Beryl-bearing Pegmatites in the Ruby Mountains and Other Areas in Nevada and Northwestern Arizona

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CONTRIBUTIONS TO ECONOMIC GEOLOGY

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BERYL-BEARING PEGMATITES IN THE RUBY MOUNTAINS AND OTHER AREAS IN NEVADA AND NORTHWESTERN ARIZONA

By Jerry C. Olson and E. Neal Hinrichs

ABSTRACT

Pegmatite occurs widely in Nevada and northwestern Arizona, but little mining has been done for such pegmatite minerals as mica, feldspar, beryl, and lepidolite. Reconnaissance for beryl-bearing pegmatite in Nevada and in part of Mohave County, Ariz., and detailed studies in the Dawley Canyon area, Elko County, Nev., have shown that beryl occurs in at least 11 districts in the region. Muscovite has been prospected or mined in the Ruby and Virgin Mountains, Nev., and in Mohave County, Ariz. Feldspar has been mined in the southern part of the region near Kingman, Ariz., and in Clark County, Nev.

The pegmatites in the region range in age from Precambrian to late Mesozoic or Tertiary. Among the pegmatite minerals found or reported in the districts studied are beryl, chrysoberyl, scheelite, wolframite, garnet, tourmaline, fluorite, apatite, sphene, allanite, samarskite, euxenite, gadolinite, monazite, autunite, columbite-tantalite, lepidolite, molybdenite, and pyrite and other sulfide minerals.

The principal beryl-bearing pegmatites examined are in the Oreana and Lakeview (Humboldt Canyon) areas, Pershing County; the Dawley Canyon area in the Ruby Mountains, Elko County, Nev.; and on the Hummingbird claims in the Virgin Mountains, Mohave County, Ariz. Beryl has also been reported in the Marietta district, Mineral County; the Sylvania district, Esmeralda County; near Crescent Peak and near Searchlight, Clark County, Nev.; and in the Painted Desert near Hoover Dam, Mohave County, Ariz.

Pegmatites are abundant in the Ruby Mountains, chiefly north of the granite stock at Harrison Pass. In the Dawley Canyon area of 2.6 square miles at least 350 pegmatite dikes more than 1 foot thick were mapped, and beryl was found in small quantities in at least 100 of these dikes. Four of these dikes exceed 20 feet in thickness, and 1 is 55 feet thick. A few pegmatites were also examined in the Corral Creek, Gilbert Canyon, and Hankins Canyon areas in the Ruby Mountains.

The pegmatite dikes in the Dawley Canyon area intrude granite and metamorphic rocks which consist chiefly of quartzite and schist of probable Early Cambrian age. The granite is of two types: a biotite-muscovite granite that forms the main mass of the stock and albite granite that occurs in the metamorphic rocks near the borders of the stock. The pegmatites were emplaced chiefly along fractures in the granite and along schistosity or bedding planes in the metamorphic rocks.

Many of the Dawley Canyon pegmatite dikes are zoned, having several rock units of contrasting mineralogy or grain size formed successively from the walls inward. Aplitic units occur either as zones or in irregular positions in the pegmatite dikes and are a distinctive feature of the Dawley Canyon pegmatites. Some of the aplitic and fine-grained pegmatite units are characterized by thin layers of garnet crystals, forming many parallel bands on outcrop surfaces. The occurrence of aplitic and pegmatitic textures in the same dike presumably indicates abrupt changes in physical-chemical conditions during crystallization, such as changes in viscosity and in content of volatile constituents.

Concentrations of 0.1 percent or more beryl, locally more than 1 percent, occur in certain zones in the Dawley Canyon pegmatites. Spectrographic analyses of 23 samples indicate that the BeO content ranges from 0.0017 to 0.003 percent in the albite granite, from 0.0013 to 0.039 percent in aplitic units in pegmatite, from 0.0005 to 0.10 percent in coarse-grained pegmatite, and from less than 0.0001 to 0.0004 percent in massive quartz veins.

The scheelite-beryl deposits at Oreana and in Humboldt Canyon, Pershing County, are rich in beryllium. Twelve samples from the Lakeview (Humboldt Canyon) deposit range from 0.018 to 0.11 percent BeO, but underground crosscuts have failed to intersect similar rock at depth. Beryl locally constitutes as much as 10 percent of the pegmatitic ore at Oreana. The beryl was not recovered during tungsten mining at Oreana and is now in the tailings of the mill at Toulon, Nev. The percentage of beryl is lower than the Oreana ore because of dilution by tailings from other ores milled at Toulon.

Beryl has been found in many pegmatite dikes in the Virgin Mountains. Both beryl and chrysoberyl occur in dikes on the Hummingbird claims, north of Virgin Peak, in Mohave County, Ariz. Spectrographic analyses of 5 representative samples of the principal dike on the Hummingbird claims range from 0.055 to 0.11 percent BeO.

INTRODUCTION

Pegmatites occur in many parts of Nevada and northwestern Arizona, but there has been little mining of pegmatite minerals such as mica, feldspar, beryl, and lepidolite. The reconnaissance on which this report is based was undertaken to search for and evaluate deposits of beryl and other pegmatite minerals, particularly muscovite.

Both beryl and muscovite are important strategic materials. The demand for beryl increased greatly during the decade 1940–50, and the price, which was formerly only about $35 per ton, increased more than tenfold during this period. The demand for muscovite reached an alltime peak during World War II, when premium prices stimulated vigorous mining in several parts of the country, particularly the Southeastern States, New England, and the Black Hills.

Investigation of beryl in pegmatites of Nevada and northwestern Arizona was focused on the Dawley Canyon area of the Ruby Mountains (pl. 3). Other areas in the Ruby Mountains, the Oreana and Humboldt Canyon localities in northwestern Nevada, and other areas reportedly containing beryl were examined. Some areas in which pegmatite but not beryl has been reported in geologic literature were also visited, verifying the reports that the pegmatites are mostly composed of only a few common minerals. Beryl was not found in any district where it had not already been reported.

PREVIOUS WORK

Pegmatites have been mentioned often in the geologic literature of Nevada and northwestern Arizona, but, because of the limited pegmatite mining in the region, little has been published on the economic value of the pegmatites as possible sources of beryl, muscovite, feldspar, or other pegmatite minerals.

Members of the Geological Survey examined several pegmatites in Nevada during World War II, as part of a study of tungsten deposits. In 1942, John H. Wiese examined a beryl prospect, locality V15, (pl. 4) in Dawley Canyon, and M. R. Klepper examined pegmatites in the Corral Creek and the Gilbert Canyon areas, and the Lakeview and Oreana deposits. D. J. Fisher made a reconnaissance of pegmatite dikes in Dawley and Gilbert Canyons, July 21–24, 1943, and collected samples for spectrographic determination of beryllium. The results of these studies during World War II were available to the writers and facilitated the fieldwork and preparation of this report.

FIELDWORK AND ACKNOWLEDGMENTS

The Dawley Canyon area of 2.6 square miles, in which beryl-bearing pegmatites seem most abundant, was mapped at a scale of 800 feet to the inch during August-September 1948 by J. C. Olson and E. N. Hinrichs, and by Olson and R. E. Burns in October and November 1948. The pegmatites were examined carefully for beryl. Several sketch maps showing geologic features of the Dawley Canyon area were prepared, and 24 samples were collected for spectrographic determination of BeO content. The Errington-Thiel mica mine area was mapped at 20 feet to the inch, and rocks from the Errington-Thiel mine were studied petrographically by Hinrichs. The Lakeview (Humboldt Canyon) scheelite-beryl deposit was examined by Burns and Olson in November 1948, and 14 samples were taken for BeO analysis. Several other pegmatite areas in Nevada and northwestern Arizona were examined by Olson in April and May 1949, and the tailings of the Toulon mill were sampled.

The spectrographic analyses for BeO were made for the U.S. Geological Survey by Saratoga Laboratories, Saratoga, N.Y. D. A. Brobst of the U.S. Geological Survey aided in mineralogic determinations, particularly of indices of refraction of plagioclase and beryl. During the fieldwork in Elko County, the writers were extended many courtesies by the staff of the Bureau of Land Management office in Elko, Nev., and by Mr. Oscar Thiel and Mrs. A. T. Errington, Ruby Valley, Nev.

The reconnaissance for beryl-bearing pegmatites was made by the U.S. Geological Survey on behalf of the Division of Raw Materials of the U.S. Atomic Energy Commission.

PEGMATITE MINING IN THE REGION

The first recorded mining of pegmatite in the region was in 1893 and 1894 by Daniel Bonelli, of Rioville, Nev., in the Virgin Mountains. At this time, 500 pounds of sheet mica was shipped from Nevada to Hamburg, Germany, and 1,300 pounds to Syracuse, N.Y. (Sterrett, 1923, p. 105–106.) Holmes (1904, p. 986) also refers to shipment of muscovite from pegmatite in the Virgin Mountains before 1900.

The total production of pegmatite minerals remained very small until 1923 when G. I. Taylor shipped feldspar to California mills from a deposit 5 miles north of Kingman, Ariz., on the east side of the Cerbat Mountains. In March 1924, the Kingman deposits were sold to the Kingman Feldspar Co. Consolidated Feldspar Corp. built a mill at Kingman in 1931 to grind all the feldspar produced by the Kingman Feldspar Co., and this mill is in operation at the present time (1958). A small amount of feldspar was shipped to Los Angeles about 1929 from the mine near Crescent Peak, Clark County, Nev. Several carloads of feldspar were also shipped from the pegmatite in Washoe County near the Red Rock road, about 18 miles north of Reno, to San Francisco in 1931 (Fulton and Smith, 1932, p. 4). The Kingman group of quarries remains the only large feldspar producer in the region.

About 1928–29, several claims were staked in the Dawley Canyon area. At this time at least one adit, locality Q5 (pl. 4), was driven by the Mutual Mica Co., but little muscovite was produced. During World War II, a small amount of mica was mined from the Errington-Thiel mine in the Dawley Canyon area, and the pegmatite at the M and P mine in Mohave County, Ariz., was prospected for muscovite.

The Oreana tungsten deposit, Pershing County, Nev., is an uncommon type of pegmatite rich in scheelite and beryl. Tungsten was mined here from 1935 to 1942, when the price for beryl was relatively low and the beryl was not recovered. The scheelite-beryl deposit in Humboldt Canyon, north of Oreana, was discovered about 1932 and was explored in 1942, but has not been mined extensively.

Demand for beryl increased during World War II and has remained high since then. Little, if any, beryl has been produced in the region, except for metallurgical tests, but prospecting has been done in the Dawley Canyon area, on the Hummingbird claims and in other areas in the Virgin Mountains.

GENERAL FEATURES OF THE PEGMATITES

GEOLOGIC SETTING

Pegmatites occur in many of the areas of Precambrian metamorphic and igneous rocks, and of Mesozoic and Tertiary intrusive rocks, in Nevada and northwestern Arizona (pl. 3). Most pegmatites are nearly homogeneous bodies of simple granitic composition. A few of the simple granitic pegmatites have been described in geologic literature, but the recorded occurrences are no doubt only a small proportion of the total in the region. Some pegmatites of potential economic value because of uncommon accessory minerals or localization of certain minerals in zones have been recorded, but others may have escaped notice because much of the region has not been investigated in detail.

The pegmatites in the region range in age from Precambrian to late Mesozoic or Tertiary. Many in Precambrian rocks seem to have been crushed and metamorphosed, and probably are Precambrian in age. Other pegmatite dikes in Precambrian rocks are relatively unfoliated and are associated with granitic rocks that show little evidence of metamorphism, and therefore are possibly younger. In several areas, pegmatites and granitic rocks cut and are therefore younger than Paleozoic sedimentary rocks. Some pegmatites in western Nevada seem to be associated with the Sierra Nevada batholith of Late Jurassic or Cretaceous age.

The progressively younger age of post-Paleozoic igneous intrusions from west to east across Nevada has been discussed by Ferguson (1929). These intrusive rocks and related pegmatites range from those that are associated with the Sierra Nevada batholith in western Nevada and are predominantly Late Jurassic or Cretaceous in age to some of Tertiary age in the eastern part of the State.

In the mining districts of eastern Nevada, most of the stocks and dikes of igneous rocks are generally similar and approximate quartz monzonite or granite porphyry in their mineral composition (Hill, 1916, p. 23). Two exceptions to the general similarity of the igneous rocks noted by Hill are the gneissic biotite and muscovite granites of the Ruby Mountains and the muscovite-biotite granite of the Kern Mountains. Pegmatites are abundant in these two areas, whereas little pegmatite is associated with most of the other intrusive bodies in the mining districts of eastern Nevada, possibly because the granites with which the pegmatites occur were intruded at greater depth.

Pegmatites containing beryl do not seem to be restricted to any particular geologic age. The granite with which the pegmatites in the Ruby Mountains are associated is shown as Tertiary on the geologic map of the United States published in 1933 by the U.S. Geological Survey, probably because many other granitic intrusive rocks in the general region are known to be Tertiary. From field evidence, however, the granite of the Ruby Mountains cannot be dated more precisely than post-Carboniferous and pre-Miocene (Sharp, 1942, p. 674). The beryl-scheelite pegmatites of the Humboldt Range are post-Triassic, probably Jurassic or Cretaceous. The beryl-bearing pegmatites in the Gold Butte district and other parts of the Virgin Mountains region are in Precambrian rocks, but the age of intrusion is uncertain.

MINERALOGY

Known occurrences of rare or accessory minerals in pegmatites or other beryl-bearing deposits in Nevada and northwestern Arizona are summarized in table 1.

ECONOMIC MINERALS

BERYL AND CHRYSOBERYL

Of the known or reported occurrences of beryl in 11 districts in Nevada and northwestern Arizona, beryl is most common in the Oreana and Humboldt Canyon scheelite-beryl deposits in the Humboldt Range, the Dawley Canyon area in the Ruby Mountains, and the Hummingbird claims in the Virgin Mountains. Chrysoberyl is also found on the Hummingbird claims.

The beryl deposits have not been developed commercially despite the high prices that have prevailed in recent years. Beryl might have been recovered if the scheelite-beryl deposits at Oreana and Humboldt Canyon were mined for scheelite with beryl prices as high as at the present time (1958). The Oreana deposit was mined when beryl prices were low, however, and the beryl is now in the tailings of the mill at Toulon, Nev., diluted somewhat by the milling of beryl-free tungsten ore from several other localities. Subsurface exploration at the Humboldt Canyon deposit failed to show that the deposit persists in depth. Although beryl occurs in 100 or more deposits in the Dawley Canyon area, none have been sufficiently large or of high enough grade to encourage mining and the milling that would be necessary to recover the fine-grained beryl.

TABLE 1.—*Rare or accessory minerals in pegmatites or other beryl-bearing deposits of Nevada and northwestern Arizona*

[X, indicates present; P, indicates probably present or reported]

District	Beryl	Chrysoberyl	Scheelite	Wolframite-huebnerite	Garnet	Tourmaline	Fluorite	Apatite	Sphene	Allanite	Samarskite-euxenite	Gadolinite	Monazite	Autunite	Columbite-tantalite	Lepidolite	Molybdenite	Pyrite or other sulfide minerals
Elko County:																		
Dawley and Hankins Canyons	X				X	X		X						X	X			
Corral Creek					X											X		
Gilbert Canyon	X				X									X	X			
White Pine County: Kern Mountains					X													
Pershing County:																		
Humboldt Canyon deposit	X		X				X											
Oreana	X		X		X	X	X	X	X									
Trinity Range																		
Seven Troughs Range					X	X										P		
RFS prospect					X	X												
Washoe County: Red Rock road								X	X	P								
Lyon County: Yerington																	X	
Mineral County: Marietta (tungsten vein)	X		X	X														
Esmeralda County:																		
Lone Mountain																		
Mineral Ridge					X			X								X		
Sylvania	X																	
Slate Ridge							X										X	
Gold Mountain Ridge																		
Nye County:																		
Bullfrog Hills						X		X										X
Bare Mountain						X												
Pahute Mesa																		
Belted Range																		X
Clark County:																		
Crescent Peak	X				X		X											
Searchlight area	P				X													
Gold Butte	X				X	X	X			X	X		X		X			
Mohave County, Arizona:																		
Hummingbird claims	X	X			X	X												
Painted Desert area	P				X													
M and P claims					X													
Kingman group										X	X	X						

The beryl in deposits such as those in the Dawley Canyon area, the Hummingbird claims, Oreana, and Humboldt Canyon is generally too fine grained to be separated easily by hand, and special methods of beneficiation would be required for its recovery. The possibility of developing milling methods to recover the fine-grained beryl from pegmatite has been investigated by the U.S. Bureau of Mines (Engel and Shelton, 1941; Kennedy and O'Meara, 1948).

A measure of the percentage of BeO in beryl may be obtained by determining the index of refraction, *n*O, of the beryl crystals. The data obtained during this investigation on the indices of beryl are given in table 2. The BeO content of 24 samples of the pegmatitic and aplitic rocks is given in table 4.

TABLE 2.—*Index of refraction, nO, of beryl in seven districts in Nevada and northwestern Arizona*

Locality	Index, *n*O	Number of determinations	Percent BeO indicated by index[1]
Dawley Canyon area	[2]1. 574–1. 581	11	13. 5
Hankins Canyon	1. 575	1	13. 5
Gilbert Canyon area	1. 575	1	13. 5
Hummingbird claims	1. 576–1. 583	2	13. 4–12. 8
Oreana	1. 586–1. 587	4	12. 4
Pine Crow claim, Marietta	1. 588	1	12. 2
Lakeview mine (Humboldt Canyon)	1. 576–1. 590	3	11. 9–13. 4

[1] Based upon curves prepared by W. T. Schaller of the U.S. Geological Survey.
[2] Mostly 1.575.

MUSCOVITE

Muscovite occurs in crystals of sufficient size to yield sheet mica in Dawley and Gilbert Canyons, the pegmatite at the RFS prospect, M and P claims, and in several areas in the Virgin Mountains including Gold Butte and the district on the north slopes of Virgin Peak. Some sheet mica has been produced in these districts, but in general only a few attempts have been made to mine mica, because it is too sparsely distributed and in all the deposits examined during this investigation the percentage of sheet mica recoverable from the mica books is low in comparison with other districts where mica has been mined profitably. The percentage of sheet mica in the total mine-run mica would probably be less than 1 percent in many deposits, because of structural imperfections in the larger mica books such as ruling, reeves, and distorted and broken crystals.

Scrap muscovite has been mined from micaceous schist in the Gold Butte district. It might be obtained from many pegmatites in the Nevada-Arizona region if they were also mined for sheet mica, beryl, or feldspar. In general, however, no pegmatite seems rich enough to sustain a mining operation based on scrap mica alone.

FELDSPAR

Feldspar is the most abundant constituent of the pegmatites, but only rarely is it sufficiently abundant and pure to be mined profitably. The value of crude feldspar is low in relation to the cost of transportation. Therefore, a decisive factor in evaluation of a feldspar deposit is proximity to railroad and to the consuming centers, such as the Los Angeles and San Francisco areas.

Potassium feldspar has been found in large pure masses only in pegmatites in the southern part of the region, near Kingman, the M and P claims, the Gold Butte district, Crescent Peak area, and the Searchlight area. The only feldspar produced, however, has come from the Kingman and Crescent Peak areas, both of which are near railroads.

Although feldspar is abundant in some poorly zoned pegmatites, hand cobbing of this mineral from the mixture of other minerals is impractical. The pegmatite on the RFS claims is poorly zoned, but because of its tremendous size and abundant feldspar, it might be a potential source of feldspar by flotation methods were it not in such an isolated location. Flotation methods are in use in New Hampshire, North Carolina, and Colorado to separate feldspar from associated minerals.

