recovered as a byproduct.

ROSE DAWN MICA MINE

The Rose Dawn mica mine (70) is about 300 feet north of the Tickon pegmatite and 800 feet northwest of the Climax mine. (See fig. 7.)

No record of the mica produced during previous operations is available, but it is reported that many tons of crude mica were recovered by the United States Mica Co. A few tons of potash feldspar have been produced by the Colorado Feldspar Co.

Mine workings.—Many of the workings described by Sterrett [29] were inaccessible in 1944 because of ex-

[29] Sterrett, D. B., op. cit. p. 51.

tensive slumping of the schist walls of the open-cut and because the later work of the Colorado Feldspar Co. caved many of the former workings. However, the probable position, though not the extent, of many of the United States Mica Co.'s tunnels and open-cuts can be roughly determined. The large tonnage of old dump material indicates that the older workings were quite extensive.

The accessible mine workings (see fig. 8) comprise two open-cuts and two tunnels. The larger open-cut is irregular. It is 160 feet long, N. 22° E., and as much as 75 feet wide and 32 feet deep at the face. Twenty-five feet northeast of the larger cut and 40 feet higher on the hillside is a second open-cut 20 feet long, 8 feet wide, and 20 feet deep. The longest of the old tunnels is at the same altitude as the floor of the larger open-cut and 48 feet to the north. It extends S. 78° E. for 83 feet under the pegmatite. The second tunnel, which was driven along the mica concentration on the hanging wall, extends S. 75° E. for 18 feet, then turns nearly south for 13 feet.

Geology.—The Rose Dawn pegmatite as exposed is a lenticular body, trending N. 28° E. and dipping 20° to 30° SE., and part of it crops out along the steep hillside as a 20-foot cliff. The pegmatite cuts across the schistosity of the pre-Cambrian quartz-biotite-sillimanite schist that forms the wall rock. The footwall contact and the northern end of the dike are poorly exposed because of heavy float and talus cover. The talus of pegmatite blocks in the open-cut at the portal of the long tunnel is so well compacted that only close examination shows its true nature. The hanging wall is well exposed along the northern half of the dike but along the southern half is exposed for only 4 feet in a distance of 120 feet. The south end of the dike is hidden.

Locally the schist is highly folded and crumpled, but its general strike in the region is nearly north and its dip is 65° to 75° E. Although the exposed contacts of the pegmatite are sharp, some pegmatitic material has been introduced into the schist. In the long tunnel the first 10 feet is migmatized schist in which pegmatitic material makes up about 50 percent of the rock. Similarly, the schist exposed in the back of the short tunnel has been injected by pegmatitic material, but here the most noticeable feature is an increase in the muscovite content of the schist.

The internal structure of the pegmatite is obscured because of past mining operations and caving of the open-cut, but two definite zones and a probable third zone can be identified. The wall zone is quartz-microcline-albite-muscovite pegmatite, and the core is quartz pegmatite. Albite-muscovite rock probably occurs between the core and the wall zone.

The most conspicuous zone is the quartz pegmatite core, which occurs only in the extreme southern part of the pegmatite. It is well exposed as five closely spaced pinnacles left standing above the level of the old workings. The core is composed of white to pale-rose quartz, with accessory subhedral masses of pink microcline. A few aggregates of fine-grained muscovite and albite are exposed at the north end of the northwest quartz pinnacle and at the east end of the caved crosscut on the south side of this pinnacle. The albite in the aggregates is chalky white, and the muscovite forms gray-green plates an inch or less in size. Crystals of mottled flesh-pink and green apatite, as much as 3 feet long and 1 foot wide, occur in the quartz on the west side of the northwest pinnacle.

The second definite zone is the wall zone, which is composed of very coarse grained quartz-microcline-albite-muscovite pegmatite. Adjacent to the hanging-wall contact and near the albite-muscovite pegmatite unit the wall zone is rich in muscovite. The plagioclase-muscovite pegmatite (see fig. 8) is believed to be a facies of the wall zone, although it has a much higher muscovite content than is normal. A small part of the wall zone was mined for microcline by the Colorado Feldspar Co.

The wall zone is composed of quartz, pink to red microcline, pink albite, and gray-green muscovite, with accessory light-brown garnet crystals. Microcline occurs in subhedral masses as much as 3 feet in size, and several crystals 10 feet across are reported to have been mined. Muscovite makes up as much as 50 percent of small parts of the zone, and books of muscovite 8 inches across and 4 inches thick occur in abundance. The muscovite is commonly strongly ruled and wavy but in general does not have pronounced "A" structure. It is black-spotted and streaked, and some pieces show tiny red spots.

The albite-muscovite pegmatite surrounding the core can be classified as a zone only tentatively. This unit is exposed along parts of the walls of the most southerly and easterly pinnacles of the quartz pegmatite only as a veneer too thin to be mapped. The position of the old working, an examination of the dump material, and the statement by Sterrett[30] that "the pegmatite was richest in mica on the east side of the quartz, but pockets of mica were also mined along the west side and to the north of it" suggest that the albite-muscovite pegmatite formed a zone surrounding the core.

The albite-muscovite pegmatite, as exposed in the veneers of the walls of the workings and in fragments on the dumps, is composed of pale-pink albite and gray-green muscovite. No beryl was seen in place, but well-

[30] Sterrett, D. B., op. cit., p. 52.

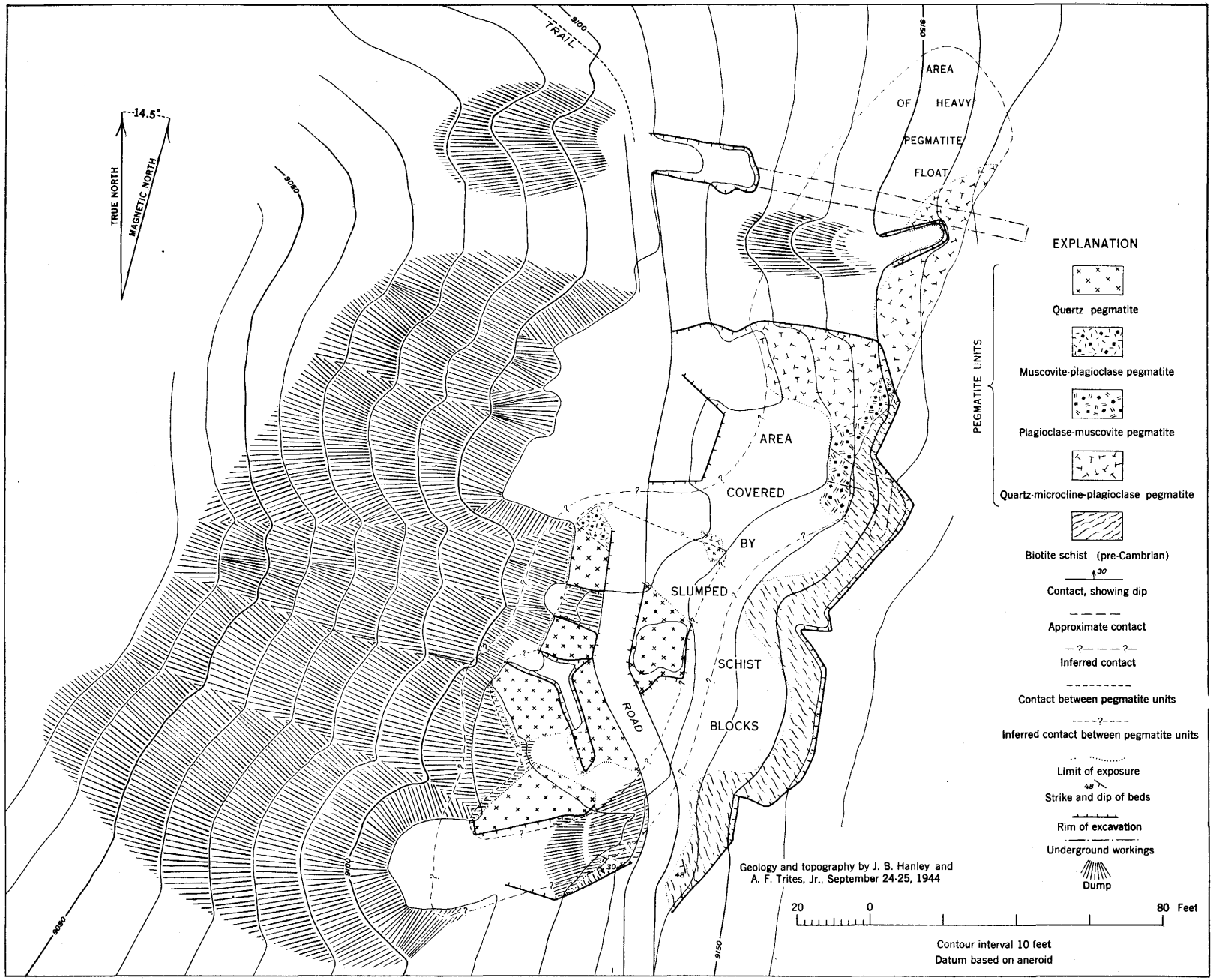

FIGURE 8.—Map of Rose Dawn mica mine, Micanite district, Park County, Colo.

formed blue-green crystals as much as 8 inches in diameter were found in the dumps.

The only record of the quality of the mica in the wall zone is from a small sample scabbed from the walls of the larger open-cut. This sample, weighing about 40 ounces, was prepared by Mrs. Merle Thompson. It was qualified by G. A. Purcell, vice president of the Colonial Mica Corporation. The results of qualification are as follows:

Quality [1]	Percent by weight	Quality [1]	Percent by weight
No. 1	5	No. 2 inf	50
No. 2	5	No. 3	40

[1] Size pattern: mostly 1" x 1"; some pieces as much as 1.5" x 2".

According to Mr. Purcell the mica might be considered on the border line between the ruby and green classifications.

Electrical tests by the National Bureau of Standards on part of this sample gave the results shown in table 5.

TABLE 5.—*Electrical tests on mica from Rose Dawn mine, Micanite district, Fremont County, Colo.*

Specimen No.	Thickness, in millimeters	Area between electrodes	Power factor, in percent	
			At 100 kilocycles per second	At 1,000 kilocycles per second
R–1 [1]	0.06	Broken film (one piece only)	0.07	0.03
R21	.04	No visible defects	.05	.01
R22	.04	do	.06	.03
R23	.08	Small black spot, broken film	.22	.06
R31	.06	Two black spots, two dark stains	.38	.15
R32	.06	Large black stain	.29	.36
R33	.08	Large black stains, broken film	.24	.14
R111	.08	Small black spot, broken film	.06	.02
R112	.06	Tiny red spots, broken film	.11	.04
R113	.07	Several black spots, broken film	.12	.12
R114	.06	Slight stain, broken film	.11	.06

[1] The numbers R–1, R21 to R23, R31 to R33, and R111 to R114 were applied by the National Bureau of Standards to test specimens from No. 1, No. 2, No. 3, and No. 2 inf. classifications, respectively.

No tests were made on muscovite from the albite-muscovite pegmatite, which was probably the main mica-producing zone of the dike, as a representative sample could not be obtained.

Reserves.—The reserves of sheet and scrap mica are not known because information as to the size and grade of the mica deposit is insufficient. However, it is probable that a large quantity of the albite-muscovite pegmatite occurs beneath the lowest level of the old workings (at 9,110 feet in altitude) and, with the mica-rich parts of the wall zone, offers promise for future prospecting.

WHOPPER MINE AND PROSPECT

The Whopper mine (87) is 700 feet southeast of the Climax mine and 950 feet southwest of the Rosemont mine. (See fig. 7.) It can be reached only by foot trail from the other mines of the northern group. It is explored by seven small open-cuts; a 20-foot inclined shaft; an 85-foot adit; two drifts from the adit, one 30 feet long connecting with the foot of the shaft, and the other extending 10 feet southward from the eastern end of the adit; and a shallow winze at the junction of the adit and the longer drift. (See fig. 9.) All the workings except the most northeasterly open-cut were made by the United States Mica Co.

The Whopper pegmatite is an irregular lens with several minor bulges and reentrants in quartz-sillimanite-biotite schist. The main axis of the body trends north. The dip is steep at the surface but is only about 15° E. in the underground workings. The pegmatite is exposed for 190 feet in length and as much as 100 feet in width. In the underground workings it is not more than 10 feet thick. The surface map is based on the distribution of pegmatite float and soil variations.

The pegmatite zones are well exposed in the adit and east wall of the shallow winze. The sequence, from contact to core, is: border zone of very fine grained quartz-microcline-muscovite-plagioclase-biotite pegmatite, wall zone of coarse-grained quartz-microcline-muscovite-plagioclase-biotite pegmatite, and inner zone of quartz-microcline pegmatite.

The border zone is exposed only in the underground workings and ranges from 0.2 to 0.8 foot in thickness. On the map of the adit level this zone is nonexistent in some places and in others ranges up to 9 feet in width, depending on the steepness and local variations of dip along the footwall contact.

The quartz-microcline-muscovite-plagioclase-biotite pegmatite of the wall zone is poorly exposed on the surface, and the mica content cannot be estimated. In the winze this zone is 2.5 feet thick on both sides of the core, but it is thicker in other parts of the dike. The zone contains white quartz, pink microcline, gray-green muscovite, light-pink plagioclase, and biotite. Plagioclase, probably near albite in composition, and biotite are minor constituents of the rock. Granular magnetite in masses as much as 3 inches in size and a mineral tentatively identified as sillimanite also occur in small quantities.

The core of the pegmatite at the surface, where it is well exposed, is about 90 percent white to pale-pink quartz with reddish microcline and very minor quantities of muscovite. The microcline commonly occurs along the outer edges of the quartz. In the underground workings quartz and microcline occur in the innermost zone of the pegmatite in nearly equal quantities. The quartz-microcline pegmatite may form an intermediate zone, but the relationship between it and the quartz pegmatite is not known. In the Climax and Rose Dawn deposits the best sheet mica occurs at the edge of a quartz pegmatite core and, by analogy, if there is any sheet mica in this deposit, it probably is in the upper part.

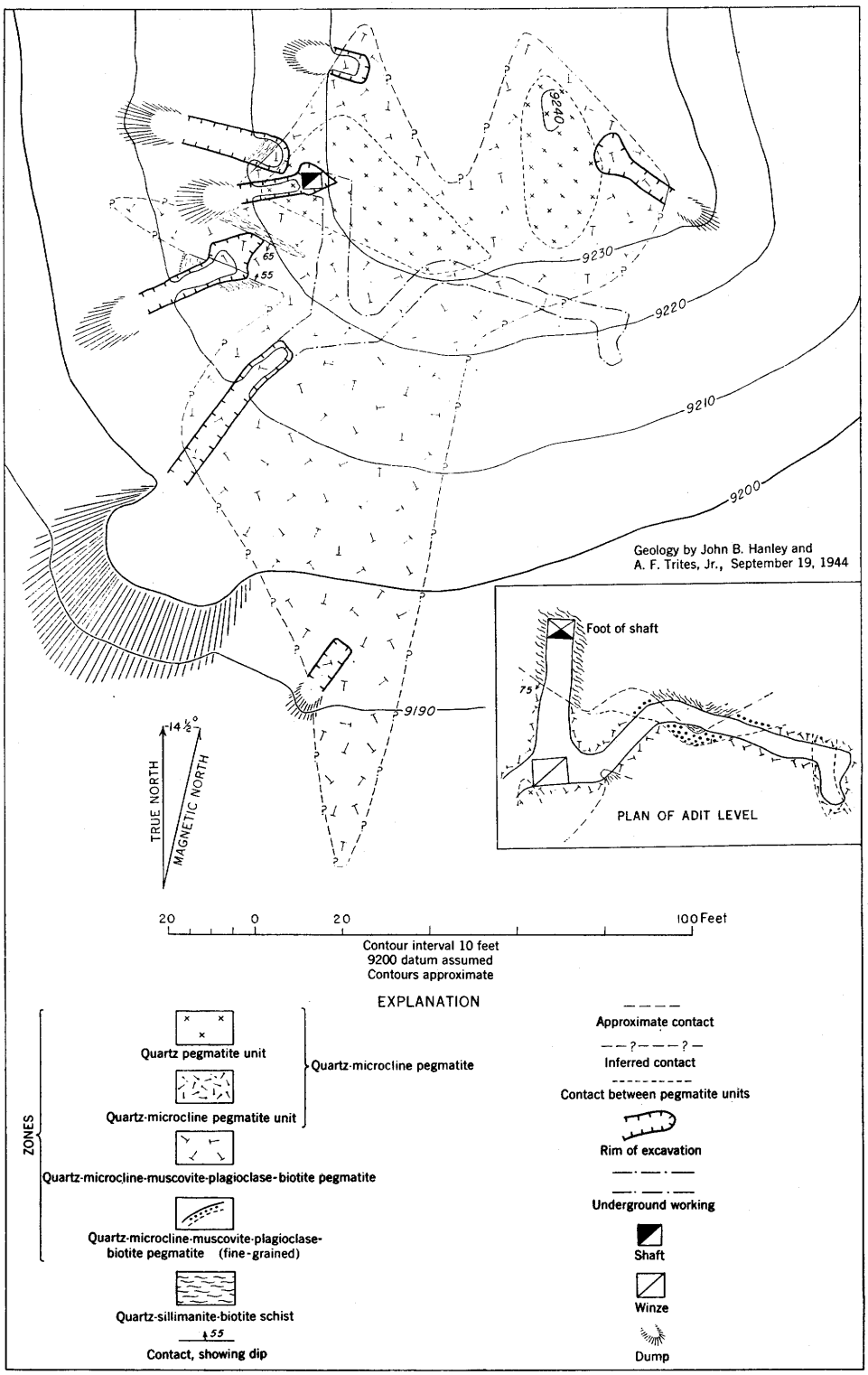

FIGURE 9.—Map of Whopper mica mine, Micanite district, Fremont County, Colo.

The muscovite observed in the wall zones occurs in flat, hard books, 6 inches in size, that break free from the surrounding minerals. It is intensely ruled and ribboned, and part of it is reeved. These defects preclude the recovery of an appreciable quantity of sheets more than an inch wide, and the mica is therefore suitable only for scrap.

The surface workings are badly caved where sheet mica might be expected to occur. However, the geological indications are that the Whopper pegmatite

may, on further exploration, yield sheet and scrap mica. These indications are the marked zonal structure of the pegmatite; the quartz core, which in other mines is associated with sheet mica; and the presence of as much as 50 percent muscovite in places and an average content of 15 percent or more. Since the quantity of microcline recoverable as a byproduct of mining is estimated to be only a few hundred tons, any operation would have to rely solely on the yield of mica for support.

Three hundred feet southwest of the Whopper adit portal a pegmatite 3 feet thick has been explored by an adit 6 feet long and a vertical shaft 6 feet deep at the west end of this adit. This pegmatite, exposed only in the underground workings, contains a border zone and a core of quartz-microcline-muscovite-plagioclase pegmatite. Scrap mica is the only recoverable mineral, and the pegmatite is too small to warrant mining.

ROSEMONT MINE

The Rosemont mine (71) is about 1,200 feet east-northeast of the Climax mine and 1,600 feet east-southeast of the Rose Dawn mine. (See fig. 7.) The mine workings consist of two open-cuts and a slightly crooked adit that extends S. 36° W. for 36 feet along the footwall of the pegmatite from a point 20 feet below the main open-cut. This cut opens to the northeast and extends S. 32° W. for 44 feet. It is as much as 19 feet wide and has a maximum depth at the face of 10 feet. The other open-cut is 6 feet long, 4 feet wide, and 5 feet deep.

The pegmatite is about 260 feet long and 10 feet thick. The northern half strikes N. 56° E. and dips 45° SE., and the rest of the dike trends N. 65° E. The footwall contact with granitic gneiss is exposed in the adit, and both the footwall and hanging wall are exposed in the main open-cut. Outside the quartz-microcline-muscovite-plagioclase pegmatite wall zone, 2.5 feet in thickness, is a narrow border zone which has the same composition but a finer texture. Quartz-microcline pegmatite forms the core.

These zones are mineralogically similar to those of the Whopper pegmatite, except that biotite commonly occurs in the wall zone as blades 1.5 feet long and 3 inches wide, oriented perpendicular to the contact. In addition, dark-brown garnet crystals as much as 1 inch in diameter occur with quartz and muscovite in the wall zone. J. E. Meyers reports that a pod of bismuth minerals, about 2 feet wide, was found near the northern side of the open-cut.

The muscovite is gray green and has a heavy black stain. It is ruled and ribboned, has pronounced "A" structure, and is commonly intergrown with the biotite. Little sheet mica was found in the exposed faces, but a few sheets up to 2 by 2 inches were obtained.

Muscovite is visually estimated to make up about 10 percent of the wall zone. Microcline is estimated to be about 50 percent of the core, and although microcline occurs in the wall zone, no substantial recovery of this mineral would be possible except in the core. The reserves of mica are about a hundred tons, of which probably less than 1 percent would contain sheet quality. The reserves of microcline are estimated to be only a few hundred tons.

STAR GIRL MINE

The Star Girl mine (81), which is about 2,400 feet north of the Climax mine (see fig. 7), has been worked twice, once during the early mica mining and later during recent feldspar operations. The underground workings made in search for mica have been almost completely destroyed by the feldspar mining. They include an inclined shaft at least 30 feet deep and a network of drifts at two levels, one 15 feet and the other 30 feet in depth. An open-cut about 60 feet in length, 50 feet in width, and as much as 30 feet in depth was excavated in mining the feldspar.

The trend of the pegmatite is north, and the dip is steep to the east. The hanging-wall contact with the granitic gneiss wall rock is obscure, and numerous pegmatite stringers extend into the wall rock.

The internal structure of the pegmatite is moderately well exposed, and three major zones can be recognized. The wall zone of quartz-microcline-plagioclase-muscovite pegmatite is separated from the core of quartz-microline pegmatite by a thin, discontinuous intermediate zone of quartz-plagioclase-muscovite pegmatite. A border zone less than half an inch thick, having the same composition as the wall zone but a much finer texture, is exposed at one place in the old workings.

The quartz-microcline-plagioclase-muscovite pegmatite contains as accessory minerals dark-brown garnet in 2-inch crystals, olive-green apatite in crystals as much as 3 inches in width, and small plates of biotite. This rock has an average grain size of 1.5 inches and is granitic in texture.

The quartz-plagioclase-muscovite pegmatite contains a pale-pink plagioclase and light-green muscovite that occurs in radiating wedges and irregular clusters as much as 4 feet in size. The muscovite is ruled and wedged and has pronounced "A" structure; none was observed that could be used as sheet mica. However, as it is hard and free of mineral inclusions, it should yield good scrap mica. The exposures in the open-cut are visually estimated to contain between 5 and 10 percent muscovite.

The quartz-microcline pegmatite contains massive white quartz and subhedral masses of light-red micro-

cline as much as 4 feet in length. Quartz is estimated to be about twice as abundant as microcline in this zone.

The scrap mica reserves are uncertain because the tonnage of mica-bearing pegmatite removed during the United States Mica Co's. operations cannot be determined, but they are estimated at a few hundred tons. Most of the microcline in the core has been mined, and the remaining reserves are estimated to be only a few hundred tons.

TICKON PROSPECT

The Tickon prospect (83) is 100 feet west of the road, about 300 feet south of the Rose Dawn mine, and 650 feet west-northwest of the Climax mine, just below the crest of the steep eastern wall of Mac Gulch. (See fig. 7.) The pegmatite is explored by three shallow open-cuts, two of them grouped together on the hillside at a higher altitude than the third. The lower cut, 50 feet long and as much as 10 feet wide, is irregular in outline and has two main branches. One of the two upper cuts, also irregular in shape, is 30 feet long and 6 to 8 feet wide, and the other, a short distance northeast of the first, is 10 feet long and 8 feet wide.

The pegmatite trends N. 70° W., and the dip of the northeast contact is 45° NE. The exposed length of the pegmatite is 150 feet, and the width is as much as 60 feet. As the exposures are poor, the structure of the pegmatite cannot be determined.

The pegmatite contains a border zone of fine-grained pegmatite of the same composition as the wall zone, which consists of quartz-microcline-albite-muscovite pegmatite, and a quartz-microcline pegmatite core. No distinct muscovite-rich zone is exposed, but the muscovite is concentrated between the quartz and microcline masses of the core and in the wall zone near the core. Except for the larger of the upper open-cuts, which extends through the core, the workings were excavated along the contact between the core and the wall zone.

All of the mica exposed in this deposit is highly ruled and ribboned, and no sheet mica was found. In all other physical properties the muscovite is identical with the mica in the Rose Dawn pegmatite.

The exposures suggest that this pegmatite has small reserves of mica and that the only possible product would be scrap mica.

SOUTHERN GROUP

LOWER SOUTH MINE

The Lower South mine (49) is about 350 feet southeast of the mill site, near the base of the eastern wall of Mac Gulch, and about 250 feet east of Colorado State Highway 9. (See fig. 7.) This pegmatite (see fig. 10) was mined by an open-cut 46 feet long, 39 feet wide, and at least 30 feet deep. The floor of this open-cut is on two levels, one 11 feet lower than the other. A vertical shaft extends 19 feet below the lower level, and at the bottom of the shaft there are two drifts, one 15 feet long, the other 50 feet long. A room 20 feet long and 11 feet wide has been made in the south wall of the open-cut 9 feet lower than the 11-foot level. At one place the floor of this room has collapsed into the south drift. The pegmatite beyond the open-cut has been explored by nine shallow prospect pits and trenches.

The pegmatite is exposed for 200 feet in length and trends N. 10° E. The dip on the east side is 20° NW., and on the southwest side it is 60° NE. The pegmatite is bluntly terminated at the south end, where it is as much as 100 feet wide, and tapers to the north. The exposures in the open-cut and mine workings show that the pegmatite is shallow and that the bottom of the dike is formed by an interfingering of the pegmatite and the granitic gneiss wall rock. A large sharp roll in the lower contact, exposed in the open-cut and shaft, plunges 22°, N. 49° W.

Outside the open-cut only the wall zone of quartz-microcline-muscovite-plagioclase-biotite pegmatite is exposed. However, as exposed in the mine workings, the zones in the pegmatite include a narrow border zone of fine-grained pegmatite with the same composition as the wall zone and a core of quartz-microcline pegmatite. In the underground workings mica-rich pegmatite is exposed. Whether it is a distinct zone in the pegmatite or a local concentration of mica in the wall zone adjacent to the core cannot be determined. This mica-rich pegmatite is considered in this description as a zone of quartz-muscovite-plagioclase pegmatite. It commonly contains 5 to 10 percent muscovite but locally contains as much as 80 percent.

The muscovite, grayish green, usually occurs in small books, none of them large enough to yield sheet mica. Although books 6 inches in size were observed, they were all intensely ruled and ribboned. Biotite occurs in the wall zone in blades half an inch thick, 1 foot wide, and as much as 8 feet long. Greenish-blue beryl occurs in small quantities in the quartz-muscovite-plagioclase zone, and orthorhombic crystals of an unidentified brown, highly altered mineral occur in the wall zone adjacent to the quartz-muscovite-plagioclase pegmatite. Quartz and microcline occur in the core in subhedral crystals 4 to 6 feet in size.

The exposures in the workings indicate that the scrap mica in this pegmatite is nearly exhausted. A small tonnage of microcline might be recovered by additional mining, but the total reserves of both microcline and scrap mica in this pegmatite are estimated at only a few tens of tons.

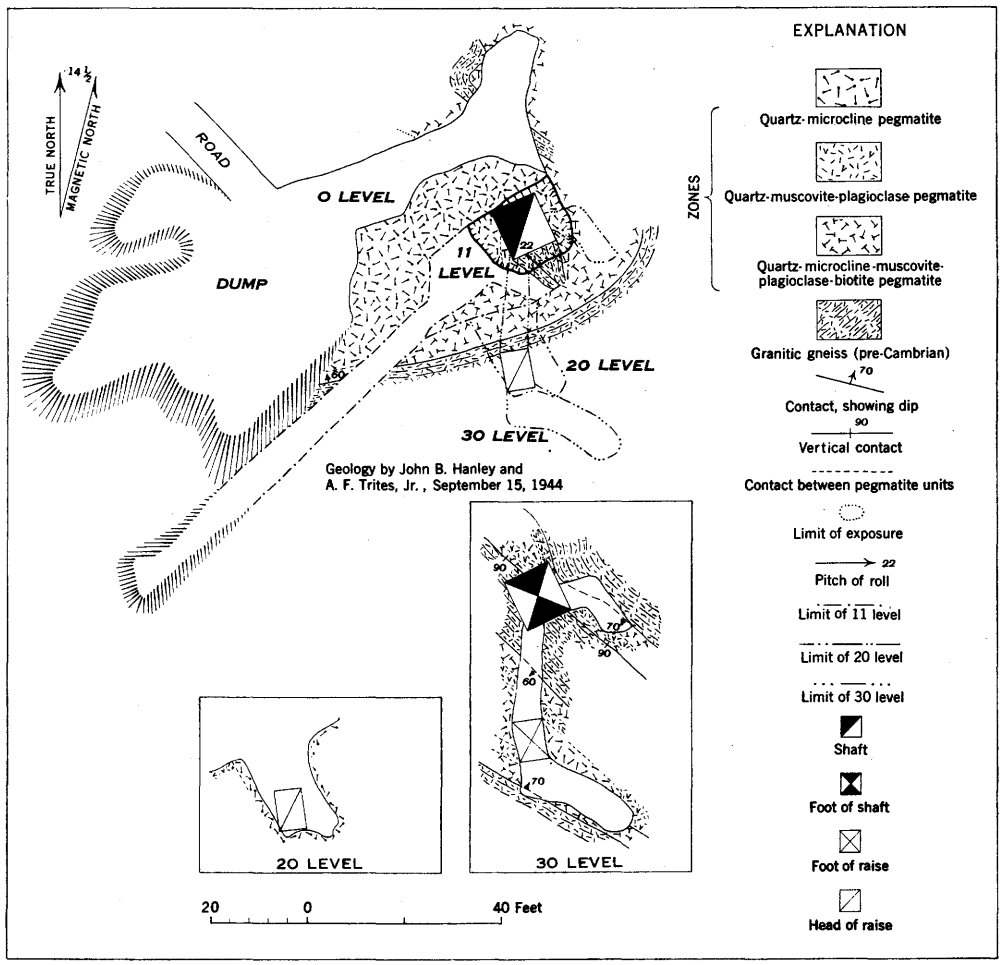

FIGURE 10.—Geology of workings, Lower South mine, Micanite district, Fremont County, Colo.

One hundred feet east of the main pegmatite is a nearly circular, unzoned pegmatite about 30 feet in diameter. Quartz is the main constituent and is associated with dark-red microcline, pale-pink plagioclase, accessory biotite, and a very small quantity of muscovite. This pegmatite probably would not yield sufficient scrap mica to repay operation.

UPPER SOUTH MINE

The Upper South mine (84) is about 750 feet east-southeast of the Lower South pegmatite and about 200 feet above it. (See fig. 7.) The pegmatite was mined along the trend by an open-cut 63 feet long, 15 to 20 feet wide, and 10 to 25 feet deep. At the north and south ends two haulage cuts were made to the west for the removal of waste and mica. Three short drifts, all less than 10 feet long, were driven from the open-cut into the walls, and a shallow pit 28 feet long and 15 to 20 feet wide was dug at the north end of the main open-cut.

The pegmatite is a shallow lens that at the surface is about 150 feet long and as much as 30 feet wide. The trend of the dike is N. 4° E. The east contact dips steeply to the east, but the dip of the west contact, though to the east, is very low. In cross section, as exposed in the north face of the open-cut, the pegmatite is a veneer 10 to 15 feet thick on the granitic gneiss wall rock. (See fig. 11.) Many aplitic pegmatite stringers, ranging in thickness from 2 inches to more than 1 foot, are apparently extensions of the border zone of the pegmatite into the wall rock. The eastern part of the pegmatite continues in depth as a stringer of border-zone and wall-zone material 3 to 4 feet thick. This stringer may have been the feeder of the main body.

A poorly defined core of quartz-microcline pegmatite, underlain by a wall zone of quartz-microcline-muscovite-plagioclase-biotite pegmatite, can be recognized. The minerals of the various zones are similar to those in the Lower South pegmatite. Muscovite occurs only in small books and is wedged, reeved, and warped and has "A" structure. Apparently only scrap mica was recovered from this pegmatite.

The pegmatite has been almost completely mined out between the two haulage cuts, and the only reserves, those in the area north of the open-cut, are estimated

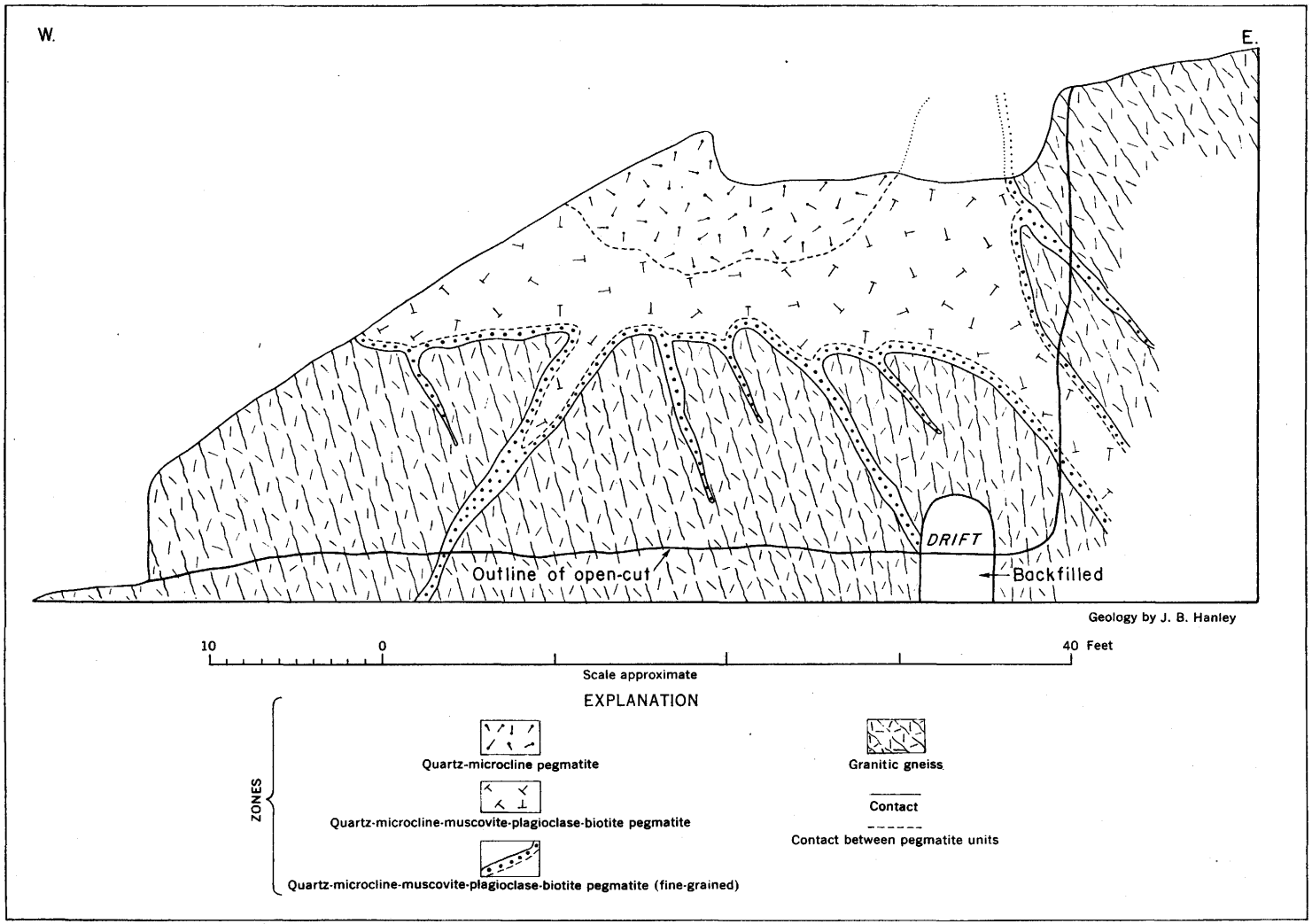

FIGURE 11.—Diagrammatic sketch, north face of main open-cut, Upper South mine, Micanite district, Fremont County, Colo.

roughly to be a few tens of tons of recoverable scrap mica and microcline.

On the summit of the ridge about 200 feet east of the main Upper South mine a pegmatite 75 feet in length and 30 feet in width has been explored by a glory hole and haulage tunnel from which several short drifts and two shallow inclined shafts extend into the deposit. The pegmatite, an irregular body, trends N. 67° E. and dips 75° SE. on both contacts. It cuts across the foliation of the granitic gneiss wall rock both in strike and in dip. Although the zonal structure is obscure, a wall zone of quartz-microcline-muscovite-plagioclase-biotite pegmatite and a core of quartz-microcline pegmatite can be recognized. Muscovite occurs in greater abundance than in the Upper South pegmatite. No sheet mica was seen in the deposit, and the occurrence of a large tonnage of scrap mica does not appear likely.

ROWE'S NORTH MINE

Rowe's North mine (73) is about 150 yards south of the main workings in the Upper South pegmatite on the sharp point of the ridge between Mac Gulch and its eastern tributary. (See fig. 7.) The pegmatite has been explored by a room about 10 feet square and 8 feet high and a narrow open-cut about 35 feet long, trending S. 80° E., that leads into this room. In addition, several small prospect pits have been made in the pegmatite.

The pegmatite has a maximum surface width of 25 feet. It trends N. 45° E. for 75 feet, and the footwall in the open-cut dips 60° SE. The pegmatite cuts across the foliation in the granitic gneiss wall rock. The zones exposed in the pegmatite include a border zone less than an inch thick, a wall zone of quartz-microcline-muscovite-plagioclase-biotite pegmatite 2.5 feet thick, and a quartz-microcline pegmatite core containing crystals of microcline 3 to 4 feet in size.

Ten feet east of the main pegmatite a second one about 10 feet wide crops out. It is similar to the main dike in structure and mineralogy, but only the wall zone is exposed on the surface and in the prospect pits.

The muscovite of the main pegmatite is concentrated in the inner 6 inches of the wall zone. The muscovite is small and would yield only scrap mica. Reserves of scrap mica and recoverable microcline in both pegmatites are estimated at less than 100 tons of each mineral.

ROWE'S NO. 2 MINE

Rowe's No. 2 mine (72) is about 4,000 feet south-southeast of the mill site and 175 feet above Mac Gulch. (See fig. 7.) It has been prospected by two open-cuts and a short drift from the northern open-cut. The first open-cut, which is about 40 feet long and 35 feet wide, is 15 feet north of the second open-cut, which is 60 feet long, 30 feet wide, and 7 feet deep. Both of these open-cuts are mainly in the granitic quartz-biotite-feldspar gneiss wall rock.

The pegmatite is about 160 feet long on the surface. It strikes N. 67° W. and dips 15° SE. In the southern open-cut is a minor fault which strikes N. 70° W. and dips 43° NE. The observed displacement of the hanging-wall contact of the pegmatite is 1 foot vertically. However, sheared pegmatite fragments have been dragged upward along the fault for a vertical distance of 4 feet. At the north end of the open-cut a vertical stringer of pegmatite cuts the wall rock.

A hanging-wall zone, 2 feet thick, of quartz-microcline-plagioclase-biotite with accessory muscovite is exposed in the northern open-cut. It is separated from a 1-foot zone of quartz-muscovite-plagioclase pegmatite by a 2-foot zone of quartz-microcline-muscovite pegmatite. At no place is the footwall of the pegmatite exposed. Muscovite occurs in the quartz-muscovite-plagioclase pegmatite in felted aggregates and books and makes up as much as 60 percent of the rock. In the quartz-microcline-muscovite pegmatite the muscovite occurs in books 6 inches long and 4 inches wide. However, it is probable, because of ruling and ribboning, that none of the muscovite seen would yield sheet mica.

This pegmatite might yield about a hundred tons of scrap mica.

ROWE'S PROSPECTS

Lower on the west side of the hill, toward Mac Gulch, three small pegmatites (see fig. 7) have been explored by shallow prospect pits. None of these deposits contains sheet mica, and the quantity of scrap mica is estimated to be very small. In general all three are similar in mineralogy to the larger pegmatites in the district. One crystal of beryl 2 inches across was observed in the largest of the three pegmatites.

ROWE'S SOUTH PROSPECT

Rowe's South prospect (74) is a few hundred feet southeast of Rowe's No. 2 pegmatite and about 35 feet higher on the hillside. (See fig. 7.) It as an open-cut 35 feet long in a northerly direction and 30 feet wide. The pegmatite is irregular in shape and splits into several branches south of the open-cut. The longest dimension of the pegmatite is 85 feet, S. 65° E., and the maximum surface width is 20 feet. Although the structure cannot be determined definitely, the pegmatite appears to be nearly flat lying. Numerous faults that strike N. 70° W. and dip about 45° NE. have crushed and granulated it. The zonal structure in this pegmatite is identical with that exposed in the No. 2 pegmatite. It is estimated that the quantity of recoverable scrap mica and microcline is only a few tens of tons.

Fifty feet northeast of the first pegmatite a cut 10 feet square has been made in a second pegmatite. This dike is 100 feet long, trends N. 15° E., and is 40 feet wide. Its lithology and zonal structure are similar to those of the No. 2 pegmatite. Light-stained muscovite occurs only in books too small to yield sheet mica. Several reddish-brown crystals identified as monazite were found associated with plagioclase and muscovite.

The only possible products from these two pegmatites are scrap mica and microcline. The second pegmatite might yield about 50 tons of scrap mica.

BERYLLIUM LODE PROSPECT

The Beryllium Lode prospect (6) in sec. 30, T. 15 S., R. 72 E., sixth principal meridian, Park County, is isolated from the two main pegmatite groups in the district, as it is 2 miles by air line northwest of the Rose Dawn mine and on the west side of Mac Gulch. (See fig. 7.) The pegmatite crops out on a moderately steep ridge between two branches of a small tributary to Mac Gulch. The prospect is about 2,000 feet west of the county road and can be reached only by trail. It was located by J. E. Meyers in April 1936, and only assessment work has been done on it. An open-cut, 3 to 5 feet in depth and from 10 to 30 feet in width, extends up the hillside for 75 feet.

The pegmatite is vertical and strikes N. 65° W. It is exposed on the surface with a length of 200 feet and a width ranging from 40 to 50 feet. As the walls of the pegmatite are not exposed, the type of wall rock is not known. Several poor surface exposures suggest that a border zone occurs in the pegmatite. The other zones, exposed on the surface and in the open-cut, include a wall zone of medium-grained quartz-microcline-plagioclase-muscovite pegmatite with accessory dark-brown garnet and a core of quartz-microcline pegmatite in which quartz constitutes at least 80 percent of the rock. The core is nearer the south wall than the north wall of the pegmatite. Muscovite and beryl are concentrated along the contacts between these two zones, but no distinct mica zone is exposed.

Greenish-brown muscovite is visually estimated to form 5 percent of the pegmatite. Most of it is too small to yield sheet mica, but a small percentage might yield some stained sheet in the smaller sizes. Pale-blue beryl crystals as much as 5 feet in length and 8 inches in diameter have been found associated with quartz and muscovite. Although only a few scattered crystals were seen in place, the dumps and the debris in the cut contain many crystals and fragments of beryl, ranging in size from half an inch to 6 inches. The ratio of beryl to rock is estimated to be between 1:500 and 1:1,000. It is estimated that 15 percent of the whole pegmatite is marketable microcline.

This deposit probably contains sufficient recoverable beryl, microcline, and scrap mica to provide wages for two men under 1935–39 conditions. The recovery of electrical mica might yield a small profit.

DEVILS HOLE BERYL MINE

LOCATION AND HISTORY

The Devils Hole beryl mine (31), is in the SE¼NW¼ sec. 20, T. 18 S., R. 73 W., sixth principal meridian, Fremont County, 6.1 miles by mine road north of Texas Creek, the nearest shipping point on the Denver & Rio Grande Western Railroad. The pegmatite is 19 miles by air line west-northwest from Canon City and 22 miles east-southeast from Salida. It is reached from these cities by U. S. Highway 50 to Texas Creek and then by a steep mine road which ends at a semipermanent mine camp. The mine workings, about 500 feet almost vertically above the camp, can be reached either by foot trail or by a 960-foot inclined tramway.

The region in which this pegmatite occurs has an altitude of about 8,000 feet and is very rugged. Most of the hillsides slope 35° to 40°, but 55° slopes are not uncommon. The stream valleys are mostly narrow gorges in which the watercourse occupies most of the floor, but a few small flat areas have been formed at the places where tributaries join main streams. The main drainage is by East and Bull Creeks, both of which have a small permanent flow sufficient for mining operations. The vegetation is chiefly cactus and yucca, with very little timber other than piñons and cedar except in the bottoms of a few gulches. The average precipitation is less than 10 inches a year, and because of the favorable weather conditions the mine can be operated throughout the entire year.

