UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

THE PEGMATITES OF THE ERRINGTON-THIEL MINE,
ELKO COUNTY, NEVADA

Open file report

by

E. Neal Hinrichs

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Dr. Phillip L. Merritt, Assistant Manager
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P. O. Box 30, Ansonia Station
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Dear Phil:

Transmitted herewith are five copies of: The pegmatites of the Errington - Thiel mine, Elko County, Nevada, by E. Neal Hinrichs; Trace Elements Investigations Report 71.

This report has been released on open file by the Geological Survey.

Two copies of this report are being sent to Mr. Jesse C. Johnson and one copy each to Messrs. E. E. Thurlow, W. G. Fetzer, and C. C. Towle, Jr.

Sincerely yours,

Esper S. Larsen

for W. H. Bradley
Chief Geologist

Enclosures 5

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The pegmatites of the Errington-Thiel mine,

Elko County, Nevada

E. Neal Hinrichs

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Abstract

An area 300 by 500 feet near the Errington-Thiel mica mine in northeastern Nevada was mapped on a scale of 1 in. = 20 ft. by the U. S. Geological Survey during the summer of 1948. Eleven pegmatite dikes, 2 to 11 feet wide, cut the Prospect Mountain quartzite of Lower Cambrian age in this area. The pegmatites are believed to have been formed by the residual fluids of an adjacent granite stock filling fractures associated with regional folding. Irregular and gradational boundaries between pegmatite and granite indicate a close genetic relationship.

The minerals found in the pegmatites are plagioclase, quartz, muscovite, perthite, garnet, beryl, microcline, apatite, zircon, hematite, biotite, phlogopite, tourmaline, and penninite. The plagioclase is albite ($\text{Ab}_{97}\text{An}_3$) except in one pegmatite, where it is oligoclase ($\text{Ab}_{88}\text{An}_{12}$). The garnet in the pegmatites differs from that in the adjacent schist in refractive index and specific gravity. Beryl crystals, 2 to 5 mm. in size, are disseminated throughout the pegmatites. The weight percent of beryl in 21 thin sections ranges from 0 to 1.62.

The alkali content of beryl found in the wall zone is greater than the alkali content in the core, the reverse of the normal variation. Microcline veinlets cut albite, evidence that albite crystallized before microcline. There is little evidence of mineral replacement. Fifteen photomicrographs illustrate grain boundary relationships, such as albite and beryl in garnet, apatite in beryl, and lobate, anhedral beryl grains in albite.

Introduction

The occurrence and origin of a group of mica-beryl deposits in the vicinity of the Errington-Thiel mine, Elko County, Nev., were investigated in the field by the writer from July 26 to September 13, 1948, while he was assisting J. C. Olson of the U. S. Geological Survey in mapping these deposits. Thirty-four hand specimens and 26 thin sections from three of these deposits were studied in detail during the following winter in the laboratories of the Department of Geology, Cornell University.

Location

The mica-beryl deposits of the Errington-Thiel property are in pegmatites in Dawley Canyon on the east side of the Ruby Mountains (fig. 1). No topographic or geologic maps or aerial photographs of the Dawley Canyon area are available, although the Jiggs and Halleck quadrangle maps (U. S. Geol. Survey, 1:62,500, 1935 and 1937) cover nearby areas of the Ruby Mountains. The Dawley Canyon area is shown on a compiled planimetric map of the Humboldt National Forest (U. S. Forest Service, 1:250,000, 1936) and on quadrangle map number 204 of Elko County (U. S. Forest Service, 1:62,500).

Field work

The field work was directed by J. C. Olson, geologist in charge of pegmatite investigations for the U. S. Geological Survey in Nevada, and the laboratory work was under the supervision of W. T. Holser, Department of Geology, Cornell University. The topography and geology of the Errington-Thiel mine, in the SE $\frac{1}{4}$

sec. 8, T. 29 N., R. 58 E., Mount Diablo base and meridian, was mapped on a scale of 1 in. = 20 ft. (pl. 2). In addition, the lower north side of Lawley Canyon was mapped on a scale of 1 in. = 800 ft.

Acknowledgments

The writer is indebted to Dr. Holser for his stimulating criticism and review of the manuscript and to Mr. J. C. Olson and L. R. Page of the U. S. Geological Survey for guidance during the field work. Mr. Oscar W. Thiel of Ruby Valley, Nev., kindly furnished information about the history of the mine.

Previous geologic work

The geology of the Ruby Mountains has been described by Hill / and Sharp /. The mica-beryl deposits were examined in 1942 by

/ Hill, J. W., Mining districts in eastern Nevada: U.S. Geol. Survey Bull. 648, pp. 54-63, 1916.

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

J. H. Wiese and in 1944 by D. J. Fisher, both of the U. S. Geological Survey. /

/ Dept. Interior information service, Geol. Survey Public Notice 103897, Beryl pegmatites of the Ruby Mountains, Nevada, December 21, 1944.

Geography

Dawley Canyon in the Ruby Mountains, Nev., is in an area of high relief typical of the Basin and Range physiographic province. Altitudes range from 6,500 feet in Ruby Valley to 10,934 feet at the crest of the Ruby Range, $3\frac{1}{2}$ miles northwest. The south slopes near the Errington-Thiel mine are as steep as 40° (pl. 1).

The climate in the Ruby Mountains is dry, and warm to cool. Little rain falls, but mountain springs and year-round snowfields feed streams that drain into Ruby Valley.

Vegetation is scarce, so comparatively fresh rock is amply exposed. Pinon pine grown on the higher slopes; mountain mahogany and buck brush grow best on lower ridges. Willow and small-toothed aspen flourish along the creeks and near the springs.