DAWLEY CANYON AREA, ELKO COUNTY

LOCATION AND SURFACE FEATURES

The Dawley Canyon pegmatite area occupies about 3 square miles on the steep east slope of the Ruby Mountains (fig. 8), a fault-block range 60 miles long and about 10 miles wide which trends N. 15° E. in the south-central part of Elko county. The Ruby Mountains are joined on the northeast by the East Humboldt Range, forming a mountain mass 80 miles long that is crossed by roads at only Secret Pass (6,465 feet altitude) and Harrison Pass (7,248 feet altitude). The flanks of the Ruby Mountains are accessible from gravel or dirt roads that encircle the range. Rock exposures in the Ruby Mountains generally are good. Lead, zinc, silver, copper, tungsten, and bismuth have been mined in several small mining districts, but no large mines have been developed. Most of the mineral deposits in the range are in limestone near the contact with granite stocks.

Altitudes in the Dawley Canyon area range from 6,075 feet in Ruby Valley to 8,800 feet 2 miles to the west. The highest altitude on the crest of the range, 2 miles west of the area, is 10,934 feet.

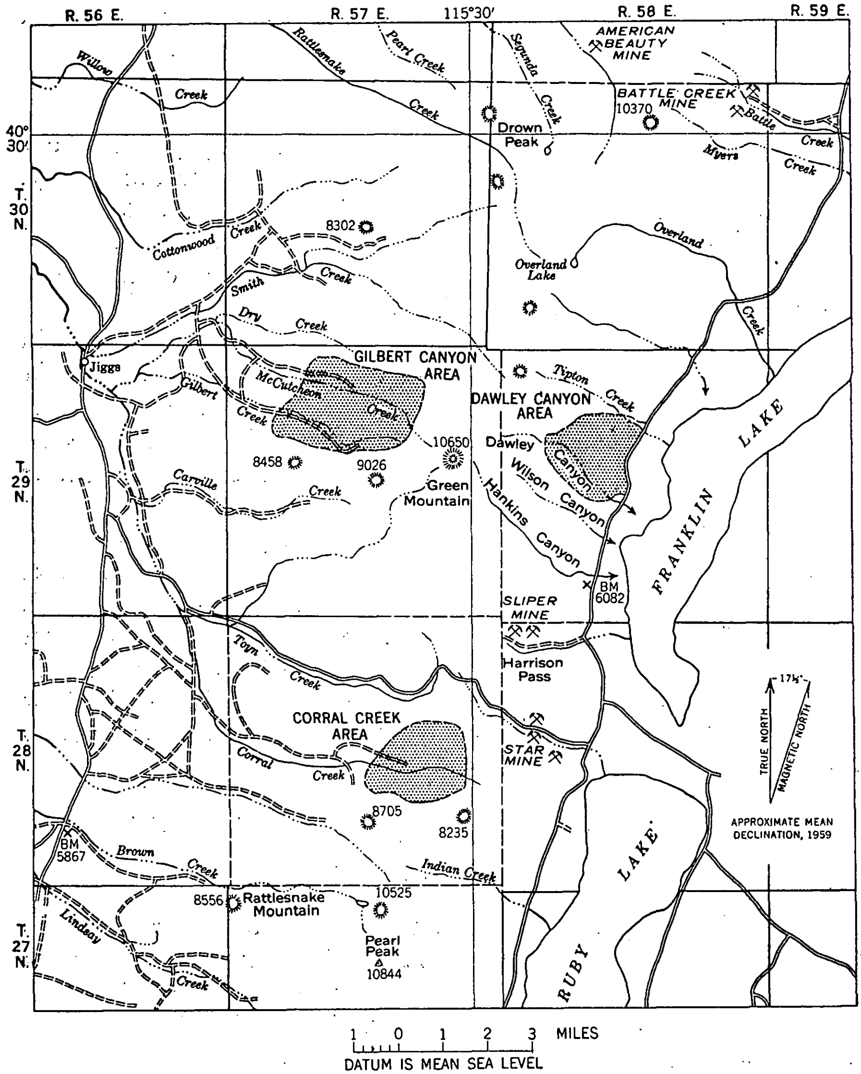


FIGURE 8.—Index map of central Ruby Mountains, showing location of areas examined.

More than 350 pegmatite dikes have been mapped in this area (pl. 4), and beryl has been found in small quantities in 100 or more of these dikes. The Errington-Thiel mine produced a small quantity of sheet muscovite during World War II. Much of the Dawley Canyon area is covered by claims staked by M. W. Young, Mrs. A. T. Errington, and Oscar W. Thiel, of Ruby Valley, Nev.; R. Lee Willis for A. E. and R. H. Downer of Stockton, Calif.; and the Mutual Mica Co. (Charles Kennedy) of Oakland, Calif. Some of the claims were staked about 1928, and others about 1943. The Mutual Mica Co. is reported to have driven an adit, locality Q5 (pl. 4), about 1929.

GEOLOGIC SETTING

The geology of the Ruby Mountains has been described by Sharp (1939, 1942). Most of the mountains are composed of metamorphic and sedimentary rocks that range in age from Early Cambrian, or possibly Precambrian, to Mississippian (?). The total thickness of this unbroken Paleozoic section is 16,450 feet (Sharp, 1942, p. 651). No indisputable evidence of Precambrian rocks has been found, although strata beneath the Prospect Mountain quartzite of Early Cambrian age may be Precambrian.

A network of dikes, sills, and irregular masses of medium-grained granite and coarse-grained pegmatite, of probable late Mesozoic or early Tertiary age (Sharp, 1939, p. 888-890), occurs in the central part of the Ruby Mountains. In general the proportion of igneous rock increases from the north end of the range southward to Harrison Pass. In the part of the range between Secret Pass and Harrison Pass, igneous rocks make up 30 to 60 percent of all the rocks exposed, and the proportion decreases sharply south of Harrison Pass.

The granite at Harrison Pass forms a nearly circular stock 7 to 8 miles in diameter (Sharp, 1942, p. 673). The pegmatites examined in the Corral Creek area are within this stock, and those in Gilbert, Hankins, and Dawley Canyons are near it on the north and northeast. The granite is mostly a gray coarse-grained biotite granite which locally contains phenocrysts of orthoclase 1 to 2 inches long. It is composed of 45 percent orthoclase, 33 percent oligoclase, 20 percent quartz, 2 percent biotite, and traces of zircon and apatite. Irregularly distributed along the borders are masses of medium-grained muscovite-biotite granite, suggesting that this may be a multiple stock.

The Ruby Mountains are a fault-block mountain range, and the highest peaks, some of which exceed 11,000 feet in altitude, are near the east edge of the block. In part of the range the block is a horst tilted so that the east margin has been uplifted higher than the west. Near the south end of the range, the west bounding fault dies out and the displacement on the east fault diminishes (Sharp, 1939, p. 891–905).

The largest fault in the Dawley Canyon area is the normal fault or fault zone, buried by the alluvium of Ruby Valley, that forms the east boundary of the Ruby Mountains fault block. According to Sharp, the dipslip displacement on the east boundary fault is not less than 6,500 feet at a point south of Harrison Pass, with the downthrown block to the east. The movement on this fault occurred from Miocene to late Pleistocene or Recent time (Sharp, 1939, p. 902–905). The marginal faults truncate the structural features within the range. The number and alinement of springs indicate the east boundary fault beneath the alluvial cover and suggest that the fault may in places be about 0.25 to 0.5 mile east of the range front.

In the Ruby Mountains, pegmatites are most abundant in the area from the Harrison Pass stock northward about 7 miles, and were investigated in the Dawley Canyon, Corral Creek, Gilbert Canyon, and Hankins Canyon areas (fig. 8).

The rocks in the Dawley Canyon area are dominantly biotite-muscovite granite, albite granite, and interbedded schist and quartzite. Pegmatite and aplite are closely associated with the granites, particularly the albite granite. Except near its mouth, Dawley Creek and the adjacent canyon sides are underlain by biotite-muscovite granite which is probably part of the granite stock of Harrison Pass to the southwest. The granite stock extends several miles north of the Dawley Canyon area. In the lower part of Dawley Canyon, granite and associated pegmatites have intruded interbedded quartzite and schist of probable Early Cambrian age.

METAMORPHIC ROCKS

The interbedded quartzite and schist in the Dawley Canyon area correspond closely to the Prospect Mountain quartzite as described by Sharp (1942, p. 651–652) and accordingly are probably Early Cambrian in age. Sharp calculated a local thickness of 1,400 feet of Prospect Mountain quartzite in part of the Ruby Mountains.

The metamorphic rocks comprise quartzite, feldspathic quartzite or graywacke, rare conglomeratic quartzite, quartz-mica schist, mica schist, quartz-biotite-muscovite-garnet schist, and quartz-biotite-garnet-sillimanite schist. These rocks are interlayered in various proportions; quartzite and quartz-mica schist predominate. Most of the metamorphic rocks are fine grained, the length of the grains averaging less than 1 mm.

The quartzite contains variable proportions of feldspar and in places has the appearance of a metamorphosed graywacke. The feldspathic quartzite or graywacke is commonly a fine-grained rock composed of about 80 to 85 percent quartz, 15 percent feldspar, 2 to 3 percent biotite, and 1 percent garnet. Rarely the quartzite is conglomeratic. The quartzite grades into quartz-mica schist. Mica schist composed almost entirely of muscovite and biotite is rare. Locally, the schist within 3 feet of pegmatites is enriched in muscovite.

Sillimanite occurs in some of the quartz-biotite-muscovite-garnet and quartz-biotite-garnet schists. Typical sillimanite-bearing schist contains 75 percent quartz, 10 to 15 percent biotite, 5 to 10 percent muscovite, and less than 5 percent sillimanite, red to lavender garnet, and magnetite.

The strata of metasedimentary rocks are considerably folded but rarely dip at angles greater than 45° except near a few granite contacts. Schistosity is at an angle to the stratification in most places and is more uniform in attitude (pl. 4). The schistosity strikes generally N. 20° W. to N. 45° E. and dips 15°–40° E., although a few westerly dips were observed.

BIOTITE-MUSCOVITE GRANITE

Biotite-muscovite granite (pl. 4) underlies a little more than half of the Dawley Canyon area. It extends westward and southwestward beyond the crest of the range, and probably forms a part of the Harrison Pass granite stock. The biotite-muscovite granite is composed of about 40 to 45 percent orthoclase, 30 to 35 percent oligoclase, 20 to 25 percent quartz, 2 to 4 percent biotite, 1 percent muscovite, and small quantities of apatite, zircon, and garnet. The granite ranges from 0.1 to 3 mm in grain size; the average is about 1 mm.

The biotite-muscovite granite generally shows no well developed planar or linear structures, but locally it has a banding or sheeting that probably originated through movements shortly after intrusion. The bands consist partly of mica-rich seams 4 to 6 inches apart along which a little movement has occurred, and partly of parallel pegmatitic streaks. At locality K1 (pl. 4), some thin pegmatites have been displaced by movement along the mica-rich seams or shear planes but other thin pegmatite dikes cut across the banding without deflection.

The biotite-muscovite granite is relatively uniform in composition and texture. It is pegmatitic locally but much less pegmatitic than the albite granite. The biotite-muscovite granite has not been found as dikes or sills in the metamorphic rocks. Within a few hundred feet of the schist areas, the biotite-muscovite granite in places grades to albite granite by an increase in the ratios of muscovite to biotite, plagioclase to potassium feldspar, and in the amount of garnet.

ALBITE GRANITE AND APLITE

The albite granite is commonly composed of about 33 percent quartz, 65 percent feldspar that is chiefly and in many places entirely albite, about 2 percent muscovite on the average, and a small amount of garnet. Potassium feldspar is scarce in much of the albite granite, and was absent in several samples examined microscopically. The quartz and feldspar grains in the albite granite are generally 1 to 2 mm in diameter, but the texture is variable and small irregular patches or streaks of pegmatite are common.

Aplite, which is closely related to the albite granite and is mapped with it (pl. 4), is generally similar in mineralogy but contains very little muscovite. Aplite occurs as irregular layers in schist and albite granite, and is gradational with albite granite. Similar rock of aplitic texture forms a few dikes cutting biotite-muscovite granite and also occurs as units or zones that are distinctly part of pegmatite bodies.

The aplite is a white, sugary-grained rock composed of interlocking albite and quartz grains commonly 0.2 to 0.5 mm in diameter. It is equigranular except that some garnet and sparse muscovite grains are somewhat larger than the albite and quartz grains. Garnet generally constitutes less than 1 percent of the rock, locally as much as 5 percent, and is either disseminated or is arranged in thin layers in the aplite. Similar rock characterized by garnet layers has been referred to as line rock in other areas (Schaller, 1925).

The albite granite occurs as sills and dikes in the metamorphic rocks, as shown on the map of the area (pl. 4). The albite granite is more heterogeneous in texture and composition than the biotite-muscovite granite and differs from it mineralogically in having albite or less commonly oligoclase as the plagioclase feldspar, very little potassium feldspar, about 2 percent muscovite, little or no biotite, and more garnet, which may be disseminated or arranged in bands.

The gradation in composition, the structural position with relation to the metamorphic rocks, and the absence of any clear crosscutting relations between the two granites, suggest that the albite granite is a border facies of the much larger biotite-muscovite granite stock.

STRUCTURAL FEATURES

SIZE AND SHAPE

At least 350 pegmatite dikes more than 1 foot thick occur in the 2.6 square miles mapped. Nearly all are long, thin, tabular dikes that dip steeply and strike N. 45° E. to N. 45° W. The thickness of 4 dikes exceeds 20 feet and 1 is about 55 feet. About 25 dikes are between 12 and 20 feet thick, and the rest are less than 12 feet. Most dikes gradually taper along the strike to a thickness of less than 1 inch. Owing to incomplete exposure the length of most of the dikes is unknown, but probably is 20 to 100 times the thickness for many of them.

The longest well-exposed dike is at least 2,200 feet long. Because of their tabular shape they probably persist to a great depth. A few bodies are oval such as locality Y6 (pl. 4). One such pluglike body, locality J19 (pl. 4), is 8 feet thick and 45 feet long, nearly vertical, and mica schist seems to wrap around the south end of the oval pegmatite body. Contacts with wallrocks are generally straight, but the borders of the pegmatites in schist locally have rolls or undulations.

DISTRIBUTION AND WALLROCK RELATIONS

Most of the pegmatites are near the contact between granite and metamorphic rocks. Because the irregular roof of the granite stock dips gently eastward, in the same direction as the slope of the ground surface, most of Dawley Canyon area is near this contact; hence, pegmatites are abundant. The pegmatites that occur in granite far from metamorphic rocks, as in the unmapped area north of Tipton Creek, are smaller in average size and are less likely to be rich in beryl than pegmatites close to the contact.

The pegmatite dikes in granite commonly have a northerly trend and steep dip parallel to the schistosity of the metamorphic rocks, the local banding or sheeting in biotite-muscovite granite, many conspicuous joints, and the east boundary fault. Within the metamorphic rocks, some pegmatite and much of the albite granite occurs as sills concordant with the bedding, as well as dikes parallel to schistosity or other fractures. As the low dip of the bedding of the metasedimentary rocks almost parallels the east slope of the range in part of the area, some of the sill-like bodies of albite granite form dip slopes.

In most places both bedding and schistosity have guided the emplacement of the pegmatite and albite granite, although some albite granite sills have a foliation at an angle to the contacts, indicating that in part the albite granite was emplaced before the schistosity was imposed upon the rocks. A network of pegmatite, aplite, and albite granite dikes, emplaced in a set of parallel fractures as well as a long bedding, occurs in some small areas, for example near locality H22. Some of the albite granite contains patches or streaks of pegmatite and bands of garnet that are cut by younger, discordant dikes of pegmatite. Aplitic dikes in fractures in quartzite are locally cut by pegmatite.

The proportions of the principal minerals—quartz, feldspars, and mica—differ among the pegmatite dikes, although several nearby dikes are likely to be similar to one another. For example, near locality F5 many pegmatites in biotite-muscovite granite contain about 25 percent quartz, 60 to 65 percent perthite, 3 percent muscovite, and 10 percent or less plagioclase. In schist or granite near E8, the typical pegmatite contains about 30 percent quartz, 33 percent each of plagioclase and perthite, and 4 percent muscovite. In general, a higher perthite-to-plagioclase ratio is found in pegmatites in biotite-muscovite granite than in schist, although there are many exceptions.

In some places granite and schist adjacent to pegmatite dikes are enriched in muscovite relative to biotite content. The granite adjacent to the dike at locality V25 (pl. 4), for example, contains 4 to 5 percent muscovite and no biotite, whereas the granite 8 inches or more from the contact contains 3 percent biotite and 1 percent muscovite that is coarser grained than the biotite.

The granitic rocks and pegmatites are all probably related to the same general period of igneous intrusion. The pegmatites were not all emplaced contemporaneously, although crosscutting relationships are not common. In several places where one dike cuts another, beryl is more common in the younger dike. Many massive quartz veins several inches to 1 foot thick cut pegmatite, granite, quartzite, and schist, and are the youngest rocks in the district.

ZONES

Both zoned and unzoned pegmatite dikes are abundant in the Dawley Canyon area. Unzoned pegmatites are either uniform in composition and texture throughout or are uniform except for scattered patches that differ in grain size or proportions of minerals. Some of the unzoned pegmatites, such as locality Y3 (pl. 4), are fine-grained albite-quartz-muscovite pegmatite, in which crudely rectangular blocks of perthite and graphite granite are disseminated rather than concentrated in any one part of the dike. Other types of unzoned pegmatite have irregular streaks of slightly differing grain size that parallel the walls but are not arranged in a systematic succession; these probably indicate that movements, after partial crystallization, localized the residual fluids in longitudinal streaks.

In this report the following grain-size classification, based on the maximum dimension of each grain, is applied to pegmatite:

	Inches
Very fine (includes sugary-grained, aplitic)	$<1/8$
Fine	1/8–1
Medium	1–4
Coarse	4–12
Very coarse	>12

A few unzoned pegmatites, including F5 and some of the larger bodies 20 feet or more thick, are generally medium to coarse grained throughout and relatively rich in perthite and graphite granite. The plagioclase is in subordinate, irregularly distributed, finer grained patches. Other unzoned pegmatites contain practically no perthite, such as the small, fine-grained plagioclase-quartz-muscovite pegmatite, containing 0.23 percent beryl, at locality K26.

Most of the pegmatites examined in the Dawley Canyon area are zoned. The zones are parts of pegmatite dikes differing from one another in texture or composition and generally arranged systematically parallel to the contacts. From the walls inward the zones are generally referred to as border, wall, one or more intermediate zones, and core. Contrast between zones ranges from sharp to indistinct. The common types in the Dawley Canyon area are illustrated in figure 9, and other examples are shown in plates 5 and 6, and figure 10. Zoned pegmatites probably crystallized progressively from the fine-grained border zones inward to the cores.

Border zones in the Dawley Canyon pegmatites are commonly composed of plagioclase, quartz, and muscovite in different proportions. The plagioclase in the four samples of plagioclase-quartz-muscovite border zones that were examined in index liquids is albite and sodic oligoclase, ranging from An_8 to An_{12}. Perthite occurs in border zones of some pegmatites rich in potassium feldspar. The border zones are commonly about 1 to 4 inches thick, but are locally as much as 12 inches thick. The grain size is generally one-fourth inch or less. The border zones are the finest grained parts of the pegmatite bodies except for units of aplitic texture. The coarsest grains in the border zones are generally muscovite and perthite. Both muscovite and the rectangular perthite grains tend to be oriented with the long dimensions of the crystals perpendicular to the contact. Border zones are best formed where the contacts with wallrocks are sharp. Where the contact with granite is gradational and irregular, for example several pegmatites near locality D7, the border zone is commonly poorly defined or indistinct even though the inner pegmatite zones are well defined.

The wall and intermediate zones are generally coarser grained than the border zones but range from fine to coarse grained. They are composed of plagioclase, quartz, muscovite, and perthite in different proportions, together with smaller quantities of garnet, beryl, or biotite. Perthite is generally more abundant in the wall and intermediate zones than in border zones. The wall and intermediate zones are commonly about 0.5 foot to 6 feet thick.

In zoned pegmatites of Dawley Canyon, the cores are composed of quartz, quartz-perthite pegmatite, or of quartz-albite-perthite pegmatite. Many cores are discontinuous, lenslike bodies along the middle of the dike. In a few pegmatites the core makes up most of the dike, flanked by thin border zones, or thin border and wall zones.