The Devils Hole mine includes two patented claims. It was first discovered by J. D. Endicott in the early 1900's and has been owned since June 22, 1922, by Earl E. Zingheim of Canon City, Colo. Operation has been intermittent, and in the fall of 1941 the mine was closed down because of increased costs of operation. In September 1943 the mine was reopened and worked for beryl and columbite until May 1944 under a financial arrangement with the Metals Reserve Company.

The geology and mineralogy of the pegmatite have been briefly described by Sterrett,[31] who referred to the deposit as the "Wild Rose claim," and a brief description of the mineralogy, particularly with respect to origin, has been published by Landes.[32]

Available production records are incomplete, but according to Earl E. Zingheim 300 tons of beryl, 16,000 tons of feldspar, and 1,600 tons of scrap mica were pro-

[31] Sterrett, D. B., op. cit., p. 56.

[32] Landes, K. K., Colorado pegmatites: Am. Mineralogist, vol. 20, pp. 330–331, 1935.

duced prior to October 1942. Since that date about 75 tons of scrap mica and less than 10 tons of beryl have been produced, and about 1,000 tons of feldspar has been mined and stock-piled on the property. About 200 tons of rose quartz for ornamental use and about 200 pounds of columbite-tantalite have been recovered.

E. Wm. Heinrich first visited this mine on October 2, 1942, and between October 25 and 31, 1942, a preliminary map was made by E. Wm. Heinrich assisted by J. B. Hanley. A more detailed map was made during intermittent work in 1943 and 1944 by J. B. Hanley assisted at various times by R. Miller III, J. H. Chivers, and A. F. Trites, Jr.

MINE WORKINGS

The Devils Hole pegmatite has been mined by two open-cuts and underground workings from each cut. The main workings (see pl. 7), at the southern end of the main pegmatite body, are an open-cut 110 feet long and 35 to 110 feet wide, having a maximum depth of 75 feet; a 28-foot drift to the west; and a 75-foot drift to the north. Three raises have been made from the north drift, of which the first, 27 feet in from the portal, goes to the west for a few feet, then turns up east at an angle of 24° until it connects with the group of irregular mica workings from the open-cut. A small stope, from which about 100 tons of rock has been mined, is connected with this raise. The second raise, 56 feet in from the portal, goes upward at an angle of 76° for 30 feet, and the third raise, at the north end of the drift, goes upward in a northeasterly direction at an average angle of 30° for 50 feet.

The northern open-cut, which starts 12 feet north of the main open-cut, is 203 feet long, 8 to 50 feet wide, and from 1 foot to 15 feet deep. Near the center of this open-cut is an almost completely backfilled shaft 2.5 feet wide by 5 feet long and reportedly 15 feet deep. About 70 feet north of this shaft, a tunnel 8 feet square, called the "north room," extends 18 feet in a northerly direction.

GEOLOGY

GENERAL FEATURES

The Devils Hole beryl pegmatite crops out in an area underlain by pre-Cambrian schists, gneisses, and igneous rocks. In the Arkansas River Canyon a few miles to the south of the mine extremely large bodies of pre-Cambrian granite are exposed. Granite may occur near the pegmatite, but no outcrops other than those of small dikes were found in the reconnaissance of the immediate vicinity. Two or three miles west, north, and east of the Devils Hole pegmatite, Tertiary volcanic flows cap the pre-Cambrian complex. Several smaller pegmatite bodies occur near the beryl pegmatite, and one of these, about 90 feet to the east and 70 feet lower than the beryl pegmatite, parallels the footwall contact of the main dike for much of its length. Most of these smaller pegmatites are equivalent to coarse-grained granites. They have uniform textures and contain no concentrations of minerals that can be mined profitably.

METAMORPHIC ROCKS

Diagnostic minerals, such as sillimanite and diopside, in the schists and gneisses in the vicinity of the Devils Hole pegmatite indicate that the metamorphic rocks are high in grade. Numerous small pegmatite and granite intrusives have been injected into these metamorphic rocks, and some material undoubtedly has been added to the original minerals of the metamorphic rocks.

The metamorphic series includes poorly exposed, interbedded quartz-sillimanite-mica schists, quartz-biotite-feldspar gneisses, amphibolites, diopside gneisses, impure marbles, and banded quartz-mica schists into which small biotite-rich pegmatites and thin quartz veins have been intruded. The foliation of the metamorphic rocks is usually parallel to the bedding, although a slight divergence, not over 10°, is not uncommon. The rocks are flexed into major open folds on the flanks of which minor folds occur. Many minute crenulations are exposed in the diopside gneiss beds.

PEGMATITE

General features.—The Devils Hole pegmatite crops out as a northward-trending body with two main branches, one of which is irregularly arcuate in shape. (See pl. 7.) The pegmatite is well exposed because of its superior resistance to erosion, but the contacts with the wall rocks are largely obscured by talus. The contacts between pegmatite units are well exposed except in a few places near the hanging wall.

The pegmatite is exposed over an area of 83,000 square feet. The eastern part, which covers 36,000 square feet, contains three zones, but the rest of the pegmatite, including the larger branches, generally contains only the wall zone. The eastern part, in which the workings have been made, is referred to in this report as the main body. The main body trends due north for 350 feet and ranges from 35 to 200 feet in width. The bulbous southern end of this main body, from which two minor branches extend, ranges from 100 to 200 feet in width for a distance of 150 feet. The western branch extends to the northwest, then curves to the south and southeast and, with the main body, forms a nearly complete but irregular circle. The eastern branch trends northeast; it is 300 feet long and

80 feet wide at the junction but tapers to 10 feet in width.

The contacts between the pegmatite and wall rock are gradational. The contact is more definite along the footwall than along the hanging wall, where the gradation from schist to pegmatite may occur over a distance of 5 feet. In general the pegmatite cuts across the bedding and foliation of the wall rock, although the contacts are parallel to the bedding in the north drift and raises.

The underground exposures of the contacts furnish evidence of the structure of a small part of the pegmatite, but the structure of the whole pegmatite can be approximated only by assuming that the internal structure of the pegmatite zones is a reflection of the external structure. The assumption is valid at least in part, for the positions of the contacts with the wall rock and of the pegmatite zones were predicted in advance of the recent mining operations.

The walls of the upper part of the main body, as shown in plate 7, sections *A–A′*, *B–B′*, *C–C′*, and *D–D′*, dip to the west at an average angle of 30° throughout the southern part of the pegmatite, but a steepening of the dip in the underground exposures (see pl. 7, sec. *E–E′*) indicates that the pegmatite may terminate at no great depth. The main body as a whole probably pinches out down the dip less than 150 feet below the floor of the main open-cut. About 40 feet north of the main open-cut the main body narrows, and to the north the east side dips 30° to 40° W. and the west side dips 55° to 60° E. The exposure in the cliff wall at the north end of the main body strongly suggests that the keel of the pegmatite plunges to the south. Cross rolls on the major structure have formed a series of structural troughs and ridges approximately at right angles to the strike of the major structure.

The form of the branches of the pegmatite cannot be accurately determined. The northeast branch probably dips to the northwest as a simple lens, and the arcuate west branch is probably shallow and forms only a veneer on the underlying metamorphic rocks. Cross section *G–G′* in plate 7 shows the inferred structure of this part of the pegmatite.

In general the pegmatite in the southern part of the main body has a maximum thickness estimated at about 90 feet. The irregular surface shape of the pegmatite body is due to the relation of the topographic surface to the major structure and cross rolls.

Zonal structure.—The main body contains a wall zone of quartz-microcline-muscovite-albite pegmatite, an intermediate zone of muscovite-albite-quartz pegmatite, and a core made up of a microcline pegmatite unit and a quartz pegmatite unit. No typical border zone occurs in this pegmatite body. The contacts with the wall rock are gradational, and the wall zone does not show any regular change in texture throughout its thickness from the contact with the metamorphic rocks to the intermediate zone.

The intermediate zone is discontinuous both along strike and along dip and ranges from a few inches to 8 feet in thickness. It is divided in this report into a footwall part and a hanging-wall part because of variations in the content of commercially valuable minerals. Small pods of muscovite-albite-quartz pegmatite are exposed at the shaft and in the northern open-cut above the north room. The pods are probably parts of the intermediate zone, but they are not connected with the main part of the zone and differ slightly from it in lithology.

The microcline pegmatite unit forms the core at the surface in the southern end of the main pegmatite body, but continued mining has shown that this unit is underlain by quartz pegmatite. In the northern end of the main body both units are exposed at the surface. The microcline pegmatite unit in most places in the northern end of the main body is surrounded by quartz pegmatite and appears to form the true core. Although both the quartz pegmatite and the microcline pegmatite seem to reflect the structure in the northern part of the main body, no evidence of structural control of either unit has been found in the southern part, where the pegmatite is best zoned and best exposed in depth.

The zoning in the northern end of the main body is not so distinct as in the southern end. The intermediate zone is less continuous, and the core units usually contain a larger percentage of the minerals of the intermediate zone. For example, beryl is restricted to the muscovite-albite-quartz pegmatite south of the major pinch structure, but to the north beryl has been observed in the quartz pegmatite and in the microcline pegmatite. Further, a few beryl crystals have been found in the wall zone as much as 5 feet away from the contact with the muscovite-albite-quartz pegmatite. The mineral distribution, particularly the distribution of beryl, within the zones in the walls and back of the north room (see fig. 12) shows that the overlapping of zones is pronounced.

Three small patches of microcline pegmatite are exposed near and on the top of the ridge on which the widest part of the western branch crops out. In these patches the microcline pegmatite contains minerals that occur in the quartz pegmatite and the muscovite-albite-quartz pegmatite in the main body, and the intermediate zone and the core are telescoped. The largest of these patches contains a small concentration of quartz pegmatite.

The structural relationship between zones in depth is best exposed in the north face of the main open-cut and in the west drift. Cross section *C–C′* of plate 7, in which the face of the open-cut is projected into the plane of the section, shows the relationship between the

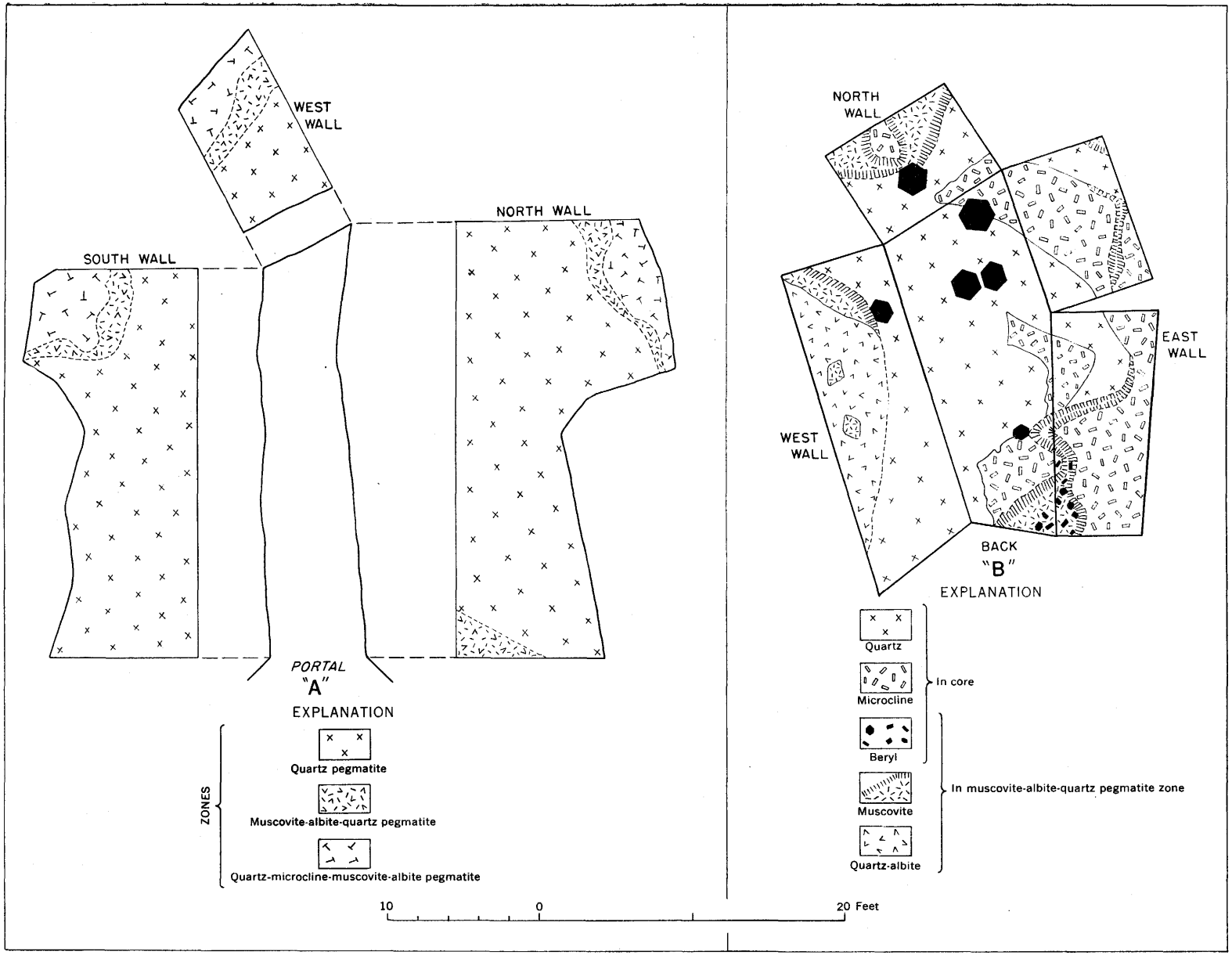

FIGURE 12.—Devils Hole beryl pegmatite, Fremont County, Colo. *A*, Geology of west drift; *B*, Mineral-distribution map of north room.

DEVILS HOLE BERYL PEGMATITE, FREMONT COUNTY, COLO.

Fracture zone in muscovite-albite-quartz pegmatite, northeast side of main open-cut, at an altitude of 8,043 feet.

hanging-wall and footwall parts of the wall zone and the intermediate zone, as well as both units of the core as they appear in the north face of the main open-cut. The quartz pegmatite unit of the core is shown in figure 12. The structural relationship between the zones along the strike of the main body is best shown on the surface, as the north drift is only in the footwall part of the wall zone. (See pl. 7, insert map of the 8,000-foot-level workings.)

The major structure of the coarse-grained zones is a trough formed by the intermediate and core zones. This structure strikes due north and dips 30° to 45° W. throughout the southern part of the main body; the keel plunges to the south from the narrow part 40 feet north of the main open-cut. To the north the trough structure continues to strike due north but is nearly vertical in dip. Seventeen feet north of the end of the northern open-cut it pinches out. According to Earl E. Zingheim, the southern end of this trough did not crop out and was discovered in mining. Minor cross rolls occur in the walls of the trough at two places north of the narrow part and at one place south of it.

The hanging-wall part of the intermediate zone, as exposed in the north face of the main open-cut, dips about 10° W. This decrease in steepness suggests that the crest of the structure was not much higher than the present erosion surface.

Smaller structures in the zones are probably direct reflections of the external structure. However, the detailed structure of the intermediate zone, as shown in cross section *C*–*C'* of plate 7, is probably not a direct reflection of the external structure but is caused by local variations in conditions at the time of formation.

The quartz-microcline-muscovite-albite pegmatite of the wall zone is 10 to 30 feet thick in the main body and forms both the eastern branch and the western branch with the exception of the microcline pegmatite patches. The chief component minerals are quartz, reddish microcline, muscovite, and pale-pink albite. The accessory minerals are biotite, black tourmaline, garnet, and magnetite. Biotite, garnet, and magnetite occur most abundantly near the contact with the wall rock and probably represent material added to the pegmatite by assimilation. The texture is granitic, and although the grain size is extremely variable the average size is about 2 inches. Small concentrations of massive quartz, the largest of which is 8 feet long and 1 foot wide, occur in this pegmatite, and blocky masses of microcline 2 feet or more in size have been observed. Bands of fine-grained pegmatite in which the grains are less than a quarter of an inch in size are exposed in the wall zone just north of the main open-cut.

The intermediate zone of muscovite-albite-quartz pegmatite is thickest adjacent to microcline pegmatite, and where it borders the quartz pegmatite it may be represented by only a few inches of albite containing a very small quantity of muscovite. In the north face of the main open-cut the footwall part of this zone, adjacent to microcline pegmatite, has an average thickness of 5 feet, but at the floor level along the west face of the open-cut the zone borders quartz pegmatite and has an average thickness of only 2 feet.

Grayish-green muscovite occurs in radially arranged masses, as much as 5 feet in diameter, composed of wedge-shaped books. It is the dominant mineral of this zone. Pale-pink or white quartz in roughly lenticular masses 2 feet or more in length occurs in the muscovite. Between the muscovite masses and the wall zone pale-pink albite is concentrated, and small crystals of columbite occur in the albite adjacent to the wall zone. Microscopic study shows that the albite has pronounced albite twinning, extinction angles with the cleavage at a maximum of 24°, the intermediate index of refraction of 1.530 ± 0.003, and is biaxial "+" with a large $2V$. These data indicate that the composition of this albite is near Ab_{95}. Beryl, the most abundant accessory mineral, occurs throughout the zone, although the larger crystals tend to occur in the muscovite and the smaller crystals are concentrated in the albite. The hanging-wall part of this zone contains less beryl and columbite than the footwall part, and the distribution of these two minerals is more erratic in the hanging-wall part. An unusual feature of the zone is the occurrence of muscovite along fractures that probably formed in the late stages of crystallization of the pegmatite. Some of the fractures are plane, others curved; all are characterized by the arrangement of large muscovite books perpendicular to the fractures and on both sides of them. (See pl. 8.) The fractures are commonly coated to a thickness of one-sixteenth of an inch or more with small muscovite plates lying parallel to the fracture surfaces. These mica-coated surfaces do not occur in any of the other zones of the pegmatite.

The core contains two units, microcline pegmatite and quartz pegmatite. The microcline pegmatite unit is nearly pure microcline. The few accessory minerals commonly occur in vugs near the contact of the microcline pegmatite with the muscovite-albite-quartz pegmatite. Quartz, in well-shaped crystals less than 2 inches in length, and a bright-yellow, fine-grained muscovite are the most abundant accessories. A few small blebs of apatite and beryl have been found in the vugs. Small quartz stringers and masses occur throughout the microcline pegmatite.

Three large distinct bodies of microcline pegmatite occur in the main body. The southern and largest of these is bordered by muscovite-albite-quartz pegmatite, and the central and northern bodies are bordered by quartz pegmatite and muscovite-albite-quartz pegmatite.

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The quartz pegmatite unit of the core consists almost entirely of pale- to deep-rose quartz, although some parts of it are white. Small quantities of accessory minerals occur in it, chiefly near the northern end of the main body. Minor quantities of an altered bismuth mineral have been found in the quartz pegmatite, and free gold is associated with quartz pegmatite in the west drift. The largest surface exposure of quartz pegmatite is 182 feet in length and as much as 30 feet in width.

MINERAL DEPOSITS

The Devils Hole mine has produced at least 300 tons of beryl, 16,000 tons of feldspar, 1,600 tons of scrap mica, and about 200 pounds of columbite. The beryl, scrap mica, and columbite are in the intermediate zone, and the feldspar is in the microcline pegmatite unit of the core.

FELDSPAR

The microcline of the feldspar deposit is pale pink to light buff and occurs in crystals of gigantic size. The mass of microcline exposed in the north face of the main open-cut is about 75 feet wide and 40 feet thick at the maximum and has an area of 2,337 square feet, yet individual cleavage planes extend unbroken across the entire mass, which is probably a single crystal. The alumina content of this microcline is reported to be high, and the feldspar always has sold at a premium price. Thin films of manganese stain occur on cleavage planes throughout the microcline, but the quantity of manganese is too small to affect the quality of the feldspar. Small quartz stringers and blebs occur in the microcline pegmatite, but these can be discarded easily in mining.

The feldspar deposit occurs in the three distinct masses of microcline pegmatite. The southern mass is exposed in the main open-cut. The larger part of this mass has been mined out, but a remnant is exposed in the west wall and north face of the main cut. The shape of the main part of this remnant is roughly triangular in plan and in section, although the upper walls are subparallel. The strike length is 131 feet, and the average thickness is 20 feet. The grade of this mass is visually estimated at 95 percent microcline.

The central mass is exposed in the northern open-cut 45 feet north of the southern end. Its surface shape is crudely elliptical, and it is triangular in section. The surface length is 50 feet, the average surface width 10 feet, and the maximum depth 8 feet. The grade of this mass is visually estimated at 90 percent microcline.

The northern mass occurs adjacent to the north room. The strike length is 20 feet, and the average width is about 5 feet.

The three microcline pegmatite masses in the western branch of the pegmatite occur at least 150 feet horizontally west of, and 95 feet higher than, the present mine workings. They are so poorly exposed that their size, shape, and grade are unknown.

MUSCOVITE

The muscovite of the muscovite-albite-quartz pegmatite occurs in large round masses of wedge-shaped books that are radially arranged. An individual mass may be continuous with adjacent masses, and the muscovite may form a large composite mass as much as 30 feet in length, 20 feet in width, and 4 to 5 feet in thickness. Single books of muscovite as much as 3 feet long and 1 foot wide occur in many of these masses. This muscovite is mostly highly reeved, has pronounced "A" structure, and is wedged. None has been found that could yield sheet mica; it can be used only for scrap.

Muscovite occurs in the intermediate zone as three large concentrations and at least six minor concentrations that can be mined profitably only as part of the feldspar mining. These minor concentrations are visually estimated to contain 30 percent muscovite. The largest and most continuous, the footwall concentration, forms a large part of the east wall in the main open-cut and is the footwall part of the intermediate zone. This concentration is tabular in plan and roughly triangular in the plane of dip. The strike length is about 95 feet, the depth down dip at the southern end is about 65 feet, and the average thickness is 4 feet. The maximum depth down the dip, along the line of cross section *C–C′*, plate 7, is 80 feet. Visual estimates and past-production figures were used to establish the grade of the mica in this concentration. Locally the mica content may vary, but the average content is 60 percent muscovite.

The northern concentration is best exposed in the north room. The south end of this concentration is 10 feet north of the shaft in the northern open-cut, and the concentration is continuous from this end to the north wall of the north room. The shape is tabular but very irregular in outline. The strike length is about 75 feet, and the average thickness is 4 feet. The average depth on the footwall is 10 feet, but the concentration probably continues around the keel onto the hanging wall. The grade is not so well established as in the largest concentration, but the average content of muscovite is estimated at 30 percent, although locally the range in grade is from 10 to 90 percent.

The third large mica concentration is the hanging-wall part of the intermediate zone and is exposed in the main open-cut and the northern open-cut. It has a surface length of at least 100 feet and an average thickness of 3 feet. It is tabular in plan and crudely triangular in the plane of dip. The grade is lower than that of the other two concentrations, and the muscovite content is visually estimated at 20 percent.

BERYL AND COLUMBITE

Beryl occurs in well-formed euhedral crystals. Most of them are greenish blue to pale blue, but they range from bluish white to deep brown. Many of the smaller crystals taper toward both ends. The beryl crystals are commonly free of mineral impurities, but several crystals observed had centers composed of intergrown beryl, muscovite, quartz, and albite. Crystals of beryl as small as a quarter of an inch in diameter have been found, but the average size is 4 inches in diameter. Ten crystals 1 foot to 2 feet in diameter have been measured. One large and unusual crystal measured 2 feet in diameter and about 4 feet in length, but it was made up of many distorted, parallel crystals about 2 inches in diameter separated by thin films of pale-pink albite. Only a very small proportion of the beryl is too small to be recovered by hand cobbing.

Preliminary optical tests on this beryl show that it contains very few microscopic mineral inclusions and that the index of refraction for the ordinary ray is $1.570 \pm .003$. This indicates a BeO content near 14 percent. A composite chip sample of about 190 beryl crystals analyzed in the Chemical Laboratories of the Geological Survey gave 12.42 percent BeO.

In 1942, during the preliminary mapping, 191 beryl crystals were measured in the pegmatite, and their aggregate weight was estimated to be at least 3.7 tons. The area of beryl exposed in parts of the zone was used in establishing the beryl content of the rock, and on this basis the beryl content of the intermediate zone was estimated to range from 0.5 to 2 percent.

Columbite is commonly most abundant in the outer albitic part of the intermediate zone and occurs in crystals that are mostly less than an inch in their longest dimension. One exceptionally large crystal was nearly 6 inches long, 3.5 inches wide, and about 2 inches thick. The specific gravity of the mineral was determined by the Chemical Laboratory of the Geological Survey as 5.52, and it thus appears that the mineral contains less than 5 percent Ta_2O_5.

Beryl and columbite occur in the same concentrations as the muscovite. The estimated beryl content of the footwall concentration is based on several beryl counts and on past-production figures, and the grade of the columbite is based on visual estimates. The beryl and columbite are unevenly distributed, but the average content of the concentration is 2 percent beryl and about 1 percent columbite.

The estimated beryl content of the northern concentration is based on past production and on beryl counts, but the content is much more variable than in the footwall concentration and is not so accurately known. A beryl count in the north room indicated a grade of 2.1 percent beryl, but the reported production of about 30 tons of beryl indicates a grade of 24.5 percent beryl in comparison with the total quantity of rock mined. The discrepancy between recovery and the grade that was indicated by counts shows that mineral counts are inaccurate where many large crystals are included. At least five crystals about 2 feet in diameter and 8 feet in length were mined in this room. Small high-grade concentrations have been found throughout the beryl deposit in the past but cannot be predicted. Columbite is visually estimated to make up 1 percent of the concentration.

The grade of the hanging-wall concentration is lower than that of the other two concentrations, and the distribution of the minerals is extremely erratic. No mineral counts could be made, but the grade of beryl is visually estimated at 0.5 percent. Columbite occurs sparsely, and the average content of this mineral cannot be established.

The grade of the six minor concentrations is visually estimated at 1 to 2 percent beryl and about 1 percent columbite.

RESERVES

The reserves of economic minerals in the Devils Hole pegmatite cannot be stated exactly. It is estimated roughly that the reserves of feldspar recoverable by hand cobbing are slightly less than half the quantity already produced. Reserves of scrap mica, beryl, and columbite, contained in approximately 5,000 tons of muscovite-quartz-albite pegmatite, are 25 to 100 tons of beryl, 1,000 to 3,000 tons of muscovite, and about 50 tons of columbite.

COTOPAXI REGION

A large number of pegmatites crop out in the region of pre-Cambrian rocks that extends to the west and north of the Arkansas River from Cotopaxi to Howard in Fremont County. The pegmatites are muscovite-poor but have a high content of biotite and magnetite. The feldspar commonly is white or light-colored. None of the pegmatites visited contain beryl, and only a few contain muscovite. Seven of these pegmatites were examined in November 1942 by E. Wm. Heinrich, and the McCoy prospects were revisited by J. B. Hanley in October 1943.

COTOPAXI FELDSPAR PROSPECT

The Cotopaxi feldspar prospect (26), in sec. 8, T. 48 N., R. 12 E., New Mexico principal meridian, Fremont County, is 4 miles north of Cotopaxi. The prospect is owned by the Colorado Feldspar Co. of Canon City and was worked by this company for several months in 1939. A few hundred tons of feldspar were produced from a shallow open-cut that is 60 feet long, 40 feet wide, and 6 feet deep. The pegmatite cropped out as an irregular knob prior to mining, but this knob has been almost

completely removed. The exposures that remain consist of graphic and granitic intergrowths of quartz and feldspar, massive quartz, nests of biotite, and distorted octahedrons of magnetite. A small quantity of buff to gray feldspar occurs in masses 2 feet in length. After crystallization of the feldspar, it was altered by solutions, and hematite, muscovite, uraninite, and another mineral tentatively identified as samarskite were deposited. One patch of pegmatite containing 75 pounds of uraninite is reported to have been found.

PINE RIDGE PROSPECT

The Pine Ridge prospect (63) is in sec. 20, T. 49 N., R. 12 E., New Mexico principal meridian, Fremont County, 7 miles north of Cotopaxi. It was located in December 1941 by Frank Ogden of Vallie. A shallow cut has exposed a narrow pegmatite that strikes almost due north. The pegmatite contains quartz, red microcline, biotite, and large irregular masses of a dark, heavy, vitreous mineral with a subconchoidal fracture. None of the feldspar is suitable for commercial use.

McCOY PROSPECTS

The McCoy prospects (50), in sec. 24, T. 48 N., R. 11 E., New Mexico principal meridian, Fremont County, are about a mile southeast of Coaldale on the north bank of the Arkansas River. The pegmatites crop out on the side of the ridge that forms the valley wall. The claims were located by G. W. Faye and L. G. Young on November 1, 1941, but had been previously worked for quartz.

These prospects were visited by E. Wm. Heinrich in November 1942 and by J. B. Hanley in October 1943. The only workings are open-cuts made by slabbing the natural cliffs formed by the pegmatites.

The pegmatites form a network of branching dikes in a fine-grained red granite wall rock, in which are exposed inclusions of gneiss several hundred feet across. The largest pegmatite strikes east and dips gently to the north. It is 120 feet long and ranges from 12 to 25 feet in width. The zonal structure in this pegmatite is ill-defined, and only the central core of quartz pegmatite, which is 7 feet thick, is distinct. The quartz-microcline-biotite-plagioclase pegmatite that surrounds the quartz core contains large masses of quartz, crystals of feldspar as much as 2 feet across, and sheets of biotite 2 feet wide. The feldspar crystals commonly have a core of graphic granite and a rim, which may be as much as 6 inches thick, of bluish-green plagioclase. This plagioclase is so highly sericitized that its anorthite content cannot be accurately determined, but the observed optical properties indicate that it is albite. The feldspar crystals have been often mistaken for beryl because of the bluish-green color but can be readily distinguished by their relative softness. Accessory minerals are magnetite, epidote, and hornblende.

The second large pegmatite, which is 100 feet to the east of the first, strikes N. 5° W., dips 40° NE., and is 20 feet wide. The contact between the pegmatite and the granite wall rock is irregular and has many sharp rolls. Adjacent to the contacts the pegmatite consists of sharply defined minute bands of fine-grained biotite pegmatite alternating with bands of fine-grained quartz-feldspar pegmatite. The coarse-grained interior of the pegmatite is composed of graphic granite and biotite with accessory magnetite.

No sizable concentrations of feldspar, the only mineral of economic significance in the dikes, have been found.

KNOB HILL PROSPECT

The Knob Hill prospect (43) is on the southeast slope of Kiln Gulch 3 miles north of Vallie, a siding on the Denver & Rio Grande Western Railroad. The prospect was located by Earl MacDaniel of Canon City and Glen Wilkerson of Coaldale in 1941. It has yielded 60 tons of feldspar.

The pegmatite contains quartz, white microcline, muscovite, biotite, and garnet. It is 20 feet wide, strikes east, and has unconformably intruded a crumpled biotite-quartz-feldspar gneiss. Coarse-grained granitic intergrowths and remnants of a few large crystals of feldspar are exposed. The pegmatite contains too little feldspar and muscovite to permit economic operation.

OGDEN PROSPECT

The Ogden prospect (60) is on the northwest slope of Kiln Gulch 3.5 miles north of Vallie. It is owned by Frank Ogden of Vallie. The pegmatite is 10 feet wide and contains crystals of feldspar that are 1 foot in length and are associated with scattered books of muscovite.

SCHAAF PROSPECT

The Schaaf prospect (77) is 1 mile northeast of the Ogden prospect and belongs to W. H. Schaaf of Vallie. The pegmatite is an intergrowth of quartz, microcline, biotite, and muscovite. No minable quantity of feldspar is exposed, and the quantity of scrap mica is small. The pegmatite has been highly sheared, and hydrothermal solutions have kaolinized and stained the feldspar.

HOWARD PROSPECTS

The Howard prospects (39), in sec. 36, T. 49 N., R. 10 E., New Mexico principal meridian, Fremont County, are 1.5 miles up Sand Gulch from its mouth. They are claimed by James Howard of Howard.

Six pegmatites, ranging in width from 8 to 25 feet, can be traced for several hundred feet along the strike. They contain graphic granite, crystals of white, pink, green, and black feldspar, quartz, biotite, magnetite,

and a little muscovite. The black color of some of the feldspar is caused by stain on closely spaced cleavage planes. One of the pegmatites contains feldspar crystals as much as 4 feet long. The pegmatites commonly contain only 5 to 10 percent of recoverable feldspar. The northernmost pegmatite narrows toward the east and grades into a biotite pegmatite that is so rich in magnetite that the outcrop is a gossan.

GUNNISON COUNTY

QUARTZ CREEK DISTRICT

LOCATION, GENERAL FEATURES, AND HISTORY

The Quartz Creek pegmatite district (see fig. 13) comprises an area of about 10 square miles in T. 49 N. and T. 50 N., R. 3 E., New Mexico principal meridian, Gunnison County. It is 17 miles by air line east of Gunnison and about 65 miles by road west of Salida. The nearest railroad shipping point, Parlin, is on the Denver & Rio Grande Western Railroad (narrow gage). The pegmatites occur along Quartz Creek, which constitutes the main drainage of the region, and its tributaries. Colorado State Highway 162 passes through the district, and wood and mine roads lead to many of the pegmatites.

The topography is moderately steep. It has a maximum relief of 1,200 feet and an average altitude of 8,300 feet. Quartz Creek is the nearest source of water

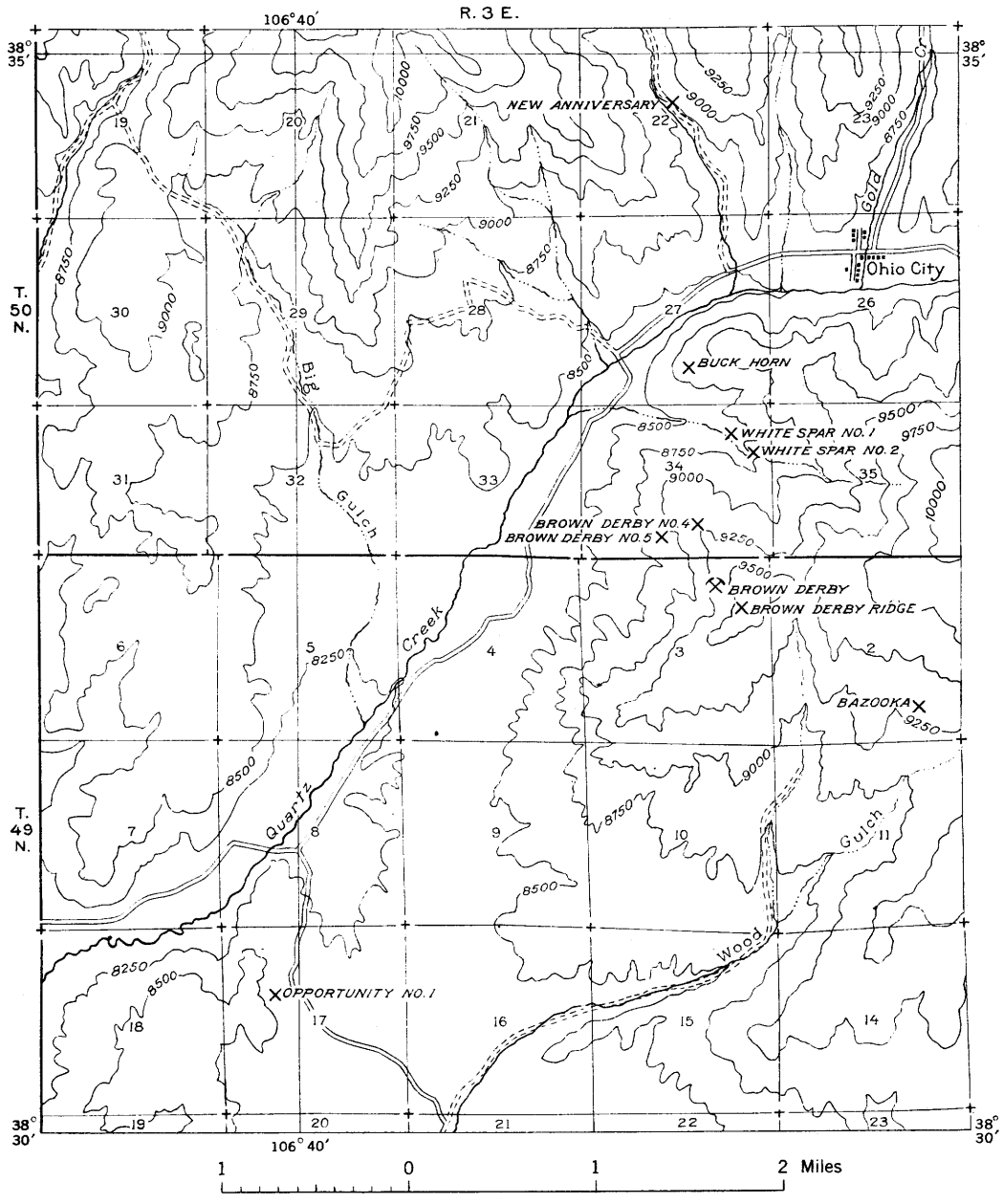

FIGURE 13.—Index map of Quartz Creek district, Gunnison County, Colo.

needed in mining. The south, east, and west slopes of the many hills in the district are covered with sagebrush, but stands of timber sufficient for mining needs grow on the north slopes of all the hills. Precipitation in the district is very low. Because of favorable weather conditions the mines and prospects can be operated throughout the year.

The first discoveries in the district were made in 1930 when O. F. Werner and William Disberger located the Brown Derby No. 1 and 2 claims; following these discoveries, most of the other pegmatites of the district were located. Although Disberger and Werner did a great deal of development work, no minerals were produced until late in 1943 when the Hayden Mining Co. leased and started mining at the four Brown Derby claims and the Colorado Feldspar Co. of Canon City began operations on the White Spar prospects. The White Spar prospects were worked intermittently up to 1945, and the Brown Derby mine was operated continuously during that time. Ten of the mines and prospects were investigated by Survey geologists at various times from September 1942 to December 1944.

GEOLOGY

The Quartz Creek district is in a region underlain by pre-Cambrian metamorphic and igneous rocks. A large granite mass is exposed between the Opportunity and the Brown Derby pegmatites and underlies most of secs. 3, 4, 8, 9, 10, 15, and 16 in T. 49 N. The pre-Cambrian igneous and metamorphic rocks are surrounded on the west, south, and east by Cretaceous sediments and lavas and on the north by Paleozoic sediments.

The pre-Cambrian metamorphic country rocks are quartz-mica schists, metadiorites, quartz-mica gneisses, and quartzite, all of them poorly exposed in the district. Metadiorite and fine-grained quartz-mica schist are the wall rocks of most of the pegmatites; the Bazooka pegmatite occurs partly in quartzite. The granite does not occur in the immediate vicinity of any of the pegmatites. It is a medium-grained, reddish granite that contains quartz, microcline, plagioclase, and biotite as the chief constituents.

In general the pegmatites of the district are fairly well exposed, but their contacts with the wall rocks are poorly exposed. Most of the pegmatites are long, narrow, tabular bodies that cut across the wall-rock schistosity. Two distinct mineralogical types of pegmatites occur in the district: a quartz-microcline-muscovite type that contains beryl and a lithia-bearing type that may contain either lepidolite or spodumene together with accessory tantalum and fluorine minerals. The beryl-bearing type is exemplified by the Buck Horn, Brown Derby Ridge, New Anniversary, and Brown Derby No. 4 pegmatites. The lepidolite-bearing pegmatites are exemplified by the Opportunity, Brown Derby No. 5, White Spar No. 1 and No. 2, and Brown Derby mine pegmatites. The spodumene-bearing pegmatites are exemplified by the Bazooka pegmatite. The beryl-bearing type of pegmatite commonly forms the outer zones of the lithia-bearing pegmatites.

Beryl commonly occurs in the intermediate zones of both types of pegmatite, and the lithia minerals commonly occur in the core or core units. In some pegmatites, of which the Brown Derby mine pegmatites are an example, beryl occurs in both the wall zone and the core.

The lithia minerals, particularly lepidolite, are generally associated with tantalum minerals and fluorine minerals. The most common tantalum mineral in the district is microlite, and the most common fluorine mineral is topaz. Lepidolite, microlite, and topaz occur in the core in the Brown Derby mine pegmatites, the Opportunity No. 1 pegmatite, the White Spar No. 1 pegmatite, and the Brown Derby No. 5 pegmatite.

OPPORTUNITY NO. 1 PROSPECT

The Opportunity No. 1 prospect (61) is on one of a group of three claims in the NW¼ sec. 17, T. 49 N., R. 3 E., New Mexico principal meridian. The prospect is at an altitude of 8,400 feet on the eastern slope of a low, north-trending ridge on the east side of Quartz Creek. (See fig. 13). It can be reached by following the Doyleville road for 0.8 mile south of the junction with Colorado State Highway 162 and then taking a poor mine road for 550 feet west to the workings. The nearest railroad shipping point is at Doyle on the Denver & Rio Grande Western Railroad (narrow gage). The claims were located by J. E. Meyers and Canon City in 1939. The pegmatites were visited by E. Wm. Heinrich in 1942 and were examined by E. Wm. Heinrich assisted by Roswell Miller III on July 23 and 25, 1943, when 11 pegmatites were mapped by plane table and telescopic alidade.

Four small open-cuts (fig. 14) are the only openings in the pegmatites. The largest open-cut is 37 feet long, 10 feet wide, and about 10 feet deep. The other three, all shallow, are less than 20 feet long and less than 10 feet wide.

The Opportunity pegmatites are extremely varied in size and shape. They occur in a fine-grained, reddish granite that locally is biotite-rich and has poorly developed foliation. Neither the granite nor the pegmatites are well exposed.

The pegmatites pinch and swell over short distances, are branching and curved, and are especially irregular in shape in their wider parts. The narrower parts are more regular in shape and are uniform in width for considerable distances. The general trend of the nar-

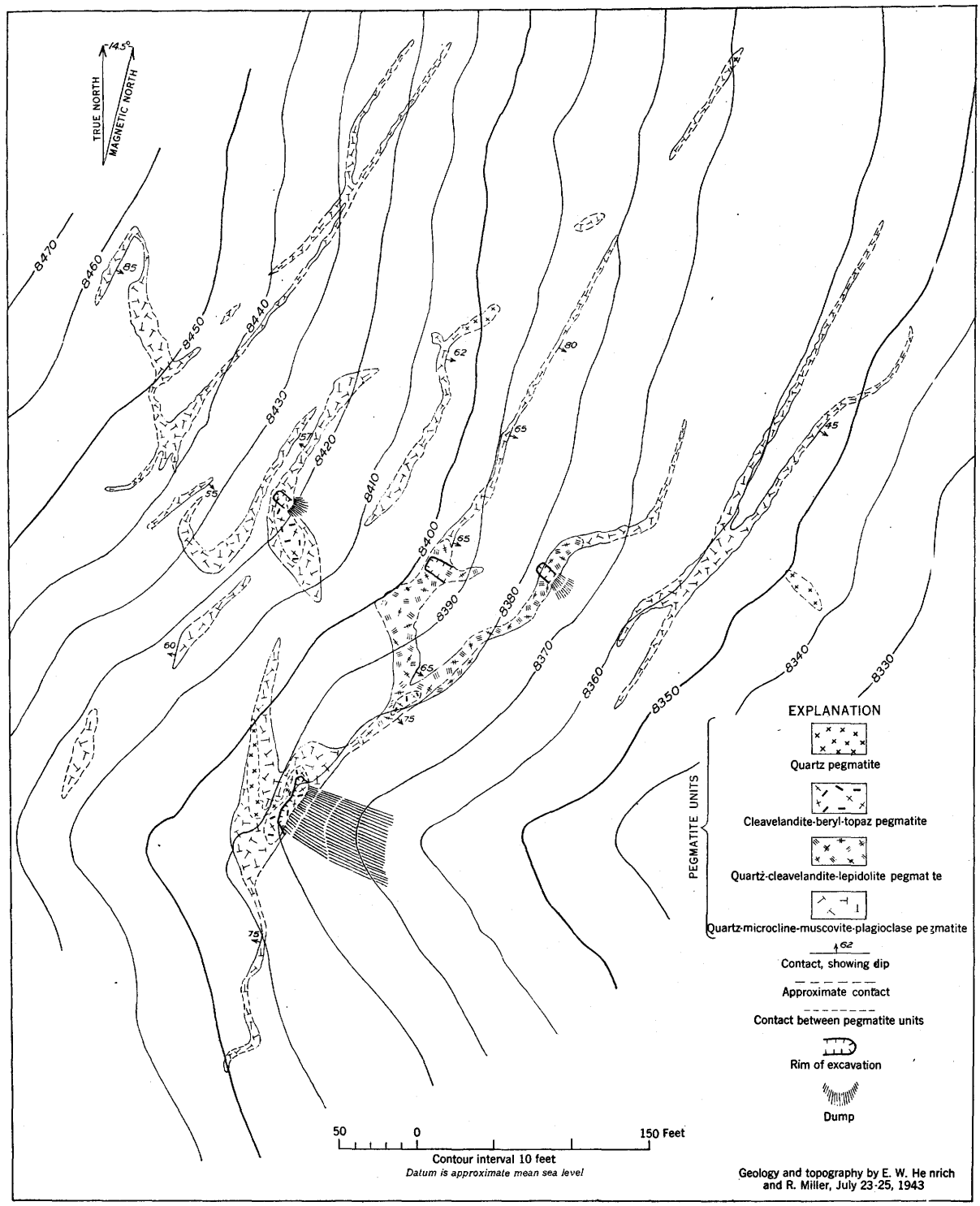

FIGURE 14.—Map of Opportunity No. 1 prospect, Quartz Creek district, Gunnison County, Colo.

row parts is N. 30° E., and the dips are 45° to 80° SE., although locally the dip of the contact may be reversed.

The largest pegmatite, the lode of the Opportunity No. 1 claim, is about 730 feet in length and as much as 50 feet in width, but for 400 feet of its length it is only 5 feet wide. The wider parts of this pegmatite probably are controlled by the intersections of joints, of which there are two sets, one striking N. 30° E., the other N. 12° W.

Nine of the eleven pegmatites in the map area are composed chiefly of medium-grained quartz-microcline-muscovite pegmatite with minor quantities of cleavelandite and lepidolite. Small concentrations of quartz pegmatite occur at the northern ends of two of the

pegmatites. None of the nine contains economic concentrations of minerals.

The largest pegmatite contains four types of rock. The narrower parts and most of the wider parts are made up of medium-grained quartz-microcline-muscovite pegmatite. The three other types, occurring in the wider parts, are: medium-grained quartz-cleavelandite-lepidolite pegmatite; coarse-grained cleavelandite-beryl-topaz pegmatite that contains accessory gray quartz, lepidolite, tourmaline, microlite, and columbite; and quartz pegmatite. These three types appear to be localized by the greater width of the pegmatite body and the presence of branches. Two pods of the cleavelandite-beryl-topaz pegmatite occur in this pegmatite body. One of the pods is exposed in the largest open-cut, and the other is 80 feet northeast of this cut. An area of medium-grained quartz-cleavelandite-lepidolite pegmatite occurs in the main pegmatite and the northerly branch at the northern end. This area starts about 45 feet northeast of the largest open-cut and has a length of 190 feet in the main body and 100 feet in the northerly branch.

A second pegmatite, about 120 feet north of the largest open-cut, likewise contains a pod of cleavelandite-beryl-topaz pegmatite. The pod occurs in quartz-microcline-muscovite pegmatite, but no quartz-cleavelandite-lepidolite pegmatite is exposed.

The three pods of cleavelandite-beryl-topaz pegmatite in these two pegmatites are the only mineral deposits in the Opportunity pegmatites. Four minerals of economic significance—columbite, microlite, beryl, and lepidolite—occur in this type of pegmatite. The columbite and microlite have been found only in the pod exposed in the largest open-cut. Columbite occurs in minute grains, although crystals as much as 2 inches in size have been reported. Microlite occurs in rough, distorted octahedrons as much as a quarter of an inch in size. The microlite is more abundant than the columbite but is estimated to make up less than 0.01 percent of the pegmatite.

Beryl occurs in all three pods either in glassy, pale-blue anhedral crystals or in dull-blue subhedral to euhedral crystals. The glassy beryl rarely occurs in crystals more than 2 inches in size, but the dull-blue beryl occurs in crystals as large as 4 inches in size. It is visually estimated to be no more than 0.5 percent of the rock exposed in the largest open-cut.

Lepidolite occurs in masses of fine-grained flakes, in long blades in quartz, and as large scattered flakes in albite. The best exposures in the quartz-albite-lepidolite pegmatite are visually estimated to contain 15 percent lepidolite, but the lepidolite is too widely dispersed in the cleavelandite-beryl-topaz pegmatite pods to be recovered economically.

The topaz in this pegmatite occurs in cream-colored subhedral crystals as much as 1 foot in length and 8 inches across. A thin film of green sericite commonly coats these crystals. The pods are visually estimated to contain 5 percent or less topaz.

The Opportunity pegmatites do not contain a large quantity of cleavelandite-beryl-topaz pegmatite. The three exposed pods have an area of only 725 square feet and probably do not extend more than 25 feet in depth. However, if a local market becomes available, the beryl, microlite, and lepidolite might be mined by a small crew at a slight profit.

An irregular, branching pegmatite about 3,000 feet long and as much as 50 feet wide is exposed at the top of the ridge west of the map area. This pegmatite contains a high percentage of quartz with a small quantity of microcline and muscovite. It has no sizable concentrations of commercially valuable minerals.

BAZOOKA SPODUMENE PROSPECT

The Bazooka spodumene prospect (2), in sec. 11, T. 49 N., R. 3 E., New Mexico principal meridian, is near the head of Wood Gulch at an altitude of 9,300 feet. (See fig. 13.) The prospect can be reached by a poorly defined trail that extends northwest from the end of the old Wood Gulch road, which branches north from the Doyleville-Quartz Creek cut-off road. The nearest railroad shipping point is Doyle on the Denver & Rio Grande Western Railroad (narrow gage). The prospect is owned by Leonard Nesbit of Parlin, who relocated the claim in July 1943. It was examined by E. Wm. Heinrich assisted by Roswell Miller III on July 20, 1943, and at that time was mapped by plane table and telescopic alidade.

Two circular pits are the only openings in the two pegmatites on the prospect. The pit in the northern pegmatite is about 5 feet in diameter and 3 feet deep. The pit in the southern pegmatite is larger, about 20 feet in diameter and at least 10 feet deep.

The Bazooka pegmatites have intruded pre-Cambrian metamorphic rocks across the contact between a hornblende gneiss and a quartzite. The hornblende gneiss is a blue-gray, massive rock that is composed of hornblende and feldspar, and the quartzite is reddish, fine-grained, uniform in texture, and highly stained by iron oxide along joints and fractures. Neither the general structure of these rocks nor their relationship to one another could be determined.

Two lenticular pegmatites that trend N. 35° E. and appear to be vertical crop out on the Bazooka claim. The southern pegmatite (see fig. 15) is 175 feet long and has a maximum width near the central part of 35 feet, but the average width is only 10 feet. The northern pegmatite is 55 feet long and has an average width of 5 feet. These two pegmatites may be connected in

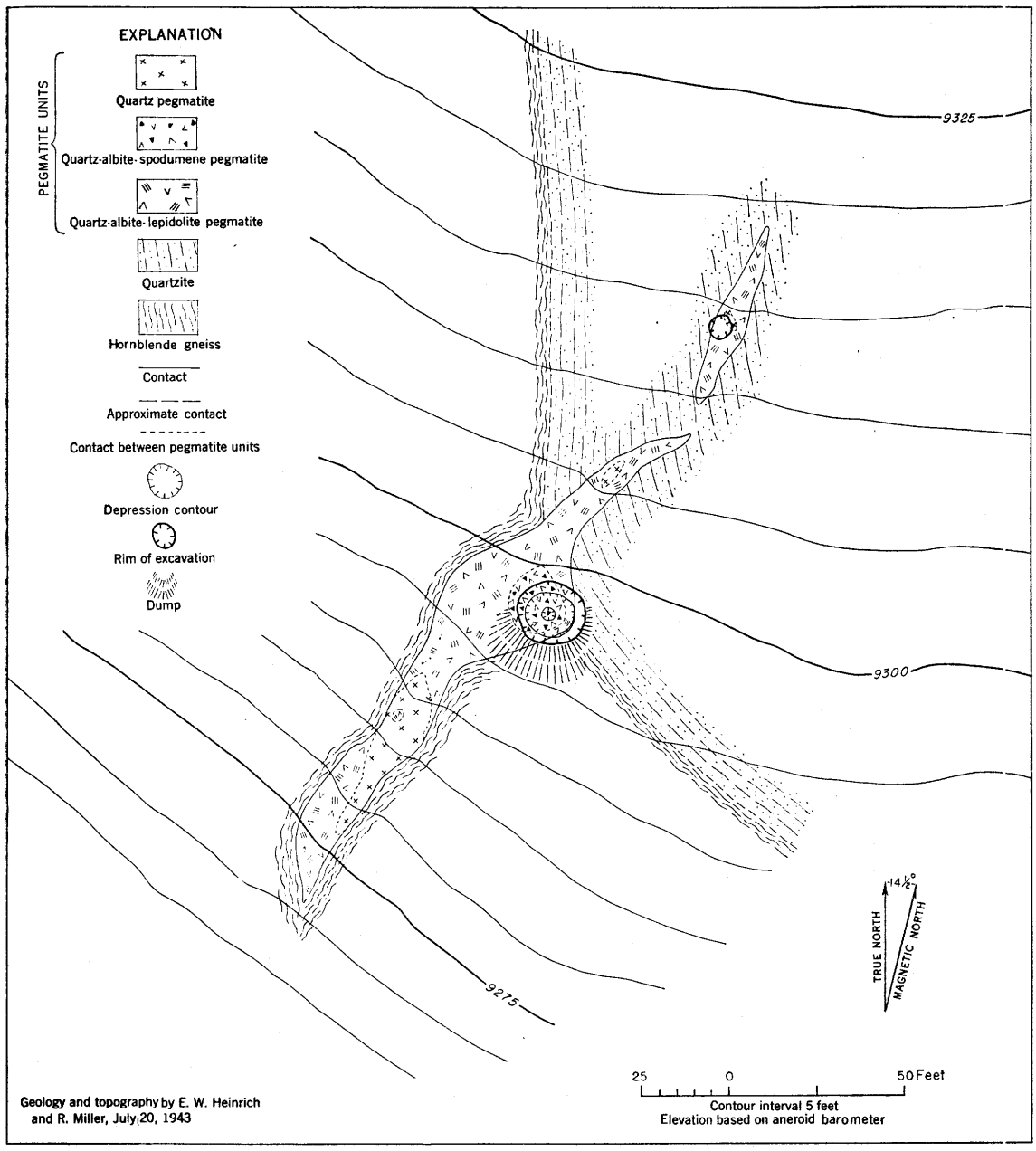

FIGURE 15.—Map of Bazooka spodumene prospect, Gunnison County, Colo.

depth. No other pegmatites were found in the vicinity of the Bazooka prospect.

Both pegmatites are zoned, although the zones are highly discontinuous. The southern pegmatite contains a wall zone of quartz-albite-lepidolite pegmatite, also pods of quartz pegmatite and a unit of quartz-albite-spodumene pegmatite. The northern pegmatite is similar to the southern one but contains no quartz-albite-spodumene pegmatite.

The wall zone is composed of a fine- to medium-grained intergrowth of quartz, albite, and lepidolite. Masses of fine-grained lepidolite as much as 2 feet in diameter occur in it. The lepidolite content of the zone in both pegmatite bodies is visually estimated to be less than 5 percent.

The quartz pegmatite occurs as a large pod in the southern part of the southern pegmatite and as a smaller pod near the northern end. A small pod of quartz pegmatite occurs near the center of the northern pegmatite; one contact of this pod strikes N. 35° E. and dips 25° SE.

The quartz-albite-spodumene pegmatite occurs as a roughly circular pod about 15 feet in diameter. It is in the widest part of the pegmatite and at the place where the pegmatite crosses the contact between the hornblende gneiss and the quartzite.

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The pegmatite of this pod is a medium- to coarse-grained mixture of quartz and albite with scattered flakes of lepidolite; scattered anhedral amblygonite masses that are 3 inches in size; patches of highly sericitized pink feldspar (microcline?); crosscutting veins and masses of spodumene; and accessory sericite, cookeite, microlite, and prochlorite, as well as several unidentified alteration products. The spodumene occurs in thin lathlike crystals, many of which are extremely friable. Individual spodumene crystals are as much as a foot in length, and these crystals commonly occur in masses as large as 1 foot by 1.5 feet. A thin coating of bright-green sericite is common on the spodumene crystals. The sericite is variegated, optically negative, with a $2V$ of 50°–60°, alpha=1.565, beta=1.585, and gamma=1.593. One honey-yellow microlite crystal found in this deposit had an index of refraction of 2.06.

Spodumene was observed to make up 12 percent of a face in the pit with an area of 25 square feet. The amblygonite content of this pegmatite is not known, but it is estimated to be far less than the spodumene.

The southern Bazooka pegmatite probably contains 800 tons of quartz-albite-spodumene pegmatite that is estimated to contain about 12 percent spodumene and 5 to 10 percent amblygonite.

BROWN DERBY MINE

LOCATION AND HISTORY

The Brown Derby mine (12), in sec. 3, T. 49 N., R. 3 E., New Mexico principal meridian, is about 17 miles by air line east of Gunnison. (See fig. 13.) The mine is on the east wall of Quartz Creek valley at an altitude of 9,300 feet, 1,000 feet above the valley floor. A 2-mile mine road provides access from Colorado State Highway 162.

The Brown Derby No. 1 and No. 2 claims, on which the mine is situated, were located by William Disberger and O. F. Werner on September 17, 1930. Extensive development work was done by these owners until their deaths, when the property passed to Mrs. Marie M. Disberger of Gunnison. For several years no work was done, but in September 1943 the Hayden Mining Co., which had leased the property, started operations. The production to the end of 1944 was 3,155.67 pounds of beryl, which was sold to the Metals Reserve Company, and 243 tons of lepidolite concentrate. In addition, a few thousand pounds of microlite concentrates had been recovered but had not been cleaned up and sold.

The mineralogy of the pegmatites in the claims has been described by Eckel [33] and by Landes.[34] The Brown Derby mine pegmatites were first investigated by J. B. Hanley and E. Wm. Heinrich November 3–6, 1942, and at that time dike 1 and part of dike 2 were mapped at a scale of 1 inch to 50 feet by plane table and telescopic alidade. In July and August 1943 this map was extended by J. B. Hanley, E. Wm. Heinrich, and Roswell Miller III to include nine other pegmatites in the adjoining area. From July 25 to August 8, 1944, following the start of the mining operations, dikes 1, 2, and 3 and also a small, previously unmapped pegmatite in this group were mapped by transit and stadia at a scale of 1 inch to 20 feet by J. B. Hanley, A. F. Trites, Jr., and J. E. Husted. During December 6–8, 1944, the new underground workings were mapped by J. B. Hanley.

MINE WORKINGS

The older workings, made prior to the Hayden Mining Co.'s operations, are in dikes 1, 2, and 3 and consist of 18 pits and trenches, 2 tunnels, and 1 inclined shaft. None of the other pegmatites on the claims have been explored. The pits and trenches are small and range from 4 to 28 feet in length, from 2 to 6 feet in width, and from 1 foot to 10 feet in depth. Tunnel 2 is 86 feet long with a 23.5-foot drift to the northeast 62 feet in from the portal, and tunnel 3 is 35 feet long with a 10-foot drift to the south at the inner end. Tunnel 1 in 1942 was level for 10 feet in from the portal and then changed into an incline down the dip of the pegmatite from this point for a distance of 15 feet. The floor of the incline is along the footwall contact of the pegmatite.

The work by the Hayden Mining Co. includes a new pit 15 feet long by 6 feet wide, 100 feet north of the incline; the enlargement of pit 2, which is 100 feet south of the incline, to 24 feet in length and 8 feet in width; the deepening of the incline to 83.5 feet down the dip; and a level from the shaft at an altitude of 9,315 feet. The level is made up of a 49-foot drift to the north of the shaft and a 10-foot drift to the south. At the end of the south drift a vertical raise about 8 feet high above the back of the drift has been made, with a second raise almost at the end of the inclined shaft. This second raise is about 6 feet high, and an 8-foot drill hole, which reached the hanging-wall contact near the end of the hole, has been made at the top. In addition to sinking the shaft, the operators drove a 16-foot raise up the dip from the inner end of the level part of the old incline. This raise connects with the surface and forms a skip way about 4 feet high and 5 feet wide. The company has also excavated several large areas in the wall rock to provide space for the mining equipment and has enlarged pit 18 in dike 3 to 20 feet in length and 10 feet in width.

[33] Eckel, E. B., A new lepidolite deposit in Colorado: Am. Ceramic Soc. Jour., vol. 16, pp. 239–245, 1933.

[34] Landes, K. K., Colorado pegmatites: Am. Mineralogist, vol. 20, p. 333. 1935.

GEOLOGY

The three lithia-bearing pegmatites, shown in plate 9, are parallel, elongate dikes that cut across the schistosity of the hornblende-rich metadiorite wall rock of pre-Cambrian age. The nine other pegmatites that have been studied generally are elongate, tabular bodies. Three are branching pegmatites. All cut across the schistosity of the pre-Cambrian wall rock, probably along a fracture system. A large area south of the dikes is granite, and the pegmatites are probably derived from the granitic magma. The lead-uranium ratio [35] of the microlite in dike 1 indicates that the age of the pegmatites is between 760,000,000 and 806,000,000 years and that they are pre-Cambrian.

Exposures of the wall rocks are very sparse in the area mapped. The wall rocks are intercalated metamorphosed igneous and sedimentary rocks. The igneous rocks are chiefly dioritic in composition and are green in color because of a high hornblende content. The sediments have been metamorphosed to grayish biotite schists. They are exposed only in the end of tunnel 3 and make up a very small part of the sequence. Most of the wall rocks are compact, dense, and massive; the rest have a poorly developed schistosity that strikes in general N. 20° E. and dips 55° SE. The rocks are closely jointed and not competent. Thin, secondary veinlets of quartz and calcite are common along the joint planes.

The pegmatites are poorly exposed, particularly south of tunnel 2, as the soil cover increases in depth toward the south. North of this tunnel the pegmatite is well exposed, and the geology can be determined fairly accurately. All three of the main lithia-bearing dikes strike N. 56° E. and dip from 30° to 35° SE. (See pl. 9.) They are similar in structure and lithology. They have pronounced zonal structures, and the arrangement of zones is such that they show marked lithologic changes along strike and dip. The zones are markedly discontinuous, and as any given zone is formed only on one side of the core, the pegmatite appears to be layered. The sequence of zones is uniform through any one exposure but changes along the length of the dikes. At least three of the zones in these pegmatites occur only as lenticular pods with small lateral extent. Dike 1 is the most distinctly zoned, containing nine easily recognizable zones; dikes 2 and 3 contain four.

The other nine pegmatites trend from due north to N. 59° E. and dip about 35° SE. One ranges in width from 4 to 80 feet; the other eight are commonly narrow. Two are slightly arcuate. None of the nine is distinctly zoned; the best in this respect contains only four zones, one of them very poorly developed. Most of these pegmatites are composed chiefly of quartz-microline-muscovite-albite pegmatite, and several contain very small quantities of beryl. One contains very minor quantities of lepidolite, but the lepidolite content is too low for economic recovery. As none of the nine pegmatites contain concentrations of commercially valuable minerals, they will not be described in detail.

Three faults are exposed at the surface, two of which cut the pegmatite, dike 10, about 750 feet N. 33° W. from the incline in dike 1. The other cuts dike 1. The southern fault in dike 10 strikes N. 28° W.; the northern strikes N. 57° E. The dips on these faults are unknown, but the displacement on the southern fault is 4 feet to the southeast and on the northern fault is 3 feet to the northeast. The faults are probably rotational, as the dip of that part of the pegmatite between the two faults is 30° SE. and, on the parts of the pegmatite north and south of the faults, is from 40° to 45° SE.

The fault in dike 1 strikes N. 45° W.; the dip is unknown. The horizontal displacement is 18 feet, and the movement on the fault was rotational, as the part of the pegmatite north of the fault dips 5° SE. and the part south of the fault dips 60° SE. In addition to this fault, four minor ones are exposed in tunnel 2, and at least two minor faults are exposed in the incline. The best-exposed minor fault is on the south wall of tunnel 2, and the striations exposed on the fault plane pitch 40° SE. The displacements along the faults are less than 1 foot, and none of the faults cut the wall rock.

DIKE 1

General features.—Dike 1 has a total length of 913 feet and contains lepidolite for 319 feet of this length. The thickness of the lepidolite-bearing part is 12 feet at the surface and about 20 feet at the bottom of the incline. The surface width ranges from 1 foot to 43 feet along the length of the dike. The dike narrows rapidly to the north of the incline and in pit 1 is not more than 5 feet thick. About 100 feet south of tunnel 2 the dike splits into an eastern and a western branch; this split probably occurs between the lithia-rich zones and the quartz-albite-mica-microcline pegmatite.

The eastern branch is very poorly exposed at the surface but by means of the pits and trenches and tunnel 3 can be traced for a distance of 142 feet south of the point where the dike branches. The western branch can be traced by means of pits and trenches for 160 feet to the southwest of that point.

The structure can be determined readily from the contacts, rolls, and lineations. At least a 1-foot thickness of the pegmatite adjacent to the footwall contact is fine-grained and resistant to erosion. A similar fine-grained pegmatite occurs along the hanging wall, al-

[35] Fairchild, J. G., with Eckel, E. B., and Lovering, T. S., Microlite from Ohio City, Colo.: Nat. Research Council, Comm. on Geol. Time, Rept. of Apr. 27, 1935, exhibit 5.

though here it is not more than 2 inches thick. The fine-grained pegmatite has preserved the external structure of the pegmatite body.

The dip of the pegmatite changes from place to place along the length, but the dip throughout the minable part is from 10° to 35° SE. Locally, particularly in close proximity to the axes of minor rolls, the dip on the contact may range from 5° to vertical. Reversals of dip are uncommon. However, the upper 6 feet of the outcrop above tunnel 2 forms a dip slope controlled by a longitudinal roll in the pegmatite.

The pitch of the axes of the rolls ranges from S. 8° E. to S. 67° E. in direction and from horizontal to 44° in angle of pitch. Of 12 axes measured, only one was found that pitched northwest. The general plunge of the pegmatite is probably 22°, S. 28° E., the average of the pitch measurements.

Internal structure.—Dike 1 contains a group of units that can be recognized by diagnostic minerals and by differences in mineral proportions. Boundaries between units are gradational and irregular. The units are markedly discontinuous, and any given unit is commonly found on only one side of the pegmatite. The major units are a wall zone of quartz-albite-muscovite-microcline pegmatite, a possible intermediate zone of albite-quartz pegmatite, and a core that probably is made up in turn of a unit of cleavelandite-quartz-lepidolite-topaz pegmatite, a second unit of lepidolite-quartz-cleavelandite pegmatite, and a third unit of cleavelandite-quartz-curved lepidolite pegmatite. A pod of quartz pegmatite occurs along the hanging wall in part of the dike, but its position in the sequence is not known.

In the western branch two units occur that have not been found in the main part of the dike. They are a unit of cleavelandite-quartz pegmatite and a unit of albite-quartz-biotite pegmatite.

The lepidolite-quartz-cleavelandite pegmatite, the quartz pegmatite and the albite-quartz-biotite pegmatite occur only as lenticular pods, the distribution of which appears to be controlled by the local structure. All the other units have great lateral extent and are nearly constant in composition and sequential position throughout the dike, although in places one or more units of the sequence are lacking. The units, except the wall zone and the possible intermediate zone, thin out markedly both to the north and the south of the incline.

The quartz-albite-muscovite-microcline pegmatite is the hanging-wall zone for most of the length of the dike and is the footwall zone except in the lithia-rich part. It is the only zone in the eastern branch. The thickness of the zone is highly variable, but the maximum in the lithia-rich part is not over 4 feet. The chief minerals are quartz, albite, and muscovite, with accessory microcline, beryl, topaz, black tourmaline, and lepidolite. Muscovite commonly occurs in the upper part of the zone just below the hanging wall. Beryl occurs in blue anhedral to subhedral crystals, one of which yielded 1,600 pounds of the mineral.

The wall zone is absent along the footwall from the point where the dike branches to a point 66 feet north of the incline. (See pl. 9.) In this part of the dike the albite-quartz pegmatite occurs along the footwall. The absence of the wall zone in the lithia-rich part can be explained in three ways. One explanation is that a peculiar local set of conditions may have prevented the formation of the wall zone in this part of the dike. The second explanation is that the wall zone formed but was later partly removed by corrosion of the liquid that formed the lepidolite-bearing units and that the albite-quartz pegmatite was deposited in its place. The third explanation is that the wall zone was hydrothermally replaced after it had formed. The available data do not indicate which is the correct explanation, but the occurrence of lepidolite, cleavelandite, microlite, topaz, and fluorite in the other units indicates that if these minerals are of primary origin, the liquid from which the pegmatite formed was strongly corrosive, so that the second explanation may well be the correct one, particularly as no definite evidence of hydrothermal replacement of preexisting pegmatite has been found.

The albite-quartz pegmatite along the footwall in the lithia-rich part of the dike has an average thickness of 1.5 feet. In the upper part of the dike it has an average thickness of about a foot. The chief mineral constituents are albite—or locally cleavelandite—and quartz, with accessory lepidolite, beryl, and black tourmaline. The average grain size in the footwall part is about 8 millimeters, but in the upper part it is larger. This unit contains no concentrations of commercially valuable minerals.

The cleavelandite-quartz-lepidolite-topaz pegmatite unit in the core is best exposed in the incline. It has an average thickness of 2 feet. It consists of cleavelandite, quartz, lepidolite, and topaz, with accessory beryl and lithia tourmaline. Lepidolite occurs in deep-lavender books as much as 10 inches in size in a distinct 8- to 10-inch band just below the overlying unit. Topaz occurs in subhedral crystals as much as 12 inches across and 4 feet long and is associated with the coarse-grained lepidolite band, but individual crystals extend into the overlying unit. Most of the crystals are milky white, but some are greenish or bluish white. Cleavelandite occurs in radial aggregates below the band of lepidolite books and grades downward into the fine-grained albite-quartz pegmatite. Bluish-green and pale-rose beryl crystals occur in the cleavelandite and also in the lepidolite band.

The lepidolite-quartz-cleavelandite pegmatite unit in the core is likewise best exposed in the incline but is also

exposed in tunnel 2 and in the pits and trenches between these tunnels. It has a maximum thickness of 8 feet in the underground workings. The mineral constituents are lepidolite, cleavelandite, and quartz, with accessory microlite and lithia tourmaline. In most of the unit the lepidolite is very fine grained, ranging in size from 1 millimeter to 3 millimeters, but it occurs also as medium-grained aggregates in which the lepidolite flakes have an average diameter of 15 millimeters. The fine-grained lepidolite occurs in irregular pods that contain the high-grade microlite shoots. This type of lepidolite contains microlite only in the incline, as far as is known. The fine-grained pods are visually estimated to contain 75 to 95 percent lepidolite. The rest of the unit is composed of coarse-grained lepidolite and contains larger quantities of quartz and albite.

A concentration of lithia tourmaline crystals occurs in a rod-shaped body between the lepidolite-quartz-cleavelandite pegmatite and the cleavelandite-quartz-curved lepidolite pegmatite in tunnel 2. The red, green, and variegated crystals are as much as 4 inches in diameter and 14 inches long, but all the exposed crystals are highly flawed and friable. Associated minerals are quartz, cleavelandite, and lepidolite.

The cleavelandite-quartz-curved lepidolite pegmatite is distinguished from the other units by pale-lavender lepidolite that occurs in curved plates. Cleavelandite and quartz are the other abundant minerals, and red or green lithia tourmaline is the only prominent accessory. The thickness of the unit is unknown but is probably about 2 feet.

The quartz pegmatite unit occurs only in an irregular pod beneath a roll in the contact above the incline. Its thickness directly above the incline is 2 feet. It is nearly pure quartz but has minor quantities of microcline. It forms the hanging-wall zone for 66 feet north and 18 feet south of the incline.

The cleavelandite-quartz pegmatite is the most widespread unit in the western branch and is composed chiefly of white cleavelandite that occurs typically in ball-shaped masses of plates that are as much as 6 inches long. Cleavelandite is visually estimated to make up 70 to 80 percent of the rock. Quartz is the only other abundant mineral. Accessory minerals are red and green lithia tourmaline and lepidolite. This unit in most of the western branch is next to the hanging wall, and the outer 2 inches is much finer grained than the rest of the unit. Its thickness is not known.

The albite-quartz-biotite pegmatite is exposed only in pit 11 and in dike 4. In pit 11 it occurs in a pod beneath a structural roll in the hanging-wall contact. The pegmatite is fine-grained and brownish white and is composed of albite, quartz, and biotite, with accessory monazite, columbite, black tourmaline, gahnite, betafite, garnet, and fluorite. Albite occurs in the same manner as in the other units, but the size of the masses is less than 2 inches. Monazite occurs in reddish-brown euhedral crystals as much as 2 inches long, 1 inch wide, and 0.4 inch thick. The columbite, which has a specific gravity of 5.61 and contains 72 percent Cb_2O_5 and 6 percent Ta_2O_5, occurs in crystals that are as much as 4 inches long, 3 inches wide, and 0.3 inch thick. Betafite occurs in small, flattened, diamond-shaped crystals with resinous luster and is closely associated with columbite. Gahnite occurs as octahedrons and masses up to 10 millimeters in size and can be recognized by its green color. The maximum thickness of this unit is 1 foot, and the lateral extent is probably less than 20 feet.

This pegmatite locally grades upward into a layer, 4 to 6 inches thick, of biotite-black tourmaline pegmatite at the hanging wall, but it may form the hanging-wall unit.

DIKE 2

Dike 2 has a total length of 437 feet and contains lepidolite for 210 feet of this length. Its average thickness is 10 feet, and its surface width ranges from 8 to 21 feet. Only four shallow pits, none revealing much of the geology, have been made in this dike. The hanging wall is well exposed for 110 feet of the total length, but the footwall is not well exposed and cannot be located definitely. The structure of the dike is therefore not known in detail, but its general dip is about 30° SE. Locally the dip is as gentle as 5° or as steep as 40°. The border zone is not resistant to erosion, and the contacts of the dike are not well preserved. The surface shape indicates that rolls occur in the contact.

Dike 2 probably connects with the western branch of dike 1. The point of connection is not known, but the structure of the two dikes, the converging course of the contacts of both, the pronounced lateral lithologic gradation from dike 1 toward dike 2, and the occurrence of a small lepidolite pegmatite pod where the dikes are believed to join suggest that they do connect. A possible point of connection is exposed in pit 21, but the exposure is too poor to be sufficient proof.

Dike 2 is composed of four major units. The contacts between the units are gradational. In order from footwall to hanging wall these units are albite-quartz-biotite pegmatite, quartz-albite-muscovite pegmatite, cleavelandite-lepidolite pegmatite, and quartz-albite-muscovite pegmatite.

The albite-quartz-biotite pegmatite is composed mainly of albite and quartz with accessory biotite, black tourmaline, and garnet. Typically, this rock is banded near the contact, showing an alternation of garnet-rich layers with black tourmaline-rich layers. The unit ranges from a few inches to 1 foot in thickness.

The two quartz-albite-muscovite pegmatite units are identical in mineral composition and may be parts of

the same zone. Their thicknesses are not known accurately, but the lower unit is about 3 feet thick and the upper unit about 3.5 feet thick. Near the central cleavelandite-lepidolite pegmatite both of these units may contain either green or red tourmaline, or both, as accessory minerals. The outer 1 or 2 inches of the upper unit is usually finer-grained than the rest and forms the border zone at the hanging wall.

The cleavelandite-lepidolite pegmatite of the core is visually estimated to contain about 80 percent cleavelandite, 15 percent lepidolite, and 5 percent accessory tourmaline and topaz. It typically contains a large quantity of ball-shaped aggregates of cleavelandite plates. Lepidolite occurs in books as much as 6 inches in size and in fine- to medium-grained aggregates. The fine-grained lepidolite aggregates occur in lenticular pods where the core is thicker beneath minor rolls in the contact. Only three or four of these pods were found. No microlite was observed, although this type of lepidolite aggregate is the microlite host rock in dike 1.

DIKE 3

Dike 3 is 680 feet long, but only 110 feet of it near the southern end contains lepidolite. In the lepidolite-bearing part it is 32 feet thick; the thickness of the northern part is unknown. The average thickness is probably about 25 feet, and the surface width ranges from 20 to 33 feet. The outcrops are poor in general except in the central part of the dike, and only three small pits explore the dike. The wall-zone pegmatite is resistant to erosion and forms a steep slope. Talus from this zone has collected along the break in slope at the footwall contact and conceals this contact. The hanging-wall contact is fairly well exposed over much of the dike, but the northern part is obscure.

The structure of this dike is not known in detail. Its general dip is about 30° SE.; locally the dip ranges from 25° to 55°. The contacts are marked by a fine-grained pegmatite, but it is not resistant enough to preserve the external structure. Neither structural rolls nor faulting was observed.

The pegmatite is very similar to dike 2 in structure and lithology. Both pegmatites bear a much closer resemblance to each other than to dike 1. Dike 3 contains four units in the southern 110 feet of its length, but the remainder consists of one unit. The units are identical in mineral composition with those of dike 2 and occur in the same sequence. The fine-grained lepidolite pods in the cleavelandite-lepidolite pegmatite contain small quantities of microlite. The largest of these pods, which is exposed in pit 18, contains microlite, and a small quantity of lepidolite and microlite was recovered in enlarging this pit. Microcline occurs in the upper quartz-albite-mica pegmatite as an accessory mineral. Beyond the northern end of the core the lower and upper parts of the quartz-albite-mica pegmatite zone merge and occupy the full thickness of the pegmatite. The average grain size of this pegmatite is about 1 inch.

MINERAL DEPOSITS

Of the minerals that occur in these pegmatites only lepidolite, microlite, and beryl are commercially valuable and beryl is important only as a byproduct.

Mineralogy.—Lepidolite occurs in a variety of forms, chiefly in platy books that are as much as 10 inches in size, in plates and aggregates of medium-grained flakes, and in fine-grained aggregates in which the size of the individual flakes ranges from 1 millimeter to 7 millimeters. The physical and optical properties of all these varieties are similar, and the only chemical difference is that the manganese content of the large plates is slightly higher than that of the smaller flakes.

An analysis published by Stevens [36] is reported to have been made on large plates of pale-purple lepidolite from Ohio City, Colo. (U. S. National Museum, specimen 97893). The only occurrence near Ohio City where lepidolite is found in large plates is in these three dikes. The analysis follows:

Li_2O	5.05	Rb_2O	1.62
SiO_2	49.58	Cs_2O	.09
Al_2O_3	23.87	H_2O-	.51
TiO_2	.06	H_2O+	1.22
FeO	[1].21	F	7.49
MgO	None		
MnO	2.78		103.19
CaO	None	Less O=F	3.15
Na_2O	.57		
K_2O	10.14		100.04

[1] Total iron.

The formula for the lepidolite as determined from this analysis is $K_4.Li_7Al_5.Al_2Si_4O_4O(F,OH)_8$. The analysis and formula probably hold for all the lepidolite in these pegmatites, except that the manganese content is lower in the smaller plates.

Microlite occurs in the fine-grained aggregates of lepidolite as spherical masses and octahedrons that range from microscopic grains to 13 millimeters in diameter. The mineral is usually rosin brown although some honey-yellow microlite has been found. It can be recognized easily by the waxy luster, conchoidal fracture, and alteration halos in the lepidolite. A detailed analysis by Fairchild [37] on a selected, purified sample of this microlite gave the following results:

[36] Stevens, R. E., New analyses of lepidolites and their interpretation: Am. Mineralogist, vol. 23, p. 615, 1938.

[37] Fairchild, J. G., with Eckel, E. B., and Lovering, T. S., Microlite from Ohio City, Colo.: Nat. Research Council, Comm. on Geol. Time, Rept. of Apr. 27, exhibit 5.

Ta_2O_5	68.47	P_2O_5	None
Cb_2O_5	4.45	CaO	9.19
TiO_2	.10	MgO	.04
SnO_2	.95	PbO	.40
UO_2	1.69	Na_2O_3	2.94
UO_3	2.40	K_2O	.25
ThO_2 and rare earths	None	F	1.51
Al_2O_3	.10	Cl	None
Fe_2O_3	1.91	Insol. & SiO_2	.92
MnO	.11	H_2O	2.84
ZnO	None		
CuO	.04		98.41
Bi_2O_3	.07	Less O=F	.64
As_2O_5	Trace (?)		
BeO	None		97.77

This analysis indicates that the mineral is a calcium tantalate close to microlite in composition. The specific gravity determined on the analyzed sample was 5.604.

The beryl from the quartz-albite-muscovite-microcline pegmatite in dike 1 contained 12.62 percent BeO, according to analyses made for the Metals Reserve Company. The BeO content of the beryl in the cleavelandite-quartz-lepidolite-topaz pegmatite in this dike is not known. The mineral occurs in blue, bluish-green, or pale-rose anhedral to euhedral crystals that are as much as 8 inches in diameter and 1.5 feet in length in the cleavelandite-quartz-lepidolite-topaz pegmatite and 2.5 feet by 4 feet in size in the quartz-albite-mica-microcline pegmatite.

Size and grade.—The lepidolite deposit in dike 1 is made up of the three units in the core and is the core in dikes 2 and 3. It is the major deposit in the dikes and also contains the microlite shoots in dikes 1 and 3. The microlite shoots do not occur throughout the lepidolite deposit but are in scattered, isolated pods.

In dike 1 the deposit is exposed for a surface distance of 319 feet, of which the northern 232 feet is probably thick enough to be mined profitably. In table 6 the minable part has been subdivided into a northern, a central, and a southern block on the basis of differences in average thickness. The central block has been explored in depth by the incline and adjoining level and by tunnel 2. The dividing lines between the blocks are a line down the dip 24 feet north of the incline and a line down the dip 40 feet south of tunnel 2.

TABLE 6.—*Size of lepidolite deposit, dike 1, Brown Derby mine, Gunnison County, Colo.*

Block	Surface length (in feet)	Average thickness (in feet)	Depth down the dip		
			Probable (in feet)	Inferred (in feet)	Total (in feet)
Northern	58	2	61	61	122
Central	132	6	85	85	170
Southern	62	3	50	50	100

The grade of the deposit is nearly uniform. The lepidolite content is visually estimated to be 40 percent. Mineral counts of two chip samples, across all the lepidolite-bearing units, taken in 1942, gave a lepidolite content of 48.0 percent and 45.0 percent, but chemical analyses by the Chemical Laboratory of the Geological Survey gave 41 percent and 20 percent, respectively. The reasons for the differences between the mineral counts and the chemical analyses are not known. A spectrographic analysis made for the Hayden Mining Co. of the richest lepidolite concentrations within the deposit gave a content of 74 percent lepidolite, and mill tests on samples for this company from the same concentrations indicated a lepidolite content of 73 percent. In order to balance the tested parts of the deposit against the untested parts, the visually estimated grade of 40 percent is used.

The largest microlite concentration is a lenticular pod that is probably controlled by local structures. It has a surface length of 104 feet, an average thickness of about 3 feet, and a depth down the dip of 31 feet at the incline, in which the bottom of the shoot probably has been reached. A few other microlite shoots occur in the lepidolite deposit, but these are so small that the quantity of microlite that might be recovered is negligible. A poorly exposed, low-grade microlite concentration occurs as a lateral extension of the major shoot. Its size and shape are not known definitely.

The grade of the largest microlite shoot is based on four analyses, two of which were made by the Chemical and Petrographic Laboratories of the Geological Survey. The microlite content of a chip sample, determined by a mineral count in the heavy mineral concentrate, was 1 percent. A spectrographic analysis of a channel sample gave 0.24 percent Ta_2O_5, or 0.35 percent microlite, on the basis of Fairchild's analysis. Two other analyses gave 0.95 percent Ta_2O_5, or 1.3 percent microlite, and 0.36 percent Ta_2O_5, or 0.68 percent microlite, on the basis of this analysis. The grade of 0.35 percent, or 7 pounds per ton, of microlite determined spectrographically in the channel sample probably is most representative of the deposit.

In dike 2 the core has a length of 185 feet and an average thickness of 1.5 feet and extends down the dip at least 20 feet. It is visually estimated to contain 15 percent lepidolite. No microlite is exposed in this pegmatite.

In dike 3 the core has a length of 108 feet and an average thickness of 1 foot and probably extends down the dip at least 15 feet. The lepidolite deposit in the core is visually estimated to contain 15 percent lepidolite. The one microlite shoot in the core is not more than 15 feet in length, 1.5 feet in average thickness, and 15 feet in depth. Its grade is not known, but it is estimated to be 0.1 percent microlite.

Beryl occurs in the lepidolite deposit only in dike 1. It is concentrated in the lower foot of the deposit, of which it is visually estimated to form not more than 0.5 percent.

Topaz occurs throughout the core in dike 1 but is most abundant in the cleavelandite-quartz-lepidolite-topaz pegmatite unit. On the basis of mineral counts and visual estimates a topaz content of 25 percent can be expected in the unit and a topaz content of 3 percent in the whole core.

RESERVES

The reserves of lepidolite and microlite, as well as of beryl, in the three pegmatites are known only roughly. Estimates are subject to error because the grade may change either laterally or vertically, the size and shape of the deposit also may change, the chemical composition of the minerals may vary, and any change in the structure of the pegmatite will affect the reserves.

Dike 1 is estimated to contain about 3,000 tons of lepidolite, and the microlite shoot in the dike is estimated to contain about 9,000 pounds of microlite in 1,300 tons of pegmatite. The reserve of beryl-bearing rock is estimated to be 2,000 tons containing 0.5 percent beryl. The reserve of topaz-bearing rock is estimated to be about 7,000 tons containing 3 percent topaz. A small quantity of columbite and monazite can be recovered from the albite-quartz-biotite pegmatite unit.

Dike 2 is estimated to contain about 80 tons of lepidolite.

Dike 3 is estimated to contain about 150 tons of pegmatite that contains 15 percent lepidolite, and the microlite shoot in this pegmatite is estimated to comprise about 30 tons of rock containing 0.1 percent microlite.

BROWN DERBY RIDGE PROSPECT

The Brown Derby Ridge prospect (15) is in sec. 3, T. 49 N., R. 3 E., New Mexico principal meridian, about 1,200 feet above the floor of Quartz Creek valley at an altitude of 9,550 feet. (See fig. 13.) It is on the crest of the hill on which the Brown Derby mine is located, about 1,000 feet by air line southeast of the mine. The claim in which the prospect is located was formerly known as the Ventura claim, owner unknown, but is now owned by the Hayden Mining Co. of Colorado Springs. This prospect was investigated on August 19, 1943, by J. B. Hanley and Roswell Miller III and at that time was mapped by pace-and-compass methods except for the southern 100 feet of the western dike.

One small discovery hole, 4 feet wide, 15 feet long, and 10 feet deep at the face (fig. 16), is the only opening in this prospect.

Two thin, elongate, beryl-bearing pegmatites crop out on this claim. The eastern one is 40 feet higher than the western. They strike N. 14° E., dip 10° to 50° SE., and cut across the foliation of the pre-Cambrian dioritic schist and amphibolite wall rock. The contacts with the wall rock are well exposed except in the few areas where the pegmatite is not resistant to erosion. The lower pegmatite is about 445 feet long and averages 3 feet in thickness. The upper pegmatite is about 440 feet long and averages 4 feet in thickness. Each is thin and tabular at its northern end but much wider at the southern.

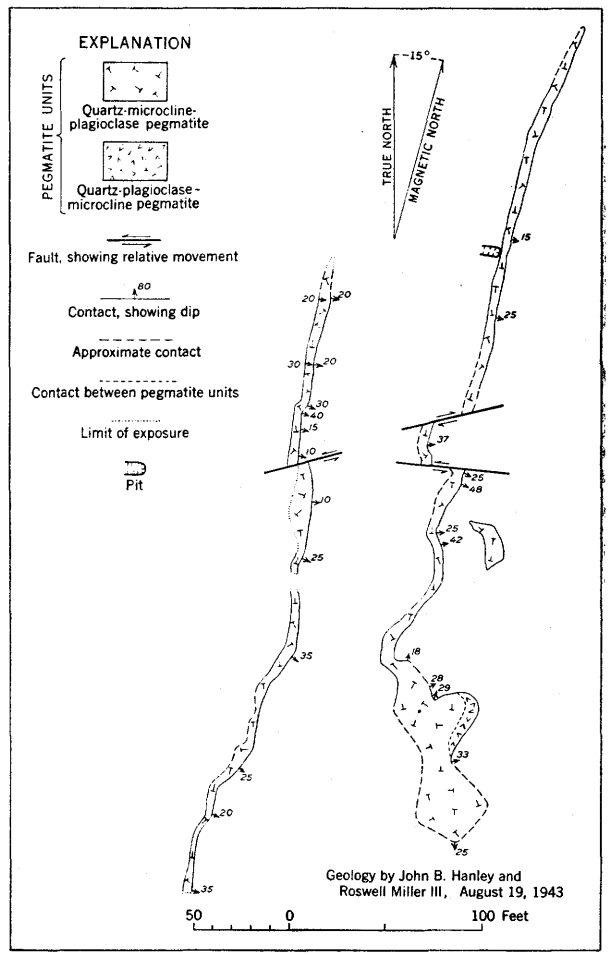


FIGURE 16.—Map of Brown Derby Ridge prospect, Gunnison County, Colo.

A rotational fault cuts the lower dike, and two others cut the upper dike. The northern fault in the upper dike strikes N. 60° E. The southern fault in the upper dike appears to connect with the northern in the area between the two dikes; it strikes N. 80° E. The dips of these faults cannot be determined, but the maximum horizontal displacement on the northern fault is 20 feet and, on the southern fault, 18 feet.