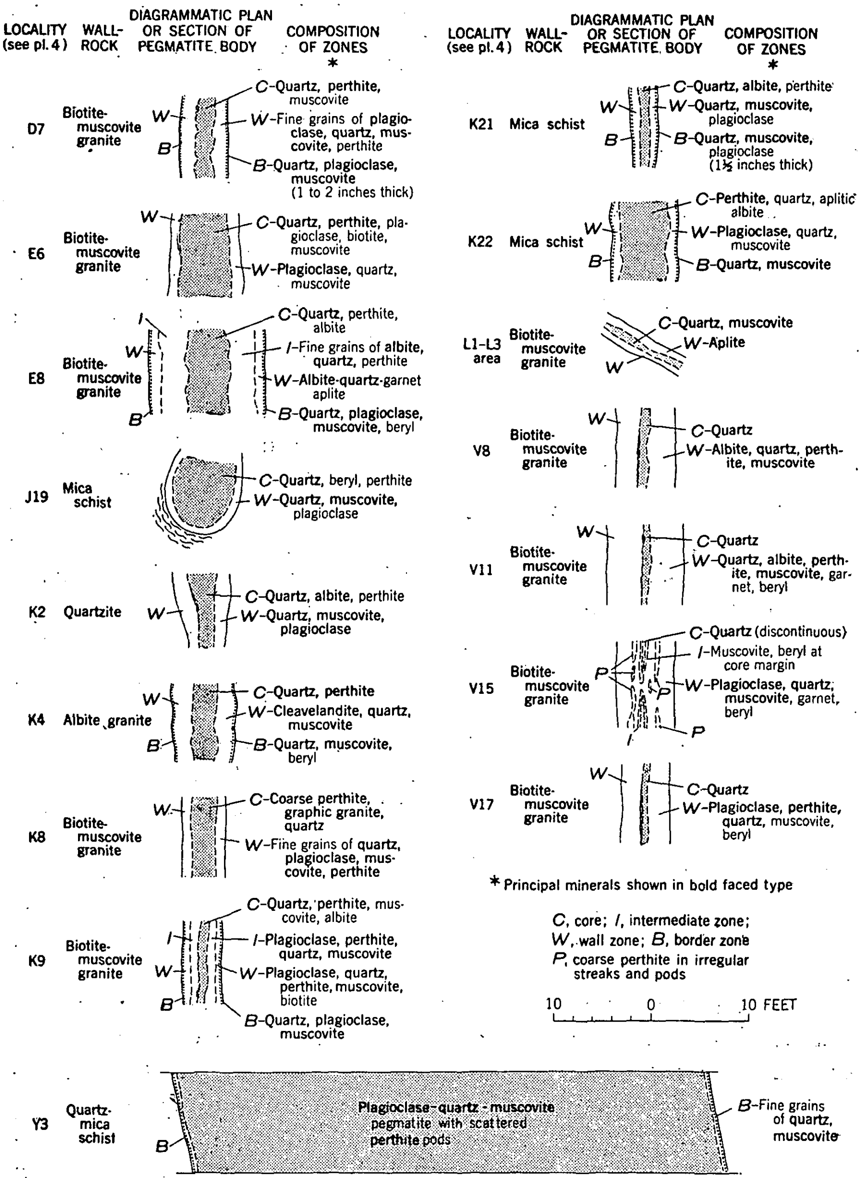


FIGURE 9.—Examples of zoning in pegmatites of the Dawley Canyon area.

COMPOSITE DIKES

Some dikes are clearly composite, resulting from two or more separate injections of pegmatitic fluid. Composite dikes may be difficult to recognize if the component pegmatites are homogeneous and similar in composition and texture. A composite dike may be recognized, however, if the zones in one component part of the dike are distinguishable from the remainder of the dike. Such a composite dike at locality J21 is illustrated in figure 10 and described on pages 167–168.

PEGMATITE-APLITE RELATIONS

The occurrence of pegmatitic and aplitic textures in the same dike is a conspicuous feature in the Dawley Canyon pegmatite area and has also been described in many other areas in the world (see, for example, Schaller, 1925; Cook, 1925; Andersen, 1931, p. 8–9, 28–31; Derry, 1931, p. 469; Vogt, 1931, p. 56–61; Brammall and Harwood, 1932, p. 222; Stockwell, 1933a, p. 27–36, 1933b, p. 37–51; McLaughlin, 1940, p. 62–63; Olson and others, 1946, p. 6, 10, 28, 54; Heinrich, 1948, p. 430; Steven, 1949, p. 263; Jahns and Wright, 1951, p. 21–22, 28–29; Hanley, 1951, p. 11; Staatz and Trites, 1955, p. 20–27).

The aplite that occurs in some of the Dawley Canyon pegmatite dikes is a white to light gray mosaic of albite, quartz, and sparse garnet grains. The grain size is as large as 1 mm but typically is about 0.2 to 0.5 mm. Locally a few muscovite grains as large as 1 cm occur but these are not typical.

In the Dawley Canyon area, pegmatite and aplite are mingled in the same dike in all proportions. The structural relations of these two rock types of markedly different grain size are not uniform throughout all the dikes. Within some dikes, the wall zones may be aplite and the core and border zone pegmatite, or the wall zones may be pegmatite and the core aplite. In pegmatite dikes the aplitic zones are interpreted to have crystallized, like other zones, at the appropriate stage in the progressive crystallization of the body from the walls inward, but the sugary texture presumably indicates an abrupt change in the conditions of crystallization, probably a sudden diminution in amount of volatile constituents. Contacts between pegmatite and aplite are commonly sharp.

In many dikes, however, the aplite is not in well-defined zones but is mixed with coarse-grained pegmatite in various proportions. A dike that is chiefly albite-perthite-quartz pegmatite may contain several irregular layers or lenses, roughly parallel to the dike walls, of albite-quartz aplite. In some dikes, perthite crystals several inches thick are scattered in an aplitic matrix or are distributed irregularly along planes parallel to the walls.

The age relations among the mixed pegmatitic and aplitic units are generally difficult to determine, except for those aplites that are in symmetrical zonal position, but undoubtedly the crystallization of coarse- and fine-grained varieties alternated in some dikes. Perthite crystals in the border zones of some dikes project inward into aplitic rock and probably crystallized before the aplite. Pegmatite cuts across the garnet bands in aplitic inclusions, which indicates that aplite preceded some pegmatite. Thin pegmatitic layers in dikes probably crystallized from residual fluids trapped along nearly parallel fractures in previously formed aplite. These relationships indicate that aplite may be both younger and older than associated pegmatite. Similar relations have been described in other areas (Stockwell, 1933a, p. 36, 1933b, p. 37–51; Andersen, 1931, p. 28–31; Vogt, 1931, p. 60–61).

The origin of dikes containing units of sharply contrasting grain sizes is puzzling. Schaller (1925, p. 269–279) suggested that the aplitic units in some pegmatite dikes are the result of replacement. In the Dawley Canyon pegmatites, fine-grained albite aplite may form small replacement bodies locally but most of the aplite shows no evidence of a replacement origin and some of it is in a zonal position that suggests crystallization in the sequence from the walls inward. The complex relations between pegmatitic and aplitic textural varieties in the Dawley Canyon pegmatites imply that delicate thermal and chemical conditions existed during crystallization and that slight changes in these conditions could bring about fluctuations between the crystallization of aplite or pegmatite.

A prevalent hypothesis is that the textural and mineralogical differences between aplite and pegmatite are the result mainly of differences in viscosity of the magmatic fluid, which in turn is a function of the content of volatile constituents, chiefly water (Andersen, 1931, p. 28–31; Vogt, 1931, p. 87; Spurr, 1923, p. 313, 325). The structural features of aplite dikes suggest a relatively dry magma of greater viscosity, whereas the internal and external features of pegmatites, as well as their extremely coarse grain size, indicate a thinner fluid with high content of volatile constituents.

If content of volatile constituents was the decisive factor in determining whether aplite or pegmatite formed, the mingling of streaks or layers of one type with the other must require considerable local variation or fluctuation in volatile content. Rapid diminution in volatile constituents at one or more times in the crystallization history of the dikes might explain the aplite near margins, in the center, or at several places within a pegmatite-aplite dike.

LINE ROCK

One of the distinctive features of the Dawley Canyon pegmatites is the widespread occurrence of garnet in thin bands, which appear as parallel lines on rock surfaces, chiefly in aplite and granite. The banded garnet-albite aplite in the Dawley Canyon area is strikingly similar to the line rock in the Pala and Rincon pegmatite areas in San Diego County, Calif. (Schaller, 1925, p. 269–279; Jahns and Wright, 1951, p. 22, 34–35; Hanley, 1951, p. 11, 13–14), the banded garnet phase of pegmatites in the Bridger Mountains, Wyo. (McLaughlin, 1940, p. 62–63), and the line rock in the Quartz Creek pegmatite district, Gunnison County, Colo. (Staatz and Trites, 1955, p. 23–24).

The bands of garnet are found mostly in very fine grained, sugary-textured aplite, although garnet crystals are also disseminated in much of the pegmatite, aplite, and albite granite. The crystals are commonly about 0.5 to 2 mm in diameter, and many of the garnet-rich layers are 0.5 to 10 mm thick. Several bands may occur in a thickness of 1 inch, separated by albite-rich aplite in which garnet may be disseminated. The bands of garnet are uniform in thickness over lengths of many feet. The banded rock, characterized by alternating layers rich in garnet and albite, persists in places for a few inches to tens of feet, but it is not known to extend for the full length of any dike. The bands of garnet generally parallel the walls of the dike. However there are many small undulations, broader "rolls," deflection around coarse crystals or masses of coarse-grained pegmatite (pl. 6), or other local swirls probably caused by plastic deformation or detachment of blocks of garnet aplite before complete solidification of the dike.

Garnet bands are most conspicuous in aplite and in the aplitic zones in zoned pegmatite, but they also are found in some coarser grained pegmatite. In the Errington-Thiel adit, for example, a single band of garnet crystals occurs locally at the boundary between the plagioclase-quartz border zone, 6 inches thick, and the coarser grained muscovite-albite-quartz wall zone, but no other garnet bands were noted in the wall zone or the cleavelandite-quartz core. This band of garnet grains may thus represent a sharp change in conditions during the crystallization of the pegmatite.

MINERALOGY

The pegmatites of the Dawley Canyon area contain quartz, albite, oligoclase, microcline perthite, muscovite, biotite, beryl, garnet, tourmaline, hematite (specularite), apatite, phlogopite, columbite-tantalite, autunite, andalusite, and sillimanite; in addition, adularia and phenakite are reported (D. J. Fisher, written communication, 1943). Of these minerals, only muscovite and beryl are sufficiently abundant to be of economic interest.

QUARTZ

Quartz commonly makes up 25 to 35 percent of the pegmatite dikes; rarely it is as much as 90 percent (loc. J19). A few small pegmatite masses are nearly all quartz except for a few muscovite books an inch across. The quartz is gray, massive, and fine to coarse grained. Smoky quartz is rare. Quartz also is graphically intergrown with perthite in some pegmatites, chiefly in the largest pegmatite bodies enclosed in granite. Quartz is in all zones of the Dawley Canyon pegmatites, but most abundant in cores and border zones. It is the chief or only constituent of many cores, and makes up more than half of many border zones. In wall and intermediate zones it commonly makes up about 15 to 35 percent.

FELDSPAR

The approximate compositions of 50 plagioclase samples from granite and several parts of pegmatites were determined by examination in index liquids by D. A. Brobst and the writers and are tabulated in table 3. The compositions were determined from the indices of refraction using the curves of Tsuboi, as diagrammed by Winchell (1951, p. 280). All but one of the 41 pegmatite samples contain albite, in the range An_0 to An_{10}. The one exception is sodic oligoclase (An_{12}) from the border and wall zones of the western dike of the Errington-Thiel mine.

TABLE 3.—*Composition of plagioclase in 50 samples of pegmatite and granite, Dawley Canyon area*

Type of pegmatite or granite	Number of samples in which anorthite content was determined			
	An_{11-17}	An_{7-10}	An_{3-6}	An_{0-2}
Pegmatites:				
Border zones composed of plagioclase, quartz, muscovite	1	3		
Wall and intermediate zones composed of quartz, albite, perthite, muscovite			26	
Cores composed of cleavelandite and quartz				2
Aplitic units in pegmatite		2	4	
Unzoned fine-grained pegmatite			3	
Granites:				
Biotite-muscovite granite	2	1	1	
Albite granite	2	2		1

The anorthite content of plagioclase in the 41 pegmatite samples reflects the zonal structure of the pegmatite bodies. The albite and sodic oligoclase in four samples from thin border zones of pegmatites is An_8 to An_{12}. Twenty-six samples from intermediate or wall zones contain albite (An_3 to An_6) and three albite grains from unzoned pegmatites are also in this range. The two most sodic albite samples (An_0 to An_2) are coarse-grained cleavelandite in or adjacent to the cores of pegmatites.

Microcline perthite is abundant in the Dawley Canyon pegmatites, although it is less abundant than albite. The quantity of perthite differs from zone to zone and dike to dike. Perthite makes up more than 50 percent of a few of the larger pegmatite masses, particularly in the northeastern and southeastern parts of the area, but many pegmatites, particularly the thinner bodies in or near metamorphic rocks, contain very little or none. The perthite is found chiefly as medium- to coarse-grained blocky crystals, but it is not generally in large pure masses that could be easily hand cobbed. Because of this feature and the long distance to railroad and to consuming centers, the feldspar has not been mined.

In coarse-grained perthite-quartz cores, the perthite commonly occurs as rectangular grains 3 or 4 inches long, rarely as much as 15 inches. Some pegmatites that are not clearly zoned contain a slightly greater percentage of large blocky perthite crystals in the center than near the margins. In some dikes the rectangular perthite crystals are oriented perpendicular to the walls of the dike; rarely in thin dikes they extend across the entire width. Another common orientation of the rectangular perthite crystals is parallel to the walls of the dike, indicative of flowage or shearing stresses at time of emplacement.

Graphic granite occurs in some cores and in lesser amounts in intermediate and wall zones. Perthite and graphic granite are common constituents of unzoned pegmatites, in which they may be either uniformly disseminated throughout the dike or clustered in irregularly spaced pods or lenses in otherwise homogeneous pegmatite.

Microcline that is not perthitic constitutes probably less than 1 percent of the feldspar in the dikes of the district but it has been noted in veinlike bodies in pegmatite. It seems to have formed relatively late in the sequence of pegmatite minerals.

MICA

The muscovite in the Dawley Canyon area ranges in size from tiny flakes to books 1 foot or more across, and locally constitutes 5 to 10 percent of parts of the pegmatites. The muscovite is very pale green to light greenish brown and is mostly clear and free of stains. Fine muscovite crystals less than 1 inch in diameter occur in nearly all parts of the pegmatites, but the coarse crystals are generally localized in cores, core-margin (intermediate) zones, and in wall zones. The coarse-grained muscovite is generally associated with quartz. The mica books may have any orientation, but those near the walls tend to be arranged with their long dimensions at right angle to the contacts. Plumose aggregates of silvery muscovite occur locally in a few pegmatites.

Coarse-grained muscovite is abundant in about six localities and a small quantity of sheet mica was produced in 1943–45 from the Errington-Thiel mica mine. However most of the muscovite would be classified as scrap mica because the crystals are commonly broken, ruled, distorted, or of small size. The proportion of large, flat sheet mica more than 1 or 2 inches in diameter to total mica is low in comparison to deposits in other mining districts. Therefore mica prices would probably have to be higher than they were during World War II to make mica mining profitable in the area.

Biotite is uncommon in the Dawley Canyon pegmatites but occurs in a few places as small flakes near contacts with schist and in or adjacent to quartz cores. Rarely, thin strips of biotite, as much as 8 inches long, occur in a crude radial arrangement.

BERYL

Beryl was found in nearly one-third of the 350 or more pegmatite dikes more than 1 foot thick in the area mapped. The beryl-bearing pegmatites are in granite, schist, and quartzite, particularly near the margins of the granite stock, and for that reason they are abundant in most of the Dawley Canyon area. In nearly half of the deposits, beryl occurs as small, sparse crystals that probably make up less than 0.01 percent of the pegmatite.

Beryl may occur in any part of a pegmatite body, but in any one dike it commonly shows a preference for only 1 or 2 zones in which its distribution is generally spotty. In some dikes it is virtually restricted to border zones. In others it is most abundant in wall zones. Beryl is also found in the cores, where it locally forms coarse crystals. Beryl occurs chiefly with plagioclase and quartz, and is relatively uncommon in perthite-rich pegmatite. For example the fine-grained albite pegmatite, which constitutes 30 to 75 percent of different parts of the dike at locality V11, contains about 0.5 percent beryl, but the percentage throughout the dike is lowered by beryl-free perthite-quartz pegmatite that makes up the remainder.

The beryl ranges in color from azure through several shades of green to white. The hexagonal prisms of beryl are fine to medium grained, and nearly all the crystals are less than 1 inch in diameter; many are 0.1 to 0.25 inch in diameter, whereas others are microscopic. The largest beryl crystal found during the investigation is 3 inches in diameter. Very few crystals in the Dawley Canyon area are large enough to be separated easily by hand cobbing.

The index of refraction of the ordinary ray of the Dawley Canyon beryl is consistently 1.574 to 1.576, which indicates a BeO content of about 13.5 percent (table 2). Little variation in composition of beryl is apparent in different zones of a pegmatite body. Of 11 beryl crystals examined microscopically, only 3 have indices greater than 1.576. A green beryl crystal from the northwestern dike at the Errington-Thiel mine (pl. 5) has an index of refraction, nO, of 1.580. The index of refraction of one from the wall zone of the western dike at the Errington-Thiel mine is 1.578, and that of an azure crystal found at locality V11 is 1.581.

The percentages of beryl in the pegmatite were estimated principally on the basis of beryl counts on exposed surfaces, because no production records are available and no systematic sampling has been done. Counts made of beryl visible in an exposure are apt to be misleading because prospectors have excavated the richer exposures and broken off many crystals of beryl. Exposures of beryl concentrations which now contain no more than 0.1 percent beryl may have seemed richer, perhaps 0.5 to 1 percent before excavation. In general, however, rock containing more than 0.1 percent beryl is probably spotty in its distribution and limited to small deposits. The beryl deposits are commonly less than 100 feet long and are not coextensive with the entire dikes. Whereas pegmatite in an exposure 20 feet long and 4 feet thick might contain 0.1 percent beryl, other exposures of the same dike might show little or no beryl, and the beryl content of the entire dike would thus be less than 0.1 percent. To make an approximate estimate of these low percentages, particularly in the finer grained rocks, visual estimates were augmented by sampling and analytical work.

Quantitative spectrographic analyses for beryllium provide confirmatory evidence of the beryl content of the dikes determined by beryl counts. Of 28 samples from several parts of the area submitted by D. J. Fisher (written communication, 1943) for spectrographic BeO determination, one contained 0.1 percent BeO, one contained 0.06 percent, two 0.03 percent, five 0.01 percent, two 0.006 percent, and seventeen 0.001 percent. Spectrographic analyses of samples taken by J. C. Olson are given in table 4, and indicate amounts of BeO similar to those obtained by Fisher.