Both dikes are indistinctly zoned and contain a narrow border zone of fine-grained pegmatite that has an average grain size of an eighth of an inch and a central part composed of quartz-microcline-plagioclase pegmatite that has an average grain size of 6 inches. Quartz

pegmatite pods as much as 1.5 feet in diameter occur along the center of each dike. In general neither pegmatite contains much muscovite, although a small quantity occurs around the edges of the quartz pods.

The most abundant mineral is pinkish to white microcline. Quartz and a small quantity of plagioclase are the only other abundant minerals. Euhedral crystals of white to pale-blue beryl occur in the central parts of both dikes. The largest beryl crystal seen was 1.5 inches in diameter, and the average size is 0.5 inch. Dark-red garnet, in crystals as much as 1 inch in diameter, and muscovite, in small books and aggregates, are the only other accessory minerals.

In both pegmatites the average ratio of beryl to pegmatite is 1:10,000, but on the hanging-wall side of the large northernmost roll at the south end of the upper dike (see fig. 16) is an area of quartz-plagioclase-microcline pegmatite, about 30 feet long and 6 feet wide, that is rich in beryl. An area of 20 square feet in this beryl-rich pegmatite contained 195 beryl crystals with an average size of .05 foot, or 2 percent beryl. However, this part of the pegmatite appears to be too insignificant in size to contain an appreciable tonnage of beryl. The crystals are too small to be recovered without milling.

BROWN DERBY NO. 5 PROSPECT

The Brown Derby No. 5 prospect (14) is in sec. 34, T. 50 N., R. 3 E., New Mexico principal meridian. The mine workings are in a small gulch on the side of the Brown Derby ridge at an altitude of 8,900 feet. (See fig. 13.) A branch road from the Brown Derby mine road leads to the workings. The property is owned by Mrs. Disberger and leased to the Hayden Mining Co. The production through 1944 was 10 to 15 tons of lepidolite. The prospect was examined by J. B. Hanley and Roswell Miller III on September 3, 1943, and at that time was mapped by plane table and telescopic alidade.

The mine workings consist of two open-cuts and a short adit from the larger of these cuts. (See fig. 17.) The larger open-cut is made up of two parts. The main part is 32 feet long, 15 feet wide, and 18 feet deep at the east face; the smaller southern part is 20 feet long, 6 feet wide, and 10 feet deep. The adit is 11.5 feet long, trending S. 57° E., and is 5 feet wide. The smaller open-cut, which is 8 feet northeast of the larger open-cut, is about 10 feet long, 6 feet wide, and 6 feet deep at the northeast face.

The Brown Derby No. 5 pegmatite is a crudely lenticular body that is at least 210 feet long and as much as 60 feet wide. It trends N. 54° E., and the dip is probably 50° to 55° SE. The contact with the metadiorite wall rock is exposed in only one place. Because the exposures are poor and sparse, the structure of this pegmatite is not well known. It may continue to the northeast beyond the mapped area.

The pegmatite is distinctly zoned. It contains a wall zone of quartz-microcline-muscovite-albite pegmatite, an intermediate zone of quartz-cleavelandite-lepidolite pegmatite that contains beryl and microlite, and a core of quartz pegmatite. A border zone is exposed in one place.

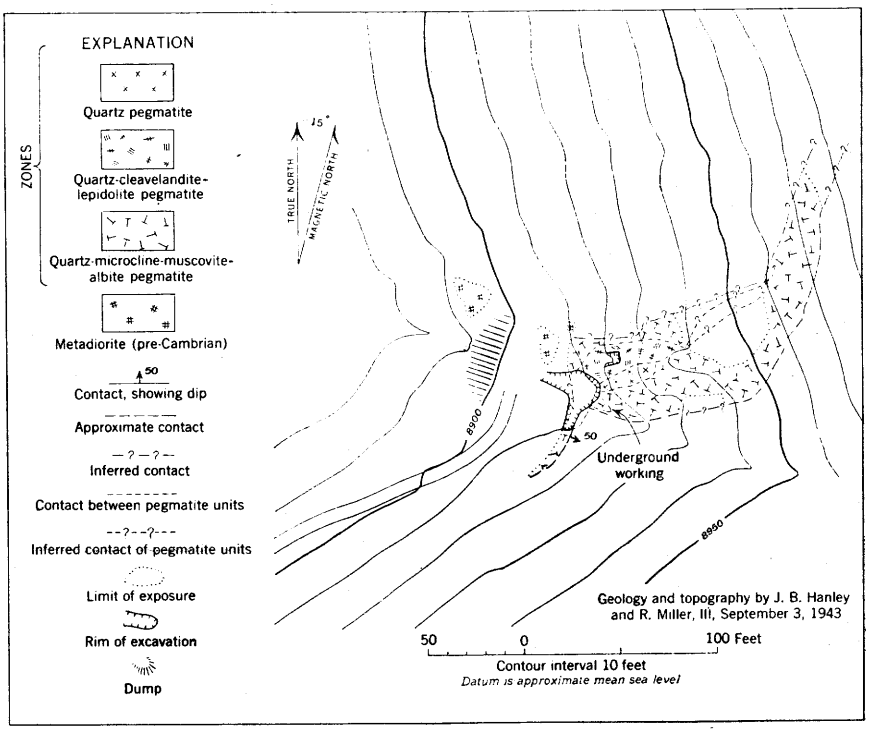


FIGURE 17.—Map of Brown Derby No. 5 prospect, Gunnison County, Colo.

The wall zone is composed chiefly of grayish-white quartz, white to pink microcline, grayish-green muscovite, and white albite, much of which is platy in habit. Lepidolite is a very minor constituent. The maximum observed thickness of the zone is 1.5 feet, but its surface width is at least 10 feet.

The intermediate zone forms a lenticular pod beneath the quartz pegmatite and a smaller pod in the northeastern end of the pegmatite. (See fig. 17.) It is composed chiefly of quartz, white cleavelandite, and lilac lepidolite. It is commonly coarse-grained, although parts are fine-grained. The accessory minerals are topaz, garnet, apatite, beryl, and microlite. The lepidolite occurs in flakes and small plates between cleavelandite plates. Clusters of pale-brown microlite crystals as much as half an inch in size commonly occur in cleavelandite adjacent to small lepidolite concentrations, but the microlite is also distributed erratically throughout the zone. Blue beryl crystals that range from half an inch in diameter and 3 inches in length to 2 inches in diameter occur in the finer-grained parts of the zone. Garnet occurs in bright-red euhedral crystals 2 inches in size, and pale blue-green apatite occurs in well-formed crystals. Milky-white subhedral crystals of topaz are distributed throughout the zone.

The core consists of milky-white quartz with accessory microcline and muscovite.

The three commercially valuable minerals—lepidolite, microlite, and beryl—occur chiefly in the intermediate zone. The lepidolite content of this zone is visually estimated at less than 5 percent, and the microlite and beryl are probably too sparsely distributed to be recovered profitably. The richest concentration of microlite is exposed in the larger open-cut, where six crystals that have an average size of a quarter of an inch occur in an area of 36 square inches. The richest beryl concentration is in the smaller open-cut where six beryl crystals, all less than 2 inches in diameter, are exposed in one face.

The lepidolite that was mined occurred in a felted aggregate of very small flakes, but this type of lepidolite was not seen in place in the prospect. The production is reported to have come from the larger open-cut, and the fine-grained lepidolite probably has been mined out almost completely.

BROWN DERBY NO. 4 PROSPECT

The Brown Derby No. 4 prospect (13) is in sec. 34, T. 50 N., R. 3 E., New Mexico principal meridian. (See fig. 13.) The prospect is owned by Mrs. Marie Disberger of Gunnison and leased to the Hayden Mining Co. It was examined by E. Wm. Heinrich in November 1942.

Two poorly exposed pegmatites, 250 feet apart, occur on the property. The eastern one has been explored by only a shallow cut at the southern end. The western pegmatite has been explored by a narrow adit that is 5 feet long.

Both pegmatites are composed chiefly of quartz, pink microcline, and muscovite with accessory beryl. Dull-blue beryl crystals as much as 3 inches in diameter are exposed in the workings. The ratio of beryl to pegmatite is very low, and neither pegmatite contains concentrations of pegmatite minerals that can be profitably mined.

BUCK HORN PROSPECT

The Buck Horn prospect (16) is in sec. 27, T. 50 N., R. 3 E., New Mexico principal meridian, on the hillside north of Tollgate Gulch at an altitude of 8,925 feet. (See fig. 13.) It is owned by the Colorado Feldspar Co. of Canon City and was located by J. E. Meyers on August 17, 1942. The property was examined briefly by J. B. Hanley, E. Wm. Heinrich, and Roswell Miller III on August 13, 1943. One small discovery pit is the only opening in this prospect.

The Buck Horn pegmatite is well exposed only near the discovery hole, where it is an oval with a length of about 300 feet and a maximum width of 55 feet. It strikes N. 70° W. and dips 25° SW. parallel to the topographic surface. The wall rock is not well exposed, but the contact of the pegmatite with highly weathered wall rock is exposed at one place. The main minerals are quartz, microcline, muscovite, and plagioclase with accessory beryl.

The pegmatite is indistinctly zoned in depth. The zonal structure appears to dip parallel to the present erosion surface, and the zones are exposed only in the discovery hole. The wall zone at the surface is quartz-microcline-muscovite-plagioclase pegmatite with granitic texture, and this zone is underlain by an intermediate zone of quartz-muscovite pegmatite that contains beryl. The mica books in the intermediate zone are as large as 18 by 10 inches. The core of the pegmatite is microcline pegmatite composed of nearly pure microcline.

The beryl in the intermediate zone occurs in small greenish euhedral crystals that can be recovered by hand cobbing. Although the quality of the beryl appears to be good, the ratio of beryl to pegmatite is visually estimated to be only 1:10,000. The muscovite in the zone is all wedged and has strong "A" structure; it can be used only as scrap mica. It is visually estimated to form about 15 percent of the intermediate zone. The microcline in the core is nearly free of mineral impurities and is visually estimated to make up 80 percent of the core.

The reserves of microcline are estimated at about 5,000 tons, the reserves of scrap mica at about 100 tons, and the reserves of beryl at less than 10 tons.

WHITE SPAR NO. 1 PROSPECT

The White Spar No. 1 prospect (85) in sec. 35, T. 50 N., R. 3 E., New Mexico principal meridian, is on the north side of Tollgate Gulch, 0.8 mile by air line north of the Brown Derby mine. (See fig. 13.) The prospect can be reached from Colorado State Highway 162 by following a mine road along Tollgate Gulch for 0.7 mile. The White Spar No. 1 claim was located in May 1942 by the Colorado Feldspar Co. It was visited by E. Wm. Heinrich in 1942 and was examined by E. Wm. Heinrich assisted by Roswell Miller III on July 29, 1943. At that time the southern 200 feet of the pegmatite was mapped by plane table and telescopic alidade.

Five open-cuts have been made in the pegmatite. The largest is irregular in shape (see fig. 18) and as much as 50 feet long and 25 feet wide.

The pegmatite crops out on the south side and top of a narrow ridge that is parallel to Tollgate Gulch. The pegmatite is concealed beneath a small east-trending gulch north of this ridge but is exposed to the north. The contact with the wall rock is not exposed.

The wall rock is a gray-green to black, dense, fine-grained hornblende gneiss that has a poorly defined foliation. In the vicinity of the pegmatite it is highly fractured and contains veinlets of a buff-colored mineral.

The pegmatite trends N. 20° E. and dips 30° to 35° SE. It is 1,400 feet long. The exposures of the pegmatite north of the small gulch were examined briefly, and no mineral concentrations of commercial value were found. Exposures of the smaller, southern pegmatite between the two gulches are about 200 feet long and have a maximum width of 85 feet. The pegmatite units in the southern pegmatite are a wall zone of medium- to coarse-grained quartz-microcline-muscovite pegmatite, a unit of quartz pegmatite 3.5 feet thick, a unit of lepidolite-microlite pegmatite 4.5 feet thick, and a unit of cleavelandite-lepidolite-beryl pegmatite 6.5 feet thick. The relationship of units 2, 3, and 4 is not known accurately.

The wall zone is 9 feet thick along the hanging wall and about 33 feet thick at the footwall. In the footwall part of the zone a series of quartz pods occurs near the center.

The lepidolite-microlite pegmatite is exposed only in a pod that strikes N. 60° E., dips 55° SE., and plunges 35°, N. 80° E. This pod, 20 feet long with a maximum thickness of 5 feet, has been almost completely removed. Lilac lepidolite, reported to contain 4 percent Li_2O, occurs in the upper part of the pod, and pale-green lepidolite, reported to contain 1 percent of Li_2O, occurs in the lower part. Rosin-colored spheres of microlite as much as three-eighths of an inch in diameter, with aureoles of red-brown lepidolite, occur only in the lilac lepidolite.

The fourth unit is a medium-grained intergrowth of grayish quartz, cleavelandite, and rose lepidolite. It contains minor quantities of topaz, microlite, columbite, beryl, and lithia tourmaline. Lepidolite occurs in flakes that are 0.5 inch in diameter. Beryl occurs in anhedral crystals, yellow to pale blue green, that have a maximum diameter of 4 inches.

A chip sample was taken across a 20-foot length of the face of the largest cut. Spectrographic analysis of this sample by the Geological Survey indicated that the Li_2O content was 0.2 percent, that the BeO content was 0.6 percent, and that Cb and Ta were absent. The Li_2O content as given by this analysis is equal to 0.5 percent lepidolite, and the BeO content is equal to 4.26 percent beryl. Two grid samples were later cut by J. B. Hanley and Roswell Miller III on the west and north walls of the largest open-cut. These samples were taken by cutting a 0.1-foot cube at each intersection of a 1-foot grid, superimposed on 30 square feet of each wall. Analyses of these samples by the Chemical Laboratory of the Geological Survey showed the BeO content to be 0.003 percent, or 0.024 percent beryl.

The White Spar No. 1 pegmatite contains a small quantity of beryl, lepidolite, and microlite, but the lepidolite-microlite pod has been almost completely mined out and the lepidolite content of the cleavelandite-lepidolite-beryl pegmatite is too low for economic recovery of this mineral. The grid samples indicate that the beryl content is so low that the pegmatite is not a promising source of beryl.

WHITE SPAR NO. 2 PROSPECT

The White Spar No. 2 prospect (86) is in sec. 35, T. 50 N., R. 3 E., New Mexico principal meridian, on the north side of Tollgate Gulch. (See fig. 13.) The mine road along Tollgate Gulch extends to a point directly below the White Spar No. 2 prospect. The pegmatite belongs to the Colorado Feldspar Co. of Canon City and was located in August 1942. This prospect was visited by E. Wm. Heinrich in 1942 and examined by E. Wm. Heinrich assisted by Roswell Miller III on July 28, 1943, when it was mapped by plane table and telescopic alidade.

Two small prospect pits are the only openings in the pegmatite. The southern pit (see fig. 19) is about 30 feet long and 25 feet wide, and the northern pit is about 40 feet long and 10 feet wide.

The pegmatite crops out on the northern side of Tollgate Gulch. It is about 260 feet long and has an average width of 25 feet but is nearly 50 feet wide at the rounded, bulbous northern end. It trends due north, but the contact with the wall rock in the southern part strikes slightly west of north and dips 70° NE. The wall rock is a dense, highly fractured, green-

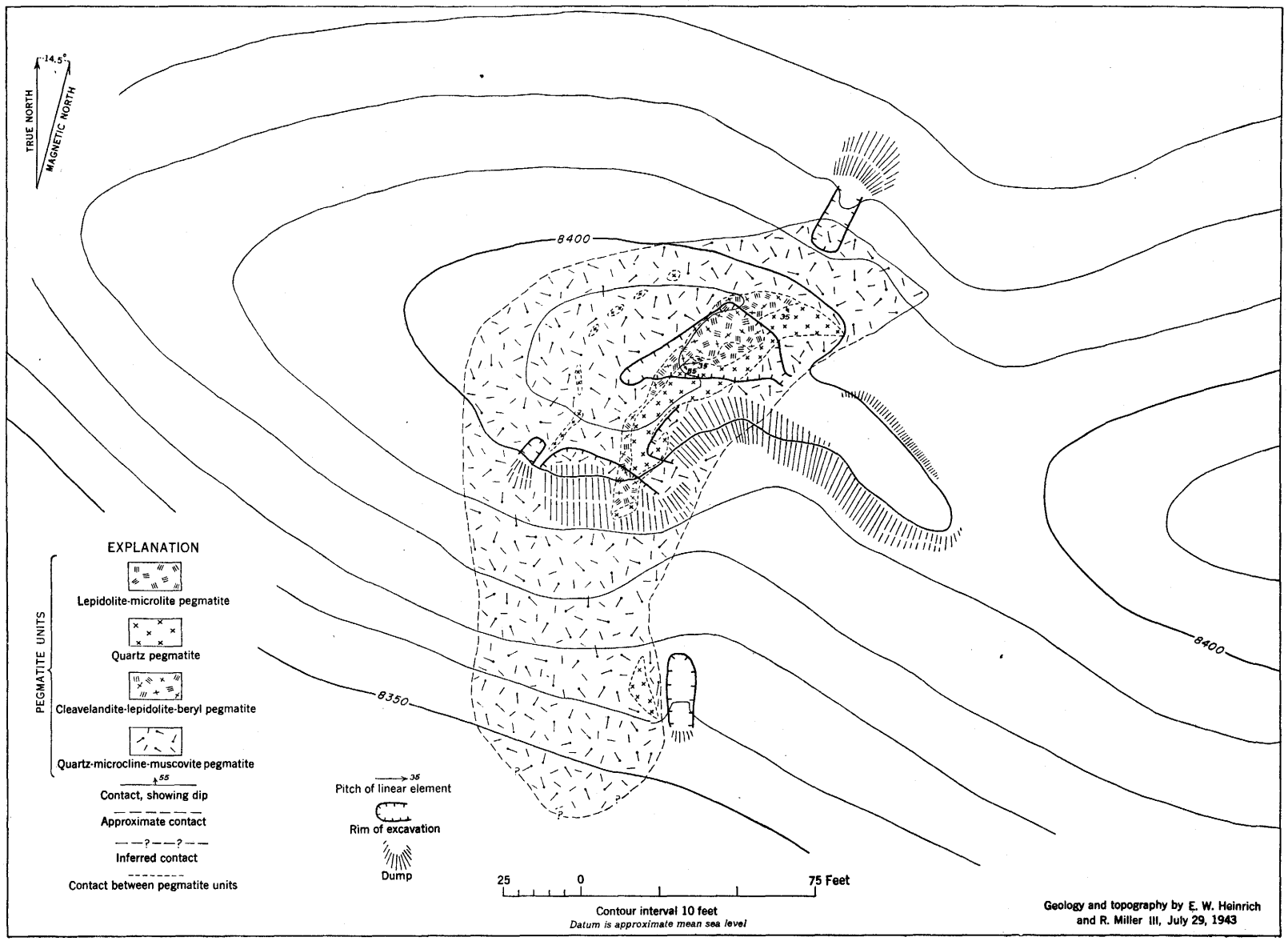


FIGURE 18.—Map of White Spar No. 1 prospect, Gunnison County, Colo.

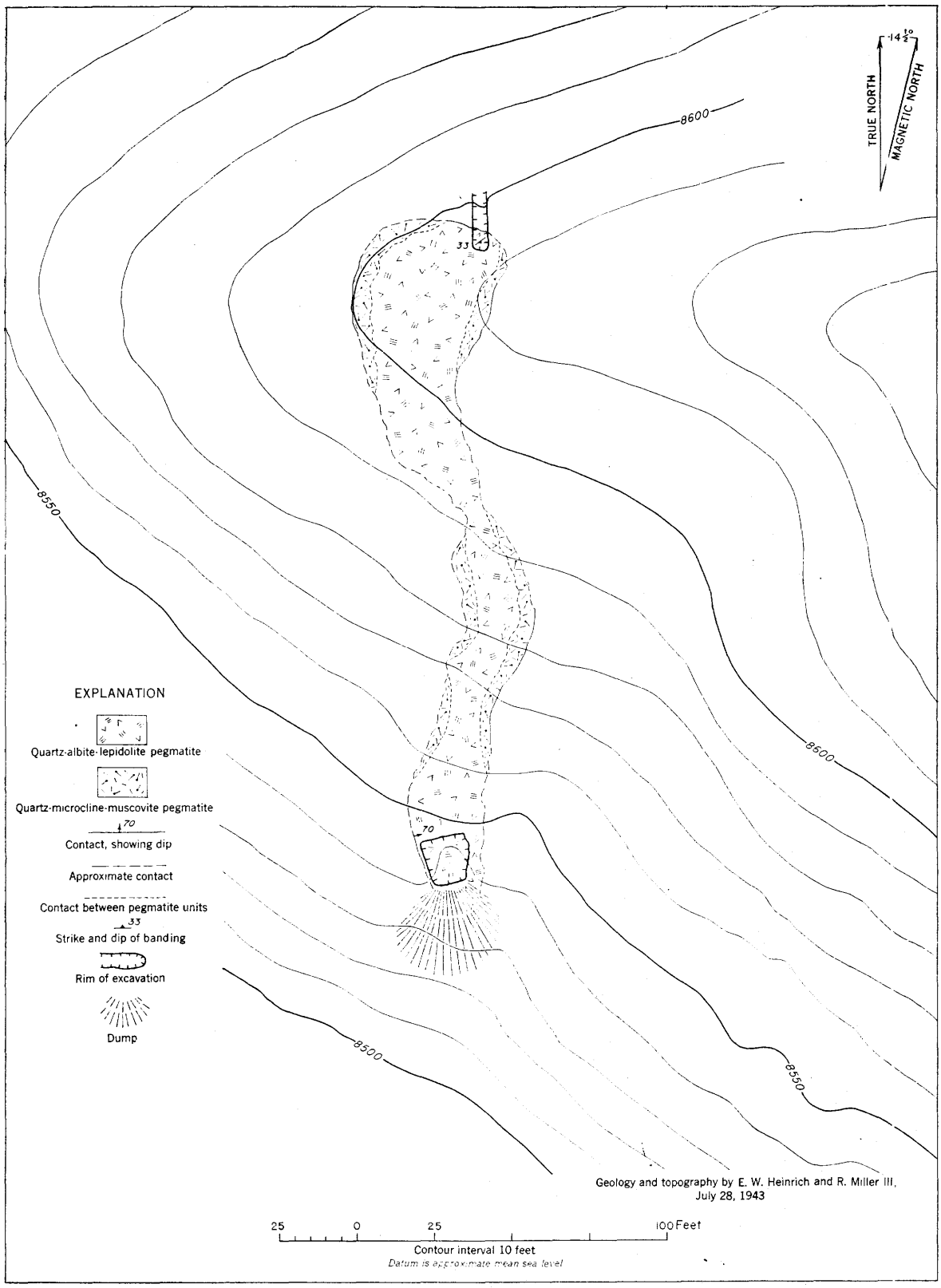


FIGURE 19.—Map of White Spar No. 2 prospect, Gunnison County, Colo.

ish-black hornblende gneiss that contains minor quantities of quartz, feldspar, and a green mineral that may be chlorite. The foliation in this gneiss strikes N. 25° W. and dips 70° to 80° NE.

The pegmatite contains two zones: a narrow discontinuous wall zone of quartz-microcline-muscovite pegmatite and a core of quartz-albite-lepidolite pegmatite. The wall-zone pegmatite is coarse-grained and contains minor quantities of albite and lepidolite, which occurs in books as much as 1 inch across.

The core is fine-grained and contains a very minor quantity of beryl. Lepidolite occurs in lenses as much as 4 inches wide and in stringers as much as 6 feet long. In the northern cut the pegmatite is banded parallel to the contact. This banding is formed by narrow wavy bands of fine-grained lepidolite that alternate with bands of coarser-grained albite and quartz. The bands commonly have a scalloped pattern. Seventeen bands were counted in 8 inches.

The core of the pegmatite contains recoverable lepidolite. A grab sample taken in the southern pit and analyzed spectrographically by the Geological Survey contained 0.7 percent Li_2O, or about 17 percent lepidolite; 0.05 percent BeO; and no Cb or Ta. The core of the pegmatite is estimated to contain 25,000 tons of quartz-albite-lepidolite pegmatite to a depth of 80 feet; it probably averages 15 percent lepidolite.

NEW ANNIVERSARY PROSPECT

The New Anniversary prospect (57) is in sec. 22, T. 50 N., R. 3 E., New Mexico principal meridian, on the north side of Willow Creek at an altitude of 8,800 feet, and about 1 mile from Colorado State Highway 162. (See fig. 13.) The prospect can be reached by the dirt road along Willow Creek. The New Anniversary claim was located on May 23, 1943, by J. E. Meyers, of Canon City, and A. L. Pearson, of Pitkin. The prospect was examined by E. Wm. Heinrich on June 22, 1943. Two small prospect cuts are the only openings in the pegmatite.

The New Anniversary pegmatite, which trends slightly west of north, is at least 2,000 feet long and ranges from 600 to about 1,000 feet in width. The pegmatite contains three zones: a wall zone of quartz-microcline-muscovite pegmatite, an intermediate zone of muscovite-plagioclase pegmatite that contains beryl, and a core of quartz pegmatite. The core and intermediate zone are markedly discontinuous, and the core occurs only as nine widely scattered and isolated pods that range from a few feet to several hundred feet in width. The intermediate zone is exposed around four of these quartz pegmatite pods, and the two prospect cuts have been made in the intermediate zone adjacent to one of the pods near the northern end of the pegmatite. In these cuts the muscovite-plagioclase pegmatite contains much gray-green muscovite that occurs in long, wedge-shaped blades, a white feldspar that probably is a plagioclase, and subhedral crystals of pale-blue to olive-green beryl. The largest beryl crystal exposed was 1 foot in length. This zone is 3 to 4 feet wide in the larger of the two cuts and appears to be vertical.

Stock piles near the prospect cuts were visually estimated to contain about 600 pounds of beryl.

COMET PROSPECTS

The Comet prospects (24), in sec. 19, T. 12 S., R. 83 W., sixth principal meridian, are near the junction of Taylor River and Bowman Creek on the old Taylor Pass road at an altitude of 10,200 feet and are 34 miles by air line north-northeast of Gunnison. The group of seven claims was located in July 1943 by Mr. and Mrs. J. R. Sigman, Mrs. Kate Sigman, Mike Perko, Jr., and Esco L. Long of Crested Butte. The claims can be reached from Gunnison through Taylor Park by 54 miles of dirt road. These prospects were examined by J. B. Hanley and Roswell Miller III on August 6, 1943.

The Comet pegmatites occur in pre-Cambrian porphyritic granites and biotite schists. The largest pegmatite seen is exposed for a length of 100 feet and a width that ranges from 4 to 6 feet. Most of the pegmatites strike north, although a few strike nearly east; all are vertical. The chief minerals are microcline, quartz, and biotite. Muscovite, pale-green apatite, and beryl are minor accessories in some of the pegmatites. Because of its color and crystal outline the apatite has been mistaken for beryl. Three beryl crystals, having an average diameter of 1 inch, were found in a pegmatite 50 feet long and 14 inches wide.

None of the Comet pegmatites contains minable concentrations of minerals.

LAST CHANCE MINE

LOCATION AND HISTORY

The Last Chance mine (44) is in sec. 1, T. 48 N., R. 5 W., New Mexico principal meridian, 8 miles by road west of Sapinero, the nearest shipping point on the Denver & Rio Grande Western Railroad (narrow gage). It is on the edge of the south rim of the Black Canyon of the Gunnison River, 1,260 feet above the bottom of the canyon. The mine can be reached from Sapinero by U. S. Highway 50 and a dirt road that extends north to the mine workings. The mine was discovered by C. Peifer of Grand Junction in 1936 and was purchased by the Colorado Feldspar Co. in 1937. Mining was started late in 1938 and continued through 1939. During this period of operation a few thousand tons of feldspar and a few tons of scrap mica were produced. The mine was examined by E. Wm. Heinrich in 1942.

MINE WORKINGS

The mine workings include an open-cut along the rim of the canyon and a small prospect cut 250 feet west of the main cut. The main cut is 40 feet long, 25 to 30 feet wide, and 40 feet deep. The prospect cut is 10 feet long, 5 feet wide, and 3 feet deep.

GEOLOGY

The Last Chance pegmatite has intruded the pre-Cambrian Black Canyon formation, which in the vicinity of the mine is a quartz-biotite gneiss. This gneiss is a blue-gray, fine-grained, faintly banded rock that has been highly injected, lit par lit, by numerous 1-inch pegmatite stringers. The lit-par-lit injection is conspicuous because of the uniform distance between individual stringers and the uniform width of the stringers. They occasionally transgress the gneissic structure and thus have produced intricate folds in the gneiss.

Overlying the pegmatite is a lava flow that is probably a member of the San Juan formation. This lava contains conspicuous phenocrysts of gray quartz, white feldspar, and biotite set in a gray to black aphanitic groundmass. The phenocrysts are as much as 0.1 inch in size. Small gas cavities are common in the lava, which was deposited upon a weathered surface that shows in the pegmatite as a 2.5-foot layer of chalky, disintegrated feldspar.

The pegmatite, which has intruded the gneiss at a slight angle to the structure, strikes about N. 65° E. and dips 85° SE. The northern contact strikes N. 70° E., and the southern contact strikes N. 55° E. The pegmatite crops out along the strike for 300 feet, ranges in width from 50 feet at the eastern end to 100 feet at the western outcrop limit, and is exposed to a depth of 50 to 100 feet along the side of the canyon.

The pegmatite is crudely zoned and contains a border zone 10 feet wide, of aplitic pegmatite, a markedly discontinuous wall zone of quartz-microcline-muscovite-biotite pegmatite, and a microcline-quartz-muscovite pegmatite core.

The border-zone pegmatite is a fine-grained, buff-colored rock that contains quartz, feldspar, and a little biotite. It is sugary in texture and has an abrupt contact with the wall zone and the core.

The wall zone is a coarse-grained granitic intergrowth of quartz and microcline with accessory muscovite and biotite. Patches of an intergrowth of reddish quartz, biotite, and red garnet also occur in this pegmatite. The zone is best exposed in the small prospect cut.

The core is composed of large masses of quartz, feldspar, and muscovite. Cream-colored microcline, the most abundant mineral, occurs in crystals 5 feet long. Large areas of nearly pure microcline, containing very little intergrown quartz, have been formed by the grouping of the feldspar crystals. The feldspar face of the open-cut contains only one patch of quartz as large as a foot in width. Massive white quartz is more abundant in the western part of the core, and feldspar is less abundant. The muscovite in the core occurs in aggregates of small felted plates and in radiating sheaves of intergrown books. The mica aggregates contain red-brown garnet crystals as much as 8 inches in diameter. A few smaller garnet crystals occur in the clusters of mica books.

MINERAL DEPOSITS

Feldspar and mica are the two minerals of economic significance in the Last Chance pegmatite. Minable feldspar makes up an unusually large percentage of it. In the open-cut the entire southeastern wall, which is 40 feet long and 40 feet high, and the southwestern face, which is 25 feet wide and 40 feet high, are composed almost exclusively of microcline. For approximately 200 feet west of the main cut the outcrops on the canyon wall are predominantly feldspar. This part of the pegmatite is visually estimated to contain 65 percent recoverable feldspar.

Muscovite is more abundant in aggregates of small felted plates than in clusters of intergrown books. On the northwest wall of the open-cut one mica aggregate is exposed over an area that is 25 feet long and 10 feet wide. The largest cluster of books is 6 feet by 3 feet in size. The muscovite is wedged, ruled, crumpled, and commonly intergrown with garnet. No mica of punch or sheet size was observed. Mica is visually estimated to make up 5 to 8 percent of the pegmatite.

BLACK CANYON BERYL PROSPECT

The Black Canyon beryl prospect (9) is 6 miles east of the town of Cimarron in the Black Canyon of the Gunnison River in sec. 6, T. 48 N., R. 5 W., New Mexico principal meridian. The prospect can be reached only by the Denver & Rio Grande Western Railroad. It was discovered in the spring of 1943 because of a rock slide that blocked the railroad tracks. Augustin Viarrial, section foreman for the railroad, picked up several beryl crystals in the slide material. The prospect was examined by Roswell Miller III and J. B. Hanley on August 24, 1943.

The Black Canyon pegmatite is exposed in the walls of the canyon for a strike length of 125 feet and ranges from 4 to 8 feet in width. It dips approximately 60° NE. and strikes about parallel to the canyon, which here bears about west. The pegmatite cuts across the schistosity of pre-Cambrian quartz-biotite-feldspar schist. At the western end it joins a 20-foot-thick pegmatite dike that strikes almost due north.

The common minerals are microcline, quartz, and biotite. The biotite commonly occurs in lathlike crystals as much as 2 feet in length. Highly shattered dark-red garnet, in crystals 2 inches in diameter, occurs in

several of the quartz concentrations in the pegmatite. Two beryl crystals 1.5 inches in diameter and 2 inches long were found adjacent to one of these quartz concentrations. The beryl is greenish yellow on the weathered surfaces and light blue on those freshly broken. The largest beryl crystal found in the slide material is reported to have been 6 inches in diameter and 2 feet in length.

No minable concentrations of minerals occur in this pegmatite.

Numerous granitic pegmatites were observed in the canyon walls to the west of the Black Canyon pegmatite, but the walls of the canyon east of the beryl pegmatites are predominantly porphyritic granite, in which no pegmatites were seen.

JEFFERSON COUNTY

BIGGER MICA MINE

LOCATION AND HISTORY

The Bigger mica mine (8) is in sec. 3, T. 6 S., R. 70 W., sixth principal meridian, at an altitude of 7,240 feet on the northern ridge of Bald Mountain, and at the divide between South Turkey and Deer Creeks. The mine can be reached from Denver, the nearest shipping point and market, by following U. S. Highway 285 for 25.5 miles to Colorado State Highway 124 and then taking this highway for 0.7 mile to the private road, a few hundred yards long, that leads to the mine.

The region immediately surrounding the mine is one of gentle relief, and the weather conditions permit operation of the mine throughout the year. The nearest water supply for the mining operations is the South Fork Turkey Creek.

The mine was discovered by a Mr. Switzer in 1884 and is reported to have been opened for tin at that time. From 1888 until about 1890 it was mined for mica. The mine was inactive from 1890 until 1937, when it was reopened as a feldspar mine. Since 1937 the operations have been irregular and intermittent. Although the recent mining has been primarily for feldspar, beryl and scrap mica found have been sorted out and sold. The mine is owned by D. N. Biggers of Littleton, Colo.

The Bigger mine has produced at least 3,000 tons of feldspar, about 100 tons of scrap mica, and 18.9 tons of beryl since 1937. The production prior to 1937 is not known.

The property has been described by Sterrett.[38] The mine was first examined by J. B. Hanley on December 10, 1942, and has since been revisited several times. In June and July 1944 the mine was mapped by plane table and telescopic alidade by J. B. Hanley assisted by A. F. Trites, Jr., and J. E. Husted.

[38] Sterrett, D. B., Mica deposits of the United States: U. S. Geol. Survey Bull. 740, pp. 57–58, 1923.

MINE WORKINGS

The mine workings made during the first period of operation included a shaft 80 feet deep, a 50-foot adit that connected with the shaft in depth, several short tunnels from the shaft at this level, an open-cut about 35 feet long and 10 feet deep northwest of the shaft, and an irregular open-cut 100 feet southeast of the shaft. This latter open-cut was about 20 feet deep, and short drifts and rooms extended from it.

The workings, when mapped by the writers, consisted of a very irregular open-cut about 215 feet long and 20 feet in average width, as shown in plate 10. In general the southwestern wall of this open-cut is vertical or overhanging, and the northeastern wall slopes steeply inward toward the southwest. The shaft has been floored over below the bottom of the open-cut and backfilled. The old adit has been converted into an open haulage cut.

GEOLOGY

GENERAL FEATURES

The Bigger mine pegmatite is a distinctly zoned arcuate body that cuts across schistose diorite. It has been displaced by two faults that are well exposed in the workings. In general, the surface exposures are poor. The pegmatite is more resistant to weathering than the wall rock, and a few scattered pegmatite outcrops can be found outside the workings.

WALL ROCK

The diorite is weathered to a depth of at least 15 feet, and because the foliation is poorly preserved, its structure cannot be determined in detail. Unaltered fragments of the diorite and a light-pink, fine-grained granite, which does not crop out, have been found in the dumps from the shaft. The granite must have been found in depth as the upper 23 feet of the shaft are in pegmatite.

FAULTING

Two faults, which are designated the "east" fault and the "north" fault, cut the pegmatite as shown in plate 10. The east fault, which strikes N. 85° E. and dips 60° NW., is a thrust fault well exposed in the open-cut. The fault plane is slickensided with pronounced grooves and less pronounced steps. The linear elements on the fault plane indicate that the movement was upward at an angle of 18°, N. 85° E., and the displacement is 8.5 feet. The fault plane is marked by 5 inches of compacted gouge, which is composed of brecciated feldspar and quartz with local concentrations of muscovite flakes.

The north fault strikes N. 46° E. and dips 30° NW. It is not so well exposed as the east fault. The displacement cannot be measured but is probably about 8 feet. In the walls of the open-cut this fault splits about

6 feet below the present surface, but the displacement occurs chiefly on the west split or main fault. Six inches of fault gouge occurs along this fault plane.

PEGMATITE

The general trend of the pegmatite is N. 40° W., and the dip is 75° SW. It is exposed on the surface for a length of 320 feet and a width of about 50 feet. Both to the northwest and to the southeast it ends in narrow prongs. The contacts are well exposed only in the new haulage and the old adit cuts.

The Bigger mine pegmatite (see pl. 10, section *A–A'*) contains a wall zone of medium-grained quartz-microcline-biotite-albite pegmatite, an intermediate zone of quartz-albite-muscovite pegmatite, and a core of microcline-quartz pegmatite.

The wall zone contains light-pink microcline, grayish quartz, biotite, and muscovite as the chief mineral constituents, with white albite and black tourmaline as accessory minerals. The average grain size is 3 inches, although the inner part of the zone contains microcline masses as large as 1 foot in size. Albite is the common accessory mineral near the intermediate zone, and black tourmaline, which occurs as small masses of felted crystals, is the common accessory near the contact. This wall zone is 6 to 11 feet wide on the footwall and 5 to 11 feet wide on the hanging wall. The average thickness is probably about 5 feet.

The intermediate zone has an average thickness of 2 feet. It is composed mainly of whitish quartz, pale-green muscovite, and white to light-pink albite with accessory beryl, columbite, bismuthinite, and monazite. The muscovite is usually wedged, reeved, and ruled, has "A" structure, and locally is heavily dark-stained, although a great many of the books contain clear, flat, pale-green sheets. The albite shows pronounced albite twinning under the microscope, has an N_m of $1.529 \pm .003$, and is biaxial (+). Light greenish-blue to green beryl occurs in crystals as large as 1.7 feet in diameter by 7.5 feet in length. Bismuthinite, bismutite, and associated alteration minerals occur in rounded and thin-bladed masses in quartz, which is typically shattered near the bismuthinite masses, and in fine-grained aggregates of muscovite, which occur at the boundary between the core and the intermediate zone. Black tourmaline is locally abundant in crystals as much as 3 inches in diameter. Columbite occurs in bladed crystals and anhedral masses associated with beryl and muscovite. Monazite occurs in euhedral crystals as much as 13 millimeters wide and long and 6 millimeters thick associated with the black tourmaline. Uraninite is reported from the mine, but none has been found recently.

The microcline-quartz pegmatite of the core contains subhedral masses of deep-pink microcline and white to light-rose quartz. They are as much as 20 feet in length, 19 feet in width, and 17 feet in height. The concentration into separate mineral masses, each very pure in mineral content, is remarkably sharp. Fine-grained aggregates of muscovite, quartz, and albite occur in scattered masses, within the core, which are comparable in size to the microcline and quartz masses. Muscovite books, which are as much as 13 inches across and 6 to 8 inches thick, and beryl crystals occur near the outer edges of the core.

MINERAL DEPOSITS

The Bigger mica mine has produced at least 3,000 tons of feldspar, about 100 tons of scrap mica, and 18.9 tons of beryl. The feldspar deposit occurs in the microcline-quartz pegmatite of the core, and the mica and the beryl deposits occur in the quartz-albite-muscovite pegmatite of the intermediate zone and in the outer edges of the core.

MUSCOVITE

A 3-pound sample was collected from several of the muscovite books on the walls of the open-cut, trimmed, and later qualified by George Purcell, vice president of the Colonial Mica Corporation, with the following results:

Quality	*Percent by weight*	*Quality*	*Percent by weight*
No. 1	16	No. 2 inf	48
No. 2	32	No. 3	4

The size pattern as determined by the Colonial Mica Corporation at Custer, S. Dak., was mostly 1.25 by 1.25 inches with some pieces 2 by 2 inches, although larger pieces have been trimmed from some of the mica at the mine.

Electrical tests by the National Bureau of Standards on part of this sample gave the results shown in table 7.

TABLE 7.—*Electrical tests on mica from Bigger mine, Jefferson County, Colo.*

Specimen No.	Thickness, in millimeters	Area between electrodes	Power factor, in percent	
			At 100 kilocycles per second	At 1,000 kilocycles per second
B11[1]	0.08	No visible defects	0.05	0.02
B12	.08	do	.03	.01
B21	.07	do	.03	.03
B22	.07	Broken films	.02	.02
B23	.08	do	.03	.03
B31	.06	Large dark spot, many small black spots, some red-brown stains.	.53	.37
B32	.05	Small red-brown and black stains	.14	.12
B111	.08	No visible defects	.05	.01
B112	.06	do	.05	.02
B113	.04	Many tiny red-brown and black stains	.37	.16

[1] The numbers B11 to B12, B21 to B23, B31 to B32, and B111 to B113 were applied by the National Bureau of Standards to test specimens from No. 1, No. 2, No. 3, and No. 2 inf. quality classifications, respectively.

Muscovite is most abundant in the intermediate zone, although some is found in the outer few feet of the core. The average thickness of the mica-bearing rock is about

7 feet. The richest concentration is exposed in the workings adjacent to the entry way and includes all the intermediate zone southeast of the north fault. In this part of the workings the core has been almost completely removed, and the walls of the open-cut are at the inner edges of the intermediate zone. Other rich concentrations may occur along the northwest side of the pegmatite from the northwest end to the east fault, particularly near the entrance of the old adit into the open-cut. The muscovite along the southwest side is commonly near the east fault plane and has been crushed.

The muscovite between the two faults also has been crushed, but the quality in this part of the zone may be better in depth.

Because of poor exposures the grade of the intermediate zone is not known accurately, but this zone is estimated to contain an average of 15 percent muscovite. However, some small areas are visually estimated to contain 30 percent muscovite, and other areas are of lower grade. The recovery of sheet mica in the test sample suggests that 10 percent of this mica might yield small and large full-trimmed sheets if prepared by skilled operators, but the sample probably is not representative of the whole deposit.

BERYL

Beryl occurs most abundantly in the intermediate zone. It has been found between the two faults and occurs also in the core immediately adjacent to the intermediate zone. The beryl deposit has an average thickness of 7 feet.

The beryl is light greenish blue to green and occurs in euhedral crystals. It appears to contain very few mineral impurities, and hand-cobbed beryl sold to the Metals Reserve Company contained an average of 12.10 percent BeO. The largest crystal measured was 1.7 feet in diameter by 7.5 feet in length. All the beryl in the deposit can be recovered by hand cobbing. Columbite is usually closely associated with it and could be recovered as a byproduct.

On February 21, 1943, measurements were made of 24 beryl crystals calculated to contain about 7 tons of beryl. During March 1943 additional crystals were found. All had been removed when the mine was mapped. The deposit is estimated to contain 1 percent beryl on the basis of past production and visual estimates.

FELDSPAR

The core contains light- to deep-pink microcline in subhedral crystals as much as 20 feet long, 19 feet wide, and 17 feet high. The feldspar contains only an extremely small quantity of mineral impurities.

The size and shape of the core are shown by the extent of the workings. This core has been mined out to the level of the floor of the open-cut but probably continues in depth. Past production indicates that microcline makes up 60 percent of the core. Mica and beryl should provide valuable byproducts of feldspar mining.

RESERVES

The reserves of muscovite that would yield sheet mica by careful preparation cannot be calculated accurately. However, the intermediate zone may contain, for each foot of depth, about 70 tons of pegmatite containing 1 percent beryl and 15 percent muscovite. Possibly 10 percent of the crude mica will yield sheet and punch mica.

If the feldspar deposit extends to a depth of 60 feet below the open-cut, it may contain about 13,000 tons of feldspar.

BURROUGHS FELDSPAR MINE

The Burroughs feldspar mine (18), is in the NE¼ sec. 27, T. 4 S., R. 71 W., sixth principal meridian, 7.5 miles by air line southwest of Golden, the nearest railroad shipping point. It can be reached from Evergreen, the nearest town, by a dirt road that connects with U. S. Highway 40 near Hosa Lodge. The mine is owned by a Mrs. Swanson of Idaho Springs and, when examined by J. B. Hanley on March 17, 1943, was operated by L. T. Burroughs of Golden. The mine produced about 6,000 tons of commercial potash feldspar in 1942–44.

The only opening in the pegmatite is a pit about 100 feet in length, 30 feet in width, and 35 feet in depth.