The BeO analyses given in table 4 are generally commensurate with the BeO content expectable from counts made of beryl crystals in the pegmatitic rocks. Many of the very fine-grained rocks, however, such as samples R–6, R–9, R–12, R–13, and R–22 of albite granite and

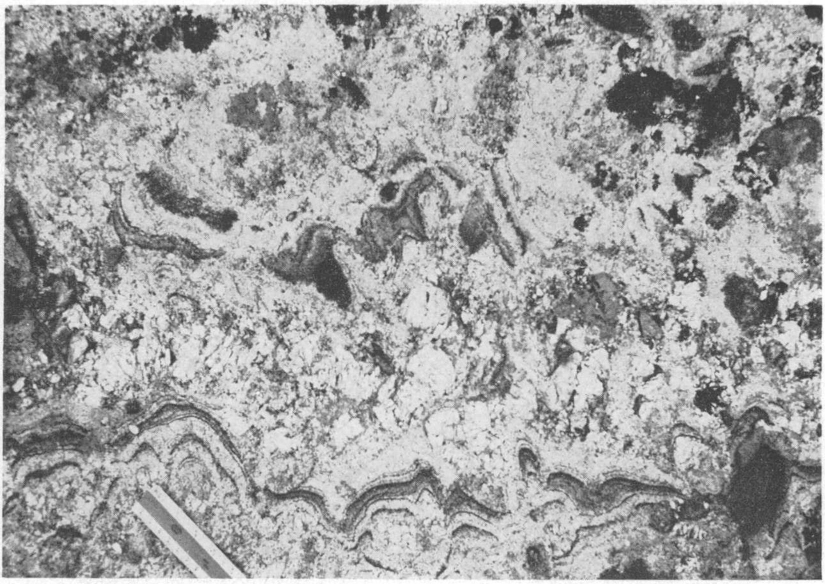
R–14, R–16, and R–18 of aplitic units in pegmatite show BeO contents of 0.0017 to 0.039 percent, yet beryl was not noticed in hand specimens of these rocks. Appraisal of the beryllium content of these fine-grained rocks would require spectrographic analyses or petrographic study of many more samples. Enough samples were analyzed, however, to indicate the approximate range of BeO content in the finer

TABLE 4.—BeO *content of samples from the Dawley Canyon area, determined spectrographically*

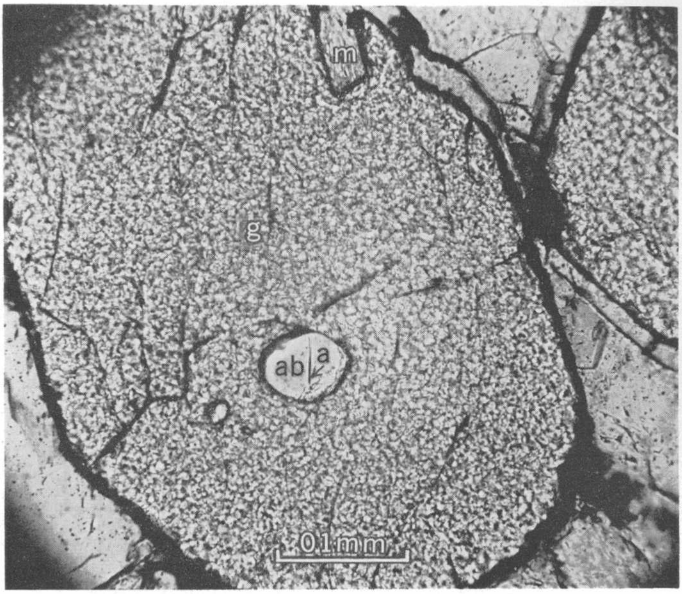
[Analyses by Saratoga Laboratories, Saratoga Springs, N.Y.]

Sample No.	Locality (pl. 4)	Description	Percent BeO
		Granite	
R–6	E2	Albite granite	0.0020
R–12	K3	do	.0030
R–13	J14	do	.0023
R–9	J6	Pegmatitic albite granite	.0017
R–22	X6	Pegmatitic albite granite, 6-ft dike	.0029
R–19	(1)	Altered granite, Sliper mine, 4 miles south of Dawley Canyon area.	<.0001
		Aplitic unit in pegmatite	
R–14	E8	Aplitic unit in pegmatite	0.039
R–21	K27	do	.0013
R–16	H25	Aplitic unit in pegmatite 6 ft thick	.012
R–18	H21	Garnet-bearing aplitic unit in pegmatite	.029
		Pegmatite	
R–24	F5	Fine-grained unzoned pegmatite	0.0025
R–4	Y4	Fine-grained wall zone of pegmatite	.0019
R–7	Y4	do	.070
R–11	Y4	Fine-grained beryl-bearing pegmatite	.10
R–2	T24	Fine-grained plagioclase-quartz-muscovite pegmatite.	.039
R–8	K4	Plagioclase-rich zone of pegmatite	.0008
R–10	(2)	Wall zone of Eastern dike	.024
R–15	J21	Albite-quartz-perthite wall zone	.0016
R–23	(2)	Plagioclase-quartz-muscovite pegmatite (near *B′* on pl. 4).	.0068
R–17	X1	Fine- to medium-grained beryl-bearing pegmatite.	.038
R–20	E8	Fine-grained pegmatite	.0011
R–5	(2)	Cleavelandite-rich core of Western dike	.0005
		Quartz veins	
R–1	J13	Massive quartz vein in schist	0.0001
R–3	J11	Massive quartz vein in granite	.0004

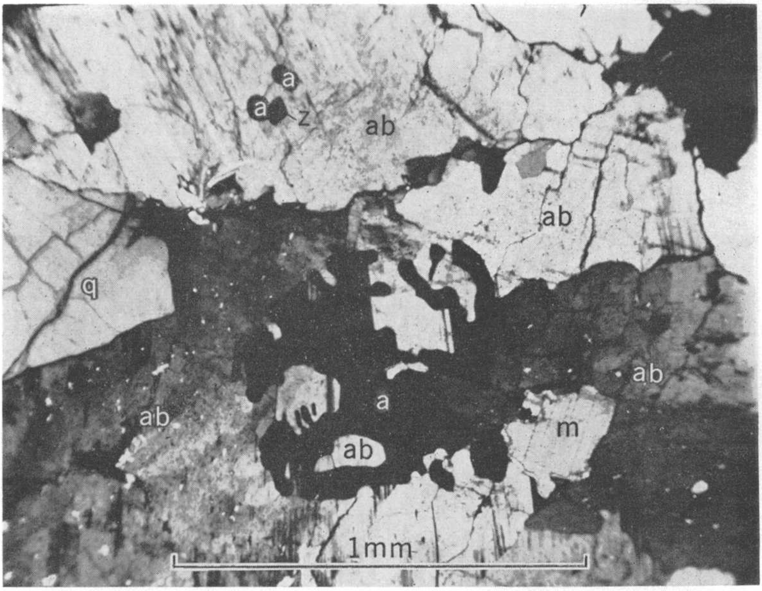
[1] Sliper mine (see fig. 8).
[2] See pl. 5.



Wavy garnet bands along borders of small pegmatite body in albite granite, locality H3, Dawley Canyon area



A. Photomicrograph of garnet, *g*, enclosing muscovite, *m*, and albite, *ab*. Apatite, *a*, inclusion in albite. Border zone at hanging wall, Northwestern dike, Errington-Thiel mine. 159×, plane-polarized light



B. Photomicrograph of skeletal apatite, *a*, in albite, *ab*, quartz, *q*, muscovite, *m*, and zircon, *z*. Wall zone near hanging wall, Northwestern dike, Errington-Thiel mine. 31×, crossed nicols grained rocks and to point out the wide distribution of beryllium in the Dawley Canyon area. In contrast, the one sample of granite from outside the Dawley Canyon area (R–19 from the Sliper mine nearly 4 miles south of Dawley Canyon) contains less than 0.0001 percent BeO. In addition, beryllium was not detected in the spectrographic analysis of a sample of the granite at Harrison Pass collected in 1954 (W. R. Griffitts, oral communication).

The BeO content ranges from 0.0005 to 0.1 percent in different parts of pegmatites. The BeO content of aplite zones of different pegmatite bodies no doubt varies considerably, although the few analyses do not show as great a variation as in the pegmatitic rocks.

GARNET

Garnet is widespread in the pegmatites, albite granite, and aplite, as well as the metamorphic rocks, and a small amount of garnet occurs locally in the biotite-muscovite granite. It generally forms a fraction of a percent of the pegmatite, but locally constitutes several percent. Garnet crystals as large as 2 inches in diameter occur in the pegmatite at locality E8, but most of the garnet in the area is in grains about 0.01 to 0.05 inch in diameter. The larger crystals, 0.1 to 2 inches in diameter, are commonly altered, fractured, iron or manganese stained, and are rusty brownish red. The smaller crystals are generally clear and little altered, and are red, orange red, or lavender.

The indices of refraction and specific gravities of garnet crystals from different rock types in the Dawley Canyon area are given in table 5.

TABLE 5.—*Index of refraction and specific gravity of garnet, Dawley Canyon area*

Rock type and locality (pl. 4)	Number of samples	Index of refraction	Specific gravity
Quartz-mica schist, Errington-Thiel mine	3	1.815–1.820	3.92–4.00
Do	1	1.809	----------
Mica-garnet schist, 200 ft. west of J27	1	1.815	----------
Albite granite, K3	1	1.815	----------
Muscovite-biotite granite, Tipton Creek	2	1.815	----------
Pegmatite, border zone, Errington-Thiel mine	1	1.82	----------
Pegmatite, wall zone, Errington-Thiel mine	2	1.815–1.820	4.13
Pegmatite, intermediate zone, Errington-Thiel mine	2	1.82	4.11–4.12
Pegmatite, quartz core, Errington-Thiel mine	1	1.82	4.11
Pegmatite, undivided, southwest of H3	1	1.82	4.13

Garnet occurs both as disseminated crystals and as concentrations in thin layers in pegmatite and aplite. It is found chiefly in albite-rich pegmatite and is rarely associated closely with perthite. The perthite-rich pegmatite at K8 contains very little garnet, but 4 feet to the east is an albite-rich, perthite-free pegmatite in which garnet is abundant, forming as much as 5 percent of the rock in one thin zone. A few flat or equant garnet crystals occur in muscovite in several localities, but these are not sufficiently common to be an important defect in the muscovite.

OTHER MINERALS

A few crystals of columbite-tantalite were found, but their occurrence seems to be only of mineralogic interest. Autunite was found in sparse flaky crystals at several places. The greatest abundance of autunite is at locality V14, where it occurs along a steeply dipping fracture zone. Black tourmaline is relatively uncommon in the area. Cavities in quartz in several pegmatites are lined with shiny plates of specularite. Sillimanite occurs in the schist and in a pegmatite only a few inches thick, a quarter of a mile north of the Errington-Thiel mine. Here it is associated with pink andalusite, quartz, muscovite, deep pink garnet, and manganese stains.

MINES AND PROSPECTS

During the fieldwork some record was obtained on about 55 excavations in the Dawley Canyon area, from which an estimated 3,100 tons of rock was moved. In addition, there are 50 or 60 pits from which 1 to 10 tons of rock each has been moved, but the total tonnage of rock moved in all prospecting in the area is probably less than 4,000 tons. About half of the 3,100 tons of rock mentioned above has been mined from 4 openings, the Errington-Thiel mica mine, the beryl prospect at locality V15 (pl. 4), the Mutual Mica Co. mine, locality Q5 (pl. 4), and an unnamed mica mine, locality K2 (pl. 4). The total amount of mica and beryl produced in the area is unknown but small. The U.S. Bureau of Mines Minerals Yearbook lists no beryl production from Nevada for the years 1937–54. A small amount of mica was produced in 1943–45, and a few pounds have probably been produced in previous years. What little beryl has been produced was mainly for specimen material or metallurgical tests, and the amount of Dawley Canyon beryl used in industry is negligible.

ERRINGTON-THIEL (BIG) MICA MINE

The Errington-Thiel (Big) mica mine is owned by Mrs. A. T. Errington and Mr. Oscar W. Thiel, who reside near the mine at Ruby

Valley, Nev. The mine produced a small quantity of sheet muscovite during World War II

In the mine area (pl. 5) about 80 feet of pale-gray medium-grained quartzite is exposed. The quartzite is composed of quartz, biotite, and muscovite, with small amounts of apatite and zircon. The quartzite layers are commonly 6 inches to 5 feet thick and are separated by quartz-mica schist layers 5 inches to 4 feet thick. Flat quartz pebbles half an inch long are near the bottom of some layers. The quartz-mica schist is composed of muscovite, hornblende, quartz, garnet, biotite, magnetite, and sillimanite.

Albite granite is exposed in the eastern part and about 600 feet northwest of the area mapped (pl. 5). In the east exposures the granite is fine to medium grained and contains small lenses of pegmatite and inclusions of quartzite and schist (pl. 5). The boundaries between textural varieties are gradational and irregular. The principal minerals of the granite are quartz, plagioclase, orthoclase, and muscovite, with accessory garnet, apatite, and zircon. Biotite-muscovite granite crops out in 2 areas at an altitude of about 7,760 feet in the southwestern part of the area mapped. It has intruded quartzite and schist and is cut by pegmatite.

Eleven pegmatite dikes and at least three small pegmatite sills have intruded the granite, schist, and quartzite in the area mapped. The dikes are parallel, strike northward, dip 40° E. to vertical, and are 10 to 50 feet apart. They are 30 to 350 feet long, and 1 to 12 feet thick. The pegmatite dikes generally parallel the more prominent joints in the schist and quartzite. The contacts of the pegmatites with schist and quartzite are generally sharp and even, but where the pegmatites cross a small body of pegmatitic albite granite their contacts are indistinct because of the similarity in composition and texture between the two rocks.

All but three small pegmatite dikes are zoned; individual zones are commonly discontinuous and therefore do not appear in every section across a dike. The border zones, generally less than 2 inches thick, are composed of muscovite grains, one-fourth inch maximum diameter, with variable but generally small amounts of quartz and plagioclase. The wall zones are composed of 0.5- to 4-inch grains of muscovite, quartz, and plagioclase. The intermediate zones generally consist of fine-grained albite and quartz with scattered clusters of perthite grains 2 to 6 inches long and cleavelandite plates 1 to 3 inches long. The discontinuous cores are elongate lenses of quartz, or quartz and muscovite.

The pegmatites on the Errington-Thiel property contain, in approximate order of abundance, plagioclase, quartz, muscovite, perthite, garnet, beryl, microcline, apatite, zircon, hematite, biotite, phlogopite, tourmaline (schorl), and penninite.

The albite, quartz, and muscovite commonly form grains 0.2 to 1.5 mm in diameter. In 23 samples taken along 6 cross sections, the plagioclase is albite (An_3) except at the northernmost pit of the Western dike, where the border and wall zones contain oligoclase (An_{12}). White to pale yellow albite is abundant in the pegmatites as anhedral grains and also as tabular cleavelandite plates about 1.5 mm thick and as much as 19 mm long. The albite commonly shows both polysynthetic and carlsbad twinning.

Quartz occurs in the pegmatites as glassy, gray anhedral grains and veinlets. Some of the grains contain streaks of very small rounded inclusions of an undetermined composition. Pale-green to pale-brown muscovite, generally free from stains, occurs in all zones. It is most abundant in the wall zones, where books as much as 5 inches in diameter show a preferred orientation perpendicular to the zone contacts. Scattered large books occur in or near the cores. Quartz, muscovite, and microline locally fill fractures in albite.

Red garnet crystals as much as 4 mm in diameter are scattered throughout the pegmatites or are concentrated in thin layers. The larger crystals are rusty red brown; the smaller ones are clear red orange trapezohedrons with small dodecahedral faces. The garnet crystals in the pegmatites are of uniform chemical composition as indicated by the specific gravity of 4.12 ±0.01, the index of refraction 1.82 ±0.005 (table 5), and the presence of manganese. These properties correspond to a composition of 54 percent spessartite, 36 percent almandite, and 10 percent andradite (Winchell, 1951, p. 384). The optical properties and specific gravity of 3 samples of garnet in the schist correspond to a composition of 65 percent almandite, 18 percent andradite, and 17 percent pyrope. The garnet crystals in the pegmatites enclose grains of beryl, albite, muscovite, quartz, and biotite (pl. 7*A*). The mineral inclusions in garnet of the pegmatites and the differences in composition from the garnet crystals of the surrounding schist suggest that the garnet in pegmatites was not derived from the schist but crystallized from the pegmatitic fluid. Some garnet is altered to hematite and penninite.

Beryl occurs in the pegmatites on the Errington-Thiel property as pale-green to white euhedral prismatic crystals generally less than 1 mm but as much as 5 mm in diameter. Many of the crystals taper and are rounded at the larger ends and terminated at the smaller by pyramids. Cross fractures are common. Beryl occurs sparingly in each zone of the dikes sampled, the only noticeable concentration being in the outer part of the wall zone. Beryl also occurs as anhedral inclusions in muscovite, garnet, and albite. The enclosure of a small rod of apatite by beryl suggests that the beryl began crystallizing after the apatite and before or during the crystallization of albite, muscovite, quartz, and garnet. In the Western dike, one crystal from the wall zone has an index of refraction of 1.580 for the ordinary ray, and a crystal from the core has an index of refraction of 1.576, a variation of 13.0 to 13.4 percent in BeO content respectively.

Fine-grained beryl occurs in some of the pegmatite and aplite in the Errington-Thiel mine area. The visual estimation of percentage of fine-grained beryl in hand specimen is sometimes difficult because part of the beryl is white and resembles the plagioclase and quartz, and in thin section it resembles apatite in shape and optical properties. Studies of 21 thin sections from pegmatites at the Errington-Thiel mine show combined beryl and apatite content ranging from 0 to 1.5 percent, the apatite generally exceeding the beryl content. This approximation of beryl content is in general accord with the results of spectrographic analyses for beryllium (table 4) in fine-grained rocks from other localities in the Dawley Canyon area.

Microcline was observed only in the wall zone of the Western dike, as veinlets in large albite grains, and in the plagioclase-quartz-muscovite intermediate zone at the north end of the Northwestern dike, where veinlets of microcline cut across cleavelandite grains.

Apatite occurs in all zones as small pale blue-green rods enclosed in quartz and albite. A photomicrograph of a skeletal crystal of apatite is shown in plate 7 *B*. Most of the rods are shorter than 0.2 mm, although one, 0.9 mm long, occurs in albite parallel to the twinning. Zircon forms clusters of minute angular grains and small tetragonal bipyramids. Hematite occurs as rims and fracture-fillings in altered garnet. Isolated cubes of hematite noted at two places are probably pseudomorphs after pyrite.

Sparse grains of biotite occur mostly near contacts with schist, and some may have been derived from the schist wallrock. Biotite is also found in the center of the Northwestern dike (pl. 5) near altered garnet. Some biotite flakes are included in garnet and muscovite. A few grains of phlogopite were identified in the hanging-wall part of the Northwestern dike. The phlogopite is colorless and except for a smaller optic angle is similar to muscovite. Black tourmaline (schorl) occurs sparingly as small irregular grains near the footwall of the Northwestern dike.

The Western pegmatite dike in the Errington-Thiel mine area (pl. 5) is about 8 feet thick and 290 feet long. It strikes N. 10° W., dips about 70° E., and is enclosed in schist, granite, and quartzite. The contacts with the schist and quartzite are generally even and distinct, but those with the albite granite are gradational. Two small bends or rolls in the hanging-wall contact of this tabular pegmatite body are exposed at the north pit, and above the adit.

The Western dike can be divided into 5 zones, of which only 4 are present in most of the exposures. The border zone, 4 inches thick, consists of fine-grained albite, quartz, muscovite, and a few crystals of beryl. The wall zone, 2 feet thick, is composed of coarse-grained muscovite, quartz, albite, and garnet. The clear, pale-green muscovite books are fractured and are commonly 3 or 4 inches in diameter. Small microcline veinlets in albite can be seen in thin section. The intermediate zone, averaging 2 feet in width, is composed of fine- to medium-grained albite and quartz that surrounds clusters of coarse-grained cleavelandite. A discontinuous core of very coarse-grained quartz and muscovite is exposed for about 6 feet at the north open pit.

In 1944 the Columbia Mica Corp. excavated about 80 feet of underground workings (pl. 5). Although sheet mica was mined from the wall zones (1.5 feet wide on the hanging wall), little sheet muscovite is now exposed in the face. Pieces of muscovite 2 by 3 inches in size are common on the dump.

The Northwestern dike is 11 feet thick, strikes roughly north, and dips about 35° E. It is exposed for about 100 feet (pl. 5). Although the same minerals occur in this dike as in the Western dike, they are not so distinctly zoned. The open pit, worked for mica first in 1938, exposes a vertical face composed predominantly of a central zone 6 feet thick of medium-grained albite, quartz, and muscovite with a few bands of small garnet crystals. Microscopic veinlets of microcline cut albite. The wall zone contains cleavelandite and coarse-grained muscovite. A small amount of beryl is in the pegmatite, mostly in the border zone. Black tourmaline occurs as a few small, flattened and broken crystals at the footwall contact with schist in the bottom of the open pit.