The pegmatite is about 180 feet long and 60 feet wide, trends N. 65° E., and is nearly vertical. It contains a wall zone of quartz-microcline-biotite pegmatite and a core of quartz-microcline pegmatite. At the west end of the pegmatite the core is predominantly milky quartz. The wall zone is exposed near the crest of the pegmatite, and at the time of examination the core was exposed at a depth of 15 feet. The microcline in the core occurs in subhedral to euhedral crystals as much as 10 feet in size, and the quartz occurs in anhedral to subhedral crystals of comparable size. Numerous clay seams and faults are exposed in both zones in the workings.

No muscovite nor beryl has been found in this pegmatite. A dark-brown, earthy mineral found was tentatively identified as triphylite.

The Burroughs pegmatite probably contains an appreciable quantity of feldspar, but this is the only mineral of commercial value.

ROSCOE BERYL PROSPECT

The Roscoe beryl prospect (69), in sec. 5, T. 4 S., R. 71 W., sixth principal meridian, is in the wall of

Clear Creek Canyon about 0.8 mile east of the former Roscoe station on the abandoned Colorado & Southern Railroad and 8 miles by air line west of Golden, the nearest railroad shipping point. The prospect can be reached by following the old railroad bed for about 3 miles east of Forks Creek. The owner of the prospect is not known. It was examined by J. B. Hanley on April 18, 1943.

The only opening is the former railroad cut through the pegmatite.

The canyon walls give a vertical section through the pegmatite, which trends N. 83° E. and generally dips 75° SW. The pegmatite cuts across the enclosing schists of the pre-Cambrian Idaho Springs formation. The dike has an average thickness of 20 feet on the north side of the canyon but is only 12 feet thick on the south side. Its length is not known.

The pegmatite contains quartz, potash feldspar, biotite, and muscovite as major constituents and has an average grain size of 2 inches. Muscovite is relatively scarce, and biotite is the more abundant mica. The biotite commonly occurs in books 6 inches across; muscovite is usually in small books not over 2 inches in size. Because of ruling and "A" structure the muscovite is suitable only for scrap mica. The common accessory minerals are magnetite, garnet, and beryl. Gadolinite and monazite are reported from the prospect but were not found. Graphic granite occurs near the borders of the pegmatite.

Beryl occurs in minor quantities associated with small quartz concentrations. The richest beryl concentration contained nine small crystals, with an average diameter of 1 inch, in 250 square feet of pegmatite. The only other minerals of commercial value are potash feldspar and muscovite.

DREW HILL PROSPECT

By J. W. Adams

The Drew Hill prospect, as nearly as can be determined, is in sec. 34, T. 2. S., R. 71 W., sixth principal meridian, Jefferson County, and is about 10 miles northwest of the town of Golden, Colo. The occurrence of chrysoberyl in this locality has been described by W. A. Waldschmidt and R. V. Gaines.[39] The only development at the property is a shallow pit about 10 feet in diameter. No production, other than that of mineral specimens, is recorded.

The pegmatite in which the chrysoberyl is found intrudes pre-Cambrian mica schist of the Idaho Springs formation. It is about 18 feet wide, strikes approximately N. 70° E., and dips 63° NW. The extent of the pegmatite is not known.

The three rock units in the pegmatite are a unit, about 4 feet wide, of microcline-quartz-muscovite pegmatite with accessory black tourmaline; a narrow and possibly discontinuous unit of quartz-muscovite pegmatite that contains chrysoberyl; and a unit, 10 to 12 feet wide, of coarse microcline-perthite pegmatite. In the exposures the sequence of the units is unsymmetrical. The microcline-quartz-muscovite pegmatite and the quartz-muscovite pegmatite occur only along the footwall.

Additional chrysoberyl probably would be found by further exploration of the pegmatite.

RAMSTETTER RANCH PROSPECT

The Ramstetter Ranch prospect (65), which probably is in sec. 15, T. 3 S., R. 71 W., sixth principal meridian, is near the Golden Gate Canyon road about 6 miles by air line northwest of Golden. It was examined by J. B. Hanley on October 15, 1944.

The pegmatite is not more than 50 feet long and 10 feet wide and is poorly exposed except in an old prospect pit. The minerals of the pegmatite are chiefly quartz and pink microcline with minor quantities of muscovite and white plagioclase. The pegmatite shows no zonal structure in the exposures. Although chrysoberyl has been found, none was seen in place. This prospect is of interest to mineral collectors but has no economic importance.

ROBINSON GULCH PROSPECT

The Robinson Gulch prospect (67), which is in sec. 16, T. 3 S., R. 71 W., sixth principal meridian, is on the Golden Gate Canyon road about 7 miles by air line northwest of Golden. It was examined by J. B. Hanley on October 31, 1943. The pegmatite is not more than 30 feet long and 3 feet wide and is poorly exposed except in a road cut. It contains potash feldspar, quartz, and minor quantities of muscovite. This pegmatite shows no zonal structure. Although chrysoberyl has been found, none was seen in place. The prospect is of no commercial interest.

CENTENNIAL CONE BERYL-MONAZITE PROSPECT

The Centennial Cone beryl-monazite prospect (19), in sec. 32, T. 3 S., R. 71 W., sixth parallel meridian, is at an altitude of about 8,000 feet, 7 miles by air line west of Golden, the nearest railroad shipping point. It can be reached from Golden by 15 miles of county and ranch roads. The prospect is on a ranch owned by Frank Termantozzi of Golden, Colo. The pegmatite was examined by J. B. Hanley and J. W. Adams on October 15, 1944. The mineralogy of the pegmatite has been described by Waldschmidt and Adams.[40]

[39] Waldschmidt, W. A., and Gaines, R. V., Occurrence of chrysoberyl near Golden, Colo.: Am. Mineralogist, vol. 24, pp. 267–271, 1939.

[40] Waldschmidt, W. A., and Adams, J. W., The beryl-monazite pegmatite dike of Centennial Cone, Colo.: Colorado School of Mines Quart., vol. 37, pp. 29–38, 1942.

The Centennial Cone pegmatite trends N. 73° E., dips 45° SE., and cuts across the schistosity of the country rock. It is 10 feet thick and may be about 500 feet long, although this length may represent several closely spaced dikes. The pegmatite has been opened up over a length of 50 feet by mineral collectors, and in this part of the dike an indistinct zoning is evident. The wall zone is fine-grained quartz-microcline-muscovite pegmatite. It forms the bulk of the dike and is the only zone exposed beyond the part of the pegmatite that has been opened. The intermediate zone is albite-quartz-muscovite pegmatite that contains beryl and monazite. It is not more than 6 inches thick. The core is quartz-microcline pegmatite in which the feldspar crystals are as much as 2 feet in length.

The beryl in the intermediate zone occurs in crystals as much as 4 inches in diameter, and euhedral monazite is associated with the beryl. The beryl content of this zone is visually estimated at 1 percent, but the zone is so narrow that the quantity of beryl available is negligible. This prospect is of interest only to mineral collectors.

CRESMAN GULCH PROSPECT

LOCATION AND GENERAL FEATURES

The Cresman Gulch prospect (27) is in secs. 17 and 18, T. 3 S., R. 70 W., sixth principal meridian, at an altitude of 6,750 feet in Cresman Gulch. This is the first gulch north of Golden Gate Canyon. The prospect is about 0.8 mile west of the county road on the west side of the Dakota hogbacks north of Golden. It is 2.5 miles by road from Golden and can be reached easily by the county road and an old wagon road that is passable only on foot. The prospect is on a homestead owned by Lyman C. and Audrey E. Ladwig of Arvada. Some potash feldspar has been produced from the mine, and it is reported that 1,000 pounds of beryl was produced prior to October 1943. From October 20, 1943, to January 11, 1944, the dumps were reworked intermittently, and 979.5 pounds of beryl was produced. The prospect was examined by J. B. Hanley on April 28, 1943, and was mapped by plane table and telescopic alidade between June 29 and July 6, 1944, by A. F. Trites, Jr., J. E. Husted, and J. B. Hanley.

The workings consist of two open-cuts, the eastern one of which is 75 feet long, 35 feet wide, and about 40 feet deep at the deepest place. This open-cut goes completely through the pegmatite. The western open-cut, 40 feet to the west, is 35 feet long, 6 to 20 feet wide, and as much as 35 feet deep.

GEOLOGY

The Cresman Gulch pegmatite cuts across pre-Cambrian Idaho Springs biotite schists and gneisses that form the wall rock. The schistosity of the wall rock strikes N. 85° W. and dips from 85° SW. to vertical.

Three other pegmatites, two of which contain small quantities of beryl, crop out along the same line of strike as the main Cresman Gulch pegmatite. The four pegmatites probably occur along a major zone of weakness in the Idaho Springs formation. The pegmatite west of the main pegmatite trends east and is at least 300 feet long and as much as 40 feet wide. It is composed chiefly of quartz-microcline-muscovite-biotite pegmatite and contains no beryl. The first pegmatite east of the main dike trends east and is 70 feet long and as much as 22 feet wide. This pegmatite contains a small quantity of beryl. The second pegmatite to the east trends N. 70° E.; it is 130 feet long and as much as 10 feet wide. It also contains a small quantity of beryl.

Two other pegmatites, which are quartz-microcline-muscovite-biotite pegmatites and do not contain beryl, crop out in the immediate vicinity of the main pegmatite. One of these, trending slightly west of north, is 100 feet long and 5 feet wide. This pegmatite may be connected with the main pegmatite in depth. The other pegmatite trends N. 69° W.; it is 410 feet long and as much as 50 feet wide, although the average width is about 10 feet. None of the pegmatites except the main one contains sizable concentrations of economic minerals.

The main pegmatite strikes due east and dips from 80° SE. to vertical. (See fig. 20.) It is about 315 feet long and as much as 35 feet wide, although the average width is about 12 feet. The contacts with the wall rock are usually sharp but are irregular and marked by many rolls. In some parts of the dike the hanging-wall contact is obscure and gradational.

This pegmatite contains a wall zone of quartz-microcline-biotite-albite pegmatite, an intermediate zone of quartz-albite pegmatite, and a core of quartz-microcline pegmatite. The wall zone and the intermediate zone cannot be distinguished easily from each other because there is no sharp contrast in texture or mineral composition. Biotite in streaks and patches is found in both zones. It is more abundant near the hanging wall, where the contact is obscure and gradational, but occurs throughout the dike. It may represent material that was assimilated from the biotite-schist wall rock.

The wall zone consists of red microcline, quartz, and biotite, with accessory albite, muscovite, and black tourmaline. The biotite books in this zone are commonly 1 foot in size; the muscovite occurs only in small plates 1 to 4 millimeters in diameter.

The intermediate zone contains quartz and albite with accessory beryl, apatite, and muscovite. The albite in this zone has an N_m of $1.524 \pm .003$ and a maximum extinction angle of 15° and is therefore near Ab_{90} in composition. Apatite occurs in small, reddish-brown sub-

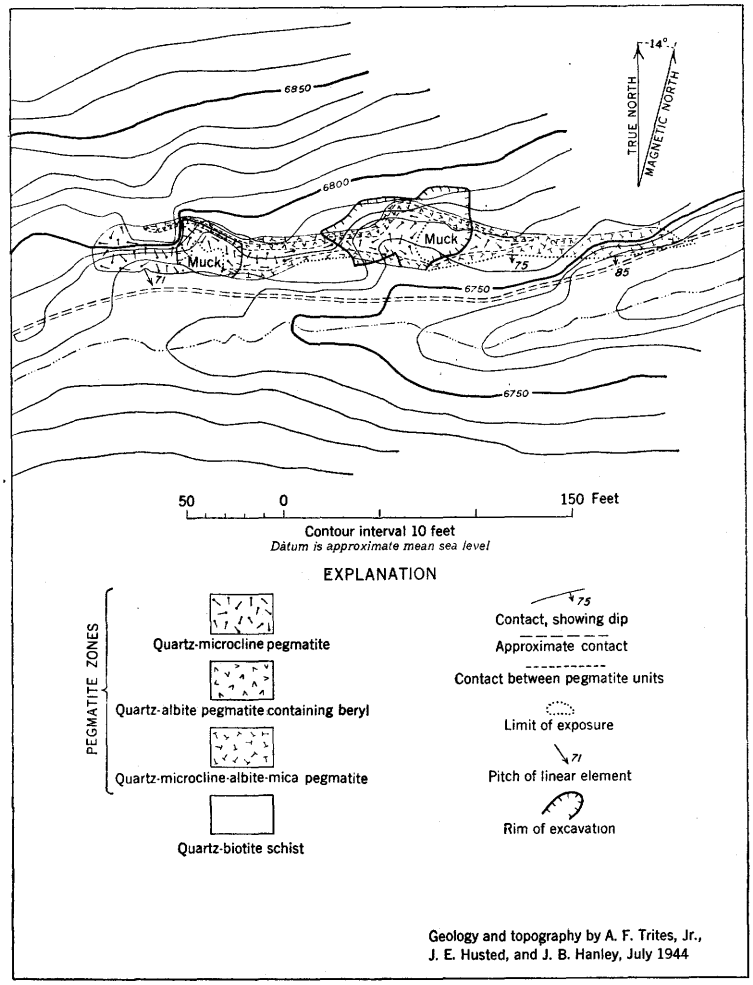


FIGURE 20.—Map of Cresman Gulch prospect, Jefferson County, Colo.

hedral to euhedral crystals. The beryl occurs in light-green, nearly opaque euhedral crystals that have an average size of 12 millimeters and commonly are coated with fine-grained muscovite. The zone is developed chiefly near the footwall and has an average thickness of 3 feet.

The core contains light-pink microcline and grayish quartz. The average grain size of this zone is about 1 foot, and the quartz and microcline are intergrown with an interlocking texture.

MINERAL DEPOSITS

The only commercially valuable mineral that occurs in sizable concentrations in the Cresman Gulch pegmatite is beryl. The average size of the crystals is 12 millimeters, and the largest crystal seen was 0.3 foot across. The index of refraction of the ordinary ray is $1.571 \pm .003$, and the beryl contains many microscopic mineral inclusions and air bubbles. The BeO content of this beryl is not known, but the index of refraction of the ordinary ray suggests a high BeO content. The beryl crystals are so small that recovery by hand-cobbing methods would be wasteful, and a high recovery could be made only by some method of milling.

The beryl occurs in the intermediate zone of quartz-albite pegmatite. This zone is exposed along the footwall part of the dike for a length of 225 feet with an average thickness of 3 feet. The beryl content is estimated to be about 1 percent on the basis of visual estimates and mineral counts. Reserves consist of probably 20 tons of beryl in 2,000 tons of the beryl-bearing rock.

LARIMER COUNTY

CRYSTAL MOUNTAIN DISTRICT

LOCATION AND HISTORY

The Crystal Mountain pegmatite district embraces an area of about 6 square miles in T. 7 N., R. 71 W., and R. 72 W., sixth principal meridian, Larimer County. It is about 18 miles by air line and 45 miles by road slightly south of west from Fort Collins, the nearest railroad shipping point. The district can be reached from Fort Collins by the Buckhorn Creek road from Masonville and a ranch road through the Turner and

Reynolds ranches. The pegmatites (see fig. 21) in the district lie south and east of Crystal Mountain, which is a distinct landmark in the region.

The topography is moderately steep, with a maximum relief of 1,500 feet and an average altitude of 8,500 feet. Sheep and Fish Creeks, both permanent streams, flow through the district and supply the water needed in mining. The country is heavily wooded, most of the trees being jack pines.

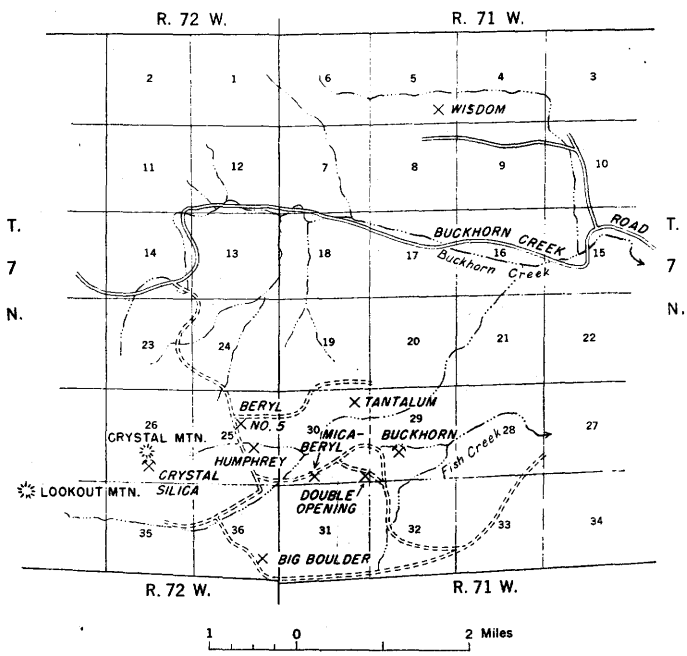


FIGURE 21.—Index map of Crystal Mountain district, Larimer County, Colo.

The first mining in the district began in 1884 when the Buckhorn mica mine was discovered and worked. This activity lasted only a few years, after which operations ceased, except for minor work at the Crystal Silica mine, until 1934, when the presence of beryl in the pegmatites was discovered. A small prospecting boom occurred at this time but died out before the year was over. In 1941 the United Beryllium Ores and Metals Corp. of Denver bought out the mineral rights on most of the homestead land in the district and secured control of practically all the pegmatites. Some mining was carried on by this company in 1941, but the district was inactive in 1942–44.

Two of the mines and prospects in the district were examined by Sterrett[41] in 1913 and briefly described.

The pegmatites discussed in the following descriptions were examined by L. R. Page and J. B. Hanley between September 22 and October 7, 1942. In addition to these, the Lookout Beryl, Radial Beryl, Plains View, White Rock, Crystal Snow, Ibex, and Sheep Creek pegmatites, as well as several others without names, are known to occur in the district and to contain beryl.

[41] Sterrett, D. B., Mica deposits of the United States: U. S. Geol. Survey Bull. 740, pp. 59–61, 1923.

GEOLOGY

The Crystal Mountain district is in a region underlain by pre-Cambrian schists and quartzites. No large, definite granitic intrusives crop out in the district, but granite occurs within a few miles. The pre-Cambrian rocks are overlain by Paleozoic sediments about 8 miles to the east.

The metamorphic rocks are quartz-biotite schists and quartzites. The wall rock of all the pegmatites is a dark-gray quartz-biotite schist that commonly is highly crumpled and folded. The regional structure of the metamorphic rocks strikes northeast, and the folds plunge steeply to the southwest.

The pegmatites of the district are similar in internal structure and mineralogy. Most are well exposed, although the heavy brush cover makes it difficult to determine the shape and structure of many of them. The pegmatites that occur on steep slopes are partly hidden beneath float and debris. All the pegmatites are rich in beryl occurring in cores composed of quartz pegmatite or quartz-microcline pegmatite and in the fine-grained quartz-albite-microcline-muscovite pegmatite of the wall zones. The beryl in the wall zones usually is fine-grained and can be recovered only by some method of milling. Three of the pegmatites, the Buckhorn, Big Boulder, and Sheep Creek, contain spodumene. The Tantalum pegmatite contains an unusually large quantity of tantalite, and the Double Opening and the Big Boulder pegmatites contain very small quantities of uranium minerals. An unusual feature of the pegmatites in the district is that muscovite typically occurs in aggregates of small flakes, which generally are less than 6 millimeters in size.

In all the pegmatites beryl is a common mineral and is abundant enough to be of potential economic importance. In a few, such as the Buckhorn, Double Opening, and Big Boulder, other minerals—particularly muscovite and microcline-perthite—occur in minable quantities.

BUCKHORN MICA MINE

LOCATION AND HISTORY

The Buckhorn mica mine (17), also known as the Emerald Gem claim, is in the SW¼ sec. 29, T. 7 N., R. 71 W., sixth principal meridian, about 17.5 miles by air line west-southwest of Fort Collins. (See fig. 21.) The mine can be reached by the Buckhorn Creek road and rather poor ranch roads through the Turner and Reynolds ranches. It was discovered in 1884 and was operated by the Buckhorn Mica Mining and Milling Co. for a short period. The mine is now owned by Roy

Hyatt, who relocated it in 1942. The past-production records are not available, but it is reported that at least 180 tons of ground mica and 2 tons of beryl have been produced during different periods of operation. The mine has been described by Sterrett.[42] It was visited by L. R. Page and J. B. Hanley on September 22, 1942, and was mapped by plane table and telescopic alidade on September 29 and 30, 1942.

MINE WORKINGS

The mine workings (see pl. 11) include three vertical shafts 50 feet apart, a large open-cut, and at least five small prospect pits and trenches. The eastern shaft is reported to be 50 feet deep but is now backfilled to 25 feet below the floor of the open-cut. According to Sterrett,[43] drifts were made from this shaft, but the underground workings were not accessible when the mine was mapped. The central shaft is at least 20 feet deep but is partly backfilled, and the western shaft is only 10 feet deep. The large open-cut, in which the two deep shafts are located, is 160 feet long, 8 to 25 feet wide, and as much as 15 feet deep.

GEOLOGY

The Buckhorn mica mine is in a zoned pegmatite that is 675 feet long and as much as 37 feet wide. It conformably intrudes laminated, dark-gray to black quartz-biotite schists, presumably of pre-Cambrian age. Southeast of the pegmatite most of the country rock is a thin-bedded gray quartzite. The schists are highly contorted but in general strike N. 65° E. and dip from 60° SE. to 70° NW. The pegmatite strikes N. 65° E. and dips from 80° NW. to vertical; locally the contact between them is very irregular. The contacts are very sharp, although the schist has been altered slightly by the introduction of tourmaline. In places, a feldspar-muscovite schist, which grades into the fine-grained quartz-microcline-albite-muscovite pegmatite of the outer zone of the Buckhorn pegmatite, has been formed by the alteration of the quartz-biotite schists.

The Buckhorn pegmatite contains four irregular units, three of which may belong to a later intrusion. The outer and earlier unit is as much as 10 feet thick and is composed of fine-grained quartz-microcline-albite-muscovite pegmatite. The outer few inches of this pegmatite are much finer grained than the rest of the rock and form the border zone. The remainder, the wall zone, is a granitic intergrowth of pink microcline, albite, quartz, and muscovite with an average grain size of less than 6 millimeters. Irregular streaks and patches of these minerals, in grains as much as 1 inch in size, occur within the finer-grained pegmatite. These streaks and patches are roughly parallel to the contact in attitude. They make up less than 25 percent of the zone. On the north side of the large open-cut the quartz-microcline-albite-muscovite pegmatite is separated from the quartz-albite-muscovite pegmatite by a strong fracture or fault plane that is coated with green muscovite. This plane may extend beyond the limits shown on the map and may mark the line along which the later types of pegmatite were intruded, as the later types appear to extend beyond the limits of the quartz-microcline-albite-muscovite pegmatite.

The quartz-albite-muscovite pegmatite is not so continuous as the quartz-microcline-albite-muscovite pegmatite and is best developed on the north side at the northeast end and on the south side at the southwest end. The unit has a maximum thickness of 15 feet and an average thickness of 6 feet. It is a coarse-grained intergrowth of muscovite books and flakes, pink and white albite, microcline, quartz, beryl, tourmaline, and phosphate minerals. The grain size of the individual minerals is varied but in general ranges from 2 to 4 inches. Much larger books of muscovite and crystals of beryl occur. Albite is the most abundant feldspar in the quartz-albite-muscovite pegmatite, but dark-pink to red microcline crystals as much as 2 feet in length are scattered sporadically throughout the quartz-albite-muscovite pegmatite.

The central part of the pegmatite is made up of a quartz-cleavelandite pegmatite unit and a quartz-cleavelandite-spodumene pegmatite unit. These units contain coarse milky to gray quartz, cleavelandite, fine-grained aggregates of muscovite flakes, and spodumene with minor quantities of beryl and columbite-tantalite. White to pink cleavelandite occurs in radial masses as much as 10 inches in size. Spodumene occurs in tabular crystals that are mostly powdery and friable.

Five small quartz-microcline-albite-muscovite pegmatites, which are essentially parallel to the bedding of the schists, have been mapped in addition to the Buckhorn pegmatite. They contain reddish granitic intergrowths of microcline, quartz, mica, albite, and tourmaline. The microcline crystals rarely exceed 3 inches in size, but masses of milky quartz as much as 12 inches in length occur sporadically near the center of the pegmatites.

MINERAL DEPOSITS

The major minerals of economic significance in the Buckhorn pegmatite are beryl and muscovite, although some spodumene and columbite-tantalite might be recovered. The richest concentrations of beryl and mica are in the quartz-albite-muscovite pegmatite and near the outer edges of the quartz-cleavelandite pegmatite and the quartz-cleavelandite-spodumene pegmatite.

[42] Sterrett, D. B., op. cit., pp. 59–60.
[43] Sterrett, D. B., op. cit., p. 59.

Some fine-grained beryl occurs in the quartz-microcline-albite-muscovite pegmatite. Mica is also scattered throughout the quartz-cleavelandite pegmatite and the quartz-cleavelandite-spodumene pegmatite. Columbite-tantalite occurs in small quantities in the quartz-cleavelandite pegmatite and in the quartz-cleavelandite-spodumene pegmatite but probably is not of commercial importance. The spodumene exposed in this pegmatite is "rotten"; the lithia content is unknown.

Beryl.—White to light-green beryl occurs as crystals, anhedral masses, and rims as much as 10 inches in diameter, although most is in crystals or masses less than 2 inches in diameter. Only a few crystals are not corroded or have not formed as rims around feldspar, quartz, and other minerals. Beryl is most abundant in the quartz-albite-muscovite pegmatite, where it is associated with albite, quartz, muscovite, tourmaline, and phosphate minerals. The beryl near the outer edges of the core is usually coarser than in the outer part of the wall zone and is replaced only at the edges of the crystals.

Beryl is found throughout the pegmatite except in the southwestern extension. Although beryl occurs in the fine-grained quartz-microcline-albite-muscovite pegmatite zone, it is not included in the beryl deposit discussed below, but a sample of this zone from the cut north of the 50-foot shaft was analyzed spectrographically by the Chemical Laboratory of the Geological Survey and found to contain 0.05 percent BeO. The main deposit includes the remainder of the pegmatite; it is 500 feet in length and ranges from 10 to 20 feet in width with an average width of 12.5 feet. The workings have explored this deposit to a depth of 50 feet. It is visually estimated to contain 0.5 to 1 percent beryl, and probably 25 percent of this beryl can be recovered by hand cobbing. Selective mining of the quartz-albite-muscovite pegmatite might result in a slightly higher recovery.

Muscovite.—The muscovite in the Buckhorn pegmatite is a green mica that is suitable for grinding, and some books would yield small quantities of punch and sheet mica. The muscovite occurs in wedge-shaped books, is highly ruled and wedged, and has "A" structure. The books have an average length of 4 inches, but some books 8 inches long were seen.

The quartz-albite-muscovite pegmatite is 500 feet in length and has an average width of 5 feet. Past-production figures indicate that the average muscovite content of the unit is 10 to 15 percent.

Spodumene.—Tabular crystals of powdery, "rotten" spodumene are distributed sparingly throughout the quartz-cleavelandite-spodumene pegmatite, but no fresh crystals were exposed. The crystals are as much as 3 feet in length and 3 inches in thickness. The quartz-cleavelandite-spodumene pegmatite in the deposit is estimated to contain 5 to 10 percent spodumene. The lithia content of the spodumene is unknown.

Columbite-tantalite.—A few clusters of tabular columbite-tantalite crystals as much as 2 inches in length are exposed near the northern end of the quartz-cleavelandite-spodumene pegmatite. Fragments of columbite-tantalite were found in the muck near the 20-foot shaft, and a few grains were recovered in three samples from the dump.

RESERVES

The beryl reserves in the Buckhorn pegmatite are estimated to be in 50,000 tons of pegmatite that may contain 250 to 500 tons of beryl. The mica reserves are in 20,000 tons of pegmatite that are estimated to contain 2,000 tons of muscovite. The spodumene and columbite-tantalite reserves are too small to be of economic importance.

DOUBLE OPENING PROSPECT

LOCATION AND HISTORY

The Double Opening prospect (32) is in the SE¼SE¼ sec. 30 and the NE¼NE¼ sec. 31, T. 7 N., R. 71 W., sixth principal meridian. (See fig. 21.) It is reached from Fort Collins by the Buckhorn Creek road and a ranch road through the Turner and Reynolds ranches. The prospect is partly on the Reynolds ranch, which is owned by the United Beryllium Ores and Metals Corp. of Denver, and partly on public land. It was located in 1934 by W. Richardson, Leslie Barker, and others, but their rights have been assigned to the United Beryllium Ores and Metals Corp. This may have been the prospect referred to by Sterrett[44] as "another mica prospect [which] was opened by Parkson & Kitchen about a quarter of a mile west of the Buckhorn mine." Several hundred tons of feldspar were mined and stock-piled in the fall of 1941, but no beryl was produced. The property was first visited by J. B. Hanley and L. R. Page on September 22, 1942, and was mapped by plane table and telescopic alidade on October 1, 1942.

MINE WORKINGS

The workings consist of two open pits. The larger pit has exterior dimensions of 40 feet in length, 35 feet in width, and 10 feet in depth and is divided into two parts by an interior wall that is 4 feet wide. (See fig. 22.) The smaller pit, which is near the southwestern end of the pegmatite, is 30 feet long, 10 feet wide, and 4 feet deep.

GEOLOGY

The Double Opening pegmatite intrudes quartz-biotite schist that is probably part of the pre-Cambrian

[44] Sterrett, D. B., op. cit., p. 60.

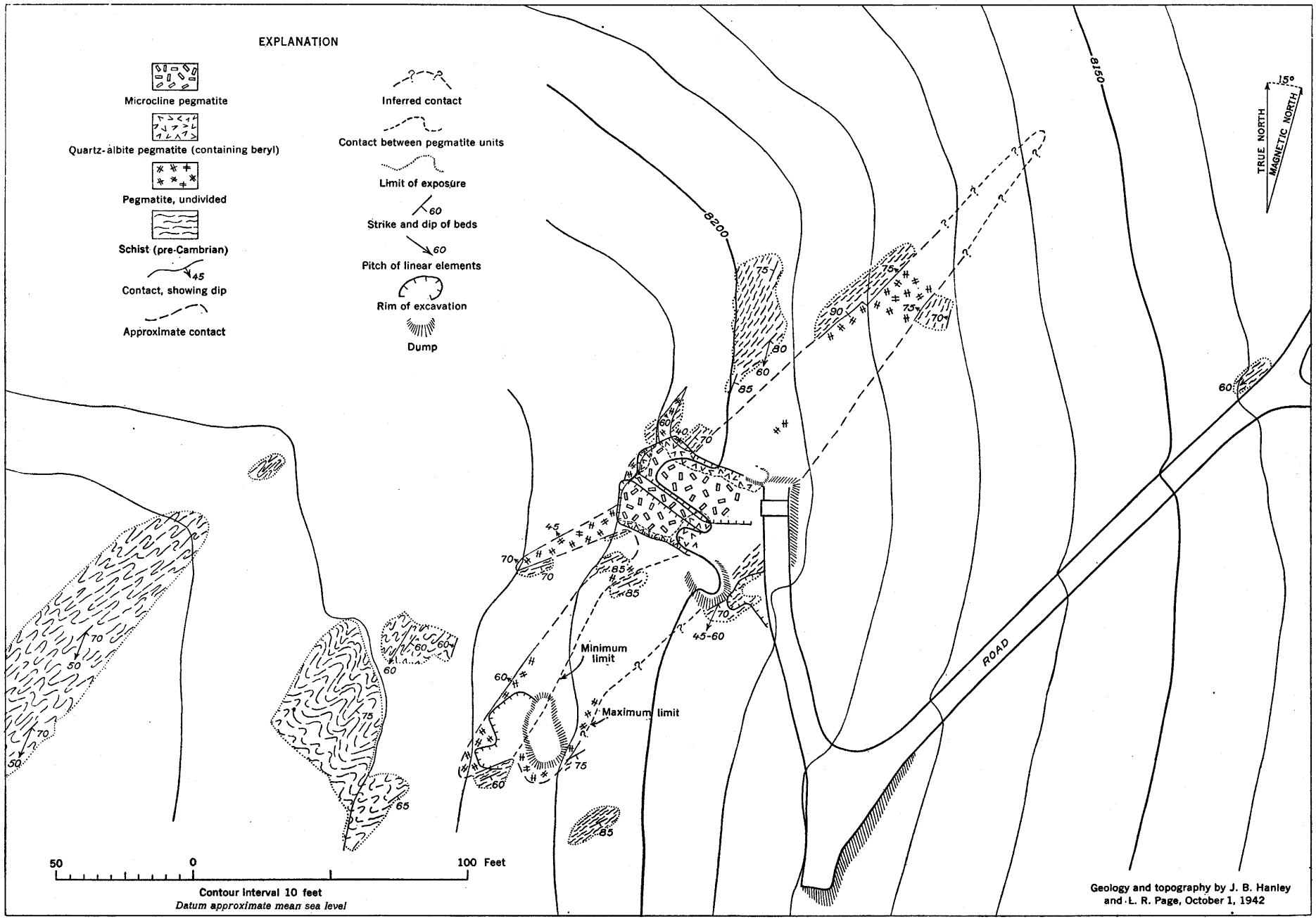


FIGURE 22.—Map of Double Opening prospect, Crystal Mountain district, Larimer County, Colo.

Idaho Springs formation. The schist is highly folded into chevron folds, which plunge 50° to 60° SW. The general strike of the metamorphic rocks is N. 43° E., and the dip is usually 60° to 85° NW. or SE.

The pegmatite strikes N. 40° E. and dips about 60° NW. It is exposed for a length of 250 feet and an average width of 30 feet. It may extend an additional 60 feet or more to the northeast, but the soil cover, dump material, and float hide the extent in this direction and also hide the width of the pegmatite between the two pits. Because it is poorly exposed the southeastern contact has been mapped in two possible positions, of which the minimum limit is based on outcrops and the maximum limit is based on small, slumped prospect holes.

The pegmatite is a conformable, elongate lens with two small offshoots of quartz-microcline-muscovite-albite pegmatite that cut across the schist structure on the northwest side. These offshoots grade into quartz-muscovite veins that pinch out in a short distance.

The main pegmatite body is quartz-microcline-albite-muscovite rock with accessory phosphate minerals, beryl, and uranium minerals. The average grain size is 6 inches, although the microcline masses in the core may be 10 feet or more in size. The zonal structure of the pegmatite can be observed only in the larger pit. The intermediate zone of quartz-albite pegmatite and the core of microcline pegmatite are not exposed beyond the limits of the pit.

The quartz-albite pegmatite of the intermediate zone is composed chiefly of milky quartz and yellowish-white albite with accessory beryl, phosphate minerals, muscovite, and uranium minerals. The albite occurs in anhedral grains with an average size of 3 inches. N_m was determined to be about equal to $1.527 \pm .003$, which indicates a composition near Ab_{98}. Beryl occurs in light-green euhedral crystals that are only rims of beryl around cores of quartz and albite. These rims are as much as 1 inch thick, and the average size of the crystals is 6 inches. Purpurite is the most abundant phosphate mineral and commonly occurs as nodules associated with several unidentified phosphate minerals. Small patches of uranium minerals—uraninite, autunite, torbernite, and gummite—occur in this zone adjacent to the microcline pegmatite core. The feldspar near these patches shows a grayish discoloration and is highly fractured and shattered.

The microcline pegmatite of the core is composed chiefly of microcline and dark smoky quartz. The quartz usually occurs in thin stringers. A small quantity of beryl occurs in the core.

MINERAL DEPOSITS

Beryl occurs in the intermediate zone of quartz-albite pegmatite, and microcline occurs in the core.

The quantity of beryl in the average crystal is small, as only a rim 13 millimeters thick around the exterior faces of the crystal is composed of beryl. These rims are light green, free of mineral impurities, and have an N_o of $1.581 \pm .003$. Euhedral beryl crystals that have an average diameter of 19 millimeters and a length of 2 inches occur in a muscovite selvage at the outer edge of the beryl deposit adjacent to the contact of the pegmatite and the schist. Some beryl crystals as large as a foot in diameter were seen.

The beryl-bearing zone is exposed in the walls of the larger pit along most of the southwest wall and in part of the northeast wall. It is 10 feet thick but is exposed over an area of only 150 square feet in the pegmatite and appears to have a slight dip away from the core.

The grade of the zone is visually estimated to be between 1 and 3 percent beryl. The occurrence in skeletal crystals would necessitate recovery by some method of milling, as the beryl cannot be recovered by hand cobbing.

Beryl occurs as scattered crystals as much as a foot in diameter near the outer edges of the microcline pegmatite core.

Microcline occurs in the core in large masses of nearly pure feldspar. It is cream-colored, low in iron content, and although it contains many quartz stringers, they are coarse enough to be discarded in hand cobbing. The core is exposed over 925 square feet in the larger pit and is visually estimated to contain more than 80 percent microcline.

BIG BOULDER PROSPECT

LOCATION HISTORY, AND GENERAL FEATURES

The Big Boulder prospect (7) is in the SE¼ sec. 36, T. 7 N., R. 72 W., sixth principal meridian, about 2 miles by air line southeast of Crystal Mountain. (See fig. 21.) It can be reached by a very poor road from the Smith ranch on the North Fork Fish Creek and also by a road leading south from Sheep Creek. Both of these roads are passable only by foot. The prospect is on public-school land. The mineral rights are said to have been optioned to Walter J. Lee of the United Beryllium Ores and Metals Corp., but Harold L. Flinn of the Mountain States Minerals Production Co. claims the property by right of location.

Roy Hyatt and H. A. Snider produced 10.5 tons of beryl from one crystal in the prospect in 1936, and in 1941 about 600 pounds of beryl was mined and stockpiled by the United Beryllium Ores and Metals Corp. The Big Boulder prospect was visited on September 22, 1942, by L. R. Page and J. B. Hanley and on October 2, 1942, was mapped by plane table and telescopic alidade.

The workings on the prospect consist of four small pits and a 10-foot discovery shaft.

GEOLOGY

The beryl-bearing pegmatite of the Big Boulder prospect is a lens (see pl. 12) at the western end of a large, irregular quartz-microcline-muscovite-plagioclase pegmatite. The lenticular, beryl-bearing pegmatite is 260 feet long and as much as 100 feet wide. It probably plunges 60° to 65° to the south and may be expected to pinch out 75 to 125 feet below the present surface. It is essentially conformable to the pre-Cambrian quartz-biotite schist except at the southern end where it joins the quartz-microcline-muscovite-plagioclase pegmatite, which cuts across the structure of the schist. Poor exposures make it impossible to study the actual connection between the two pegmatite bodies. The schists are folded isoclinally, and at the north end of the beryl-bearing pegmatite both the axes of the minor folds in the schist and the pegmatite appear to pitch about 65° S. The cross sections (see pl. 12) indicate the probable shape of the pegmatite.

The Big Boulder pegmatite contains two zones, both of which contain beryl. A fine-grained outer zone of quartz-albite-microcline-muscovite pegmatite surrounds a central core of coarse-grained quartz-microcline pegmatite. The outer zone is a granitic intergrowth with an average grain size of about an inch. Most of the zone is composed of white to pink albite, pink to red microcline, quartz, and muscovite with accessory beryl, black tourmaline, and apatite. Radial to platy clusters of black tourmaline and some blue apatite are associated with the beryl.

The core of the pegmatite contains crystals several feet across. It is composed mainly of milky quartz and large crystals of microcline, which makes up at least 30 percent of the pegmatite. In the shaft (see pl. 12) a few powdery, "rotten" spodumene crystals are exposed associated with small quantities of the uranium minerals, autunite and gummite, in albite, microcline, and smoky quartz.

An offshoot, 1.5 to 8 feet wide, of core material cuts across the outer zone to the wall-rock contact on the northwest side of the pegmatite. (See pl. 12.) This offshoot is composed chiefly of white quartz and a small quantity of microcline.

MINERAL DEPOSITS

Beryl occurs in both zones of the pegmatite. In the quartz-microcline pegmatite one crystal was 6 to 7 feet long by 5.5 feet in diameter and tapered toward both ends. At least two other crystals more than 12 inches in diameter were mined in 1941. The beryl is green to slightly bluish green and contains few mineral inclusions. Only a few small crystals were seen in place in the core.

Blue, green, and white beryl occurs in crystals and anhedral grains that are 1 inch or less in diameter in the quartz-albite-microcline-muscovite pegmatite. In the cliff at the north end of the pegmatite body, solid beryl grains or crystals appear to be distributed uniformly throughout the pegmatite. At the south end, where albite is more abundant, the beryl occurs both as solid crystals and as skeletal crystals around albite and quartz.

The beryl deposit in the outer quartz-albite-microcline-muscovite pegmatite is from 5 to 60 feet wide and is estimated to contain 600 tons of pegmatite in each foot of depth over the exposed area. The maximum vertical exposure is 50 feet. Visual estimates suggest that this zone will contain 1 to 2 percent beryl, which can be recovered only by milling.

The beryl deposit at the outer edges of the quartz-microcline pegmatite core is lenticular; it has a maximum length of 160 feet and a possible width of 85 feet. The average length is 140 feet, and the average width may be 60 feet. This core probably extends 50 to 80 feet below the present surface. The grade of the deposit is estimated, on the basis of past production, to be comparable to the grade of the outer zone. In addition to beryl, this deposit contains at least 30 percent large microcline crystals that are probably of marketable grade.

RESERVES

The reserves of fine-grained beryl in the quartz-albite-microcline-muscovite pegmatite are roughly estimated to be 450 tons of beryl in 45,000 tons of rock. The reserves in the core are estimated to be about 25 tons of beryl, separable by hand cobbing, and about 10,000 tons of recoverable feldspar.

CRYSTAL SILICA MINE

LOCATION, HISTORY, AND GENERAL FEATURES

The Crystal Silica mine (29), in sec. 26, T. 7 N., R. 72 W., sixth principal meridian, is situated between 9,300 and 9,600 feet in altitude on a ridge that is half a mile west of Crystal Mountain. (See fig. 21.) The mine can be reached from Sheep Creek, which is half a mile to the south, by two trails that are accessible by automobile from Fort Collins via the Buckhorn Creek road and the Reynolds ranch road.

The mine is reported to have been worked for bismuth prior to 1900, but no records of those operations are available. In 1923, Leon M. Day, of Lyons, patented two claims called the Crystal Silica Placer claims, on which the mine is located. There has been no production during the time that Mr. Day has owned the mine.

Part of the Crystal Silica pegmatite was mapped by plane table and telescopic alidade by L. R. Page, assisted by J. B. Hanley, on October 6 and 7, 1942. Storms prevented the complete mapping of the eastern slope of the ridge.

The mine workings that have been made during the long life of the mine include a 40-foot vertical shaft, 2 adits, 4 large open-cuts, and at least 19 small open-cuts and prospect trenches. The largest open-cut is 50 feet long, as much as 35 feet wide, and about 30 feet deep.

GEOLOGY

The Crystal Silica pegmatite is a zoned dike that intrudes highly folded and crumpled biotite schists of pre-Cambrian age. (See fig. 23.) It is probably part of a large granitic pegmatite dike that can be followed for a mile or more to the west but terminates abruptly a few hundred yards to the east of the area mapped. It contains four zones: a wall zone of fine-grained quartz-microcline-muscovite-plagioclase pegmatite, an intermediate zone of muscovite-beryl pegmatite, a microcline-quartz-mica pegmatite unit, and a quartz pegmatite unit. The last two units lie inside the others, but which is the true core is uncertain.

Quartz - microcline - muscovite - plagioclase pegmatite.—The quartz-microcline-muscovite-plagioclase wall zone in the area mapped encloses the coarser-grained zones and continues a mile or more to the west as a large dike. A 2-inch selvage of quartz and muscovite occurs outside this zone at the contact with the schist wall rock. The wall zone is granitic in texture with minerals rarely larger than 6 millimeters in grain size. Coarser-grained patches of pink microcline, muscovite, and smoky quartz, which are as much as 13 millimeters in grain size, locally form small irregular streaks and masses that grade imperceptibly into the normal pegmatite. The pegmatite in this zone should be called alaskite or granite on the basis of composition and texture but is called pegmatite because of its close genetic relationship to the other coarse-grained units.

The main feldspar is sodic oligoclase or albite, as the minimum indices of refraction are above 1.54 in some specimens and below 1.54 in others. This feldspar is definitely more calcic than that in the other pegmatite zones. Quartz makes up 40 to 50 percent and muscovite 10 to 20 percent of the pegmatite. Red garnet and blue-green apatite may form as much as 1 percent.

Muscovite-beryl pegmatite.—The muscovite-beryl pegmatite occurs in two exposures that are 75 to 125 feet west of the shaft. This type of pegmatite probably occurs in a narrow, discontinuous zone along the southwest and east sides of the quartz pegmatite. Specimens from the pits below 9,530 feet in altitude on the east side of the ridge suggest that a similar zone occurs around the quartz pegmatite in this area. Small patches of fine-grained aggregates of muscovite flakes that do not contain beryl occur north of the shaft and in the pits on the east side of the ridge.