The Eastern dike is 8 feet thick and 350 feet long (pl. 5). It strikes north and dips 50°–80° E. Two small dikes branch off the larger one into the surrounding schist. Two sills, each about a foot thick, branch from the Eastern dike and crop out in the cliff of quartzite in the northeastern part of the area mapped. The 3-inch border zone consists of medium-grained quartz and muscovite. The wall zone, 1 foot wide, is composed of fine- to medium-grained albite, quartz, muscovite, and a few beryl crystals as large as 5 mm in diameter. Wavy bands of garnet are a distinctive feature of the Eastern dike. Thin layers of small garnet crystals separate the intermediate from the wall zone and from the core. The intermediate zone consists of fine-grained albite and quartz with scattered clusters of perthite crystals 2 to 4 inches long in coarse-grained quartz, muscovite, and albite. The core is discontinuous and is composed of coarse-grained quartz and muscovite. The pegmatite is cut by three small quartz veins in faults of slight displacement; the faults probably formed shortly after crystallization of the pegmatite.

OTHER LOCALITIES

Locality J21.—The composite pegmatite dike at locality J21 is illustrated in figure 10. The dike, which dips 80° N., is enclosed in albite granite. Four pegmatite zones are shown in the map of this

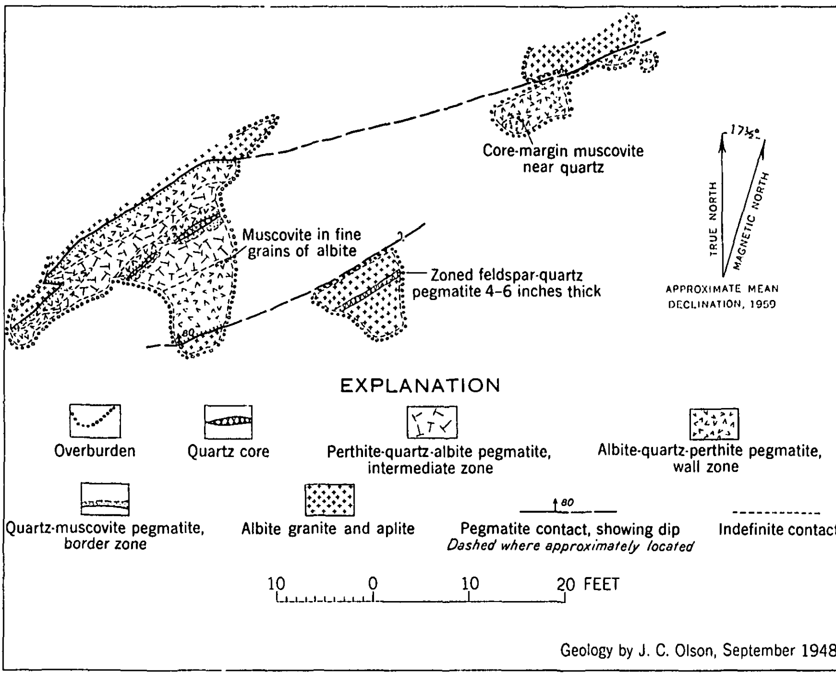


FIGURE 10.—Sketch map of composite pegmatite dike at locality J21, Dawley Canyon area.

pegmatite. The fine-grained border zone consists of about 80 percent quartz, 5 percent plagioclase, and 15 percent muscovite which forms books commonly oriented normal to the walls. It is 2 inches or less thick around the outer margins of the dike. However alongside the slabs of albite granite separating the 2 parts of the composite dike the border zones are 2 to 9 inches thick.

The wall zones, 1 to 6 feet thick, are composed of 5 to 20 percent perthite, 40 to 60 percent fine-grained albite (An_4), 25 to 45 percent fine-grained quartz, 2 to 4 percent muscovite, and beryl in one place.

The intermediate zone is 1 to 4 feet thick and is composed of about 45 percent perthite in crystals as much as 15 inches long, 25 to 45 percent quartz, 8 to 30 percent albite, and 2 percent muscovite. The core is an oval mass of quartz 1.5 feet thick, bordered by a few coarse crystals of muscovite.

Albite granite forms the walls of this composite dike, and thin slabs of granite in the central part of the dike divide the body into two parts. Garnet bands in the slab of albite granite are cut by the dike. Each of the two parts of the composite body has its own border, wall, and intermediate zones, which are dissimilar in size and shape.

Beryl constitutes about 0.26 percent of an area of 5.5 square feet in the south wall zone, but was not found elsewhere in the dike. A sample of the wall zone in another place, showing no beryl, contains 0.0016 percent BeO.

Locality K2.—At locality K2, a pegmatite dike more than 200 feet long has been explored by an 80-foot drift, at the end of which is a raise 25 feet to the surface, and 3 pits to the north. The underground work was done about 1931. The dike strikes N. 5° E., dips 70° W., and cuts quartzite. The dike is 7 feet in maximum thickness and thins to only 1 foot at the south end; at the north end it splits into 2 dikes 1.5 and 2 feet thick. The pegmatite has a quartz-plagioclase-muscovite wall zone and quartz-albite-perthite(?) core. Muscovite is abundant in the quartzose wall zone. Muscovite books are as much as 1 foot in diameter, but are bent, broken, and hence nearly all of scrap grade. The mica is clear, pale greenish brown. A few beryl crystals occur in the exposed pegmatite. Garnet in the albite has an index of refraction of 1.81 (D. J. Fisher, written communication, 1943), indicating spessartite with a small amount of almandite.

Localities K4 and K24.—Localities K4 and K24 are pits in a pegmatite dike at least 200 feet long and 5 to 7 feet thick. At the north end of the exposure, K4 is a pit 12 feet long and 7 feet in maximum depth; K24 is a small pit at the south end of the exposure. The dike strikes slightly east of north and dips 60° W. The pegmatite at the K4 pit has a 2-inch quartz-muscovite border zone containing several small beryl crystals, a cleavelandite (An_4)-quartz-muscovite wall zone in which most of the muscovite crystals are less than 2 inches in diameter, and a quartz-perthite core containing blocks of perthite as much as 1 foot long. A chip sample of the cleavelandite-quartz-muscovite wall zone analyzed spectrographically contained only 0.0008 percent BeO.

The pegmatite exposed in the K24 pit is similar in internal structure to K4. A quartz-muscovite border zone containing beryl is 0.5 to 1 foot thick. The beryl crystals are as much as 1 inch in diameter and are pale green to nearly white. Most of the remainder of the pegmatite is albite. The core consists of albite-quartz-muscovite pegmatite containing muscovite books 2 to 4 inches in diameter.

Locality V8.—The workings at V8 consist of an opencut 30 feet long, 15 feet wide, and 14 feet deep, from the west end of which an adit extends 30 feet N. 78° W. These workings are in alluvial detritus and granite. Above the adit, a small quarry 20 feet long exposes a face 8 feet high of pegmatite.

The pegmatite in the small quarry is 6 feet thick, at least 50 feet long, strikes N. 2° E., and dips about 70° E. in granite. The dike has a quartz core 1 foot thick. The remainder consists chiefly of fine-grained albite and quartz containing blocky crystals of perthite, some with graphic intergrowths of quartz as much as 1 foot in length. A small quantity of biotite occurs in the pegmatite near the footwall. A few small beryl crystals were estimated to make up about 0.02 percent of the 72-square-foot area of pegmatite exposed in the face. As some beryl may have been removed selectively from the quarry face by prospectors, this percentage may be somewhat less than is actually in the dike. Scrap muscovite makes up 3 to 4 percent of the pegmatite.

Locality V11.—The vertical pegmatite dike in biotite-muscovite granite at V11 is 7 to 8 feet thick, at least 250 feet long, and strikes N. 15° E. The pegmatite has a quartz core 0.5 to 1 foot thick. Between the core and the walls the pegmatite is composed of quartz, cleavelandite, perthite, muscovite, and garnet. A few blue beryl crystals less than 0.5 inch in diameter occur in fine-grained cleavelandite near the core.

Two en echelon pegmatite dikes occur in schist between V11 and the road to the south. Just north of the road are 2 pits in a dike about 10 feet thick that dips 60° E. The dike is well zoned, having a vuggy quartz core 2.5 feet thick. The core is flanked on the hanging wall side by an intermediate zone 2 feet thick of cleavelandite and quartz containing coarse perthite crystals as much as 2 feet thick. The wall zone is 3.5 feet thick and is composed of quartz and muscovite with a small amount of albite and garnet. Specularite was noted in vugs in a 4-foot quartz core in one outcrop of this pegmatite. The pegmatite zones between the core and the footwall are less well exposed and are composed chiefly of cleavelandite, quartz, muscovite, and garnet.

Fifty feet east of the dike just described is a small pit in a dike 5 feet thick composed chiefly of vuggy quartz with sparse beryl crystals.

In a small vug in the quartz, D. J. Fisher (written communication, 1943) noted some minute (about 0.5 mm) glassy pseudorhombohedrons of adularia, which seem to be contemporaneous with the drusy quartz that lines the cavity.

Locality V14.—At locality V14 a pegmatite dike 2.5 to 3 feet thick is exposed in a small pit. The dike is nearly vertical and contains a discontinuous quartz core. The west contact of the pegmatite at this point is probably a vertical fault. A quartz vein 1 foot thick cuts the granite 3 feet west of and nearly parallel to the pegmatite, and the granite between the pegmatite and the quartz vein is sheared, decomposed, and contains a small amount of autunite. The pegmatite is also sheared but to a lesser extent. A few small beryl crystals were found on the dump of the pit, and 5 beryl crystals make up about 0.02 percent of an exposure of the pegmatite 100 feet south of the pit.

Locality V15.—The drift 140 feet long at locality V15 was driven about 1940 in a nearly vertical pegmatite dike 6 feet thick. The dike strikes N. 9° E., dips 85° E., and has an exposed surface length of about 400 feet. Most of the dike is made up of plagioclase-quartz-muscovite pegmatite. Perthite is much less abundant than plagioclase and occurs chiefly in irregular coarse-grained streaks in the central part of the dike. Beryl and garnet occur locally. The well-defined but discontinuous core of gray to smoky quartz is 1 foot thick. Small mica flakes occur in pegmatite near the quartz core. The visible beryl makes up less than 0.01 percent of the entire exposed dike and is concentrated alongside the quartz core.

Locality Y3.—The largest pegmatite dike in the mapped area is exposed in 2 large outcrops 700 feet apart at locality Y3. The dike is 55 feet thick in the north outcrop, strikes slightly east of north, dips 65° W., and is discordant to the foliation of the schist.

The pegmatite is mostly homogeneous, fine grained, unzoned, and is composed chiefly of plagioclase, quartz, muscovite, and a small amount of garnet. Rectangular block crystals of perthite and graphic granite, as much as 1 foot long, occur in scattered coarse-grained pods. Within 6 inches of the schist is a border zone of fine-grained quartz-muscovite pegmatite. Beryl occurs as rare small crystals.

Locality Y4.—At locality Y4, a prospect pit 13 feet long and 4 feet deep has been dug at the east edge of a pegmatite outcrop 50 feet wide. The contact with schist, where exposed, strikes N. 25° E. and dips 80° NW. An inclusion or pendant of schist in the pegmatite is exposed in the pit.

The pegmatite dike is not regularly zoned. Patches of coarse- and fine-grained pegmatite are irregularly distributed. The fine-grained albitic pegmatite at the pit contains mica flakes commonly 10 mm in diameter and quartz, feldspar, and beryl grains 1 to 10 mm in diameter. Two beryl crystals 1 inch in diameter were noted in coarse-grained pegmatite near a schist inclusion. Beryl makes up about 0.1 percent of the area of the pit face. A sample of fine-grained albite pegmatite from the pit contained 0.07 percent BeO.

Locality Y6.—Locality Y6 is an elliptical outcrop of pegmatite nearly 50 feet wide in which a small trench has been excavated. The dike is composed of a mixture of fine-grained albite-rich pegmatite with irregular coarse-grained patches of microcline perthite. Small garnet crystals are common, and beryl crystals 0.1 to 0.5 inches in diameter are sparsely disseminated in the pegmatite.

OTHER AREAS IN ELKO COUNTY

CORRAL CREEK

Pegmatites cut the Harrison Pass stock near the head of Corral Creek, and one pegmatite in this area is reported to contain lepidolite (Sharp, 1942, p. 674). Several granitic pegmatites were examined in one day in this area by the writers in 1948 and by M. R. Klepper in 1942. A small amount of green microcline occurs in some of the pegmatites but neither lepidolite nor beryl was found.

GILBERT CANYON

The Gilbert Canyon area is on the west side of the Ruby Mountains, 9 miles east of Jiggs, at an altitude from 7,000 to 8,000 feet (fig. 8). Several pegmatites in the area were examined by M. R. Klepper in 1942, by D. J. Fisher in 1943, and by the writers on August 14, 1948. Pegmatites have been found on the sides of Gilbert and McCutcheon Creeks, but the prospecting has been done principally on the north side of Gilbert Canyon. The pegmatites are in biotite granite that is probably a part of the Harrison Pass granite stock.

The pegmatite in the Gilbert Canyon area has been explored chiefly by a trench and small pit in the SE¼ sec. 9, T. 29 N., R. 57 E. These workings, just north of Gilbert Creek, are at the edge of a white quartz mass 8 feet thick that apparently forms the core of a pegmatite body. Between the core and the granite footwall of the dike are (a) a core-margin zone containing perthite, coarse-grained muscovite, and two exposed beryl crystals; (b) an intermediate zone 3 to 4 feet thick composed of perthite with some albite, quartz, and fine-grained muscovite; and (c) a wall zone 2 to 3 feet thick that is chiefly graphic granite in which a few small blades of biotite are found near the granite contact. The quartz core seems to dip 30°–60° W., and the pegmatite above the quartz core is not exposed. A small amount of biotite occurs in shear planes in the lower part of the quartz mass.

The two blue-green beryl crystals have a total exposed area of 14 square inches, or about 0.1 percent of the 105 square feet of pegmatite exposed in the wall of the pit. A few broken crystals of blue-green and honey-colored beryl and a little columbite-tantalite were found on the dump. Red-brown garnet is plentiful in the pegmatite. A small piece of uraninite(?) and its alteration products was found by D. J. Fisher.

Fine-grained pegmatite containing a few scattered green beryl crystals has been explored by a small pit on the north side of McCutcheon Creek, near the center of sec. 4, T. 29 N., R. 57 E. Columbite-tantalite also occurs and a sample of it collected by M. R. Klepper is reported by Charles Milton of the Geological Survey to have a specific gravity of 6.1, which indicates a Ta_2O_5 content of about 30 percent.

Several other pegmatite dikes in the Gilbert and McCutcheon Creek drainage area are indicated by patches of pegmatitic float. In general, however, the exposures of pegmatite are few, and the brief reconnaissance did not disclose any other significant deposits of beryl or other pegmatite minerals.

HANKINS CANYON

The pegmatites in Hankins Canyon, about 2 miles south of Dawley Canyon, are thinner but are otherwise similar to those in the Dawley Canyon area, of which Hankins Canyon is an extension. In the Hankins Canyon area, 17 pegmatite dikes more than 1 foot thick were examined in a day's reconnaissance, and beryl was found in 14 of them. Nearly all of these dikes are less than 18 inches thick, however, and only 1 is as much as 4 feet thick. A 40-foot exposure of this pegmatite dike was estimated to contain between 0.05 and 0.1 percent beryl. Some of the thinner pegmatites also contain about 0.1 percent beryl. Like the Dawley Canyon area, Hankins Canyon probably is near the roof of a granite mass, for granite predominates lower in the canyon whereas quartzite is abundant higher on the canyon sides.

STAR MINE NEAR HARRISON PASS

The tungsten deposits at the Star mine are 2 miles east of Harrison Pass, on both sides of the Harrison Pass road. The tungsten-bearing tactite bodies occur along the irregular contacts of the Harrison Pass granite stock with interbedded silicated marble and hornfels, which Sharp (1942) has mapped as the Pogonip formation of Ordovician age. The Star mine was mapped and studied in 1942 and

1943 by M. R. Klepper, J. H. Wiese, and Peter Joralemon of the U.S. Geological Survey (written communication).

Sampling in 1949 indicates significant quantities of beryllium in tactite bodies and the granite immediately adjacent to them, but not in other metamorphosed rocks of the contact aureole or in the interior of the granite stock (Cameron, E. N., written communication). Of 18 samples of the tactite, silicated sedimentary rocks, and related rocks collected by Cameron, 2 contained 0.056 and 0.029 percent BeO, respectively, and the rest were less than 0.01 percent. The beryllium in the Star tungsten deposit, and the widespread occurrence of beryl in the pegmatites in areas nearby, indicate that emanations from the Harrison Pass granite stock were abnormally rich in beryllium.

WHITE PINE COUNTY

Pegmatites occur in several areas in White Pine County. The pegmatites of the Kern Mountains, in eastern White Pine County, at latitude 39°45′, longitude 114°10′, have been described briefly by Hill (1916, p. 30).

According to Hill (1916, p. 30), the large stock of the Kern Mountains is a fine-grained muscovite granite, locally a muscovite-biotite granite, which has intruded sedimentary rocks of supposed Cambrian age. Near the margin of the stock the mica flakes are locally abundant, and at the contact the granite is schistose. Large bodies of muscovite pegmatite are in the granite and in the sedimentary rocks near the contact. At one place, Hill noted a pegmatite dike that seemed to grade into a pure quartz vein.

Pegmatites in Water Canyon, on the southwest side of Kern Mountains, have been described by Hill. At the Regan tungsten prospects at Tungstonia, on the southeast side of the mountains, the muscovite-biotite granite country rock is cut by quartz veins containing huebnerite, galena, sphalerite, bismuthinite, and purplish fluorite. These quartz veins resemble some phases of the pegmatitic dikes that grade into quartz veins near Water Canyon, and according to Hill (1916, p. 207) are the end products of pegmatitic intrusions.

The only pegmatites examined in the Kern Mountains during this reconnaissance are on the west front of the range, about 30 miles by dirt road east of Schellbourne station, which is 40 miles north of Ely on U.S. Highway 50. Granite, which forms most of the west front of the range at this point, is bounded on the west and north by an irregular contact with limestone, which occurs on spur ridges at the base of the mountains.

The fine- to medium-grained muscovite granite is heterogeneous in composition and texture and locally contains biotite. Porphyritic and pegmatitic textures are common and several types may occur in the same exposure. Porphyritic parts contain potassium feldspar phenocrysts as much as 1 inch in diameter. The granite contains many small pegmatite masses, mostly less than 2 feet thick, and veins of massive quartz as much as 1 foot thick. The pegmatites are fine to medium grained, not conspicuously zoned, and are composed of potassium feldspar, quartz, plagioclase, a few garnet crystals, and muscovite flakes as much as 2 inches in diameter, many of which have hexagonal outlines. The pegmatites examined in these localities in the Kern Mountains, as well as those reported in earlier literature, are not known to contain beryl or any other minerals of economic interest.

PERSHING COUNTY

The pegmatite areas examined briefly in the reconnaissance of Pershing County include the Humboldt Canyon and Oreana areas in the Humboldt Range, the Trinity Range, and a locality in the Bluewing Range west of Granite Springs Valley. Pegmatite has also been reported in the Seven Troughs Range. Tailings from the Toulon mill of the Rare Metals Corp., where the beryl-bearing Oreana tungsten ore was milled, were sampled for a determination of BeO content.

LAKEVIEW (HUMBOLDT CANYON) SCHEELITE-BERYL DEPOSIT

The Lakeview scheelite-beryl deposit is in Humboldt Canyon near the north end of the Humboldt Range at an altitude of about 6,500 feet, in secs. 6, 7, and 8, T. 31 N., R. 34 E. The deposit is reached by a 4.5-mile dirt road southeast from U.S. Highway 40 at Humboldt, a section point on the Southern Pacific Railroad. Four claims, known as the Lakeview group, were located about 1932 by Mr. Fred Nagle of Lovelock, and leased in 1942 to the United Strategic Metals Co. of Winnemucca. The deposit has been explored on the surface by trenches and a small open cut, and its extension underground has been sought in 450 feet of crosscuts.