The zone is composed mainly of muscovite with accessory beryl, albite, microcline, quartz, apatite, and columbite. Muscovite in haphazardly arranged flakes and books makes up 50 to 90 percent of the rock. Blue-green beryl is intergrown with this fine- to medium-grained muscovite, and both minerals have an average size of 13 millimeters. The beryl is subhedral because of interference with other beryl crystals or muscovite flakes during growth. In the two exposures of the zone, beryl constitutes 0.5 to 1 percent of the pegmatite and is associated with an equal quantity of cream-colored albite. The cream-colored plagioclase of the fine-grained aggregates of muscovite in the northern adit is sodic oligoclase, but the cream-colored plagioclase associated with the beryl is albite. The feldspars and quartz are interstitial to muscovite and beryl. The blue-green apatite is streaked like perthite and probably is a manganese apatite that formed before the albite and microcline. One blade of columbite that was 25 by 3 millimeters in size was seen in the feldspar.

Microcline-quartz-mica pegmatite.—The microcline-quartz-mica pegmatite probably underlies a rather large area south and west of the shaft. The only exposure is in the shaft, which was inaccessible when the mine was mapped, but large crystals of microcline could be seen in the quartz in the walls. Scattered flakes and small books of mica found in the float suggest that this pegmatite is closely related to a 5-foot dike that cuts the quartz-microcline-muscovite-plagioclase pegmatite west of the southern end of the quartz pegmatite. The pegmatite in this dike is visually estimated to contain 85 percent microcline, 10 percent quartz, and 5 percent muscovite. The microcline occurs in masses as much as 10 inches in size. However, quartz is probably the most abundant mineral in the large area near the shaft, and some fine-grained aggregates of mica and beryl also are probably present.

Quartz pegmatite.—The quartz pegmatite is very well exposed and forms a cliff on the east side of the ridge. Outcrops of the quartz pegmatite that were not mapped in detail occur on the east side of the ridge down to an altitude of 9,300 feet and probably extend somewhat south of the area mapped.

The quartz pegmatite is mainly massive, milky quartz with local patches of colorless or rose quartz as much as a foot or more in diameter. The centers of the colorless quartz patches are usually small vugs in which subhedral quartz crystals as much as an inch in cross section occur. Closely spaced vertical joints cut the quartz, and few fragments of clear quartz over an inch or so in size can be picked out by hand. Much of the quartz that appears colorless when dry is slightly milky when placed in water.

Scattered crystals of white microcline and muscovite occur in the quartz pegmatite. On the northeast side of the pegmatite 12 euhedral microcline crystals as much as a foot in size and three 2-inch books of musco-

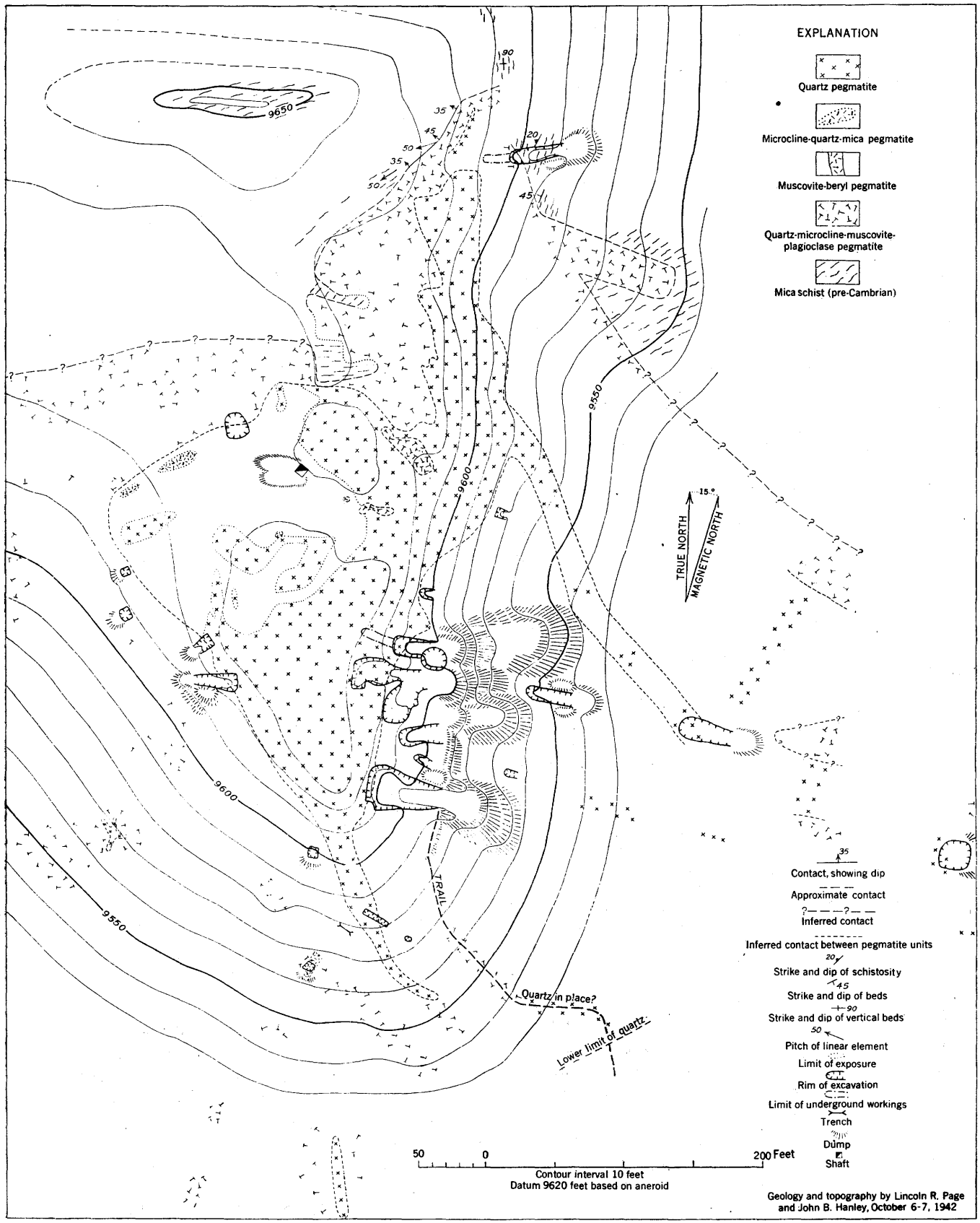


FIGURE 23.—Map of Crystal Silica mine, Crystal Mountain district, Larimer County, Colo.

vite occur in an area of 1,250 square feet. No other microcline crystals occur in the quartz pegmatite, although small clots of fine-grained aggregates of muscovite are present.

MINERAL DEPOSITS

Some beryl might be recovered from the Crystal Silica pegmatite. This beryl is dark to light green, blue, pale yellow, or opaque white and generally is in crystals less than 1 inch in diameter. Crystals as large as 6 inches in size were seen in the float but not in place. The beryl commonly is intergrown with muscovite and because of this intergrowth cannot be recovered by hand cobbing.

Only two small exposures of the muscovite-beryl pegmatite contain beryl in place. However, beryl float occurs down the slope to an altitude of 9,500 feet over the entire southwest side of the ridge and also down to the shallow valley on the west. Beryl float is common on the east side of the ridge as far north as the northernmost open-cut and downhill to an altitude of 9,300 feet. The large quantity of beryl in the float and on the dumps, as well as the position of the workings, suggests that a narrow but very rich zone of beryl-bearing pegmatite occurs between the wall zone and the coarser-grained core. This zone probably occurs over a length of 700 feet along the contact between the wall zone and the south half of the core. In addition, the dumps at the workings on the east slope indicate that the beryl deposit is not restricted to the main quartz pegmatite core but may occur also around other quartz pegmatite bodies.

The attitude of the beryl deposit is unknown. The few measurements on the contact of the wall zone indicate a dip of 35° to 45° NW. and a plunge of 50° SW. The beryl deposit may be parallel to the wall-zone contact, but sufficient evidence is lacking to prove that the deposit is parallel.

The grade of the beryl deposit in the intermediate zone cannot be determined, but the approximate maximum grade may be established from a study of the dump material at what is probably the richest spot. Beryl crystals which had an average size of 13 millimeters were hand-picked from 375 square feet of dump at the largest open-cut on the southwest side of the quartz pegmatite core. This sampling gave a grade of 3 percent beryl. The muck in the floor of the open-cut was visually estimated to contain 10 percent. The dump at the smaller open-cut that is 25 feet to the north contained 2 to 3 percent. The slope between this open-cut and a small pit that is 50 feet to the northwest was visually estimated to contain slightly less than 0.5 percent beryl.

In order to determine the content of fine-grained beryl in the wall zone, a grab sample of the dump material from the small pit 50 feet northwest of the second open-cut, a chip sample from all the exposures of the wall zone on the northwest side of the dike, and a 10-foot chip channel sample from the wall zone on the east side of the dike were spectrographically analyzed by the Chemical Laboratory of the Geological Survey. The samples contained only a few thousandths of 1 percent beryl and indicate that the beryl content of the wall zone is negligible.

The beryl reserves in the Crystal Silica pegmatite cannot be estimated until more development work has been done.

MICA-BERYL PROSPECT

The Mica-Beryl prospect (53*A*), in the SW¼ sec. 30, T. 7 N., R. 71 W., sixth principal meridian, is on the Reynolds ranch (see fig. 21) and is owned by the United Beryllium Ores and Metals Corp. of Denver. It can be reached from Fort Collins via the Buckhorn Creek road and the road through the Reynolds ranch. The prospect is about 200 feet south of the road from the Reynolds ranch house to the Buckhorn mica mine. No production is reported from this prospect, which was mapped by pace and compass by L. R. Page and J. B. Hanley on September 26, 1942.

The only opening in the prospect is a 5-by-7-foot shaft that is about 20 feet deep.

The Mica-Beryl pegmatite (see fig. 24) intrudes quartz-biotite schists that probably belong to the pre-Cambrian Idaho Springs formation and is conformable to the schist structure. The pegmatite trends N. 55° E. and is 138 feet long and as much as 49 feet wide. The contact on the northwest side dips 65° to 70° NW. and on the southeast side dips 80° SE. The pegmatite crops out at about the same level as the surrounding schists.

The pegmatite contains a border zone of quartz-muscovite pegmatite less than 2 inches wide, a wall zone of quartz-plagioclase-muscovite pegmatite that contains beryl, an intermediate zone of plagioclase-quartz pegmatite with an average grain size of 12 inches, and a core of quartz-perthite pegmatite. The wall-zone pegmatite is composed of gray quartz, white plagioclase, and green muscovite that occurs in flakes as much as 1 inch in size and in streaks more or less perpendicular to the contact. Muscovite is visually estimated to make up 40 percent of this rock. Bright-green beryl occurs with the muscovite in subhedral to euhedral crystals about 1 inch in diameter but is not very abundant. The ratio of beryl to rock is estimated to be 1:800. The quartz-perthite pegmatite of the core contains buff perthite in large subhedral crystals and also felted aggregates of small muscovite flakes.

HUMPHREY BERYL PROSPECT

The Humphrey beryl prospect (40), in the SE¼ sec. 25, T. 7 N., R, 72 W., sixth principal meridian, is on the

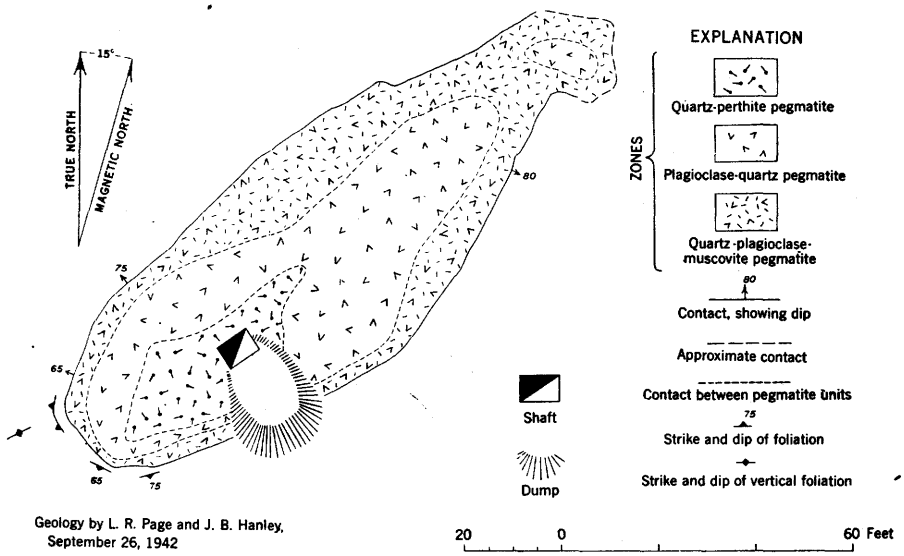


FIGURE 24.—Map of Mica-Beryl prospect, Crystal Mountain district, Larimer County, Colo.

Reynolds ranch (see fig. 21) and is owned by the United Beryllium Ores and Metals Corp. of Denver. The prospect may be reached from Fort Collins via the Buckhorn Creek road and the road through the Turner ranch. The pegmatites crop out in the Reynolds ranch yard. No production is reported from them. The prospect was mapped by J. B. Hanley and L. R. Page by plane table and telescopic alidade on October 3, 1942.

The only opening in the main dike is a small pit 6 feet long, 5 feet wide, and 2 feet in average depth. The other two pegmatites have not been explored.

In the Humphrey prospect (see fig. 25), three beryl-bearing pegmatites intrude quartz-biotite schists that are probably part of the pre-Cambrian Idaho Springs formation. Outcrops of the schist are poor and sparse near the pegmatites. The general strike of the schist is N. 40° E., and the average dip is 60° SE.

The main pegmatite strikes N. 45° E. and dips 55° NW. to vertical, although locally the contact is highly irregular. The pegmatite is 210 feet long and has an average width of 10 feet. The smaller, poorly exposed pegmatite 100 feet to the northwest is parallel to the main dike in strike and dips vertically. It is 100 feet long and as much as 7 feet wide. The small pegmatite 15 feet north of the northeast end of the main dike strikes N. 80° E., dips 40° NW., and plunges 20° to the northeast. It is 40 feet long and about 3 feet wide. The contacts between the pegmatite and schist are sharp in all three dikes.

Two minor faults have offset two of the pegmatites. The main pegmatite is displaced 12 feet horizontally near its southwest end by a fault that strikes N. 53° W. The trace of the fault that displaces the smaller pegmatite is N. 10° W., and the movement was probably rotational. The dips of the faults are not known.

The three pegmatites are identical in lithology. They are composed of quartz, albite, and muscovite with accessory microcline and beryl. The average grain size in all the dikes is about 1 inch. A small patch of massive quartz occurs in the central part of the northwestern pegmatite. The narrow northern extension of the main pegmatite is almost entirely quartz-muscovite pegmatite with a small quantity of albite.

The quartz in these pegmatites occurs as anhedral grains with an average size of 1 inch or less. Albite occurs in light-pink anhedral crystals that are usually less than 1 inch in size, although near the pit and in a few other places the grain size is as much as 3 inches. Albite is visually estimated to make up about 40 percent of the pegmatite. Deep-pink microcline occurs throughout the dikes but is most abundant near the pit. Subhedral microcline crystals as much as 6 inches in size are exposed in the walls of the pit. The quantity of microcline in the dikes is too small to repay mining.

Beryl occurs throughout the pegmatites in crystals that range from 3 to 40 millimeters in size. The crystals are bluish green and contain no mineral impurities. The BeO content of this beryl is not known, and its recovery would require milling. The average beryl content in the main pegmatite is visually estimated to be 1 percent.

Muscovite occurs in books as much as 3 inches long and is most abundant near the northwest walls of the dikes. It is ruled and ribboned and can be used only as scrap mica.

BERYL NO. 5 PROSPECT

The Beryl No. 5 prospect (5), in sec. 25, T. 7 N., R. 72 W., sixth principal meridian, is on the Reynolds ranch (see fig. 21) and is owned by the United Beryllium Ores and Metals Corp. of Denver. It was examined briefly

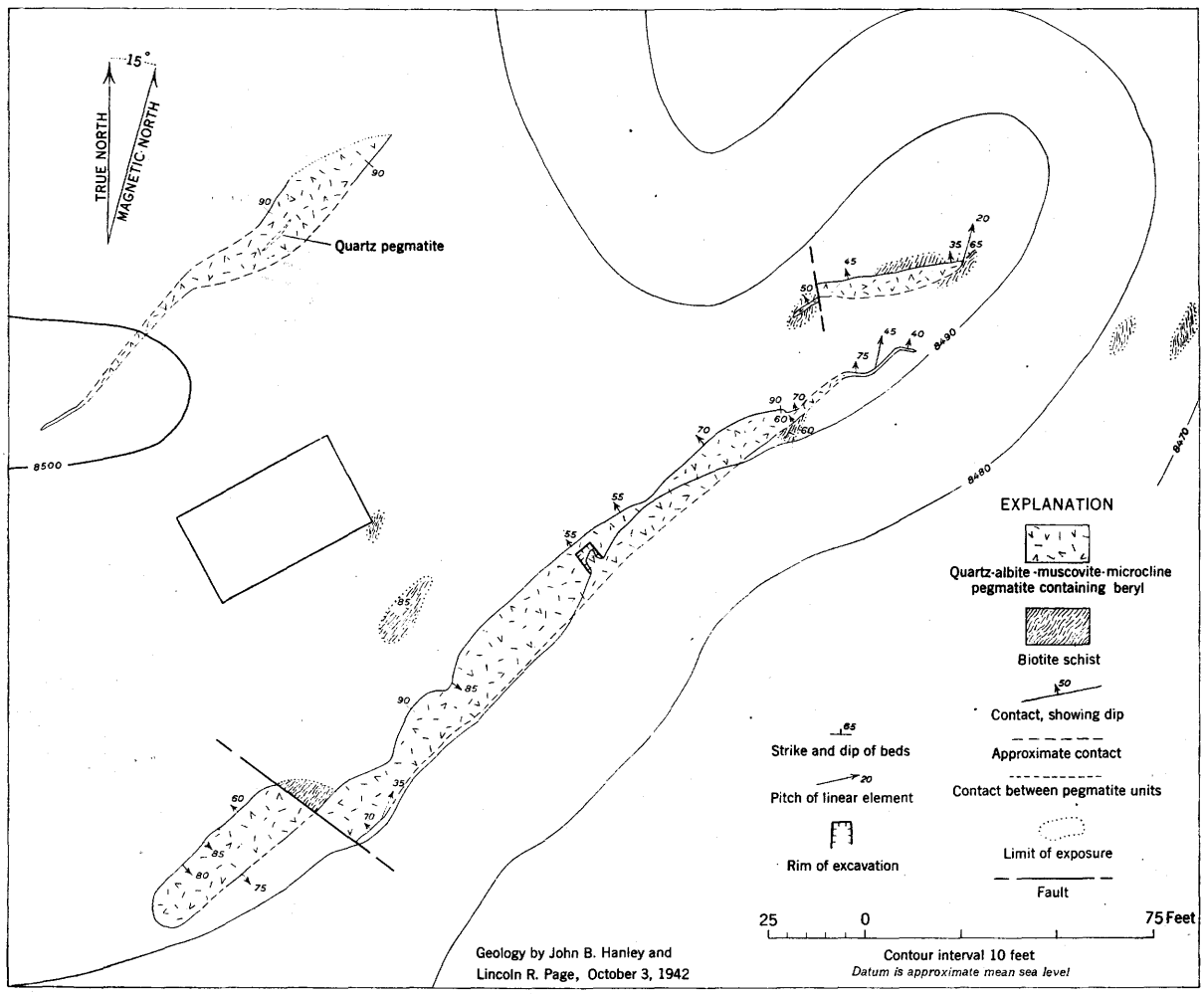


FIGURE 25.—Map of Humphrey beryl prospect, Crystal Mountain district, Larimer County, Colo.

by L. R. Page assisted by J. B. Hanley on October 3, 1942.

The only opening in the prospect is a pit that is 18 feet in length, 10 feet in width, and as much as 8 feet in depth.

The Beryl No. 5 pegmatite is poorly exposed beyond the limits of the pit, and its exact length and width are not known. In the pit the pegmatite is 10 feet wide. The contacts with the quartz-biotite schist exposed in the pit strike N. 30° E. and dip from 55° SE. to vertical. West of the pit the pegmatite appears to strike N. 55° E. and is vertical.

The pegmatite contains a fine-grained border zone and a coarse-grained core. The fine-grained border zone of quartz-feldspar-mica pegmatite is 6 to 12 inches wide, and the rest of the pegmatite body is made up of the quartz-perthite core. The muscovite in the border zone occurs in books as much as 2 inches in size, and the garnet crystals in this zone also are as much as 2 inches in size. The perthite in the core occurs in subhedral crystals that are as much as 5 feet in size. Beryl is reported to have been mined from the pegmatite, but none could be found in place.

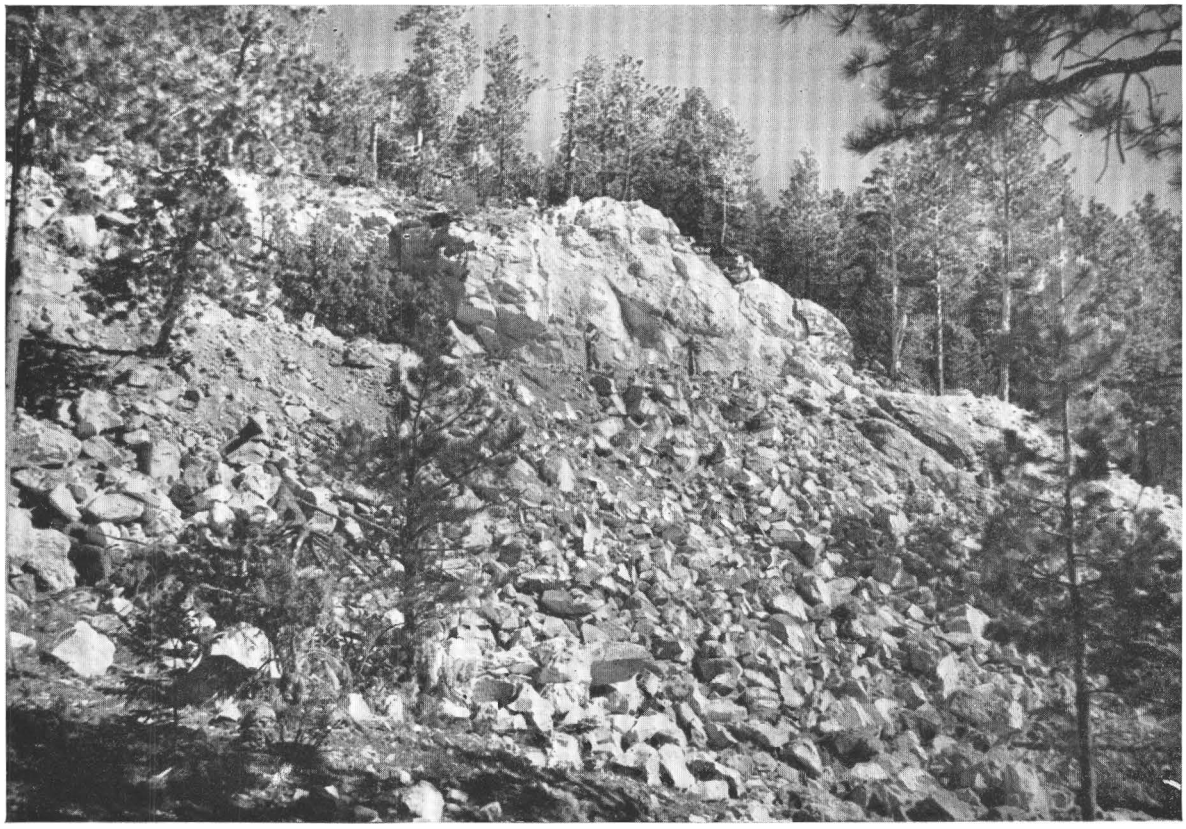
TANTALUM PROSPECT

The Tantalum prospect (82), in the NE¼ sec. 30, T. 7 N., R. 71 W., sixth principal meridian, is about 3 miles by air line north-northeast of Crystal Mountain (see fig. 21) and can be reached from Fort Collins by the Buckhorn Creek road and ranch roads through the Turner and Reynolds ranches. It is on the Reynolds ranch and is owned by the United Beryllium Ores and Metals Corp. of Denver. There has been no production from the prospect. It was examined by J. B. Hanley and L. R. Page on October 3, 1942, and was mapped by pace-and-compass survey.

The only opening in the prospect is a discovery shaft that is 6 feet square and 6 feet deep.

The Tantalum pegmatite is a blunt-nosed, tabular body (see fig. 26) that has intruded pre-Cambrian quartz-biotite schists. It is poorly exposed, and most of its surface is covered by a thin mantle of disintegrated pegmatite and soil. It trends N. 71° E.; the dip is

A. PRIOR TO MINING.



B. AFTER MINING.

Photograph taken from same location as *A*.

HYATT PEGMATITE, LARIMER COUNTY, COLO.

unknown. The pegmatite is exposed for at least 110 feet in length and 22 feet in width and may extend for 55 feet more to the northeast. The relationship between the pegmatite and the wall rock is unknown.

The pegmatite is composed of quartz, albite, and muscovite with accessory microcline, beryl, and tantalite. The average grain size is about 2 inches, but the beryl and microcline crystals are usually larger than the average size. No zonal structure is exposed in the pegmatite. The muscovite commonly occurs in aggregates of light-green flakes, about 6 millimeters in size, associated with white or light cream-colored albite. Beryl and tantalite occur with the fine-grained muscovite aggregates. Beryl is uncommon in the pegmatite and does not occur in sufficient quantity to be economically significant. Tantalite is unusually abundant in euhedral, equant crystals as large as 1 inch in width. The specific gravity of this mineral as determined by the Chemical Laboratory of the Geological Survey is 7.32, and this high specific gravity indicates a composition near 76 percent Ta_2O_5 and 10 percent Cb_2O_5.

The tantalite content of the Tantalum pegmatite is not known and cannot be determined until more development work is done. However, because tantalite is unusually abundant in the pegmatite, 12 samples (see fig. 26) of the loose material near the pegmatite were collected and concentrated by panning. All the samples contained tantalite in quantities that were estimated to range from slightly less than half a pound to 3 pounds per cubic yard of loose material.

HYATT BERYL MINE

LOCATION AND HISTORY

The Hyatt beryl mine (41) is in the NE¼NW¼ sec. 28, T. 6 N., R. 71 W., sixth principal meridian, on the Fred Hyatt ranch. It is about 1 mile by air line north of the North Fork Big Thompson River and about 1.5 miles by air line north-northwest of the town of Drake on U. S. Highway 34. The mine can be reached from

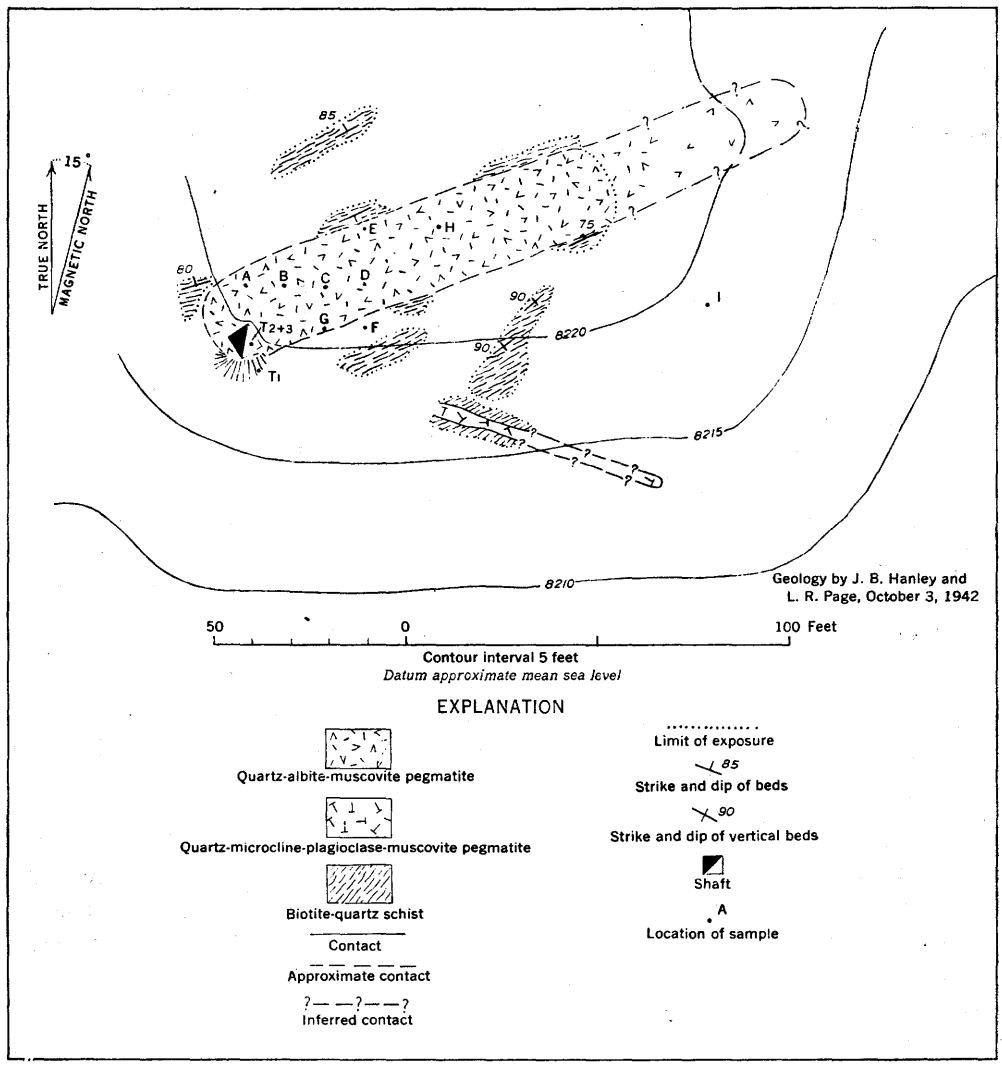


FIGURE 26.—Map of Tantalum prospect, Crystal Mountain district, Larimer County, Colo.

Drake by a one-way mountain road through the Hyatt ranch to the mine workings. The nearest shipping point is Loveland, 20 miles by road from the mine, on the Colorado & Southern Railroad.

The topography of the region adjacent to the mine is rough. The relief is very great near the Big Thompson River and necessitates circuitous routes for the roads. Most of the streams near the mine are intermittent, and the nearest permanent stream is the North Fork Big Thompson River. The region is heavily wooded, and the timber needed in mining can be secured in the vicinity of the mine.

The deposit was discovered in 1936 by Roy Hyatt. Very little work was done at that time, and the mine was inactive until September 1942 when it was leased to the United Beryllium Ores and Metals Corp. of Denver. It was operated intermittently in the fall of 1942 by this company and was worked steadily from June to December 1943 under a financial arrangement with the Reconstruction Finance Corporation. During 1944 the mine was inactive.

The intermittent operation since 1936 has resulted in the production of 34.75 tons of hand-cobbed beryl that contained an average BeO content of 11.04 percent. Thirty-four tons of beryl was produced during the operations from June to December 1943.

The mine was first visited by J. B. Hanley on September 21, 1942, and was mapped by him and L. R. Page by plane table and telescopic alidade on October 9 and 10, 1942. It was remapped from September 7 to September 13, 1943, by J. B. Hanley and Roswell Miller III and from June 17 to June 21, 1944, by J. B. Hanley, A. F. Trites, Jr., and J. E. Husted. A 3,000-pound sample of the fine-grained beryl pegmatite was collected by James F. Piquette of the Metals Reserve Company with the assistance of the Geological Survey in September 1943.

MINE WORKINGS

The mine workings (see pl. 13) at the Hyatt beryl mine comprise two large open-cuts, a third open-cut that is buried beneath dump material, and three prospect and sample trenches. The largest cut is 118 feet in length and as much as 47 feet in width and has a maximum depth of at least 35 feet. The other cut is 65 feet in length, as much as 45 feet in width, and at least 25 feet in depth. The backfilled cut was 472 square feet in area with an average depth of 10 feet.

GEOLOGY

In the vicinity of the Hyatt beryl mine numerous pegmatite and gray granite bodies intrude dark-gray schists, which probably belong to the pre-Cambrian Idaho Springs formation. In some exposures the granites are cut by the pegmatites and hence are older, but both rocks are probably pre-Cambrian in age.

METAMORPHIC ROCKS AND GRANITE

The metamorphic rocks are composed of alternating beds of gray quartz-mica schist and quartz-biotite-feldspar gneiss. The general strike is N. 20° E., but the beds are tightly folded. The general plunge of the folds is 60° SW. The schists are poorly foliated, and the foliation locally strikes at an angle of 40° with the bedding. The southeastern half of the area mapped is underlain by the metamorphic rocks.

The granite is a grayish rock containing both muscovite and biotite. Beyond the limits of the area mapped it contains numerous inclusions of schist, apparently oriented parallel to the walls of the granite intrusive. Many small, discontinuous quartz veins and a few small pegmatites cut the granite that forms the wall rock of the central part of the Hyatt pegmatite.

PEGMATITES

Two large and two small pegmatites crop out in the area mapped. The Hyatt pegmatite, which is the largest, is zoned and contains beryl, as does one of the small pegmatites. The other pegmatites do not contain beryl.

The Hyatt pegmatite is a large, roughly lenticular body that has been intruded across a small projection of granite into the schist. It is at least 350 feet in length and as much as 60 feet in width and, prior to the mining, was exposed for a vertical height of 50 feet in a natural cliff. (See pl. 14.) The general trend of the pegmatite is N. 60° E., and the dips of the contacts range from 30° to 45° NW. except at the southwest and northeast ends where locally they dip 45° S. to vertical. The plunge of the pegmatite is about 25° SW. The contacts with the wall rock are well exposed at the northeastern and southwestern ends and prior to the mining were well exposed along most of the southeast side. Along the northwest side the contact is obscured by granite float from the ridge above the pegmatite.

In the largest open-cut the pegmatite is crossed by a fracture that strikes N. 50° E., dips southeast, and branches downward. The fracture is marked by a 4-inch thickness of soft and very friable gouge, which is composed of brecciated quartz, feldspar, beryl, and mica. Despite the thick layer of gouge no displacement can be found.

The Hyatt pegmatite contains, besides a discontinuous border zone, a wall zone of fine-grained microcline-quartz-muscovite-beryl pegmatite, a discontinuous and highly irregular intermediate zone of quartz-albite-muscovite pegmatite that contains beryl, and a core of coarse-grained microperthite pegmatite. A large body of quartz pegmatite was exposed at the hanging-wall contact prior to the mining, but the relationship of this unit to the zones is not known.

Microcline-quartz-muscovite-beryl pegmatite.—The wall zone of the pegmatite is composed of pink microcline, white to pink plagioclase, grayish quartz, and small books of muscovite, with minor quantities of light bluish-green to blue beryl that occurs in euhedral crystals with an average size of 6 millimeters. This zone is exposed over an area of 10,150 square feet and makes up the bulk of the pegmatite at the surface. The average grain size of this pegmatite is about 1 inch, although some of the microcline crystals are several times this size. The grain size decreases toward the contact with the schist wall rock, but no change in grain size was observed near the contact with the granite wall rock. Beryl is uniformly distributed throughout the zone and is visually estimated to compose 1 to 3 percent of the pegmatite.

Quartz-albite-muscovite pegmatite.—The intermediate zone is a series of disconnected lenticular pods between the wall zone and the core. It is composed chiefly of quartz, white albite, and greenish-white muscovite with accessory beryl, black tourmaline, lithiophilite-triphylite, uraninite, torbernite, autunite, and bismuthinite. The albite commonly forms in small anhedral crystals with a composition indicated by the indices of refraction as about Ab_{95}. Muscovite occurs in wedge-shaped books that are as much as 1 foot long, are reeved, and have "A" structure. No punch nor sheet mica has been found; the muscovite is suitable only for scrap mica. Light bluish-green to blue beryl occurs in euhedral crystals and bundles of crystals as much as 1 foot in diameter and 4 feet in length. This beryl commonly is fractured subparallel to the basal cleavage, and the fractures have been healed by grayish-white quartz or by a fine-grained quartz-albite-muscovite pegmatite that has a typical aplitic texture. Narrow stringers of this aplitic pegmatite occur as healing material along fractures in all zones of the pegmatite except the core. When the pegmatite was first examined, seven separate clusters of beryl crystals were exposed in the cliff face. The largest of these clusters contained 31 beryl crystals in 30 square feet of pegmatite. Black tourmaline occurs in the muscovite and albite as euhedral crystals that range from less than 3 to 25 millimeters in diameter. It commonly occurs on the crystal faces of the beryl. The lithiophilite-triphylite minerals, as well as associated purpurite, and the uranium minerals occur in lenticular patches that are oriented parallel to the structure of the intermediate zone near the contact between the intermediate zone and the core. These patches are commonly associated with the albite-rich parts of the zone rather than with the muscovite-rich parts. Bismuthinite and alteration products occur at the inner edge of the intermediate zone.

Microperthite pegmatite.—The microperthite pegmatite of the core is composed chiefly of white microperthite in masses several feet in size. Milky quartz and black tourmaline are minor accessories. Some of the microperthite, particularly near the surface, is iron-stained, but this staining does not continue in depth except along fractures. Adjacent to the intermediate zone the microperthite pegmatite contains albite, beryl, and muscovite in small quantities.

The smaller beryl-bearing pegmatite is about 40 feet south of the Hyatt pegmatite and is exposed for 180 feet. It ranges in width from less than 1 foot to 6 feet. Its general strike is N. 70° E., and its dip is 60° SE. The western end of this pegmatite has been displaced 10 feet horizontally to the south by a small fault that trends N. 10° E. The dip of the fault could not be determined.

This pegmatite is composed chiefly of quartz, microcline, plagioclase, and muscovite with accessory beryl and has an average grain size of 3 inches. Quartz pegmatite occurs as small, discontinuous pods along the center of the dike. About 30 feet east of the fault 84 beryl crystals with an average size of 10 millimeters are exposed in an area of 32 square feet. This pegmatite is similar to the wall zone of the Hyatt pegmatite but is small and contains little beryl.

The larger of the two quartz-microcline plagioclase-muscovite pegmatites ranges in width from 12 to 50 feet and is at least 400 feet long. Its average grain size is 2 inches. Near the west end it has been displaced by a minor fault that strikes N. 76° W. and dips 80° NE. The displacement on the fault is mainly rotational. No beryl is exposed in the pegmatite.

The smaller quartz-microline-plagioclase-muscovite pegmatite is exposed only for a length of 48 feet. It is as much as 4 feet wide, strikes N. 70° E., and dips 60° NW. The pegmatite is similar to the larger quartz-microcline-plagioclase-muscovite pegmatite and has an average grain size of about 18 millimeters. No beryl is exposed in it.

MINERAL DEPOSITS

The Hyatt pegmatite contains an appreciable quantity of beryl in the wall and intermediate zones. The beryl produced has been mined from the intermediate-zone beryl deposit. A mica deposit in the intermediate zone and a feldspar deposit in the core of microperthite pegmatite are large enough to repay mining operations.

BERYL

The wall-zone beryl deposit is exposed over 10,150 square feet of the surface of the pegmatite. The thickness of this zone is variable, and its average thickness is not known. It probably extends at least 50 feet below the original surface of the pegmatite. The beryl content was visually estimated to be between 1 and 3 percent. A spectrographic analysis by the Chemical Laboratory of the Geological Survey of a part of the Metals Re-

serve Company's bulk sample from this zone showed a BeO content of 0.07 percent, or 0.5 percent beryl that contains 13 percent BeO. However, the sampling was not representative of the zone and is significant only in that it shows beryl is present.

The intermediate-zone beryl deposit is exposed as a series of lenticular pods over a surface area of 1,100 square feet. The thickness of this zone is variable, and the average thickness cannot be determined. The probable extent of this deposit in depth is 50 feet. The past-production figures indicate that the beryl content of the zone is about 2 percent. Prior to the mining, seven clusters of beryl crystals were exposed in the natural cliff face. The beryl crystals in these clusters, which projected above the surface of the surrounding rock, were measured, and the quantity of beryl thus exposed totaled 3,300 pounds.

MUSCOVITE

The greenish-white muscovite of the intermediate-zone mica deposit occurs in large wedge-shaped books as much as 1 foot in length. It is wedged and reeved, has "A" structure, and is suitable only for scrap mica. Small black tourmaline crystals are commonly associated with the muscovite.

The muscovite deposit occurs in the same zone as the beryl deposit. Its grade is visually estimated to be 10 to 15 percent scrap mica.

FELDSPAR

White microperthite occurs in the core in masses that are several feet in size. Milky quartz and black tourmaline occur in minor quantities in the microperthite, and very small quantities of muscovite, albite, and beryl occur near the outer edges of this deposit.

The feldspar deposit is exposed over a surface area of 3,825 square feet and to a vertical depth of 30 feet. It probably continues for 20 feet more in depth. It is visually estimated to contain about 50 percent microcline.

LEWIS BERYL PROSPECT

The Lewis beryl prospect (46), on the south slope of Storm Mountain in sec. 18, T. 6 N., R. 71 W., sixth principal meridian, is 10 miles by air line northeast of the town of Estes Park. The prospect is on a minor ridge that extends westward from the main mass of Storm Mountain. It can be reached by foot trail from the Hyatt ranch but is difficult to find without a guide. The claim on which the prospect is situated was located on June 3, 1943, by Jack Lewis of Cheyenne, Wyo. The prospect was examined by J. B. Hanley and Roswell Miller III, on September 12, 1943.

The development work on the prospect consists of a shaft 10 feet square and 10 feet deep and two small open-cuts near the shaft. The larger of these cuts is 15 feet long, 3 feet wide, and 2 feet deep, and the smaller one is 10 feet long, 4 feet wide, and 2 feet deep.

The Lewis pegmatite trends east and dips 70° S. It is exposed for a maximum length of 200 feet and a maximum width of 150 feet and is probably conformable to the structure of the enclosing pre-Cambrian quartz-mica schists. The pegmatite contains two distinct mineralogical zones. The wall zone is a fine-grained potash feldspar-quartz-muscovite pegmatite that contains no beryl. The core of the pegmatite is coarse-grained and contains irregular patches of potash feldspar, quartz, albite, and fine-grained aggregates of muscovite flakes. All the muscovite in the pegmatite is small and can be used only as scrap mica. The potash feldspar is cream or pink in color, and the albite is whiter and less abundant.

Pale-green to white beryl occurs in euhedral crystals and is sparingly found in radial masses of crystals associated with quartz. Small muscovite flakes in fine-grained aggregates are commonly associated with the beryl, and mica was found corroding the beryl. Beryl also occurs with the albite and is likewise corroded by this mineral. Only a small quantity of beryl was seen in place, and the largest crystal observed was about 6 inches in diameter. The beryl content of the pegmatite is not known definitely but is estimated roughly to be about 1 ton of beryl in 1,000 tons of rock.

No estimate of the quantity of beryl and other commercially valuable minerals in the Lewis prospect is possible.

WISDOM RANCH PROSPECT

LOCATION, HISTORY, AND GENERAL FEATURES

The Wisdom Ranch prospect (88), in the S½ sec. 5, T. 7 N., R. 71 W., sixth principal meridian, is 15.5 miles by air line and 29 miles by road west of Fort Collins. Bellvue, the nearest shipping point on a railroad, can be reached by 15 miles of dirt road. Although the prospect is on a ranch owned by C. C. Wisdom, the mineral rights are held by the United Beryllium Ores and Metals Corp. of Denver. The prospect was discovered and first worked by Leslie Barker in the spring of 1941 and in August 1941 was acquired by Eugene Bruell for the United Beryllium Ores and Metals Corp. About 15 or 20 tons of beryl mixed with chrysoberyl has been produced. The prospect was examined by L. R. Page assisted by J. B. Hanley, and part of it was mapped by plane table and telescopic alidade during 4 days in September 1942. At that time other pegmatites in the vicinity were examined, but no beryllium-bearing minerals were found in them.

The openings in this prospect include one large open pit that has an average length of 70 feet, an average width of 10 feet, and an average depth of 5 feet; a 33-

foot drift from this open-cut; and eight small prospect pits and trenches.

GEOLOGY

The Wisdom Ranch pegmatite and the other pegmatites in the vicinity intrude dark-colored, pre-Cambrian biotite-sillimanite schists and injection gneisses, which are probably part of the Idaho Springs formation. The schists are intruded by pink to gray granite, probably of pre-Cambrian age, about half a mile north of the prospect. Diabase dikes cut both the schists and the pegmatites.

INJECTION GNEISSES AND SCHISTS

Highly folded and contorted injection gneisses predominate in the area mapped. (See pl. 15.) In general they strike east and dip 50° to 75° N. The contact between pegmatite and schist or gneiss is obscure because of poor exposures and intimate mixing of the rocks. Outcrops of the gneiss are indicated in plate 15, and most of the area between these outcrops is probably underlain by pegmatite. Only a few outcrops of schist to which little or no igneous material has been added can be found.