The Lakeview deposit was examined in 1942 by M. R. Klepper of the U.S. Geological Survey (written communication) and by R. E. Burns and Olson in November 1948.

The scheelite-beryl deposit is in limestone near the contact with a quartz monzonite(?) stock. Near the mine the limestone, with some argillaceous beds, dips 45°–60° NW. and contains sericite, quartz, fluorite, and possibly diopside. The quartz monzonite(?) crops out in cliffs just southeast of the mine and has been sheared and silicified near the contact, suggesting that the contact may be a fault. The scheelite-beryl deposit is separated from the outcrops of quartz monzonite(?) to the southeast by a poorly exposed barren zone that is probably about 50 feet wide.

The scheelite and beryl occur in a zone in the limestone of small pockets and stringers composed of quartz, muscovite, fluorite, dark blue tourmaline, and well-crystallized creamy scheelite and colorless beryl. The crystals of beryl are a fraction of an inch to 2 inches long, and in general the amount of beryl and scheelite in the rock increases with the abundance of quartz veins. At the surface one or more of the minerals of the pegmatite have been leached out, leaving cavities lined with brown powder, probably an iron oxide. The veins and altered zones in the limestone strike north-northeast and dip 50° E. to vertical; the average dip is 70° E.

The zone of limestone containing pegmatite, quartz veins, scheelite, and beryl is 30 to 40 feet wide. On the surface it is poorly exposed, but it may be as much as 140 feet long. The extent of the mineralized zone underground is not known, for the 450 feet of crosscuts passed beneath the open cut but failed to intersect the scheelite-beryl rock. At the south end of the adit, the limestone is cut by nearly vertical quartzose veins and probably contains a few grains of scheelite, but a sample of this rock contains only 0.0056 percent BeO.

Twelve samples were collected by R. E. Burns in an area of 40 by 60 feet on the surface and 2 samples in the heading of the adit. The twelve surface samples range from 0.018 to 0.11 percent BeO, averaging 0.0475 percent BeO. Spectrographic BeO determinations on the 14 samples are given in table 6.

A specimen of colorless beryl associated with scheelite crystals in vugs in ore from the Lakeview deposit was determined by J. W. Adams of the U.S. Geological Survey to have an index of refraction,

TABLE 6.—BeO *content of samples from localities on Lakeview claim, determined spectrographically*

[Analyses by Saratoga Laboratories, Saratoga Springs, N.Y.]

Locality Samples from area 40 by 60 feet on surface	BeO (percent)	Locality Samples from area 40 by 60 feet on surface	BeO (percent)
H2	0.081	H9	0.037
H3	.056	H10	.079
H4	.018	H11	.033
H5	.037	H12	.022
H6	.025	H13	.042
H7	.030	H15 [1]	.0056
H8	.11	H1 [2]	.0009

[1] Chip sample 0–5 feet from heading of adit.
[2] Chip sample 5–20 feet from heading of adit.

nO, of 1.590. The index of refraction nO, of beryl from the interior of a quartz vein is 1.576, and that of beryl associated with muscovite flakes is 1.578, according to determinations made by W. R. Griffitts. These data indicate that the BeO content of the beryl ranges from about 11.9 to 13.4 percent.

OREANA SCHEELITE-BERYL DEPOSIT

The Oreana tungsten deposit was discovered by George V. Gordon in 1933 and was purchased by Rare Metals Corp. shortly after its discovery (Vanderburg, 1936, p. 33–34). The Oreana mine of the Rare Metals Corp. was operated continuously between March 1935 and June 1942, and the ore was milled at Toulon, Nev. The geology of the deposits and of the surrounding area has been described in other reports (Kerr, 1935; 1938; 1946, pl. 7, p. 189–192; Jenney, 1935), and will be reviewed only briefly here.

At the Oreana mine, scheelite and beryl occur in pegmatitic veins that cut a mass of metadiorite in limestone. The pegmatites, which are associated in origin with the nearby dikes of aplite and stock of granite, contain quartz, oligoclase, albite, fluorite, beryl, scheelite, phlogopite, and smaller amounts of potassium feldspar, rutile, sphene, apatite, muscovite, sericite, calcite, chlorite, tourmaline, garnet, and a pinkish zoisite that resembles thulite.

Aplite dikes of several ages, and dikes composed of both aplite and pegmatite in various proportions, were recognized in the area by Kerr (1946, p. 189–190). West of the granite stock, where the Oreana deposit occurs, the aplites tend to grade into pegmatites. Occasional grains of scheelite are found in aplite dikes (Kerr, 1946, p. 190), as well as in the Oreana pegmatites, indicating the genetic relationship of aplite, pegmatite, and scheelite.

The principal body mined at Oreana is nearly vertical, commonly 1 to 5 feet thick, and has been explored over a length of about 2,000 feet. The minerals are distributed irregularly along the vein, and parts of the ore body are composed largely of quartz or of fluorite. The distribution of beryl and scheelite is also erratic. The beryl is pale green and forms irregular masses as well as slender prisms several inches long.

The northwest end of the small western pegmatite body, in the segment 200 feet long northwest of a shaft, contains a high percentage of beryl. The average thickness of the body at the surface over this distance is probably less than 2 feet. The proportion of beryl is generally less than 1 percent, but small, exceptionally rich patches contain as much as 10 percent beryl. A sample of a beryl-rich part of the western pegmatite contains 1 percent BeO according to spectrographic analysis. The index of refraction, nO, of 4 specimens of Oreana beryl was determined to be 1.586 to 1.587, which corresponds to a content of about 12.4 percent BeO.

According to Kerr (1946, p. 191), the discovery ore body at Oreana was about 100 feet long, vertical, and enclosed in metadiorite. At a depth of 75 feet, where the metadiorite is underlain by limestone, the pegmatite ended abruptly. The metadiorite was generally favorable to the formation of pegmatite masses whereas the underlying limestone was not. Extensive exploration in the limestone beneath the discovery ore body disclosed only a band of silicified rock about 4 feet thick with occasional grains of scheelite associated with disseminated fine-grained quartz and acicular zoisite.

Beryl was not recovered during the tungsten mining at Oreana and is now mostly in the tailings of the Toulon mill diluted by tailings from beryl-free ore from other tungsten deposits in the region. Samples of the Toulon tailings that had been milled more than once range from 0.0023 to 0.049 percent BeO, according to spectrographic analyses of 28 samples from auger drill holes. Tailings that were milled only once, representing material derived from Oreana pegmatite alone, make up a very small part of the total tailings. Two samples of this material contain 0.051 and 0.081 percent BeO, corresponding to about 0.4 and 0.64 percent beryl.

In the area between Oreana and the Lakeview claims, tactite adjoining the quartz monzonite intrusive body in Rye Patch Agnes Canyon (Vitaliano, 1944), was sampled in two places by J. C. Olson. Spectrographic analyses indicate that a sample of tactite from the upper mine opening of the Rye Patch Agnes mine contains 0.0006 percent BeO, and a sample of tactite adjoining the northeast corner of the Rye Patch intrusive body contains 0.0023 percent BeO. E. N. Cameron (written communication) collected 27 samples of similar rocks including some aplite, on the west side of the Humboldt Range, and the highest BeO content was 0.007 percent in a sample from Rye Patch Agnes Canyon.

TRINITY RANGE

Six small pegmatite dikes were examined in the Trinity Range about 9 miles northwest of Lovelock, near the pass where Nevada Highway 48 crosses the crest of the Trinity Range. Several small pits have been dug in the area for tungsten.

Pegmatites occur sparsely in the granite which underlies a large area near the pass. Some varieties of the granite are biotitic, others are light colored and almost aplitic. The largest of 6 pegmatite bodies seen in a brief reconnaissance is 3 feet thick and at least 75 feet long.

The pegmatites consist of quartz, potassium feldspar, fine-grained plagioclase, muscovite, and biotite. The potassium feldspar crystals tend to be euhedral in the rock, are 2 or 3 inches long, and they commonly are oriented with their long dimensions nearly at right angles to the walls of the dike. Parts of the dikes are predominantly quartz.

SEVEN TROUGHS RANGE

Pegmatites are reported in the Seven Troughs Range by Hague and Emmons (King, 1877, p. 775–778). The range is composed almost entirely of Precambrian granite and schist, which are cut by pegmatite dikes and overlain locally by flows of rhyolite and basalt. In Crusoe Canyon, a fine-grained pearl-gray granitic rock forms the groundmass of very coarse-grained masses of pegmatite. Among the minerals of the pegmatite bodies are massive and fine-grained quartz; orthoclase crystals 3 or 4 inches long; transparent muscovite flakes 1 inch or more in length; thin laminae of lepidolite; long black tourmaline needles, commonly in segregated bunches; and both massive and well-crystallized brownish-red garnet which is closely associated with the colorless muscovite. No biotite, hornblende, or beryl was found in this rock.

Another dike reported by Hague and Emmons (King, 1877, p. 777–778) in the metamorphic rocks in the same region has a similar composition but is finer grained. The tourmaline is so abundant and so well distributed that the dike may be classed as a tourmaline granite.

Several dikes of fine-grained white granite were noted by Hague and Emmons (King, 1877, p. 778) in the metamorphic rocks west of the summit of Pah-keah Peak, one of the peaks in the Seven Troughs Range. These resemble the finer grained granite of Crusoe Canyon and also contain segregations of the coarser grained material.

RFS FELDSPAR-MICA PROSPECT, BLUEWING MOUNTAINS

The RFS feldspar-mica prospect (pl. 3) is at an altitude of about 4,500 feet near the east base of the Bluewing Mountains, west of the central part of Adobe Flat in Granite Springs Valley. The prospect consists of four claims in Tps. 27 and 28 N., R. 26 E., just west of the southwest edge of the Lovelock quadrangle. This area is about 30 miles by road west of Toulon, Nev., which is on U.S. Highway 40 and the Southern Pacific Railroad.

The property was named from the last initials of the claim-owners, Paul Read, Charles Fitzgerald, and Ira Stanley, of Lovelock, Nev. The deposit was prospected in 1944, when 1 or 2 small pits were excavated, but this work terminated the same year when the area was closed by the Navy for use as a bombing range.

The pegmatite is well exposed in a canyon where it strikes about N. 30° W. and is about 1,200 feet wide. Its length was not determined, but Mr. Stanley reports that it is also thick where it occurs in a canyon 2 miles to the northwest, and it may continue northwestward several miles beyond this point. The pegmatite body passes beneath the alluvium of the valley several hundred feet southeast of the RFS claims. The body is so large and the contacts so irregular because of apophyses that its dip is not certain. The east contact seems to dip steeply eastward to vertical, and the west contact 45° W. to vertical. The wallrocks and inclusions are mostly mica schist and quartzite, presumably of metasedimentary or metavolcanic origin. The layering in the fine-grained schist west of the pegmatite dips 45° W., apparently the general attitude of the country rocks in this part of the Bluewing Mountains.

The pegmatite is composed of perthite, quartz, plagioclase, black tourmaline, muscovite, garnet, and biotite. Probably at least 80 percent of the mass is coarse-grained perthite-plagioclase-quartz pegmatite. About 15 percent is fine-grained granitic pegmatite, composed largely of plagioclase and quartz with some tourmaline and garnet. Inclusions of schist and quartzite make up less than 5 percent of the 1,200-foot width. In the canyon that crosses the pegmatite body, inclusions of wall rock are rare. However they are more abundant on the ridge north of the canyon, suggesting that the exposures on the ridge are nearer the roof of the body.

Perthite is abundant in the pegmatite, probably more so than plagioclase in the coarse-grained parts where some perthite crystals are as much as 3 feet long. Graphic granite is common. Black tourmaline, occurring as crystals ranging from pin-point size in the fine-grained rock to prisms nearly 1 foot long in the coarse-grained pegmatite, makes up about 1 percent of the rock. Biotite occurs only locally, and in the one place where it is conspicuous it is associated with an inclusion of biotite schist near the west contact of the pegmatite body. Small red to yellow-brown garnet crystals are common in the fine-grained pegmatite, but less abundant in the coarse-grained pegmatite.

The fine- and coarse-grained parts of the body do not seem to be zoned. Outcrops in the canyon are alternately fine and coarse grained or mixtures of the two grain sizes. In places the variation in grain size forms crude layers that strike about N. 15° W. and dip about 45° NE. In several exposures, long tapering tourmaline crystals in the coarse-grained pegmatite are oriented at right angles to the contact with adjacent fine-grained pegmatite, suggesting that at these points the fine-grained pegmatite crystallized before the coarse-grained, and that all the material of the dike was not intruded simultaneously. The fine-grained pegmatite is most abundant in the west half of the body and near the east contact; it is less common in most of the east half of the body.

The pegmatite is cut by several diorite(?) dikes about 5 feet thick that strike about N. 65° W. and dip steeply.

The pegmatite dike is of interest chiefly because of its tremendous size. It was prospected for mica, but muscovite was not observed in concentrations or sizes comparable to those mined in other parts of the country. One distorted mica crystal measures 8 by 12 by 2 inches, but it probably would yield no sheet mica. The amount of scrap mica that would be recoverable by milling is probably no more than 1 percent of the rock. No beryl was seen in the pegmatite. The long distance to feldspar consumers and the 22-mile distance to the railroad make it doubtful that feldspar could be produced profitably. Some coarse-grained potassium feldspar could be hand cobbed, and if the pegmatite were not in such an isolated location, it might be a possible source of feldspar production by flotation methods.

WASHOE COUNTY

Pegmatites occur in several areas in Washoe County. The occurrence of mica "to the northward of Pyramid Lake" is noted by Clarke (1885, p. 911). Pink dumortierite is associated with quartz and muscovite in segregations in granite rear the south end of the Granite Range about 8 miles northwest of Gerlach (Grawe and others, 1928, p. 10).

The only pegmatite area in Washoe County examined during this investigation is near the Red Rock road, about 18 miles north of Reno. The pegmatite area may be reached from Reno by going northwestward 7 miles on U.S. Highway 395 to the Red Rock road. This road is followed northward 19 miles to a point where a side road branches toward the southwest about half a mile to the locality. The principal workings and many outcrops of pegmatite and aplite within half a mile of them were examined by J. C. Olson on April 24, 1949.

Granitoid rock related to the Sierra Nevada batholith underlies many square miles of low rolling hills around the pegmatite area examined. In the pegmatite area the country rock is mainly a fine-grained biotite granite, some parts of which are nearly aplitic. Small areas of more basic dark igneous rocks containing hornblende and biotite occur in the granite. Some of these seem to be dikes younger than the granite, but some are dark inclusions cut by thin granite dikes. The pegmatites seem to be well within the extensive granite mass, although the inclusions suggest the pegmatites may be near the roof of the granite body.

The pegmatite dikes commonly strike north to N. 20° E. and are nearly vertical, parallel to prominent joints in the granite. Most of the dikes are 1 foot or less in thickness, several are about 3 feet, and the thickest observed is about 9 feet. The dikes are commonly one-third pink microcline perthite with white albite (An_{10}), and clear, gray, or smoky quartz. Biotite is a widespread constituent in small quantities. Graphic intergrowths of potassium feldspar and quartz are common. Accessory minerals include muscovite, apatite, sphene, magnetite, hematite, epidote, and allanite(?). Malachite occurs sparsely in one pegmatite.

Aplite occurs both as separate dikes and mixed with pegmatite in various proportions. Zoning is not apparent in the pegmatites or the dikes that contain both pegmatite and aplite. Some dikes are largely aplitic but contain small, irregularly-distributed pegmatitic patches.

Several carloads of feldspar were shipped from this area to San Francisco in 1931 (Fulton and Smith, 1932, p. 4). A small open cut was probably excavated then at the locality at the end of the side road into the area. About 1945–1947 this pegmatite was further prospected by bulldozer and trenching over an area of 75 by 175 feet. These workings expose a pegmatite body that is about 3 feet thick where best exposed and is probably slightly thicker elsewhere. It seems to strike about N. 50°–60° E. and dip 60°–70° NW. The pegmatite is about 25 percent quartz, nearly 40 percent blocky pink perthite, 35 percent cleavelandite in platy crystals as much as 4 inches long, a small percentage of biotite in small blades mostly less than 1 inch wide, and sparse accessory minerals.

Small-scale prospecting with pick and shovel has been done in several other pegmatites in the area. Although the perthite is probably of very good quality, the dikes examined seem to be too small to support a profitable feldspar mining operation. The rarer minerals such as allanite (?) make up only a small fraction of a percent of the rock. No beryl was noted in the pegmatites.

LYON AND MINERAL COUNTIES

Molybdenite occurs in pegmatite in the Yerington district (Schrader, Stone, and Sanford, 1916, p. 196), but no beryl has been reported.

Beryl has been found in a wolframite-scheelite vein in the Marietta district in Mineral County. The tungsten prospects occur at elevations of 6,000 to 7,000 feet in the hills west of Teels Marsh 4 to 8 miles southwest of Marietta. In this district metasedimentary rocks of the Dunlap formation of Jurassic age (Ferguson and Muller, 1949, pl. 1) have been intruded by granite.

In 1942 tungsten deposits in the Marietta district were examined by D. M. Lemmon and P. C. Bateman (written communication, 1942) from whom the following information on beryl in the Pine Crow claims was obtained. At the Pine Crow prospect, a wolframite-scheelite vein occupies a steep west-dipping fault that strikes northward at right angles to the tactite bodies in the main tungsten belt. The footwall of the vein is of granite, the hanging wall of metamorphic rocks. The vein consists of 6 inches of quartz on the granite footwall, bordered on the west by 5 feet of gouge and breccia. High-grade streaks of scheelite and wolframite occur both in the quartz and as nodules in the gouge. The quartz contains small crystals of light-blue beryl along the granite wall, and some bismutosphaerite (after bismuthinite). The index of refraction, *n*O, of needlelike beryl crystals collected by D. M. Lemmon from a small vug in the vein was determined by J. W. Adams to be 1.588, which corresponds to a BeO content of about 12.2 percent.

ESMERALDA COUNTY

Pegmatites are reported in several areas in Esmeralda County, among which are Lone Mountain, Mineral Ridge, the southern part of the Silver Peak quadrangle, the Sylvania district, Slate Ridge, and Gold Mountain Ridge. Beryl has been found in the Sylvania district.

LONE MOUNTAIN

The granite of Lone Mountain, according to Ball (1907, p. 53), grades locally into pegmatite in which some grains are an inch in diameter. Graphic granite and veins of pegmatitic quartz are also present, but beryl has not been reported.

MINERAL RIDGE

The Mineral Ridge area, which is in Tps. 1 and 2 S., Rs. 38 and 39 E., Esmeralda County, was mapped by the Stanford University geological survey, and the pegmatites are described in detail by Bailly.[1] About 700 mappable pegmatites were found in the area studied. Bailly divided the pegmatites into two groups, biotite pegmatites in granite and muscovite pegmatites in the Precambrian rocks. The muscovite pegmatites are further divided into an older and a younger group.

[1] Bailly, P. A., 1951, Geology of the southeastern part of Mineral Ridge, Esmeralda County, Nevada: Unpublished doctor of philosophy dissertation, Stanford Univ. 186 p.

The pegmatites range from dikelike bodies 0.25 inch to 50 feet thick and as much as 300 feet long to podlike bodies 20 to 500 feet in diameter. The pegmatites contain about 20 to 35 percent quartz, 8 to 10 percent silvery muscovite, potassium feldspar, oligoclase, biotite, garnet, apatite, zircon, and magnetite. One of the younger pegmatites contains lepidolite both as large crystals and massive aggregates of small crystals. Pods of quartz occur near the centers of some of the bodies. The following description of the lepidolite-bearing pegmatite is quoted from Bailly (op. cit., p. 85–86):

> A lepidolite-bearing pegmatite occurs 2,500 feet N. 70° E. from the Custer Gulch mine. This pegmatite, about 100 feet long and 30 feet wide in outcrop, is intrusive into the "Proterozoic" dolomite marble. It was somewhat deformed after its emplacement, as attested by its cataclastic texture. The lepidolite is concentrated in an elongated band in the center of the pegmatite. The relations between the outer muscovite-potash feldspars-quartz pegmatite and the central lepidolite-potash feldspars-oligoclase-quartz pegmatite are much obscured by deformation . . .

SOUTHERN PART OF SILVER PEAK QUADRANGLE

The pegmatites, aplites, and alaskites in the Silver Peak quadrangle, which includes Lone Mountain, Mineral Ridge, and an area in the southern part of the quadrangle, have been described by Spurr (1906, p. 22–26, 129–156). In the area of granitic rocks in the southern part of the quadrangle, pegmatite and aplite are abundant but beryl has not been reported.

SYLVANIA DISTRICT

The Sylvania district is about 25 miles directly south of Silver Peak, in the south half of T. 6 S., R. 39 E., about 12 miles southeast of Oasis, Calif., the nearest post office and supply point. Time did not permit the examination of pegmatites in this area, but beryl was discovered in samples from the Sylvania district submitted to the U.S. Geological Survey by V. C. Heikes, Carmel, Calif., on July 10, 1938.

SLATE RIDGE

The post-Jurassic granite of Slate Ridge is cut by pegmatite dikes and locally grades into irregularly shaped masses of coarse-grained pegmatite; some quartz veins grade into pegmatites, according to Ball (1907, p. 192–193). At the Bullfrog-George mine, fluorite and molybdenite, and its alteration product molybdite, occur in a quartz vein. Molybdenite occurs sporadically as small tablets and irregular areas in and between quartz grains. Purple fluorite occurs in crevices in the quartz and as quarter-inch cubes lining vugs in the quartz.

GOLD MOUNTAIN RIDGE

The granite of Gold Mountain Ridge, according to Ball (1907, p. 185), is cut by coarse-grained pegmatite dikes and grades into masses of similar pegmatitic rock. Graphic granite is common and at many points forms a transition facies between granite and coarse-grained pegmatite. Pink aplite dikes also cut the granite and are generally older than the pegmatite. In one place an aplite dike passes along its strike into a dike with narrow aplitic border zone and pegmatitic core. Beryl and other pegmatite minerals of economic interest have not been found in Gold Mountain Ridge.

NYE COUNTY

BULLFROG HILLS

Pegmatites of the Bullfrog Hills have been described by Ball (1907, p. 179; 1908, p. 43–44) and by Ransome, Emmons, and Garrey (1910, p. 23–24). The pegmatites occur in pre-Silurian quartz-biotite schist and augen gneiss, the largest area of which is less than 1 mile long and is about 3 miles west of the old Bullfrog mining camp and about half a mile southwest of the Original Bullfrog mine. Some of the pegmatites in the district were examined briefly by Olson in 1949, but no beryl was found.

The pegmatite bodies range from a fraction of an inch to 100 feet in width and are mostly concordant with the foliation of the schist. They consist of quartz, potassium feldspar, albite, oligoclase, muscovite, biotite, magnetite, and pyrite. According to Ball (1907, p. 178–179) the pegmatite grades into alaskite, but pegmatite predominates. The associated alaskite is a white, medium-grained rock composed of quartz, feldspar, muscovite, a small quantity of altered biotite, and accessory apatite, zircon, magnetite, and tourmaline(?). The pegmatites are sheared and granulated, and are overlain by rhyolite of Tertiary age. Ball (1908, p. 43–44) dated them provisionally as post-Jurassic and pre-Tertiary, and found some evidence of two separate intrusions. The older feldspar-muscovite-quartz pegmatite is cut by a pegmatite dike of almost pure quartz. Fine biotite and muscovite flakes about 0.1 inch in diameter are disseminated through much of the feldspar.

BARE MOUNTAIN

Pegmatite is reported by Ball (1908, p. 43) to be the only granular siliceous igneous rock at Bare Mountain. Post-Jurassic pegmatite dikes 2 inches to 4 feet thick, which cut Eureka quartzite in the northern part of the range, near Gold Center, are mostly composed of feldspar, quartz, and muscovite in grains less than half an inch in diameter (Ball, 1907, p. 155-156). Another type of pegmatitic rock in the area is composed of glassy quartz which contains many biotite flakes as much as one-eighth inch in diameter. A few black tourmaline rods up to one-fourth inch in diameter occur in clusters and along minute cracks in a quartz-muscovite pegmatite. Pegmatitic quartz veins with small quantities of feldspar and muscovite are very common. The pegmatites cut Paleozoic rocks, and fragments of pegmatite are included in Tertiary volcanic rocks.

PAHUTE MESA

Post-Jurassic granite forms the hills at Trappman's camp and crops out 5 miles northwest of Whiterock Springs. Pegmatites occur in both these granite masses, according to Ball (1907, p. 134), from whose report the following notes are abstracted. The granite at Trappman's camp grades into and is cut by irregularly shaped masses and dikes of pegmatite composed of feldspar and quartz anhedra up to 1 inch in diameter. Quartz veins, some of which are several hundred feet long and 40 feet wide, are common. The granite northwest of Whiterock Spring contains ellipsoidal masses of quartz-feldspar pegmatite from 4 inches to 5 feet in diameter, with both sharp and gradational borders. The pegmatite is composed of quartz and feldspar grains as much as 6 inches in diameter and a few platy biotite crystals. The ellipsoidal form and the absence of apparent channels from one mass to another in the plane of observation suggest that the pegmatite formed in place from the residual fluids of the granitic magma (Ball, 1908, p. 43).

BELTED RANGE

Pegmatite dikes are common in the Belted Range (Ball, 1907, p. 124-129). Among the constituents of the pegmatites are feldspar and quartz in masses as much as 12 inches across, limonite pseudomorphs after pyrite, graphic granite, and biotite blades 0.5 to 1 inch long embedded in feldspar. One medium-grained granite mass, 1.5 miles southeast of Oak Spring, is 200 yards in diameter and grades into coarse-grained pegmatite, which in turn grades into pegmatitic quartz. Each of the rocks contains pyrite altered to limonite, in cubes as much as half an inch in diameter; the pyrite was apparently an original constituent of the pegmatite. The pegmatite has some miarolitic cavities lined with quartz and feldspar crystals 1 inch long.

Some of the quartz veins in the area 1.5 miles south of Oak Spring contain pyrite, chalcopyrite, galena, and sphalerite (Ball, 1907, p. 128-129). They are 1 to 3 feet thick and have been prospected for gold and silver.

CLARK COUNTY

CRESCENT PEAK

A feldspar mine about 1 mile N. 5° W. of Crescent Peak may be reached by a mine road that extends southeastward 1 to 2 miles from the Nipton-Searchlight road at a point 4 miles east of Nipton, Calif., a station on the Union Pacific Railroad. The pegmatite and dump form a white prominence that is visible for several miles. The mine was opened about 1926, and feldspar has been shipped to Los Angeles by A. B. Robbins of Goodsprings, Nev. Probably between 2,000 and 3,000 tons of pegmatite have been mined in 3 small open cuts ranging from 20 to 50 feet in length, and at least 1,000 tons of feldspar has been produced. The mine seems to have been idle for several years.

The pegmatite body is enclosed in granite, is several hundred feet long and at least 50 feet thick, and is composed of perthite, plagioclase, quartz, muscovite, garnet, fluorite, and beryl. Green beryl was noted chiefly in one area on top of the low ridge formed by the pegmatite. In an area 40 feet square, 14 beryl crystals with an aggregate weight of less than ½ pound were found in a 15-minute search. The other parts of the pegmatite that were examined hastily contain little or no beryl. Small quantities of beryl and scrap muscovite might be recovered if the deposit were mined for feldspar.

SEARCHLIGHT

The Sunrise and Moonbeam claims are 9 miles by road northeast of Searchlight and 30 miles from the Union Pacific Railroad at Nipton, Calif. They may be reached by driving north from Searchlight 4 miles on U.S. Highway 95, then turning northeast 5 miles on a dirt road to the camp at the St. Louis mine. The Sunrise prospect is a prominent white exposure about a third of a mile north of the camp. The Moonbeam prospect is about 0.6 mile north of the Sunrise, at only slightly higher altitude, and is also visible from a distance as a light-colored exposure. The two pegmatites are just a few hundred feet above the base of the west slope of the Eldorado Mountains. The claims were prospected about 1947 or 1948, presumably for mica and beryl.

At both localities, sheared gray granitoid rock of probable Precambrian age encloses pegmatite consisting of quartz, medium-grained perthite, plagioclase, muscovite, and a small amount of biotite and garnet. Beryl is reported but was not observed in a brief examination. Graphic granite is abundant. Each pegmatite contains some massive quartz, and in the Sunrise pegmatite the quartz mass is as much as 6 feet thick. Very coarse blocky perthite crystals border the massive quartz, and some relatively fine-grained plagioclase pegmatite containing wrinkled, ruled, light brownish-green muscovite books occur near the quartz masses. The wall zones are mostly medium grained, irregular mixtures of the feldspars, quartz, graphic granite, and scrap muscovite. The potassium feldspar is coarse-grained but the amount has been insufficient to encourage mining.

In plan the pegmatite on the Sunrise claim is an elongate lens. Over a length of 100 feet it is 20 to 30 feet thick, dips steeply, and strikes nearly north. North of this 100-foot segment it probably pinches out abruptly, and south of it the pegmatite gradually tapers over a distance of at least 125 feet. The quartz core is thickest in the 100-foot segment, and about 100 tons of rock was excavated from the pit in the core-margin zone along the west edge of the quartz core.

The pegmatite on the Moonbeam claim occurs as two bodies that strike slightly west of north and dip steeply. Because of talus it is not known whether the two bodies are en echelon dikes or one pegmatite body offset by faulting. The thickness of the bodies is as much as 50 feet and probably exceeds 25 feet over a length of at least 200 feet. In mineralogy and internal structure, this pegmatite is much like the pegmatite on the Sunrise claim. Small pits have been dug where the rock is weathered, but no pegmatite minerals have been produced.

GOLD BUTTE DISTRICT, VIRGIN MOUNTAINS

Pegmatites are found over a large area in the Gold Butte district as far south as the shores of Lake Mead. Small pegmatites are abundant and large ones at least 30 feet thick are especially numerous in some parts of the southern Virgin Mountains. The north wall of Virgin Canyon is cut by a prominent swarm of pegmatite dikes. Most of the following description is based upon published reports. Gold Butte was visited briefly in 1948 by R. E. Burns of the Geological Survey.

Mica was mined in 1893 and 1894 by Daniel Bonelli, of Rioville, Nev., and 500 pounds of sheet mica was shipped from Nevada to Hamburg, Germany, and 1,300 pounds to Syracuse, N.Y. (Sterrett, 1923, p. 105–106). The deposits are about 15 miles northeast of the confluence of the Virgin and Colorado Rivers. One of the claims, the Pioneer, is about 5,000 feet above sea level.

Holmes (1904, p. 986) refers to the pegmatites on the Czarina and Snowdrift groups of claims, which were explored to a depth of about 45 feet. The Czarina claims are 16 to 25 miles northeast of the confluence of the Virgin and Colorado Rivers, at an altitude of about 5,000 feet. The pegmatites cut granitic schist and contain muscovite, garnet, tourmaline, columbite, and beryl as accessory minerals. Mica was shipped from these deposits before 1900, and sheets 2 by 3 inches to as large as 8 by 13 inches were obtained.

The Precambrian rocks of the Virgin Mountains region, described by Longwell (1936, p. 1404–1406), consist of gneiss, schist, and coarse-grained igneous rocks. Among the principal granitic bodies are a red granite and the porphyritic granite at Gold Butte. The coarse-grained porphyritic granite at Gold Butte is about 4 miles long in east-west dimension, 2 miles wide, and is composed of potassium feldspar, a small amount of oligoclase, about 30 percent quartz, and some biotite and hornblende (Hill, 1916, p. 43). Phenocrysts of microperthite are commonly 1 inch or more long, and some are nearly 3 inches long. The age of the granite is uncertain, for it has not been found cutting the Paleozoic sedimentary rocks. The granite is relatively fresh and undeformed compared to Precambrian granites in the region, and silicification of adjacent Paleozoic limestone (Hill, 1916, p. 47) suggests that the granite may be younger than Precambrian. Dikes of fine-grained, nearly white aplite cut both the granite and the schist.

Most of the pegmatite dikes in the granite at Gold Butte and in the Precambrian metamorphic rocks contain few minerals other than feldspar, quartz, and mica (Longwell, 1936, p. 1404–1406). Many contain pink microcline like that in the red granite, whereas others are rich in albite and seem nearly white. Some pegmatites of the Gold Butte district contain small quantities of samarskite, columbite, allanite, monazite, fluorite, beryl, and magnetite, in addition to the more common pegmatite minerals. Mica, feldspar, beryl, and the radioactive minerals have been prospected in small surface workings. Mica schist has been mined and ground for scrap mica from an open cut about 400 feet long near Gold Butte.

VIRGIN PEAK

Pegmatites in the Virgin Peak area occur on both sides of the Nevada-Arizona boundary, on the north slopes of Virgin Peak (Bunkerville Mountain), about 15 miles southeast of Bunkerville. The deposits in Nevada were not examined by the writer. The general geology of the area, and description of the Hummingbird claims, east of the State line, are given in the later discussion of pegmatites in Mohave County, Ariz.

In Nevada just west of the State line, about 1.5 miles southwest of the Hummingbird claims, a pegmatite was prospected in 1949, primarily for mica; beryl and possibly phenakite(?) occur there. The belt reportedly containing beryl is several miles long and extends southwest of this prospect; northeast of the Hummingbird claims, pegmatite has been prospected for mica near the edge of the Precambrian block, just west of an area of Cambrian limestone. Small-scale mining for mica was done in this belt many years ago, probably about 1897. Holmes (1904, p. 986) examined mica samples of good quality from deposits on the Snowdrift group of claims on the north side of Virgin Peak.

MOHAVE COUNTY, ARIZONA

Many pegmatite dikes occur in the Precambrian rock areas of northwestern Arizona in a wide belt from the Virgin Mountains southward across Lake Mead, through the Cerbat Mountains, the Hualpai Mountains south of Kingman, the large area between Kingman and Wickenburg, and thence southeastward in southern Arizona and Mexico. Four areas in Mohave County north of Kingman were examined briefly. Beryl has been found in tungsten-bearing veins at the Boriana mine, 20 miles southeast of Kingman (Hobbs, 1944, p. 254). Other pegmatite areas to the southeast have been studied and described in detail recently by Jahns (1952).

HUMMINGBIRD CLAIMS, VIRGIN MOUNTAINS

A pegmatite containing beryl and chrysoberyl on the Hummingbird claims, on the north side of Virgin Peak (Bunkerville Mountain), in Mohave County, Ariz., was prospected on a small scale for 2 or 3 months beginning February 13, 1949, by Belle Hope Mines, Ltd. This company owns a group of six claims, known as the Hummingbird Nos. 1, 2, and 3 and the Whitebird Nos. 1, 2, and 3. The most recent work was on the Hummingbird No. 3. This deposit, about 12 miles south-southeast of Bunkerville, Nev., may be reached by turning off U.S. Highway 91 at the south end of the Virgin River bridge between Bunkerville and Mesquite. From this point a dirt road extends southeastward about 10 miles to a camp at the base of the range at an altitude of about 3,550 feet. From this camp, a steep mine road extends southward into the range 2 miles to the deposit, which is at an altitude of about 4,550 feet. The pegmatite dike crosses two ravines near their junction.

The Hummingbird prospect is probably the same prospect described by Callaghan (Hewett and others, 1936, p. 162–163) as the

Fool's Gold Nos. 1, 2, and 3. Six samples were collected by Olson in 1949 for spectrographic determination of BeO content and a sketch map of the pegmatite body (fig. 11) was made showing the locations of the samples.

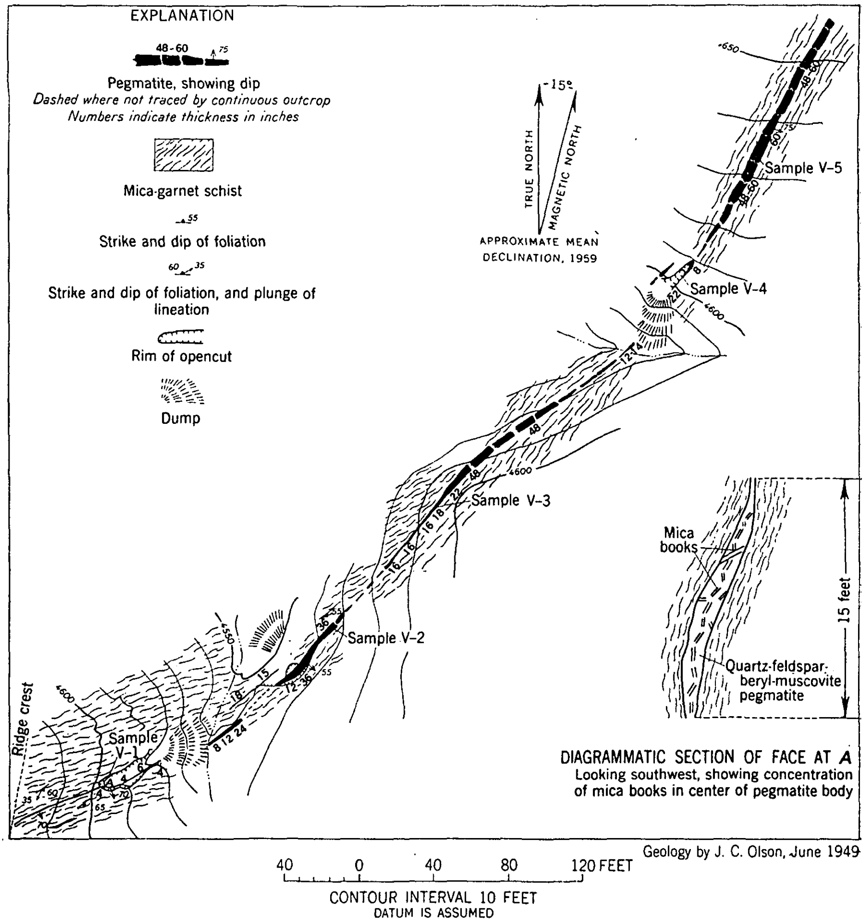


FIGURE 11.—Sketch map of beryl-bearing pegmatite on the Hummingbird claims, Mohave County, Ariz.

The north slopes of Virgin Peak are underlain by Precambrian metamorphic and igneous rocks comprising mica-garnet schist, interlayered amphibolite and quartz-mica schist, and granitic augen gneiss. Some massive kyanite reportedly has been found in the area. Between the prospect and the base of the range 2 miles to the north, the exposures consist of steeply dipping, probably tightly folded, schist and amphibolite, with a general northeasterly strike, containing many concordant thin sills of pegmatite. Pegmatite bodies as much as 4 feet thick are common; the schist is also impregnated by much pegmatitic material in thinner bodies. The sills pinch and swell markedly, as shown by the sketch map (fig. 11). Fracture intersections at one place in the schist plunge 35° SW., but the plunge of the pegmatite prospected was not determined.

Three pits 15 feet in maximum depth have been dug in the area shown on the sketch map (fig. 11). It is not certain whether the three pits are all in one pegmatite body, or in two or three very closely related, en echelon bodies. The pegmatites have a northeasterly strike and a dip that ranges from 55° SE. to vertical, averaging about 75°. Southwest of the southwest cut shown on the sketch map (fig. 11), the pegmatite is only 3 to 4 inches thick and consists of quartz and tourmaline; it apparently pinches out near the ridge crest. Northeast of this pit, the thickness ranges from 4 to 60 inches. At the northeast end of the area mapped, the pegmatite may be slightly offset by a fault, but the extension northeastward was not studied.