The gneisses are composed of granulose layers of pink to red feldspar and quartz that are separated by schistose layers of biotite, muscovite, sillimanite, and quartz. The individual layers show a wide range of composition and thickness. The granulose layers in places contain large quantities of sillimanite, magnetite, and hematite, which were probably derived from the assimilation of the adjacent schistose material.

PEGMATITE

The Wisdom Ranch pegmatite, of which only the beryllium-bearing part was mapped, may be followed for more than a mile in an easterly direction. Beryllium minerals occur only at the workings and are confined to one small area. The pegmatite is parallel in general to the gneiss in strike and dip, although locally it cuts across the gneiss structure. In the drift the pegmatite contacts dip 45° N., but elsewhere the dips are probably only slightly greater than the surface slope. The pegmatite is very irregular, both in plan and in section.

The pegmatite contains four distinct zones, of which only the quartz pegmatite zone is shown separately in plate 15. The microcline-quartz-muscovite pegmatite zone, the albite-quartz-muscovite pegmatite zone, and the microcline pegmatite zone were grouped together because they are too poorly exposed to be mapped accurately. A few of the large microcline crystals at the outer edge of the quartz pegmatite are shown on the map, but the microcline pegmatite zone is more continuous than the mapping indicates.

The largest part of the pegmatite is a pink to red, granitic-textured microcline-quartz-muscovite pegmatite that contains large quantities of sillimanite, magnetite, and hematite near schist inclusions and the contacts. Microcline occurs in subhedral crystals that are as much as 6 inches in diameter, but the average size is 2 inches. Graphic intergrowths of pink microcline and gray quartz are common in this zone. Muscovite flakes rarely make up more than 5 percent of the pegmatite. Sillimanite locally may make up 50 percent of the zone but generally occurs as scattered masses of fibrous aggregates 1 to 3 inches across. These masses are partly altered to sericite. Magnetite crystals partly altered to hematite also occur near the contacts. The average size of these crystals is about three-eighths of an inch, but they may be as much as 1 inch in diameter. Locally magnetite makes up 15 to 20 percent of the pegmatite. Both sillimanite and magnetite probably formed as the result of assimilation of the wall rock. The microcline-quartz-muscovite pegmatite grades imperceptibly into a lighter-colored albite-quartz-muscovite pegmatite that contains beryl, chrysoberyl, and garnet near the quartz pegmatite zone. The albite-quartz-muscovite pegmatite is composed of pink albite that has a composition near Ab_{95}, gray quartz, and small books of muscovite. Pale bluish-green beryl, yellowish-green to dark-green chrysoberyl, and brown manganese garnet are the accessory minerals. Muscovite books are rare, but some highly ruled mica books with "A" structure occur in the pegmatite. Most of the mica occurs in aggregates of small flakes associated with the chrysoberyl. The brown garnet occurs in masses as much as 12 inches in diameter that are made up of individual crystals or aggregates. Many of these masses are intergrown with quartz, beryl, chrysoberyl, and albite. Alteration of the garnet has produced manganese oxides, which have stained the surrounding minerals.

A zone of very large microcline crystals occurs between the albite-quartz-muscovite pegmatite and the quartz pegmatite. One microcline crystal is 11 feet long, and crystals 3 to 4 feet across are not uncommon. The albite-quartz-muscovite pegmatite and the microcline pegmatite together form a zone with an average thickness of about 5 feet.

The quartz pegmatite is composed almost entirely of massive milky-white to rose quartz. This quartz typically has an intricate pattern of crisscrossing streaks of more opaque quartz; these streaks may represent healed fractures. The quartz pegmatite is well exposed, although heavy quartz float hides the actual limits and contacts with the other zones. The individual masses of quartz pegmatite are very irregular in shape but probably are relatively thin and roughly parallel to the surface slope. Their irregular outcrop pattern

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is probably caused by a combination of structure and erosion.

DIABASE

Two poorly exposed diabase dikes cut across the gneisses and pegmatite in the area mapped. The eastern dike is offset by an east-trending fault. The northern segment of the dike strikes N. 40° W. and is exposed for a width of about 30 feet. The southern segment strikes about N. 10° W. and has a maximum width of 23 feet. The dip of the dike is unknown. The diabase is a black, fine- to medium-grained rock that contains a few plagioclase crystals as much as 6 millimeters in length. Aggregates of biotite and hornblende give the rock a mottled appearance. The western dike strikes N. 25° to 30° W., dips about 40° SW., and is about 30 feet thick. The diabase is black and slightly porphyritic and has a fine- to medium-grained groundmass. Plagioclase phenocrysts as much as 1 inch in length project as knobs above the weathered surface of the dike.

MINERAL DEPOSITS

The Wisdom Ranch prospect contains only one known deposit of beryllium-bearing minerals. It is possible that additional deposits may occur adjacent to three other quartz pegmatite masses.

Beryl, the chief beryllium-bearing mineral, occurs in the albite-quartz-muscovite pegmatite in pale bluish-green crystals that are as much as 8 inches in diameter. Part of one crystal, which was 3 inches in diameter and 12 inches in length, was observed in place. The indices of the beryl were determined to be $N_e = 1.567 \pm .003$ and $N_o = 1.572 \pm .003$, indicating that the beryl has a low alkali content. The beryl is usually associated with albite but occasionally is found in contact with microcline.

Chrysoberyl also is an important beryllium-bearing mineral in the deposit. It is yellowish green to dark green in color and occurs with beryl, albite, quartz, and garnet in plates as much as 3 inches long and 13 millimeters thick. It also occurs associated with muscovite in quartz nodules that are 3 to 6 inches in diameter. These nodules are commonly enclosed in light-pink albite. Chrysoberyl makes up as much as 50 percent of some of the nodules. A few plates of chrysoberyl were seen in albite, but the albite generally appears to have formed after the chrysoberyl.

The size of the deposit is not known because exposures are poor and little development work has been done. The deposit is exposed only in the large open-cut, and so far as is known the maximum length is 70 feet and the width 5 feet. The grade of the deposit is based only on past production, as only one beryl crystal and a few chrysoberyl crystals have been found in place. The grade indicated by past production may be as much as 10 percent beryl and chrysoberyl. No estimate of reserves of beryllium-bearing minerals can be made until more development work is done.

CHANEY-SIMS BERYL PROSPECTS

The Chaney-Sims beryl prospects (20), near the line between sec. 1 and sec. 2, T. 8 N., R. 74 W., sixth principal meridian, are on the north valley wall of a small unnamed stream that flows into the Cache la Poudre River at the Rugh ranch and are about 2 miles by trail west of this ranch. The prospects are 45 miles by Colorado State Highway 14 from Fort Collins, the nearest railroad shipping point. The claims on which the prospects are situated were first located by Alfred Daykin and Oscar J. Baer on November 30, 1935, and were relocated on August 1, 1940, by H. L. Sims and Roy P. Chaney as the Cimarron, Camp Bird, and Blue Bird claims. These prospects were examined by J. B. Hanley on May 4, 1943. A discovery shaft is the only opening on the prospects.

The only pegmatite on the claims is a small lens that is 150 feet in length and as much as 30 feet in width. It trends N. 5° E., dips vertically, and is parallel to the foliation of the gneissic granite that completely surrounds the pegmatite. Two small branches, which range from 3 to 5 feet in width, are separated from the main pegmatite by 5 to 6 feet of the gneissic granite. No zonal structure was observed in the main pegmatite.

The pegmatite contains potash feldspar, muscovite, quartz, plagioclase, and beryl. Graphic intergrowths of potash feldspar and quartz are common. Several small quartz patches, the largest of which is 5 feet long and as much as 3 feet wide, are exposed in the pegmatite, and near these patches beryl is concentrated. Yellow-green to blue-green beryl occurs in subhedral to euhedral crystals that have an average size of 13 millimeters, but one crystal 6 inches in diameter was seen. About 60 percent of the beryl exposed is either corroded by the plagioclase or occurs as rims around a quartz and feldspar core and cannot be recovered by hand cobbing. The beryl content of the pegmatite is visually estimated to be 1 part in 5,000.

The Chaney-Sims pegmatite probably does not contain an appreciable quantity of beryl, as the pegmatite is small and the beryl content is low.

MONTROSE COUNTY

GOAT HILL NO. 1 PROSPECT

The Goat Hill No. 1 prospect (35) is on the steep north side of Cimarron Valley 1 mile east of the town of Cimarron in Montrose County. The claim was located by Clarence Spalding and C. L. Davis in July 1935, but no development work has been done. The prospect was visited by E. Wm. Heinrich on October 16, 1942.

The Goat Hill pegmatite is several hundred feet in length and at least 50 feet in width and is exposed for

75 feet in depth. It strikes in a general easterly direction and is nearly horizontal. The wall rock is a blue-gray biotite gneiss, which is highly contorted and injected by pegmatite stringers. The pegmatite is composed of a granitic intergrowth of quartz and microcline with patches of graphic granite. Light-brown to gray microcline occurs in crystals 6 inches long. Gray muscovite occurs in books as much as 5 inches across and also in strips 2 inches wide and 6 inches long. Flakes of biotite that are 1.5 inches in size, reddish-brown garnet in ¾-inch crystals, and black tourmaline in crystals as much as 1 inch long are the common accessory minerals.

MUSCOVITE NO. 1 AND NO. 2 PROSPECTS

The Muscovite No. 1 and No. 2 prospects (56) are on the north side of the ridge on which the Goat Hill No. 1 claim is situated. These claims were located by Clarence Spalding and C. L. Davis in July 1935, but no development work has been done. The prospects were visited by E. Wm. Heinrich on October 16, 1942.

The Muscovite No. 1 and No. 2 pegmatites are mineralogically similar to the Goat Hill pegmatite, except that they contain both light-red and white feldspar. The Muscovite No. 1 pegmatite is more than 1,500 feet long and 100 feet wide and is exposed over a vertical distance of 200 feet. The feldspar in these pegmatites is of good quality but occurs only in small masses. Muscovite makes up 3 to 5 percent of the pegmatite but is all of scrap quality, and no mica was seen that would yield sheet or punch sizes.

PARK COUNTY

FAMOUS LODE MICA PROSPECT

The Famous Lode mica prospect (34) and the adjoining Little Joe from Kokomo claim, in sec. 18, T. 15 S., R. 72 W., sixth principal meridian, are 1.5 miles east of the town of Guffey. They are owned by A. B. Dell, Buford Dell, and Charles Dell of Guffey. The prospects were examined by J. B. Hanley and A. F. Trites, Jr., on September 26, 1944.

The openings in the prospects are extremely small holes of the "post hole" type, and in most of these openings the mica-bearing pegmatites were completely mined out before a depth of 3 feet was reached.

Although the surface exposures are poor, enough openings have been made so that an examination of the prospects was possible. The pegmatites are mostly very small pods or lenses that are concordant with the structure of the schistose country rock. The largest pegmatite was a lens 20 feet long and 3 feet thick. The majority of the pegmatites are not more than 5 feet long and 1 foot wide.

All the pegmatites examined are extremely rich in mica and contain as much as 60 percent muscovite, but the quantity of mica of sufficient size to yield 1-by-1-inch pieces is very low. Samples of sheet mica recovered were qualified by the Colonial Mica Corporation as containing a reasonable proportion of good-quality mica, but it is estimated that the recovery of sheet and punch mica from crude mica would be less than 1 percent.

The small quantity of pegmatite, in addition to the low recovery of sheet and punch mica, indicates that the possibility of profitable operation is very slight.

COPPER KING PROSPECT

The Copper King prospect (25), in sec. 21, T. 15 S., R. 73 W., sixth principal meridian, is on Thirty-one Mile Creek 1.5 miles southwest of its junction with Currant creek and about 3 miles by air line southwest of the town of Guffey. Formerly it could be reached from Colorado State Highway 9 by a dirt road along Currant Creek, but this road has washed out. The pegmatite is on a patented claim acquired in 1939 by J. E. Meyers of Canon City. A small quantity of feldspar has been mined by the Colorado Feldspar Co. The prospect was examined by E. Wm. Heinrich in October 1942.

Several tunnels, one of which has cut through the pegmatite, have been made in search of copper.

The pegmatite is narrow and poorly exposed. It occurs in a series of actinolite and anthophyllite schists that locally are impregnated with bornite and chalcopyrite. The pegmatite contains granitic intergrowths of quartz and deep-red microcline associated with books of biotite as much as 2 feet in diameter. Feldspar and scrap mica are the only minerals of economic significance, and the quantity of these minerals is small. The feldspar may have a high iron content.

The Copper King pegmatite is a low-grade feldspar deposit but probably could be mined for feldspar and scrap mica if it were more accessible.

MEYERS' RANCH MINE

LOCATION AND HISTORY

The Meyers' Ranch mine (52), in sec. 31, T. 15 S., R. 73 W., sixth principal meridian, is 15 miles northwest of the town of Guffey. Colorado State Highway 9 is less than a quarter of a mile from the mine, which is connected with the highway by a poor mine road. The nearest shipping point and market is Canon City, which is 40 miles by road to the southeast.

The mine has been known since 1908, when it was owned by Alonzo MacDonald and worked for mica that was sold to the United States Mica Co. at Micanite. J. E. Meyers of Canon City purchased the ranch on which the mine is located in 1930 and worked the mine until 1931. It was leased to Matt Reed in 1939 and worked for 2 months.

The production since 1930 comprises 200 tons of feldspar, 150 tons of scrap mica, 25 tons of beryl, and about 1 ton of columbite-tantalite.

The mine was examined on October 4, 1942, by E. Wm. Heinrich, who mapped it by plane table and telescopic alidade from October 20 to October 27, 1942. It was remapped by E. Wm. Heinrich and J. B. Hanley in June 1943.

MINE WORKINGS

The mine workings consist of five highly irregular open-cuts, two drifts from two of these open-cuts, and six small prospect cuts and pits. (See pl. 16.) An opening that may be an adit or open-cut is now covered with dump material. The largest open-cut is 70 feet long, ranges from 4 to 16 feet in width, has a maximum depth of 20 feet, and consists of workings on at least three levels. Three of the other open-cuts are of comparable size. The larger of the two drifts is 14 feet long and 7 feet wide, and the other is 7 feet long and 4 feet wide.

GEOLOGY

The Meyers' Ranch pegmatite is a blunt-nosed lens that intrudes a fine- to coarse-grained red granite gneiss of pre-Cambrian age and crops out as a distinct knob.

The granite gneiss wall rock is composed of quartz, red feldspar, and biotite. The biotite shows a preferred orientation and forms a pronounced foliation in the granite. It makes up as much as 30 percent of the rock. To the southwest of the pegmatite knob the granite gneiss is capped by a dark-brown aphanitic lava, probably of Tertiary age. It is poorly exposed and forms low, rounded hills with gentle slopes. Float from the lava is abundant near the pegmatite.

The Meyers' Ranch pegmatite trends N. 30° E., and its contacts dip inward on all sides. (See pl. 16.) It is about 375 feet long and ranges from 30 to 130 feet in width. The external and internal structure of the pegmatite suggests that it has the form of a steep-sided basin. The northeast part of this basin probably plunges about 8°, S. 24° W. The contacts with the granite gneiss are gradational and obscure.

The pegmatite has been shattered and fissured in a shear zone that strikes northwest and dips southwest near the center of the pegmatite. Bent plates of muscovite, shattered beryl crystals, slickensided and iron-stained feldspar, and brecciated quartz fragments occur in this shear zone. A set of fractures, striking to the northwest and dipping to the northeast at a low angle, also occurs in the pegmatite.

The pegmatite contains a wall zone of quartz-microcline-muscovite-plagioclase pegmatite, a markedly discontinuous intermediate zone of quartz-muscovite-albite pegmatite that contains beryl and columbite, and a core of quartz-microcline pegmatite. The core occurs in two distinct and isolated pods, the larger in the main part of the pegmatite and the smaller near its north end.

The wall zone contains quartz, microcline, and a small quantity of muscovite with accessory plagioclase, garnet, and black tourmaline.

The intermediate zone is composed mainly of quartz, muscovite, and albite with accessory beryl, columbite, apatite, garnet, black tourmaline, and bismuth carbonate minerals. This zone has an average width of 5 feet and a maximum width of 17 feet. The gray-green to rum muscovite occurs in thin, hard, bladelike books that are as much as 8 inches long and commonly are perpendicular to the fracture planes in this zone. Beryl occurs in bright-blue to olive-yellow or golden crystals as much as 10 inches in diameter. Columbite occurs in rounded and distorted crystals as large as 4 by 3 by 2 inches.

The core is composed predominantly of light- to deep-rose quartz, which locally contains biotite books. Subhedral crystals of microcline as large as 12 feet in length, 10 feet in width, and 10 feet in height occur around the margin of the quartz core.

MINERAL DEPOSITS

Four minerals of commercial value—feldspar, muscovite, beryl, and columbite-tantalite—occur in the Meyers' Ranch pegmatite. The feldspar occurs in a discontinuous deposit along the margin of the quartz core. The muscovite, beryl, and columbite-tantalite occur in a deposit that is coextensive with the intermediate zone of quartz-muscovite-albite pegmatite.

FELDSPAR

The recoverable feldspar in the core is cream-colored microcline that occurs in subhedral crystals with an average size of 6 feet. Most of the feldspar has been mined, but the feldspar content of the core is visually estimated at 10 to 15 percent. The occurrence of feldspar cannot be predicted, but the mineral probably will be found between the quartz core and the intermediate zone.

MUSCOVITE

The muscovite in the intermediate zone occurs in green-gray to rum-colored books that are as much as 8 inches in size. It is wedged, has "A" structure, and commonly contains red-brown spots and stains that are caused by hematite. Many of the mica books are hard and clear and contain areas that would yield punch and small sheet mica. Pieces of sheet mica 3 by 3 inches in size were split from weathered books.

The intermediate zone has a total length of 180 feet and an average width of 5 feet. It may extend to 50 feet in depth. It dips inward around the core and is

exposed below the core in the small drift. It is probably trough-shaped and pitches 8° S., 24° W.

The mica content of the zone is not known accurately but is visually estimated at about 25 percent muscovite, of which 2 to 3 percent might yield punch or sheet mica.

BERYL

The beryl occurs in bright-blue to olive-yellow euhedral crystals as much as 10 inches in diameter. One crystal is reported to have contained 11 tons of beryl. The beryl contains few inclusions of foreign minerals and should have a high BeO content. It is in the same zone as the muscovite.

The beryl content of the zone is not uniform. An area of 56 square feet in the intermediate zone contained nearly 2 percent beryl on the basis of a mineral count, but past-production figures indicate a beryl content of 3.5 percent. The average beryl content of the zone is estimated to be between 0.5 and 2 percent.

COLUMBITE

Columbite occurs in rounded and distorted crystals as much as 4 inches in length, 3 inches in width, and 2 inches in thickness. Crystals as large as 6 inches in length are reported from this mine. The specific gravity of the mineral is 5.62, and an analysis made for the Metals Reserve Company by Ledoux & Co. gives a Ta_2O_5 content of 26.53 percent, a Cb_2O_5 content of 48.28 percent, a TiO_2 content of 2.64 percent, and a SnO_2 content of 0.19 percent.

The columbite occurs in the same zone as the muscovite and the beryl. The content of columbite in this zone is visually estimated to be between 0.2 and 0.5 percent.

RESERVES

The Meyers' Ranch pegmatite has produced at least 200 tons of feldspar, 150 tons of scrap mica, 25 tons of beryl, and about 1 ton of columbite. The reserves are difficult to estimate, as the percentages of muscovite, beryl, and columbite in the zone vary from place to place, and the extent of the deposit in depth is not known sufficiently.

The reserves of muscovite, beryl, and columbite are contained in an estimated 7,500 tons of the intermediate zone that contains about 1,900 tons of muscovite, 38 to 150 tons of beryl, and 15 to 30 tons of columbite.

The reserves of microcline cannot be estimated, as the occurrence of this mineral beyond the present exposures cannot be predicted. A quantity of feldspar that is equal to the tonnage produced in the past probably can be mined from the margin of the quartz-microcline core.

SUMMIT COUNTY

MONTE CRISTO PROSPECTS

Some of the pegmatites (55) on the slope of Quandary Peak above Monte Cristo Gulch contain small quantities of beryl. These pegmatites are probably in sec. 3, T. 8 S., R. 78 W., sixth principal meridian. They were examined briefly by Ogden Tweto of the Geological Survey. Beryl occurs in the pegmatites as scattered crystals that range from 8 to 13 millimeters in diameter and as irregular aggregates of finely crystalline beryl. The beryl content of the pegmatites is very low, and the prospects are accessible only with difficulty.

WYOMING PEGMATITES

ALBANY COUNTY

MANY VALUES PROSPECT

The Many Values prospect is in the SE¼ sec. 32, T. 13 N., R. 78 W., sixth principal meridian. It can be reached by a logging road, 1.4 miles long, that leads north from Wyoming State Highway 230 at a point 1 mile southwest of the road to Fox Park. The nearest shipping point is Fox Park, which is 4 miles by road from the prospect on the Laramie, North Park & Western Railroad.

The prospect was first located as a placer claim by John L. Funk of Laramie on August 25, 1930. It was located as a lode claim by R. R. George of Laramie on September 19, 1941, and was subsequently relocated by Mr. Funk.

The production from this prospect up to 1942 was 36,600 pounds of scrap mica, 2,500 pounds of punch mica, 500 pounds of rifted sheet mica, 2 tons of beryl, and 85 pounds of tantalite-columbite, according to court records made when the ownership was in dispute.

The property was examined on September 4, 1942, by J. B. Hanley, and at that time a pace-and-compass map at a scale of 1 inch to 50 feet was made. The prospect was revisited briefly on October 6, 1943, by J. B. Hanley and R. Miller III.

The workings (see fig. 27) in the prospect include two pits, one of which is about 90 feet long, 10 feet wide, and 10 feet deep and the other 30 feet long, 10 feet wide, and 5 feet deep. Two timbered shafts also explore the prospect. One of them, 20 feet deep, is covered by a cabin, and the other, 15 feet deep, is located at the east end of the main pit. The shafts and pits were partly filled with debris when examined. Several badly slumped prospect pits serve to delimit the extent of the pegmatite on the east.

The Many Values pegmatite occurs in pre-Cambrian, tourmalinized mica schists and gneisses. It trends N. 50° E. and dips 85° NW. The southeast contact, which is exposed in the haulage cut, strikes N. 65° E. and

dips 85° NW. The pegmatite is exposed for a length of 140 feet and a width of 15 feet in the pits and trenches. An extensive soil cover at least a foot thick and dumps piled adjacent to the workings completely hide the extent of the pegmatite beyond the workings.

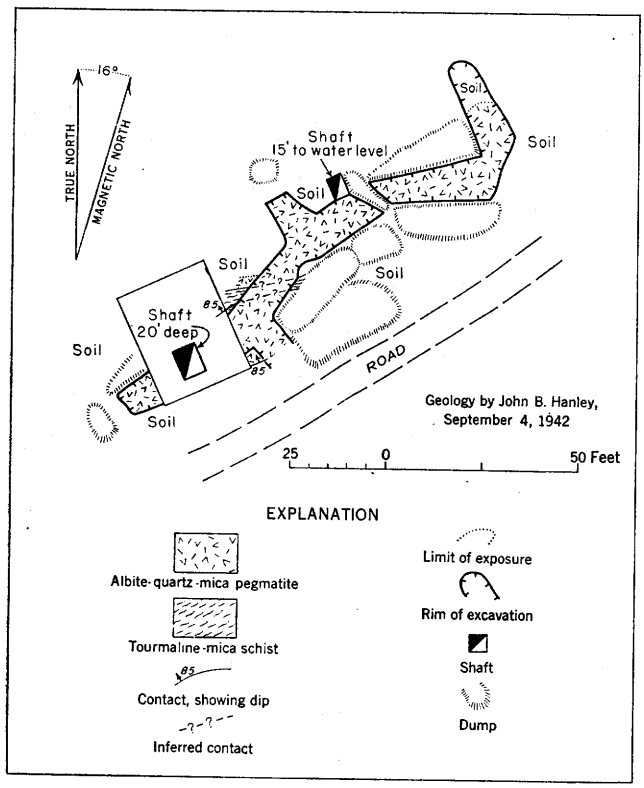

FIGURE 27.—Map of Many Values prospect, Albany County, Wyo.

A tongue of tourmalinized mica schist is exposed in the walls of the main pit about 3 feet east of the cabin over the 20-foot shaft. This schist may indicate that the pegmatite branches and extends farther west than it is exposed. The schist tongue is about 4 feet thick but does not extend to the floor of the pit. The schist body probably plunges to the west at a low angle.

About 75 feet north of the west end of the main pit a quartz-potash feldspar-mica-plagioclase pegmatite is exposed as a wall about 3 feet high. This pegmatite strikes about north and is vertical. There is no apparent connection between the two pegmatites.

The Many Values pegmatite is mapped as a single unit of albite-quartz-muscovite pegmatite because of the limited exposures. It is composed mainly of albite, quartz, and muscovite with minor quantities of garnet, tourmaline, beryl, tantalite, and a lustrous black mineral that may be fergusonite.

Albite occurs as blocky white to gray crystals, as white to pink cleavelandite, and as a fine-grained white aggregate. It is the only feldspar in the pegmatite, and microscopic determinations show that its composition ranges from Ab_{95} to Ab_{100}. Some of the albite has been altered to montmorillonite.

Muscovite occurs most abundantly near the hanging wall of the pegmatite in large books that commonly are ruled and show "A" structure. It is light green, highly speckled with magnetite, and stained by other iron oxides. The largest book seen was 13 inches wide by 16 inches long. Only a small quantity of this mica is of sheet quality, but some punch mica could be recovered. About 10 percent of the mica would yield punch and sheet on the basis of past production.

Beryl was found in the debris in the smaller pit but was not seen in place in any of the workings. It is pale green or white and commonly is corroded by albite. The BeO content of the hand-cobbed beryl sold was 12.39 percent. The indices of refraction further indicate that its alkali content is low.

The only tantalite found in place was in the lower level of the main pit near the cabin. The masses are small and very impure. The tantalite occurs in albite as small tabular crystals as much as 6 millimeters in width and 2 inches in length and as skeletal crystals that may be 13 millimeters in width and 3 inches in length. The skeletal crystals have cores of albite, and the tantalite usually contains some muscovite as an impurity.

Garnet occurs in pink euhedral crystals and orange subhedral crystals that average 13 millimeters in diameter. Black tourmaline occurs as matted fibers filling the interstices of the large cleavelandite plates. The mineral tentatively identified as fergusonite occurs in small, spherical, lustrous, brownish-black masses about 3 millimeters in diameter.

The Many Values pegmatite contains beryl, tantalite, and muscovite. Past production indicates for each ton of pegmatite an average content of 50 pounds of recoverable mica containing about 10 percent punch and sheet quality, 5 pounds of beryl, and 0.1 pound of tantalite. The entire body is probably equally rich in the three minerals throughout its length of 140 feet and its width of 15 feet. If this pegmatite extends 40 feet below the present surface with no change in size and grade, it should contain about 7,500 tons of pegmatite.

IONE PROSPECT

The Ione prospect, in sec. 32, T. 13 N., R. 78 W., sixth principal meridian, was visited by J. B. Hanley on September 4, 1942. This prospect is owned by John L. Funk of Laramie.

The Ione pegmatite occurs in pre-Cambrian schists and is exposed only in a pit 40 feet long and 12 feet wide. The pegmatite is composed chiefly of quartz, microcline, and muscovite with accessory albite. No tantalite nor beryl was found in place, but one specimen of each was found in the debris on the floor of the pit.

The pegmatite is very small and probably does not contain large quantities of microcline, beryl, tantalite, or muscovite.

FREMONT COUNTY

WHIPPET PROSPECTS

LOCATION AND HISTORY

The Whippet prospects are along the southern margin of the Owl Creek (Bridger) Mountains, in the Copper Mountain district, about 16 miles north-northeast of Shoshoni, and about 9 miles by air line east of the Boysen Dam in the Wind River Canyon. They are in secs. 22, 27, and 28, T. 40 N., R. 93 W., sixth principal meridian. Unsurfaced dry-weather roads connect the region in which the prospects are located with U. S. Highway 20 at Shoshoni, and automobiles can be driven along pediments to places within half a mile of all the major prospects. The road from Shoshoni to the Quien Sabe Ranch is a graded county road, but from this ranch to the pegmatites, a distance of about 1½ miles, there are only unimproved wagon trails.

The topography in the region is rough and the relief is high, particularly in its northern part. Cottonwood and Hoodoo Creeks and their tributaries are permanent streams flowing southward and draining the entire region.

Numerous claims have been staked throughout the region during several periods of mining activity in the past 40 years. Most of the pegmatites are in the Whippet group of claims owned by J. Stephensen, A. H. Maxwell, W. Marion, and associates of Lander. Open-cut prospecting and validation work have been carried on by these owners for many years. Most of the activity took place between 1928 and 1940, when small quantities of beryl and tantalite were sold.

In 1939 Morris Kline and associates of Riverton filed on the tantalum-bearing dikes that were prospected by Stephensen and his associates and on two other claims to the east. The ownership of these claims had not been settled when the prospects were examined.

The pegmatites in sections 27 and 28 were mapped by T. G. McLaughlin.[45] A brief reconnaissance examination of the pegmatites and a plane-table survey of the richest tantalum-bearing pegmatites and the richest beryl-bearing pegmatite were made by J. D. Love assisted by J. B. Hanley from August 4 to August 28, 1942. L. R. Page and E. Wm. Heinrich spent a day on the property during this period. A brief examination was made, also, of the pre-Cambrian rocks surrounding the pegmatites, and the location and type of pegmatite were checked against McLaughlin's map.

[45] McLaughlin, T. G., Pegmatite dikes of the Bridger Mountains, Wyo.: Am. Mineralogist, vol. 25, pp. 46–68, 1940.

GEOLOGY

The Whippet pegmatites intrude a complex sequence of pre-Cambrian metamorphic and basic igneous rocks that forms the core of the Owl Creek Mountains. The pegmatites are confined largely to an area about 4 miles long from east to west and 2 miles wide. To the east of the pegmatite area the pre-Cambrian rocks are chiefly granites; to the south Eocene sedimentary rocks and alluvium overlap the pre-Cambrian sequence. Regional relationships suggest that neither the pegmatites nor the other pre-Cambrian rocks extend very far south beneath the cover of alluvium and Eocene rocks.

METAMORPHIC AND BASIC IGNEOUS ROCKS

The predominant rock types near the Whippet prospects are complex basic schists, amphibolites, gneisses, and basic igneous dikes. The schists show considerable variation, including gray biotite-muscovite-feldspar schist, dark-gray to black garnet schist, dark gray-green phyllitic schist, and gradations between the more basic schists and the dark-greenish to black gneisses. The foliation and bedding of these schists are essentially parallel, and distinct beds can be followed for several miles. The foliation strikes N. 70° to 80° E. and dips 50° to 60° SE.

Numerous basic dikes that trend about N. 85° W. cut and, in many places, offset the schists. The dikes commonly dip more steeply than the schists and gneisses. They differ in thickness, ranging up to 75 feet. Some have been altered to schists, but others contain a coarse gabbroic facies in which the feldspar phenocrysts are as much as 2 inches in size.

GRANITES AND PEGMATITES

Granite dikes and pegmatites cut all the schists, gneisses, and basic igneous rocks. The granites and pegmatites are not all of the same age. On the crest of the hill directly south of the westernmost tantalum-bearing pegmatite a graphic granite pegmatite crops out. It is cut by coarse-grained white quartz veins, and both it and the quartz veins are cut by a coarse-grained quartz-potash feldspar-muscovite pegmatite that contains crystals of beryl.

The granite and pegmatite bodies range in thickness up to more than 100 feet but commonly are not more than 20 feet thick. The general trend of the pegmatites is northeast, although some in the western part of the region trend nearly north and some in the central part nearly east. No generalization can be made about the attitude of these pegmatites, as the regional structure is very complex. Some pegmatites in the central part of the region follow sharp, almost isoclinal folds; some of the large pegmatites in the southern part are almost flat; and in all the pegmatites the dips of the contacts change rapidly within short distances.

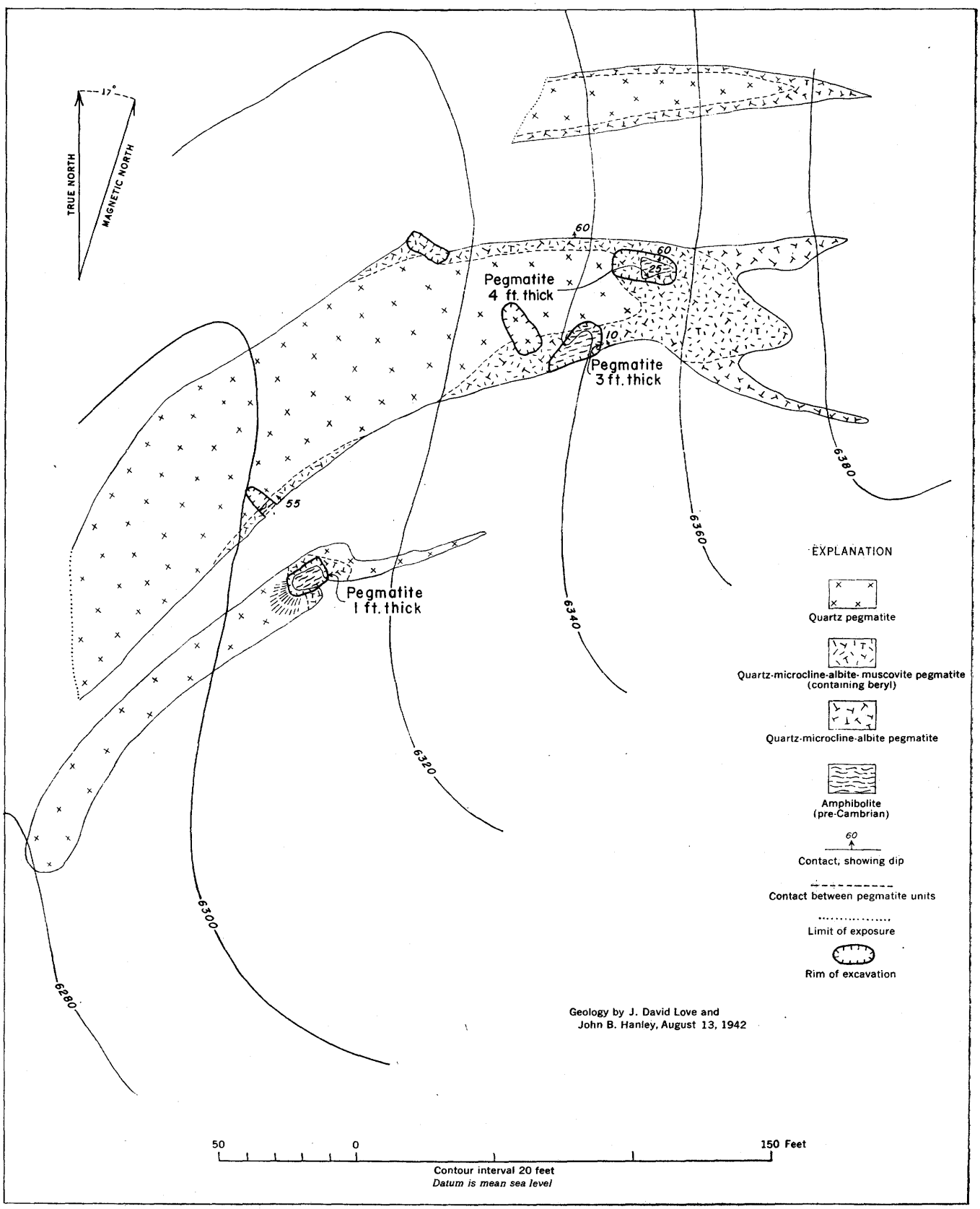

FIGURE 28.—Map of Whippet No. 1 prospect, Fremont County, Wyo.

The pegmatites are extremely variable in texture and composition. Snowy-white to bluish potash feldspar crystals occur abundantly in the coarse-grained pegmatites, and some of these crystals are as much as several feet in size. Quartz is mostly white and coarse-grained, but the grains rarely show crystal faces. Albite is abundant and coarse-grained in some dikes. Small sheared books of muscovite are abundant in some pegmatites, particularly in the central part of the region. Garnet and black tourmaline are abundant locally. Lepidolite occurs in 1 pegmatite, petalite in 1, tantalite in 3, columbite in 5, and beryl in 10.

WHIPPET NO. 1 PROSPECT

The Whippet No. 1 prospect is in a beryl-bearing pegmatite in the east-central part of section 28. It was mapped by plane table and telescopic alidade on August 13, 1942, by J. D. Love and J. B. Hanley.

The Whippet No. 1 pegmatite (see fig. 28) is exposed for a length of 320 feet and a maximum width of 60 feet. It trends N. 65° E. and dips 10° to 60° NW. It follows one or more shallow anticlines plunging to the southwest. The pegmatite is very irregular but probably has an average thickness of 4 to 6 feet. The southwestern part is composed almost entirely of white quartz. The northeastern and thinner part contains a large quantity of coarse-grained potash feldspar, albite, and muscovite with smaller quantities of euhedral beryl crystals. This part of the pegmatite is only 4 feet thick. Associated with the beryl are a few large sheaves of columbite crystals and several small ones. Specific-gravity determinations on this columbite made by the Chemical Laboratory of the Geological Survey gave a result of 6.56, which indicates a Ta_2O_5 content of 48 percent and a Cb_2O_5 content of 34 percent.

The beryl in this pegmatite is visually estimated to make up 1 part in 250 parts of pegmatite in the beryl-bearing zone.

Another parallel pegmatite is exposed directly north of the beryl-bearing pegmatite. This northern pegmatite contains numerous books of sheared muscovite, a few scattered crystals of beryl, and small quantities of columbite. It is composed chiefly of white quartz, potash feldspar, and albite. Muscovite, beryl, and columbite do not occur in large quantities.

A third pegmatite in the same claim as the Whippet No. 1 prospect crops out at the top of a high ridge about 600 feet northeast of the beryl-bearing pegmatite. This pegmatite is thin and contains small quantities of lepidolite and tantalite. Lepidolite occurs in pale-lavender flakes of small size, and the tantalite occurs in small crystals.

WHIPPET NO. 8 PROSPECT

Two tantalum-bearing pegmatites that are separated by a small area of alluvium occur in the Whippet No. 8 prospect. They were mapped by J. D. Love and J. B. Hanley on August 12, 1942, by plane table and telescopic alidade.

The pegmatites have intruded amphibolite. They contain the largest quantity of tantalite of any of the pegmatites in the region and also contain beryl. At least 250 pounds of tantalite are reported to have been sold from them.

The northeastern pegmatite (see fig. 29) is exposed for a length of 400 feet and a maximum width of 30 feet. It is separated from the southwestern pegmatite by a valley partly filled with alluvium, but the pegmatites are similar and probably are parts of a single body. The valley may have cut completely through the pegmatite, or the pegmatite may extend beneath the alluvium.

Coarse white quartz is abundant along the margins of the pegmatites and commonly is associated with coarsely crystalline, white to blue-gray potash feldspar. Fine-grained aggregates of muscovite also occur near contacts with the wall rock. Large beryl crystals are present near the hanging-wall contact, and finer-grained beryl crystals occur near the footwall. Tantalite occurs in considerable abundance as small subhedral to euhedral crystals in a fine-grained albitic pegmatite. The tantalite sold is reported to have contained from 75 to 80 percent Ta_2O_5. No tantalite was observed in the northeast or southwest ends of the pegmatite. The part of the pegmatite that contains the tantalite is about 200 feet long and as much as 2 feet thick.

Both above and below the fine-grained albitic pegmatite zone are a few irregular masses of petalite. They are too small and scattered to be of commercial importance. The lower 3 to 4 feet of the pegmatite consists of coarse-grained quartz-potash feldspar-muscovite-albite pegmatite containing numerous small beryl crystals.

This pegmatite body is estimated to contain about 11,500 tons of tantalite-bearing rock to a depth of 20 feet below the present surface. The tantalite content, based on visual estimates and past production, probably is 1 pound of tantalite in each ton of rock. The beryl in this pegmatite is confined chiefly to the lower 3 or 4 feet of the pegmatite and is visually estimated to make up 5 to 10 percent of the zone. This part of the pegmatite is estimated to contain about 750 tons of rock to a depth of 20 feet.

The southwestern pegmatite is only about 180 feet long and has a maximum outcrop width of 25 feet. The average thickness is about 10 feet. The west end of the pegmatite is blunt and probably plunges steeply to the southwest. This pegmatite is not so uniformly zoned as the northeastern pegmatite, albite is less abundant, and much less beryl and tantalite are exposed. Tantalite occurs in small crystals, chiefly in fine-grained aggregates of muscovite near the center of the pegma-

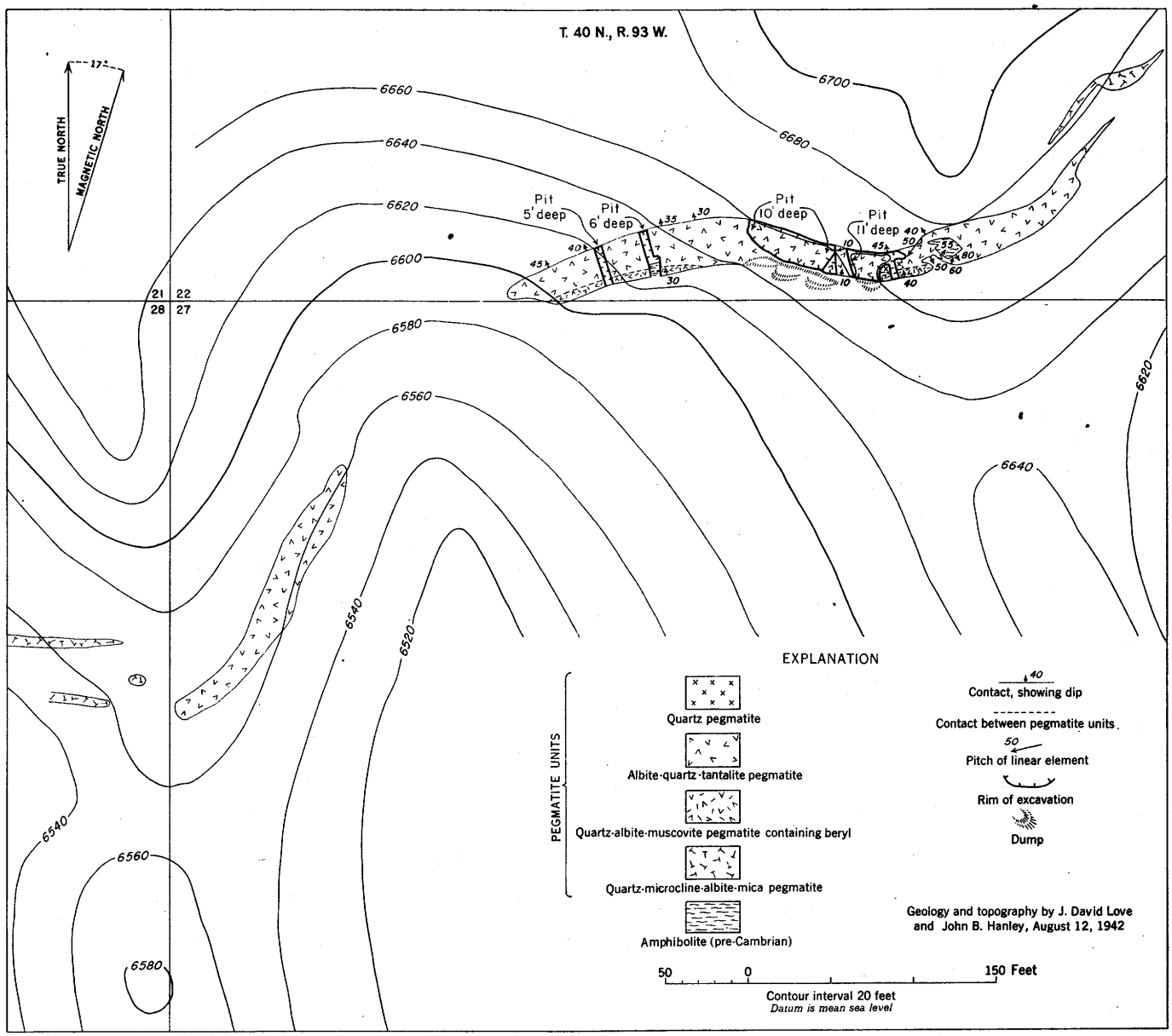

FIGURE 29.—Map of Whippet No. 8 prospect, Fremont County, Wyo.

tite. The greater part of the pegmatite consists of white quartz, potash feldspar, and small books of muscovite. Both the upper and lower contacts are extremely irregular and poorly exposed.

This pegmatite is estimated to contain about 2,250 tons of tantalite-bearing pegmatite to a depth of 10 feet, and the tantalite content is estimated to be the same as in the northeastern pegmatite—a pound of tantalite to each ton of pegmatite.

GOSHEN COUNTY

HAYSTACK RANGE DISTRICT

LOCATION AND HISTORY

The Haystack Range district comprises an area of 2 square miles bounded by Whalen Canyon on the west, Cottonwood Canyon on the east, McCanns Pass on the north, and an east-west line through Haystack Peak on the south. Most of the pegmatites in the district are in secs. 26, 34, and 35, T. 28 N., and in secs. 1 and 2, T. 27 N., R. 65 W., sixth principal meridian. (See fig. 30.) The district is about 10 miles by air line northeast of Guernsey and can be reached by an all-weather graveled road and a mine road, 1.6 miles long, that leads to the Crystal Palace prospect. The other prospects are not connected by roads.

The topography of the district is moderately rough, with a relief of 600 to 700 feet, and most of the pegmatites are exposed at altitudes of 5,000 to 5,400 feet. The district is very dry, with low rainfall and no permanent streams, and therefore is sparsely wooded.

The mica pegmatites in this district were discovered in 1881 by Joseph L. Stein. Development work was

carried out until the early 1900's, when activity ceased. During this time the New York, Chicago, Crystal Palace, Savage, and Ruth prospects were worked and some mica produced. Either at this time or slightly later the Haystack No. 2 prospect was mined for scrap mica and a mill was built on the property. In 1942 L. T. Sisson of Guernsey owned 30 claims in the district and Mrs. Minnie Frederick of Guernsey 11, but none of them were in operation. L. T. Sisson reopened the Crystal Palace prospect in 1943 and shipped a small quantity of scrap mica. In 1944 Oliver Adams and associates of Los Angeles, Calif., prospected the Ruth, New York, and Chicago pegmatites, which belong to Mrs. Frederick, and a number of other pegmatites that had formerly been prospected for mica. The Ruth, Chicago, and New York pegmatites were sampled by the Colonial Mica Corporation.

The general geology of the district has been described by Smith,[46] and the detailed geology of some of the pegmatites has been described by Ball.[47] Sterrett quotes Ball's description in his bulletin on the mica deposits of the United States.

The Savage prospect was visited by J. B. Hanley on August 30, 1942. Fifty pegmatites in this district were investigated by J. B. Hanley and R. Miller III between September 29 and October 5, 1943. At that time the Crystal Palace prospect was mapped by plane table and telescopic alidade, and the Savage, Ruth, Chicago, and New York prospects were mapped by tape-and-compass surveys. Fairly detailed investigations were made of several of the other prospects, and brief reconnaissance surveys were made of the remainder examined. The five prospects that were mapped were chosen because they are better exposed than the others as a result of past development work. In July 1944 some of the larger prospects were visited by L. R. Page, and these were revisited in September 1944 by L. R. Page in the company of Stuart Ferguson of the Colonial Mica Corporation.

GEOLOGY

The pegmatites in this district are concordant lenses of different sizes in the pre-Cambrian Whalen group of schists and gneisses. They range from 40 feet to 400 feet in length and from less than 1 foot to 75 feet in

[46] Smith, W. S. T., U. S. Geol. Survey Geol. Atlas, Hartville folio (no. 91), 1903.

[47] Ball, S. H., Mica in the Hartville uplift, Wyo.: U. S. Geol. Survey Bull. 315, pp. 423–425, 1907.

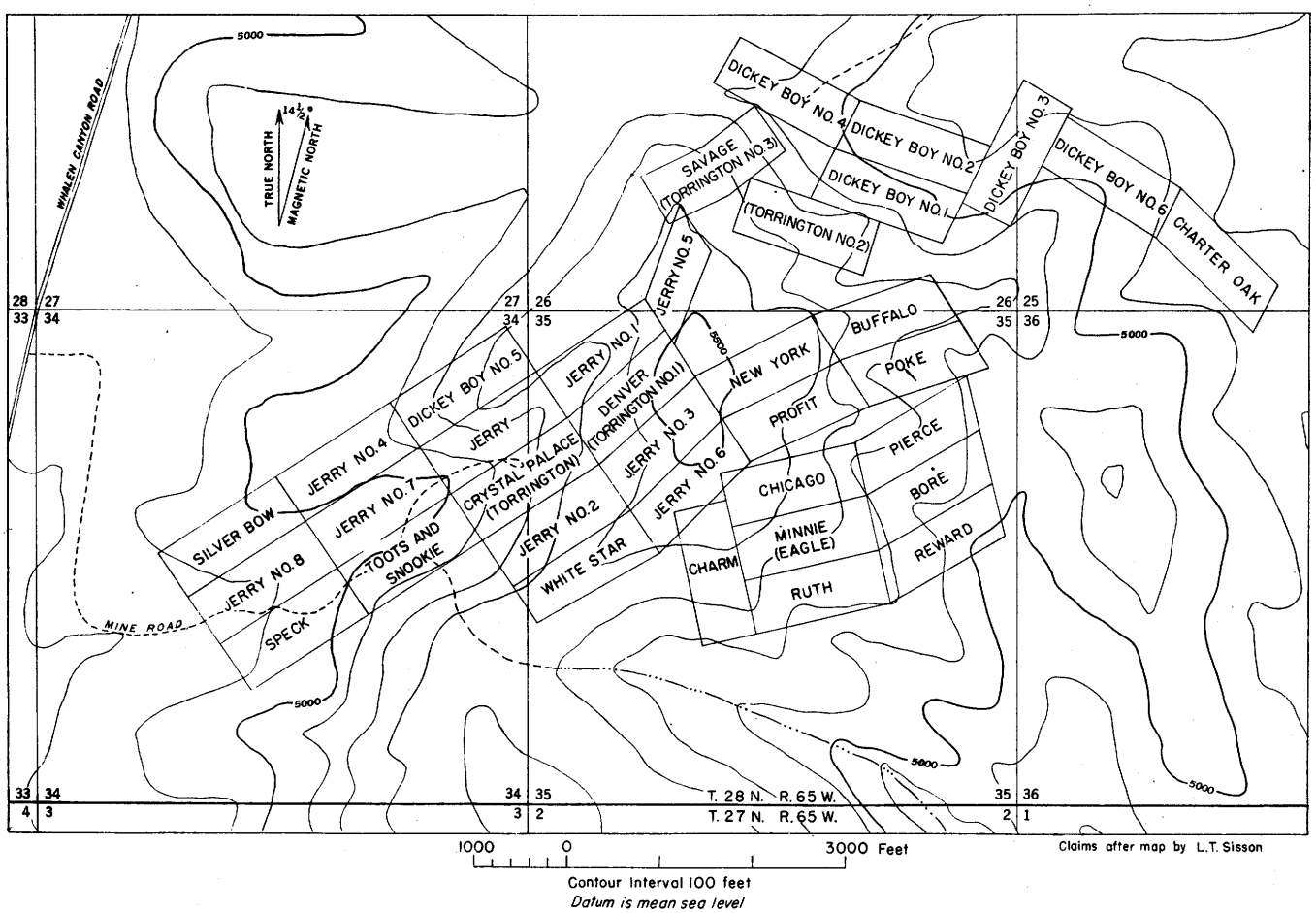

FIGURE 30.—Map of pegmatite prospects, Haystack Range district, Goshen County, Wyo.

width. All the pegmatites examined are conformable to the enclosing wall rocks, and all are bluntly terminated. The general trend of the pegmatites is N. 60° E., although the range in trend is from N. 45° E. to S. 80° E., and the general dip is steep to the northwest. Usually the hanging walls dip 70° to 80° NW. and the footwalls 50° to 70° NW., but locally these directions and the steepness range considerably. A pronounced arrangement of individual pegmatites along definite lines in the schist was observed. At first sight the pegmatites along one of the lines in the schist appear to form a single pegmatite of great length, but detailed investigation shows that it is composed of many separate pegmatites.

In the few pegmatites exposed in depth by development work a pronounced narrowing indicates that the probable maximum continuation in depth is less than 50 feet.

These bodies are predominantly potash feldspar-quartz-muscovite pegmatites with accessory plagioclase, apatite, black tourmaline, and beryl. Their texture is medium to coarse, the grains ranging from 4 inches to several feet. Graphic intergrowths of potash feldspar and quartz occur in many of the pegmatites, and black tourmaline is found in almost all of them, either near the contacts or in the form of a core such as that in one of the pegmatites in the Crystal Palace prospect. Quartz pegmatite cores are very common. A few of the pegmatites are plagioclase pegmatites, and the best muscovite and beryl pegmatites have plagioclase as the most abundant feldspar.

The potash feldspar in these pegmatites is either red or mottled gray and white. The accessory plagioclase in the pegmatites that contain the mottled feldspar is also grayish but is not mottled. A few pegmatites near the granite typically contain white potash feldspar.

CRYSTAL PALACE PROSPECT

LOCATION AND OWNERSHIP

The Crystal Palace prospect (see fig. 30) is about on the line between secs. 34 and 35, T. 28 N., R. 65 W., sixth principal meridian, 10.8 miles by road from Guernsey. It can be reached by the Whalen Canyon road and a mine road that leads to the workings. It is owned by L. T. Sisson and formerly was worked as a mica mine. The ruins of a grinding mill are located near the workings (see pl. 17), which include an open-cut that is 96 feet long, as much as 32 feet wide, and about 20 feet deep on the main pegmatite, as well as two small open-cuts on another pegmatite about 100 feet northeast of the main one.

GEOLOGY

The three pegmatites in the Crystal Palace prospect are conformable to the bedding of the biotite schists of the Whalen group. Both the pegmatites and the schists are unconformably overlain by semiconsolidated Quaternary alluvium. This alluvium is at least 8 feet thick near the workings and partly conceals the Crystal Palace pegmatite. The contact between the alluvium and the Whalen group as shown in plate 17 occurs at an altitude of 4,780 feet.

Crystal Palace pegmatite.—The Crystal Palace pegmatite is exposed for a length of 70 feet and a width of 10 feet. The only exposures are in the workings, where the pegmatite has been almost completely mined out. It strikes N. 52° E., dips 45° to 60° NW., and plunges 50° to 75°, N. 12° W. The converging dips on the footwall and hanging wall indicate that it probably pinches out a short distance below the floor of the open-cut.

The pegmatite is indistinctly zoned but contains a wall zone of muscovite-rich pegmatite with accessory beryl and black tourmaline and a core of quartz-plagioclase pegmatite. The zones could not be mapped because exposures of the pegmatite are poor. No border zone occurs, but the wall rock at the contact has been altered by the introduction of a large quantity of black tourmaline.

The wall zone is visually estimated to contain 15 percent muscovite along the hanging wall and 10 percent or less along the footwall. The muscovite books are as much as 8 inches in size in these zones. The muscovite is clear and only slightly ruled but is highly crumpled. It was estimated that this muscovite would yield, after proper preparation, a small quantity of punch and sheet mica of which about 5 percent would be No. 1 quality, about 10 percent No. 2, and the rest No. 2 inferior. White beryl occurs only in very minor quantities in the wall zone and is of mineralogical interest only. The quantity of mica in this pegmatite is small.

Other pegmatites.—The pegmatite that is about 100 feet northeast of the Crystal Palace pegmatite is a body 180 feet long and as much as 14 feet wide. It strikes N. 55° E., dips 60° to 70° NW., and plunges 40° to 60°, N. 23° W. It contains a narrow border zone of fine-grained pegmatite, a wall zone of quartz-plagioclase-muscovite pegmatite, and a core of plagioclase-black tourmaline pegmatite, the central 6 inches of which is almost completely black tourmaline in felted needles.

The wall zone contains muscovite books similar in physical properties and quality to the mica in the Crystal Palace pegmatite. The books are as large as 5 inches in size, and some are wedged and have "A" structure. A small quantity of beryl is exposed in the upper open-cut. Scattered throughout the pegmatite are crudely circular brown iron stains around altered pyrite crystals.

One small pegmatite on the same strike is 1 foot wide and 20 feet long; another is only 6 inches wide and 30 feet long.

A quartz-microcline-plagioclase pegmatite body about 15 feet southeast of the larger pegmatite is 180 feet long and as much as 12 feet wide. It strikes N. 58° E. and dips 55° to 80° NW. The pegmatite contains a fine-grained border zone that is 1 foot wide, but otherwise it is unzoned. It contains only a very small quantity of muscovite. A stringer of quartz-muscovite pegmatite extends for 32 feet to the southwest from the end of the main body.

None of these pegmatites contains appreciable quantities of muscovite or beryl.

DENVER PROSPECT

The Denver prospect (see fig. 30), now known as the Torrington No. 1, is about 1,450 feet by air line northeast of the Crystal Palace prospect and is owned by L. T. Sisson.

The Denver pegmatite is about 400 feet long and as much as 30 feet wide. Trending N. 65° E. and dipping in general 60° NW., it is concordant with the enclosing Whalen schist. The northeastern 150 feet, only 5 to 6 feet wide, dips 70° NW. In the wider parts of the pegmatite a schist septum, which dips 80° NW., is exposed near the center.

This pegmatite is composed chiefly of quartz, microcline, muscovite, and albite. It is fine-grained near the contacts with the schist but coarse-grained near the center. Muscovite books as large as 4 inches in size occur near the footwall in concentrations that are 1 foot in width by 4 feet in length. This muscovite appears to be of fair quality. A few quartz pegmatite pods occur near the center of the pegmatite but have no mica zones surrounding them. However, some beryl crystals are exposed adjacent to the pods. The beryl occurs in euhedral crystals 13 to 18 millimeters in diameter and usually is white on fresh fracture surfaces, although commonly it is iron-stained. Black tourmaline occurs throughout the pegmatite.

The Denver pegmatite probably contains only a very small quantity of beryl and a small quantity of muscovite.

NEW YORK PROSPECT

The New York prospect (see fig. 30) is about 2,850 feet by air line east-northeast of the Crystal Palace prospect. It is owned by Mrs. M. Frederick. The only opening is an open-cut 45 feet long, 4 to 8 feet wide, and as much as 6 feet deep.

The New York pegmatite (see fig. 31) is a tadpole-shaped body that is 85 feet in length and as much as 35 feet in width. It trends N. 72° W., and its contacts dip from 50° to 85° NE. It contains the following zones: a border zone, about 6 inches thick on both walls; a mica-bearing wall zone, 2 to 3 feet thick, the outer 1 to 2 feet of which is rich in black tourmaline; and a core of quartz-microcline pegmatite containing subhedral mi-

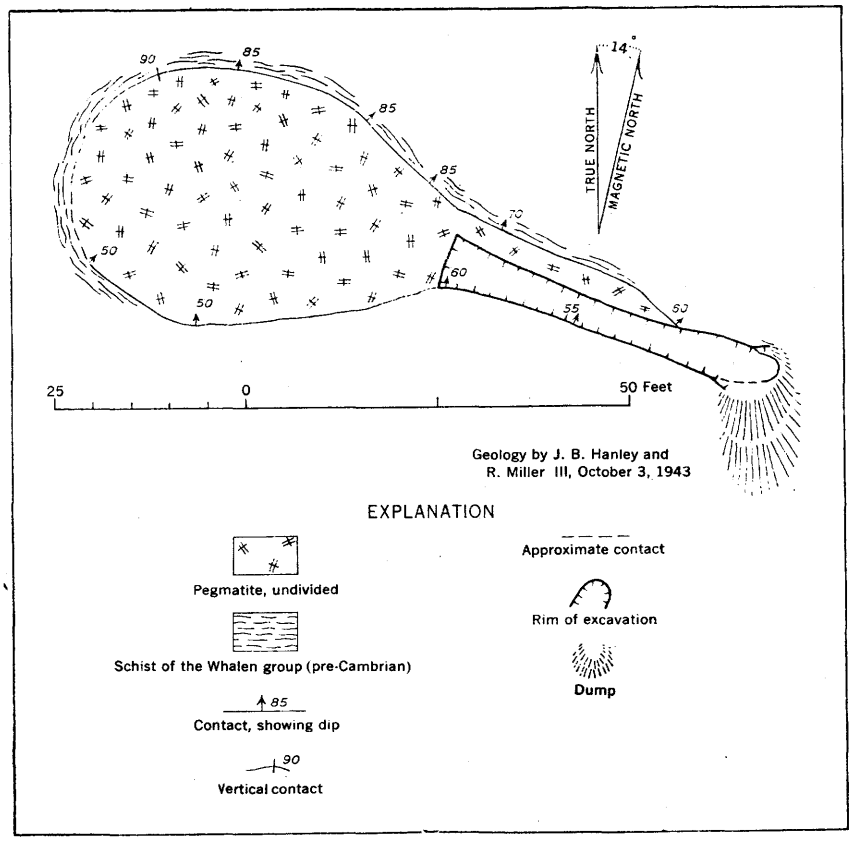

FIGURE 31.—Map of New York prospect, Haystack Range district Goshen County, Wyo.

crocline crystals as much as 2 feet wide by 4 feet long. The pegmatite is so poorly exposed that the zones could not be shown on the map.

Along the hanging wall the mica-bearing zone is visually estimated to contain 10 percent muscovite, but along the footwall it contains less. The muscovite is highly ruled, tied, and crumpled. It occurs in books as large as 10 inches in width by 18 inches in length. Black tourmaline crystals as large as 8 inches in diameter occur in the outer part of the mica zone. A small quantity of whitish-green beryl, the crystals of which are commonly cut by quartz stringers, occurs in the mica zone and the core.

At the time the prospect was visited by L. R. Page and Stuart Ferguson it was estimated that, after proper preparation, the muscovite would yield a small quantity of punch and sheet mica of which less than 5 percent would be No. 2 quality, about 15 percent No. 3, and the rest No. 2 inferior.

CHICAGO PROSPECT

The Chicago prospect (see fig. 30) is about 2,900 feet east of the Crystal Palace prospect. It is owned by Mrs. M. Frederick. The workings include an open-cut 55 feet long, as much as 8 feet wide, and about 4 to 6 feet deep, with a 20-foot haulage cut at the east end.

The Chicago pegmatite (see fig. 32) is a long, narrow pegmatite with a slightly bulbous western end. It is about 215 feet long and as much as 23 feet wide. The average width is only 8 feet. The pegmatite trends N. 72° E. and on the footwall dips 55° to 80° NW. The western half of the hanging wall dips 60° to 70° NW.; the eastern half dips 75° to 80° SE. The pegmatite is poorly zoned but contains a border zone less than 2 inches wide; a wall zone that contains quartz, muscovite, plagioclase, and black tourmaline; and a quartz-microcline core. These zones were not mapped, as they are well exposed only in the open-cut.

Beryl occurs in the wall zone as light-cream to whitish-green euhedral crystals that range from 13 millimeters to 4 inches in diameter. The crystals commonly are cut by quartz stringers, and some have cores of quartz and plagioclase. The richest concentration of beryl exposed contains 1 percent beryl on the basis of a mineral count, but the concentrations probably occur only near structural rolls in the contact. The average beryl content of the wall zone is estimated to be very small.

Muscovite occurs in clear books as large as 9 inches wide and 18 inches long. It is not highly ruled and not crumpled. Occurring throughout the pegmatite, it is more abundant in the wall zones, where it is visually estimated to make up 5 to 10 percent of the rock. When the prospect was visited in September 1944, it was further estimated that after proper preparation the muscovite would yield a small quantity of punch and sheet mica of which less than 5 percent would be No. 1 quality, about 15 percent No. 2, and the rest No. 2 inferior. The pegmatite appears to contain little beryl or muscovite.

A quartz-microcline-muscovite-plagioclase pegmatite 20 to 30 feet northwest of the Chicago pegmatite is parallel to the latter in trend and is similar in length and width, but it contains no beryl and no muscovite from which punch or sheet mica could be prepared.

RUTH PROSPECT

The Ruth prospect (see fig. 30) is about 3,300 feet by air line southeast of the Crystal Palace prospect. It is owned by Mrs. M. Frederick. The workings include an open-cut 33 feet long, 9 to 13 feet wide, and as much as 30 feet deep at the face, with a 50-foot adit from the face of the open-cut.

The Ruth pegmatite (see fig. 33) in plan is an oval 155 feet long and as much as 80 feet wide. The axis of the oval trends N. 85° E. The footwall dips 50° to 80° N., and the hanging wall dips 75° N. to vertical. The pegmatite is indistinctly zoned but contains a narrow border zone, an irregular wall zone of graphic granite, a discontinuous, thin intermediate zone of quartz-muscovite pegmatite that contains beryl, and several quartz pegmatite pods that are segments of a discontinuous core. At least two of these large quartz pegmatite pods with surrounding intermediate zones are exposed in the pegmatite. The intermediate zone forms thin shells of quartz-muscovite pegmatite around the pods.

About 80 percent of the wall zone is graphic granite, with which occur accessory black tourmaline and green apatite. The intermediate zones contain small quantities of yellow-white or light-green beryl in crystals as much as 2 inches in diameter and 8 inches long, some columbite(?), and books of muscovite as large as 8 inches by 2 feet. Beryl counts in some parts of the intermediate zone indicate a beryl content of 2 percent, but the average content of the zone is visually estimated to be slightly less than half of 1 percent. The muscovite commonly is ruled, warped, and highly curved. It is visually estimated to make up 5 to 10 percent of the intermediate zone. When the prospect was visited in September 1944 by L. R. Page and Stuart Ferguson it was estimated that this mica would yield, after proper preparation, a very small quantity of punch and sheet mica of which at least 10 percent would be No. 2 quality and the rest No. 2 inferior.

The intermediate zone in the Ruth pegmatite cannot be mined selectively because it is too thin and discontinuous; therefore any recovery of beryl and mica would be low.

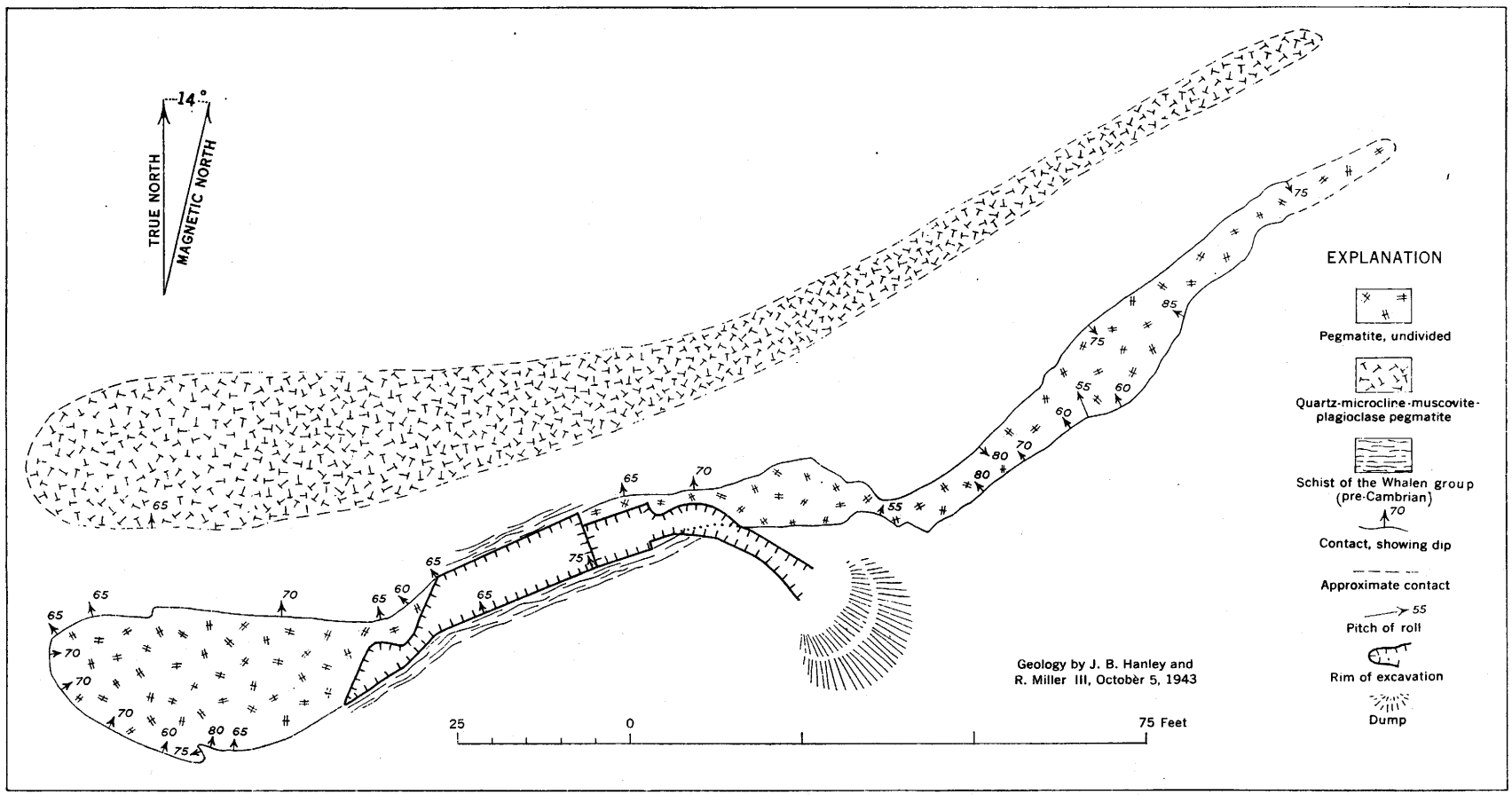

FIGURE 32.—Map of Chicago prospect, Haystack Range district, Goshen County, Wyo.

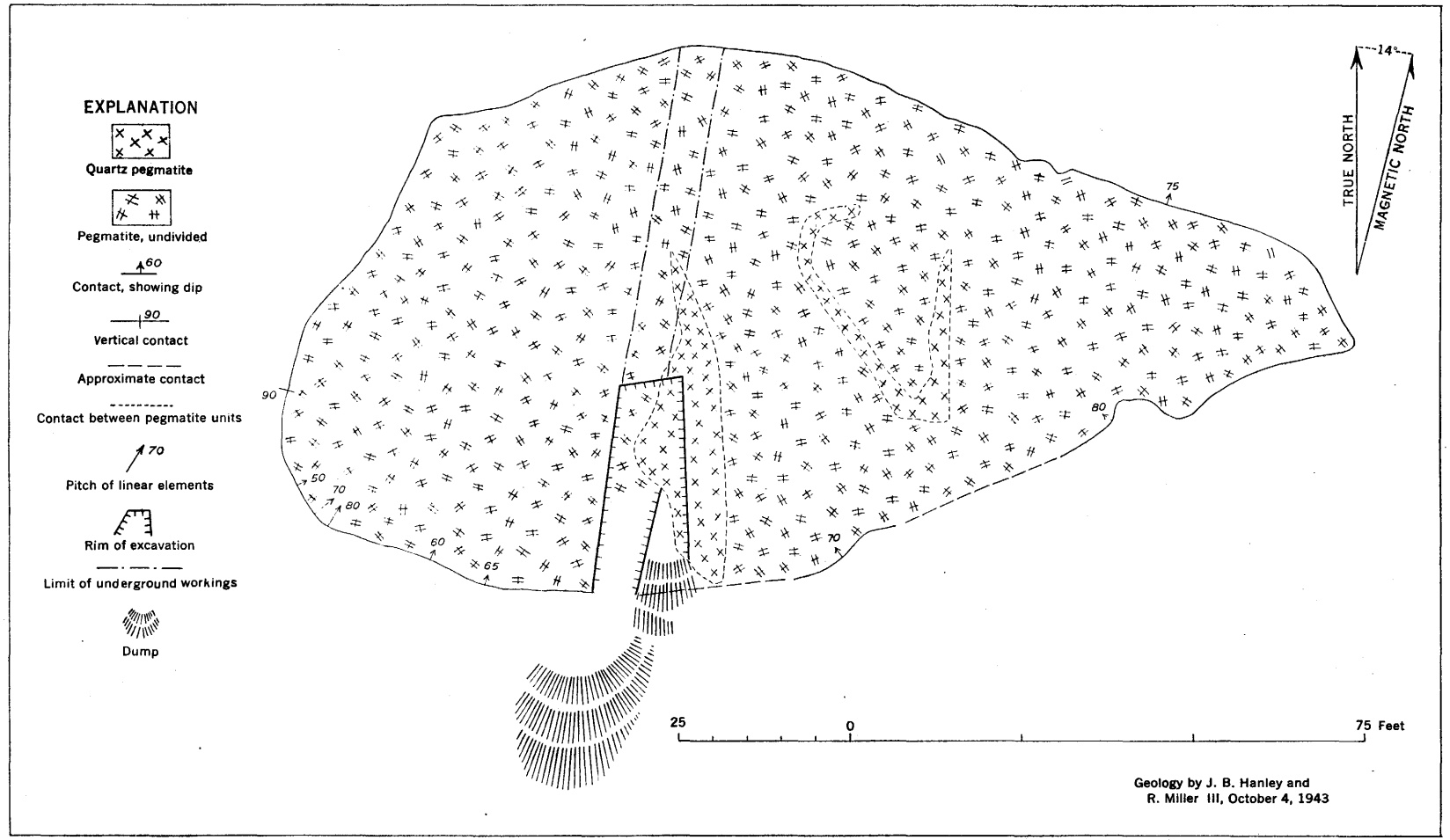

FIGURE 33.—Map of Ruth prospect, Haystack Range district, Goshen County, Wyo.

SAVAGE PROSPECT

The Savage prospect (see fig. 30) is about 4,000 feet by air line northeast of the Crystal Palace prospect. It is owned by L. T. Sisson. The workings include an irregular open-cut that is parallel to the trend of the pegmatite and is 40 feet long, as much as 25 feet wide, and 12 to 15 feet deep at the face. A second open-cut, 15 feet long and 12 feet wide, connects with the larger cut.

The Savage pegmatite (see fig. 34) is a long, narrow lens that trends N. 80° E. and dips about 75° NW. parallel to the bedding of the Whalen schists. It is about 220 feet long and as much as 20 feet wide in its central part but narrows rapidly to about 5 feet both to the northeast and southwest. Because it is more resistant to erosion than the schists, the pegmatite forms a cliff 10 feet or more high.

Two faults are exposed in this pegmatite. The one near the southwestern end has displaced the pegmatite 12.5 feet horizontally; the movement on this fault was probably rotational. The other is in the center of the pegmatite, and the fault surface forms one wall of the open-cut. It is roughly parallel to the trend of the pegmatite and dips 75° NW. Slickensides and steps on the fault plane indicate that the northwest side moved down. The pegmatite along this fault surface has been silicified. Numerous joint planes in the pegmatite strike N. 20° W. and dip 75° SW.

The pegmatite is unzoned and is composed chiefly of potash feldspar, quartz, and muscovite with accessory plagioclase, black tourmaline, and beryl. The muscovite is clear, highly ruled and crumpled, and small in size. No mica of punch or sheet quality was observed. In the part of the pegmatite between the fault and the south contact, muscovite is visually estimated to form 10 percent of the rock. Beryl occurs in white to light-green crystals that range from 13 millimeters to 5 inches in diameter. The average size is less than 1 inch; hence the beryl cannot be recovered by hand cobbing. It commonly occurs in clusters of 10 or more crystals separated from adjacent clusters by areas of barren pegmatite. The richest concentrations are visually estimated to contain 1.5 percent beryl, but the average content of the pegmatite is about 0.5 percent. This pegmatite probably contains only small quantities of beryl and sheet-bearing mica.

WHITE STAR PROSPECT

The White Star prospect (see fig. 30) is about 1,150 feet by air line southeast of the Crystal Palace prospect. It is owned by L. T. Sisson. The only opening is an open-cut 25 feet long, N. 60° W., 6 to 10 feet wide, and 15 feet deep at the face.

The White Star pegmatite is about 1,000 feet long and as much as 60 feet wide. It trends N. 45° E. and dips 75° NW. Several schist septa are enclosed in the pegmatite; one exposed in the cut is about 30 feet long and 5 feet wide, and although it is parallel to the pegmatite in trend, it dips 80° NW. The pegmatite is composed chiefly of mottled microcline, quartz, and muscovite with accessory black tourmaline. Quartz pegmatite pods are exposed near the center of the pegmatite, and most of these pods generally are surrounded by a narrow zone of muscovite-rich pegmatite. The muscovite in this pegmatite would yield only scrap mica, and the quantity is small.

HAYSTACK NO. 1 PROSPECT

The Haystack No. 1 prospect is probably in sec. 1, T. 27 N., R. 65 W., sixth principal meridian. It was relocated on June 3, 1943, by Mrs. M. Frederick, Mrs. H. Blake, and Woodruff Blake. The only opening is a discovery hole 10 feet in length and 5 feet in width. It is only a short distance north of the contact between the granite and the Whalen group.

The Haystack No. 1 pegmatite is poorly exposed outside the discovery hole, but in this cut it is composed chiefly of microcline and quartz with abundant black tourmaline. Muscovite occurs as sparsely scattered books that are less than 1 inch in size. A few euhedral garnet crystals are exposed. Some of the feldspar is iron-stained, and a minor quantity of a discolored iron mineral occurs in the pegmatite. The quantity of muscovite and recoverable microcline in this pegmatite is small.

HAYSTACK NO. 2 PROSPECT

The Haystack No. 2 prospect was formerly operated as a scrap mica mine, and a grinding mill was located near the prospect. It is owned by Mrs. M. Frederick, Mrs. H. Blake, and Woodruff Blake. It is a short distance north-northwest of the Haystack No. 1 prospect, probably in sec. 1, T. 27 N., R. 65 W., sixth principal meridian. The workings on this prospect include an open-cut 200 feet long and as much as 8 feet wide, trending N. 75° W., and a 15-foot adit at the west end of the cut.

Two pegmatites crop out on this prospect. The eastern one trends N. 75° W. and dips 65° NE. It is 6 feet wide and at least 15 feet deep and has been almost completely mined out. The schist wall rock wraps around both ends and the bottom of this pegmatite, which nearly pinches out at a structural roll in the schist 60 feet from the western end of the open-cut.

The western pegmatite, also 6 feet wide, extends downward about 10 feet. The adit was driven in schist vertically below it, but the pegmatite shows no continuation in depth.

Both pegmatites are quartz-potash feldspar-mica pegmatites in which the muscovite is concentrated near

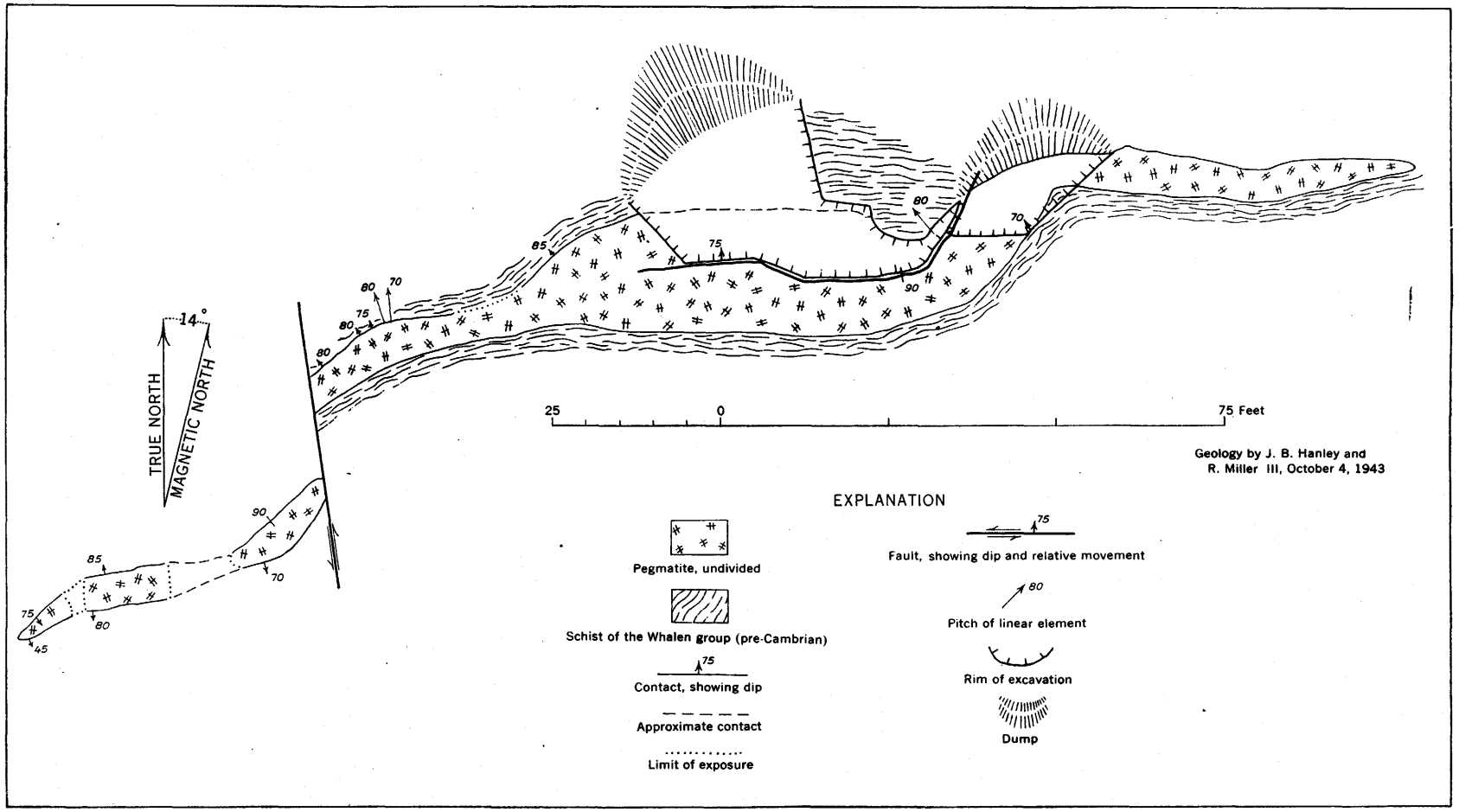

FIGURE 34.—Map of Savage prospect, Haystack Range district, Goshen County, Wyo.

the hanging wall. The muscovite occurs in books less than 2 inches broad and is visually estimated to make up 25 percent of the pegmatite. Most of it is suitable only for scrap mica because of the small size, but a very small quantity of punch and sheet mica might be recovered by proper preparation. Accessory minerals are pale-green apatite, biotite, and dark-brown garnet in crystals about 1 inch in diameter.

The eastern pegmatite has been almost completely mined out, and the quantity of muscovite and feldspar in the western pegmatite is small.

NATRONA COUNTY

BLACK MOUNTAIN SPODUMENE PROSPECT

The Black Mountain spodumene prospect, owned by J. Stephensen of Lander, is in the SE¼ sec. 36, T. 33 N., R. 89 W., sixth parallel meridian. It is 70 miles by air line north of Rawlins and 60 miles by air line west of Casper and can be reached only by unimproved ranch roads. U. S. Highway 20 is 18 miles to the north. The prospect is on the top of the north spur of Black Mountain, just above the old King Solomon gold mine and south of the headwaters of Sage Hen Creek. It was visited by J. B. Hanley and J. D. Love on August 17, 1942.

The only opening in the prospect is a discovery hole that is 8 feet long, 5 feet wide, and 5 feet deep.

Black Mountain is a knob of pre-Cambrian basic igneous and metamorphic rocks that are cut by quartz veins, granite dikes, and pegmatites. It is partly buried by Oligocene tuff beds. Strongly folded Paleozoic and Mesozoic rocks are exposed 6 miles north and northwest of the prospect.

The strike of the foliation in the schists is nearly east, and the dip is 60° to 80° S. The quartz veins, granite dikes, and pegmatites were intruded nearly parallel to the structure of the schist. Some of the pegmatites trend slightly north of east, and some slightly south of east. Most of them are less than 20 feet thick.

The Black Mountain pegmatite is well exposed in all three dimensions at the discovery pit, but it crops out in most places at the same level as the wall rock, so that its structure cannot be determined. At the pit the trend of the pegmatite changes from N. 75° E. to south. To the northeast of the pit the pegmatite is exposed for 150 feet, pinches down to a few inches in width for 5 or 10 feet, and then widens again on the same trend for about 40 feet. South of the pit the pegmatite is exposed for 40 feet and is 10 feet wide. It pinches and swells throughout its length. About 50 feet northeast of the pit the outcrop width is less than 1 foot, but 50 feet beyond this point it is 10 feet. South of the pit the outcrop width is 10 feet.

The hanging wall of the pegmatite dips 60° S. and is exposed in the floor and the face of the pit. The footwall dips 30° in the same direction. The maximum thickness of the pegmatite in the pit is 5 feet.

Spodumene occurs in the wide parts of the pegmatite, and bluish-gray potash feldspar occurs in the narrow parts. The spodumene is in blue-gray, greenish, or pale-lavender crystals as much as 8 inches thick and 18 inches long. It is visually estimated to make up 50 percent of the pegmatite near the hanging wall but is progressively less abundant toward the footwall, where it is estimated to form about 10 percent of the pegmatite. The spodumene is reported to contain 6 to 6.3 percent lithia. The remainder of the pegmatite consists of quartz, potash feldspar, and albite with accessory black to green-black tourmaline, apatite, and muscovite. The albite is partly altered to montmorillonite. The quantity of spodumene is small.

The spodumene pegmatite crops out just south of a quartz-potash feldspar-mica-plagioclase pegmatite, there being no visible connection between the two. This second pegmatite is 20 feet thick and contains large subhedral crystals of both pink and blue-gray microcline, which has been mistaken for spodumene. The quantity of microcline in this pegmatite is small.

UTAH PEGMATITES

TOOELE COUNTY

GRANITE MOUNTAIN PROSPECTS

LOCATION AND GENERAL FEATURES

The Granite Mountain prospects were discovered on August 18, 1938, by Harry W. Parker of Los Angeles, Calif. The pegmatites in which the prospects are located are in T. 8 S., R. 12 W., Salt Lake meridian, Tooele County, about 57 miles by air line southwest of the city of Tooele. This area is in the bombing and gunnery range of the Wendover Air Base, United States Army. Granite Mountain is at the north end of the Dugway Mountains and is surrounded on three sides by the Great Salt Lake Desert. The topography varies from nearly flat and undissected on the desert to very rough on the mountain, which has a relief of about 2,000 feet. No water, except that in small springs, is available for many miles.

The prospects can be reached by 62 miles of fair road from St. John station on the Union Pacific Railroad, the nearest shipping point. Graded and graveled roads extend as far as the Chemical Warfare Service Base, United States Army, at Dugway. The remaining 25.7 miles of road is unimproved and unmaintained.

No beryl nor any other minerals have ever been produced from these prospects, and no development work has been done.

The prospects were examined by J. B. Hanley and G. A. Kennedy on April 6, 1943.

GEOLOGY

The Granite Mountain beryl-bearing pegmatites cut an intrusive igneous rock identified by Butler [48] as a light-gray granite. In the vicinity of the pegmatites the granite is biotite-rich and dark gray. Fresh exposures are rare, and most of the outcrops are covered with desert varnish. Sand blasting has eroded the rocks in a fretwork design. A few quartzite roof pendants were found in the granite.

The pegmatites are invariably small, isolated, extremely irregular podlike bodies that are oriented haphazardly in the granite wall rock. The largest and best-exposed pegmatite is on the top of the mountain. It is about 125 feet long, about 55 feet in maximum width, and only 5 to 6 feet thick. The average length of the larger pegmatites is 55 feet, and the average thickness is 4 feet. No structural control of these pegmatite bodies is evident. A few of the pegmatites cut across other pegmatites, and many are branching and fingering in shape.

The pegmatites are separated from one another by masses of wall rock ranging in thickness from a few inches to tens of feet. The pegmatites are not connected at the surface, and all the exposures indicate that they are not connected in depth. The bodies have the irregularity that would be expected of pegmatites that are formed by segregation in a granite. The contacts between the pegmatites and the granite wall rock are extremely irregular and gradational. No fine-grained border zones were seen.

The pegmatites show the full range in texture from aplitic to pegmatitic. In the pegmatitic types the average grain size is 2 inches. All types of pegmatite may be intermixed in a single pegmatite body, and commonly the outer parts of a pegmatite are coarser-grained than the inner. The common minerals are potash feldspar and quartz. Albite, rather abundant in large subhedral crystals and masses, is reported to contain 6 to 7 percent beryllium oxide, but two specimens spectrographically analyzed by the Chemical Laboratory of the Geological Survey contained only a trace of beryllium. Accessory muscovite is visually estimated to make up about 3 percent of some of the pegmatites. It does not occur in all of them and is commonly found in books less than an inch in size.

Beryl occurs in light- to bright-blue crystals that range in diameter from 1 millimeter to 2.5 inches, with an average size of 3 millimeters. The beryl content of the different pegmatites is visually estimated to range from 1 part of beryl in 10,000 parts of pegmatite to 1 part of beryl in 1,000 parts of pegmatite. Because of the small size of the beryl crystals, hand cobbing is impossible. The only possible means of recovery is some method of milling.

The Granite Mountain pegmatites are so thin and irregular that very few of them could be mined without removing large quantities of wall rock at the same time. The quantity of pegmatite in any one body is very small, as the largest is estimated to contain only 3,300 tons of rock. This body is one of the richest beryl-bearing pegmatites of the area but is visually estimated to contain only 1 part of beryl in 1,000 parts of pegmatite.

The beryl in these pegmatites can be recovered only by some method of milling, and the total quantity of beryl-bearing pegmatite appears to be small. In addition, the lack of water near the deposit and the long distance from the nearest town would hinder any attempt to mine the pegmatites.

[48] Butler, B. S., The ore deposits of Utah: U. S. Geol. Survey Prof. Paper 111, p. 460, 1920.

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