The pegmatite is composed of white to gray quartz; white, fine- to medium-grained feldspar that is probably mostly plagioclase; rarer perthite as much as 8 inches in grain size; pale green muscovite commonly stained by black inclusions; light bluish-green beryl; yellow and greenish-yellow, tabular, striated crystals of chrysoberyl; black tourmaline; and garnet. The pegmatites in the area are mostly fine grained, although muscovite and perthite are locally coarse-grained. The coarse-grained perthite was noted chiefly in the feldspathic pegmatite about 200 feet northwest of the prospect pits. The largest muscovite books, as much as 18 inches long, occur in pegmatite 6 to 18 inches thick in the southwest cut. In general, the muscovite occurs mostly in the quartzose parts of the pegmatites. The thinner parts are generally more quartzose than the thick, feldspathic pegmatites.

The pegmatites show a banding or streakiness parallel to their walls. The banding in the southwest cut is illustrated by diagrammatic section (fig. 11). Northeast of this point the streakiness is in large part a foliation produced by shearing of the pegmatite and drawing out of the quartz into thin stringers. Curved surfaces coated with fine, pale-greenish muscovite are common in the sheared pegmatite. The 22-inch pegmatite exposed at the northeast pit is foliated and banded as follows: the 3- to 4-inch border zone of quartz, muscovite, and plagioclase is foliated parallel to the walls of the dike; the wall zone of plagioclase, quartz, muscovite, and beryl is also streaked or foliated parallel to the walls; and the core is a sharply defined layer of massive white quartz, which forks in places into two or more nearly parallel quartz layers.

Beryl can be found in nearly every exposure of pegmatite shown on the sketch map. The coarsest grained and most abundant beryl was found in the southwest cut, where it constitutes about 3 percent of the pegmatite 6 to 18 inches thick that is rich in muscovite and quartz. One crystal of beryl 3 inches long was seen in the southwest cut, and crystals 15 inches long have been found. The beryl is mostly in fine grains less than half an inch long, however, and the average grain size is so fine that hand sorting of the beryl would be a costly and impractical method of recovery. The fine grain size also makes it difficult to determine the percentage of beryl in the rock by grain counts, and samples were therefore taken at six points for spectrographic determination of BeO. The beryl content of a considerable part of the pegmatite is probably within the range of 0.5 to 1 percent as indicated by the spectrographic BeO determinations given in table 7.

TABLE 7.—BeO *content of pegmatite samples from Hummingbird claims, determined spectrographically*

Sample (fig. 11)	BeO[1] (percent)	Thickness of pegmatite where sampled (feet)
V-1	0. 11	1. 0
V-2	. 11	2. 5
V-3	. 11	1. 5
V-4	. 066	1. 5
V-5	. 055	4. 5

[1] BeO content determined spectrographically by Saratoga Laboratories, Saratoga Springs, N.Y.

A pegmatite dike 200 feet northwest of and parallel to the Hummingbird prospects also contains beryllium in the minerals chrysoberyl and beryl. This dike strikes northeast, dips steeply southeast, and pinches and swells in thickness to a maximum of about 10 feet. It contains abundant plagioclase and potassium feldspars. Quartz is not abundant. Other minerals include chrysoberyl, beryl, black tourmaline, and numerous garnet crystals, some exceeding 1 inch in diameter. A sample across the dike 8 feet wide, containing both chrysoberyl and beryl, contains 0.091 percent BeO by spectrographic analysis.

PAINTED DESERT

The presence of beryl in pegmatites in the Painted Desert region is mentioned by Nolan (Hewett and others, 1936, p. 17) as follows:

Painted Desert.—5 miles from branch railroad at Boulder City, Nev. Recent prospecting in this district has disclosed pegmatites containing minor beryl, quartz-specularite veins containing copper in pre-Cambrian gneiss cut by basic dikes, and gold-bearing lodes. Early in 1934 some gold ore was being developed in a sheared basic dike, associated with barite and specularite. No production has been made.

The area 3.5 to 4 miles east of Hoover Dam and nearly 2 miles south of the Painted Desert is underlain predominantly by Precambrian igneous rocks. These rocks are somewhat heterogeneous in color and composition, strongly sheared, and are intruded by pegmatites and basic dikes. The pegmatites are mostly 1 to 3 feet thick, dip steeply, and many of them strike about N. 30° W. The pegmatites consist of feldspar, quartz, biotite, garnet, specularite, hornblende, and chlorite. Beryl is reported but was not found in many pegmatites examined in a half-day reconnaissance. Feldspar is by far the most abundant constituent. Quartz is a relatively minor constituent in much of the pegmatite. However one feldspathic pegmatite grades, within a few feet along the strike, into a quartz-specularite pegmatite containing only a small amount of feldspar. The large area of Precambrian intrusive rocks east of the mining area probably contains pegmatites also, but they are not known to contain minerals of economic interest.

M AND P MICA CLAIMS

Charles M. Sisson, of Los Angeles, Calif., and his two partners hold six claims known as the M and P group, in Mohave County, Ariz. The claims are reached from a point on U.S. Highway 93 about 30 miles north of Kingman, thence northeastward on the Pierce Ferry road about 22 miles to the intersection with the road down Hualpai Wash from Hackberry. At this intersection a right turn is taken and followed southeastward about 3 miles to an abandoned ranchhouse, where a smaller road branches northeastward and extends about 2 miles to the base of the mountain range. The mine is just a few feet above the break in slope at the base of the range. Mr. Sisson and his partners began working the M and P mine in 1943, and ceased about 1944 or 1945. A small quantity of sheet mica was sold to Colonial Mica Corp. during World War II.

The pegmatite is enclosed in granite. The contacts are very poorly exposed, and the size and attitude are uncertain, but the pegmatite is probably an irregularly-shaped body about 60 feet wide and 200 feet long, with a northwesterly strike and a dip of about 60° N.E. A fault exposed in the gully southeast of the mine may cut the pegmatite at its south end, but there are no exposures at this point.

Four small pits and one 40-foot drift with 15-foot winze have been excavated in the pegmatite where coarse books of muscovite are associated with irregularly shaped pods of massive quartz as much as 6 feet thick. The coarsest grained muscovite is exposed in the drift and winze. Blocks of light-green muscovite individually weighing several hundred pounds occur in feldspar-quartz-muscovite pegmatite just above the upper edge of a mass of quartz that dips 60° NE. The muscovite books are characterized by "A" structure, having reeves or ridges in the form of an A or chevron.

The pegmatite contains quartz, perthite, plagioclase, muscovite, garnet, biotite, and hematite. Part of the body is relatively fine-grained feldspar-quartz-muscovite pegmatite, part is coarse-grained perthite-quartz pegmatite, and part is the muscovite-rich rock containing coarse mica books, feldspar, and quartz. These rock types are rather irregular in distribution. Patches or pods of quartz occur sporadically in the pegmatite, and coarse-grained muscovite is associated with some of them. The pegmatite as a whole probably contains less than 5 percent muscovite. The largest muscovite concentration seems to be in the drift, where the mica-rich zone above the quartz is at least 20 feet long and at least 15 feet downdip. This zone about 5 feet thick probably contains about 10 percent muscovite in coarse books, most of which are 1 or 2 feet long. The mica is nearly all scrap, but careful trimming yields some sheet mica, part of which is clear and part black stained. The depth of the mica-rich zone is unknown because the quartz masses may be discontinuous pods. Large mica blocks are visible in the drift and winze, and it is inferred that the mica-rich zone 5 feet thick is at least as large as 20 by 40 feet. Coarse-grained potassium feldspar could be mined from the perthite-quartz pegmatite adjacent to the massive quartz pods, but it would be costly to haul it about 40 miles to the railroad at Hackberry or 60 miles by road to the feldspar mill at Kingman.

Other pegmatites and quartz veins occur on the hillside southeast of the mine and about half a mile to the northwest in a small area at the point of a ridge, suggesting that the pegmatites may be localized in a belt in the granite trending N. 45° W. Several other small pits have been dug in this belt, but none of the other pegmatites seem to be as large or as rich in mica as the one mined. No minerals of economic interest other than the mica and feldspar mentioned above were noted when the area was examined on June 22, 1949.

FELDSPAR MINES AND PROSPECTS NEAR KINGMAN

Feldspar was first mined near Kingman in 1923 by G. I. Taylor, and the crude feldspar was shipped to California mills. In March 1924 the deposits were sold to the Kingman Feldspar Co. Consolidated Feldspar Corp. built a mill at Kingman in 1931 to grind all the feldspar produced by the company. Much of the ground feldspar from Kingman is used in the California ceramic industry. The Kingman deposits have yielded more than 100,000 tons.

The principal deposits that have supplied the grinding mill are about 5 miles to the north on the east side of the Cerbat Mountains where 5 quarries have been excavated in an area about 3,000 feet long. These quarries and three other prospects near the south end of the Cerbat Mountains were examined briefly in June 1949. The southwesternmost of the 5 quarries is about 300 feet long, 50 to 70 feet deep, and trends N. 68° E. Northeast of it is a quarry 150 feet long, 50 to 100 feet wide, and 30 feet in maximum depth. The pegmatite in this cut is more than 100 feet thick and contains a quartz core about 50 feet thick. Adjoining it on the northeast is another open cut about 250 feet long. These three quarries are probably in the same large pegmatite body.

One thousand feet in a N. 25° E. direction, and separated from the group of 3 quarries by an interval that is talus covered, is an open cut 170 feet long and as much as 50 feet wide and 45 feet deep. This pegmatite body is possibly 200 or more feet thick and its south contact strikes N. 65° E. and dips 70° N. The pegmatite dike has a quartz core, bordered by large masses of coarse-grained blocky perthite, and streaky, finer grained, biotite-bearing wall zones as much as 20 feet thick. Between 1,000 and 1,500 feet N. 5° W. of this cut is another quarry not examined by the writer. It is in a thick pegmatite body that is probably separate from those quarried in the other cuts.

The pegmatite dikes in this group of five quarries are large and are enclosed in the granite that underlies large areas in the southern part of the Cerbat Mountains. The pegmatite bodies are characterized by thick quartz cores surrounded by large masses of blocky perthite; hence they are exceptionally good sources of potassium feldspar. The entire dike is not mined because the wall zones are finer grained and commonly contain biotite. Beryl has not been found in these pegmatites. Euxenite in masses of as much as 50 pounds, allanite, and gadolinite are reported (Galbraith, 1941, p. 53, 55, 62).

In 1949 the Consolidated Feldspar Corp. also had a claim about 3 miles N. 25° W. of the group of quarries described above. No feldspar has yet been produced from this deposit, but assessment work consisting of construction of a short road to the prospect and minor surface exploratory work has been done. The pegmatite body is large, and consists mostly of potassium feldspar and quartz, with some plagioclase in the finer grained parts, and a small amount of muscovite, biotite, and magnetite.

A feldspar deposit known as the Hopkins prospect is about 1 mile S. 75° W. of the main group of quarries. The thick, steeply-dipping pegmatite body strikes about N. 75° E. and has a composition similar to other pegmatites in the region. A road had just been built to the deposit in 1949, and the extent of the pegmatite and the feldspar deposit was being determined.

Another group of feldspar prospects is in an area of pegmatite dikes 5 miles northwest of Kingman, on the southwest side of the Cerbat Mountains. This area is about 0.5 mile north of the junction of Arizona Highway 68 and U.S. Highway 93, and is on the southeast side of a spur of the Cerbat Mountains. A group of pegmatite dikes characterized by abundant white quartz forms conspicuous white patches on the drab granite slopes in an area about half a mile long and several hundred feet wide, trending N. 35° E. Within this area are about a dozen of the white quartz patches, some of which may be interconnected. Most of the individual pegmatite bodies, of which the quartz is a part, dip steeply, but some seem to dip about 30° SE. parallel to the slope of the hillside. The pegmatites consist of quartz; pink to light-gray perthite; white plagioclase, some of which is platy; biotite; and a few flakes of muscovite. Perthite is probably at least twice as abundant as plagioclase.

The massive white quartz bodies are mostly 5 to 15 feet thick and about 10 times as long. In general they form the cores of the pegmatite bodies, although in places the quartz extends to the contact with granite. Giant perthite blocks occur mostly in the pegmatite around the quartz cores, and the perthite grain size generally decreases toward the walls, although a few large blocks of perthite occur at the contact with granite. The plagioclase content is greatest in medium-grained pegmatite near the walls. Coarse, curved blades of biotite occur mostly in the marginal parts of the massive quartz and are nearly parallel to the margins of the quartz core. Fine-grained biotite occurs locally near the walls of the pegmatite. A few blocky perthite crystals occur in the massive quartz.

The largest pegmatite body in this group has been prospected at three points to expose feldspar-rich rock, but apparently no feldspar has been produced. This pegmatite body strikes N. 15° E. and dips 80° E. It is about 400 feet long and seems to pinch out abruptly at each end. The contacts with granite are irregular in detail. It is estimated roughly that pegmatite from which 40 percent or more potassium feldspar could be easily hand cobbed occurs over a strike length of 225 feet and an average width of about 40 feet.

In addition to the pegmatites mentioned above, other large pegmatite bodies form prominent light-colored patches on the hills of darker, weathered granite near the south end of the Cerbat Mountains, and the quantity of pegmatite and feldspar in the area is apparently large.

LITERATURE CITED

Andersen, Olaf, 1931, Discussion of certain phases of the genesis of pegmatites: Norsk geol. tidsskr., v. 12, p. 1–56.

Ball, S. H., 1907, A geologic reconnaissance in southwestern Nevada: U.S. Geol. Survey Bull. 308, 218 p.

——— 1908, The post-Jurassic igneous rocks of southwestern Nevada: Jour. Geology, v. 16, p. 36–45.

Brammall, A., and Harwood, H. F., 1932, The Dartmoor granites: Their genetic relationships: Geol. Soc. London Quart. Jour., v. 88, p. 171–234.

Clarke, F. W., 1885, Mica: U.S. Geol. Survey Mineral Resources U.S., 1883 and 1884, p. 906–912.

Cook, C. W., 1925, Molybdenite deposit near New Ross, Nova Scotia: Econ. Geology, v. 20, p. 185–188.

Derry, D. R., 1931, The genetic relationships of pegmatites, aplites, and tin veins: Geol. Mag., v. 68, p. 454–475.

Engel, A. L., and Shelton, S. M., 1941, Ore-testing studies, 1939–40: U.S. Bur. Mines Rept. Inv. 3564, 29 p.

Ferguson, H. G., 1929, The mining districts of Nevada: Econ. Geology, v. 24, p. 115–148.

——— and Muller, S. W., 1949 (1950), Structural geology of the Hawthorne and Tonopah quadrangles, Nevada: U.S. Geol. Survey Prof. Paper 216, 55 p.

Fulton, J. A., and Smith, A. M., 1932, Nonmetallic minerals in Nevada: Nevada Univ. Bull., v. 26, no. 7, 8 p.

Galbraith, F. W., 1941, Minerals of Arizona: Arizona Bur. Mines, Geol. Ser. No. 15, Bull. No. 149, 82 p.

Grawe, O. R., and others, 1928, Dumortierite: Nevada Univ. Bull., v. 22, no. 2, 47 p.

Hanley, J. B., 1951, Economic geology of the Rincon pegmatites, San Diego County, Calif.: California Div. Mines, Spec. Rept. 7–B, 24 p.

Heinrich, E. W., 1948, Pegmatites of Eight Mile Park, Colorado: Am. Mineralogist, v. 33, p. 420–448, 550–587.

Hewett, D. F., Callaghan, Eugene, Moore, B. N., Nolan, T. B., Rubey, W. W., and Schaller, W. T., 1936, Mineral resources of the region around Boulder Dam: U.S. Geol. Survey Bull. 871, 197 p.

Hill, J. M., 1916, Notes on some mining districts in eastern Nevada: U.S. Geol. Survey Bull. 648, 214 p.

Hobbs, S. W., 1944, Tungsten deposits in the Boriana district and the Aquarius Range, Mohave County, Arizona: U.S. Geol. Survey Bull. 940–I, p. 247–264.

Holmes, J. A., 1904, Mica: U.S. Geol. Survey, Mineral Resources U.S., 1902, p. 985–991.

Jahns, R. H., 1952, Pegmatite deposits of the White Picacho district, Maricopa and Yavapai counties, Arizona: Arizona Bur. Mines Bull., no 162, Mineral Tech. Ser. no. 46, 105 p.

Jahns, R. H., and Wright, L. A., 1951, Gem- and lithium-bearing pegmatites of the Pala district, San Diego County, Calif.: California Div. Mines, Spec. Rept. 7–A, 72 p.

Jenney, C. P., 1935, Geology of the central Humboldt Range, Nevada: Nevada Univ. Bull., v. 29, no. 6, 73 p.

Kennedy, J. S., and O'Meara, R. G., 1948, Flotation of beryllium ores: U.S. Bur. Mines Rept. Inv. 4166, 18 p.

Kerr, P. F., 1935, Scheelite-beryl deposit at Oreana, Nevada (abs.) : Am. Mineralogist, v. 20, p. 207.

——— 1938, Tungsten mineralization at Oreana, Nevada: Econ. Geology, v. 33, p. 390–427.

——— 1946, Tungsten mineralization in the United States: Geol. Soc. America Mem. 15, 241 p.

King, Clarence, 1877, U.S. Geological Exploration of the 40th Parallel: v. 2, Descriptive geology: U.S. Army, Eng. Dept., Prof. Paper no. 18.

Longwell, C.R., 1936, Geology of the Boulder Reservoir floor: Geol. Soc. America Bull., v. 47, p. 1393–1476.

McLaughlin, T. G., 1940, Pegmatite dikes of the Bridger Mountains, Wyoming: Am. Mineralogist, v. 25, p. 46–68.

Olson, J. C., and others, 1946, Mica deposits of the Franklin-Sylva district, N.C.: North Carolina Dept. Conserv. and Devel. Bull. 49, 56 p.

Ransome, F. L., Emmons, W. H., and Garrey, G. H., 1910, Geology and ore deposits of the Bullfrog district, Nevada: U.S. Geol. Survey Bull. 407, 130 p.

Schaller, W. T., 1925, Genesis of lithium pegmatites: Am. Jour. Sci., 5th ser., v. 210, p. 269–279.

Schrader, F. C., Stone, R. W., and Sanford, Samuel, 1916, Useful minerals of the United States: U.S. Geol. Survey Bull. 624, 412 p.

Sharp, R. P., 1939, Basin-range structure of the Ruby-East Humboldt Range, northeastern Nevada: Geol. Soc. America Bull., v. 50, p. 881–920.

———1942, Stratigraphy and structure of the Southern Ruby Mountains, Nevada: Geol. Soc. America Bull., v. 53, p. 647–690.

Spurr, J. E., 1906, Ore deposits of the Silver Peak quadrangle, Nevada: U.S. Geol. Survey Prof. Paper 55, 174 p.

——— 1923, The ore magmas, McGraw-Hill, New York, N.Y.

Staatz, M. H., and Trites, A. F., 1955, Geology of the Quartz Creek pegmatite district, Gunnison County, Colorado: U.S. Geol. Survey Prof. Paper 265, 111 p.

Sterrett, D. B., 1923, Mica deposits of the United States: U.S. Geol. Survey Bull. 740, 342 p.

Steven, T. A., 1949, Geology and fluorspar deposits of the St. Peters Dome district, Colorado: Colorado Sci. Soc. Proc., v. 15, no. 6, p. 259–283.

Stockwell, C. H., 1933a, Genesis of a lithia pegmatite on the Bear Mineral claim, southeast Manitoba: Royal Soc. Canada Trans., 3d sec. v. 27, sec. 4, p. 27–36.

——— 1933b, The genesis of pegmatites of southeast Manitoba: Royal Soc. Canada Trans., 3d ser., v. 27, ser., 4, p. 37–51.

Vanderburg, W. O., 1936, Reconnaissance of mining districts, in Pershing Co., Nevada: U.S. Bur. Mines Inf. Circ. 6902, 57 p.

Vitaliano, C. J., 1944, Contact metamorphism at Rye Patch, Nevada: Geol. Soc. America Bull., v. 55, p. 921–950.

Vogt, J. H. L., 1931, The physical chemistry of the magmatic differentiation of igneous rocks, III, 2d half, On the granitic rocks: Norske Vidensk-Akad. Oslo Skr., I. Nat.-Naturv. Kl. 1930, 242 p. (1931).

Winchell, A. N., 1951, Elements of optical mineralogy, v. 2, 4th ed.: New York, John Wiley and Sons.

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