Geologic setting

General features

The upper part of Dawley Canyon is underlain by a granite stock that extends across the Ruby Range southward to Harrison Pass. In the lower part of Dawley Canyon granite and associated pegmatites have intruded the Prospect Mountain quartzite and interbedded schist of Lower Cambrian age.

Metamorphic rocks

The Prospect Mountain quartzite dips generally eastward in Dawley Canyon, but on the western side of the hill on which the pegmatites are exposed, local intrusions have reversed the dip (pl. 2). Jointing is prominent only in the northeastern outcrop (pl. 1), where five or six joints strike about N. 15° E. and dip about 83° SE.

In the area mapped, about 80 feet of pale-gray medium-grained Prospect Mountain quartzite is exposed. The total thickness of this formation in the southern Ruby Mountains is 1,400 feet, according to Sharp. / Quartzite layers, 6 inches to 5 feet thick, commonly

/ Sharp, R. P., Stratigraphy and structure of the southern Ruby Mountains, Nevada: Geol. Soc. America Bull. vol. 53, pp. 651, 675, 1942.

are cross-bedded and are separated by quartz mica schist beds 3 inches to 4 feet thick. The quartzite that lies directly above schist contains flat quartz pebbles half an inch long. The quartzite is composed of quartz, biotite, and muscovite, with minor amounts of apatite and zircon.

The foliation of the quartz-mica schist is irregular, knotty, and poorly developed parallel to the bedding. The schist is composed mainly of muscovite, hornblende, quartz and biotite. The accessory minerals are garnet, apatite, magnetite, and thin acicular crystals that are probably sillimanite. The average composition of the garnet from three localities, as determined from its refractive index and specific gravity, / is 65 percent almandite, 18

/Winchell, A. N., Elements of optical mineralogy, vol. II, pp. 176, 180, Wiley, 1933.

percent andradite, and 17 percent pyrope, although one specimen from a knotty schist has an apparent composition of 96 percent grossularite, 2 percent andradite, and 2 percent almandite.

Intrusive igneous rocks

Muscovite granite, biotite-muscovite granite, and pegmatites intrude the schist and quartzite. The largest mass of muscovite granite is exposed about 200 yards northwest of the area mapped. Muscovite granite also crops out in the eastern part of the mapped area (pl. 2). In both exposures the granite varies in textures. In the eastern exposure it is fine-to medium-grained and contains small pegmatitic lenses, areas of porphyritic texture, and xenoliths of quartzite and schist (pl. 3,A). The boundaries between these textural types of granite are gradational and irregular. The principal minerals of the muscovite granite are quartz, oligoclase, orthoclase, and muscovite. The accessory minerals are garnet, apatite, and zircon. Phenocrysts of orthoclase as much as $1\frac{1}{2}$ inches long occur in the small outcrop in the northeast corner of the area mapped.

Biotite-muscovite granite crops out in two areas at an altitude of about 7760 feet in the southwest part of the area mapped. It intrudes quartzite and schist and is intruded by a pegmatite. This is part of the granite stock exposed at Harrison Pass and described by Sharp / as a coarse-grained to porphyritic biotite granite

/ Sharp, R. P., Stratigraphy and structure of the southern Ruby Mountains, Nevada: Geol. Soc. America Bull., vol. 53, p.673, 1942.

/ Sharp, R. P., Basin-range structure of the Ruby-East Humboldt Range, northeastern Nevada: Geol. Soc. America Bull., vol. 50, p. 888, 1939.

composed of quartz (about 20 percent), orthoclase (45 percent), well-zoned oligoclase (33 percent), biotite (2 percent), and minor quantities of apatite and zircon. Masses of medium-grained muscovite-

biotite granite along the borders indicate that the stock may be a multiple intrusion. Sharp believes that the age of the stock is late Jurassic or early Tertiary.

Three facts suggest that the area mapped is probably underlain by a large intrusion of muscovite granite: First, the Prospect Mountain quartzite, which has a gentle to moderate dip on the east side of the Ruby Range, dips 5° - 46° west, near the Errington-Thiel mine. The intruding muscovite granite probably tilted a block of quartzite westward. Second, quartzite-schist xenoliths (pl. 3,A), are present in the muscovite granite exposed in the eastern part of the area mapped (pl. 2). The intruding granite buoyed up and isolated fragments of the overlying quartzite and schist. Finally, large granite intrusions are numerous in this and adjacent areas.

The pegmatites very likely are offshoots of the underlying granite. The four contacts of muscovite granite and pegmatite that are exposed show only that the pegmatites intrude the granite; the wide variation in texture of the muscovite granite, however, may indicate that the pegmatites are genetically related to the granite. Gradations between granite and pegmatite occur in many small, irregular-shaped areas with porphyritic and pegmatitic textures.

Quartz veins intrude the quartzite, granite, and pegmatites. The quartz veins in schist are small and concordant with the foliation. At an outcrop near the center of the Eastern dike (pl. 2) a quartz vein separates quartzite and granite and cuts across the end of a small dike. A quartz vein intrudes the wall zone of the Western dike (pl. 3,B).

Pegmatite

Distribution and size

Eleven pegmatite dikes and at least three small pegmatite sills intrude the granite, schist, and quartzite in the area mapped, but only the Western, Northwestern, and Eastern dikes were studied in detail. The dikes, 10 to 50 feet apart, are parallel, strike northward, and dip eastward from 40° to vertical. They are 30 to 350 feet long, and 2 to 12 feet thick.

Structural and textural characteristics

The pegmatite dikes, particularly the Eastern dike, strike parallel to the more prominent joints in the schist and quartzite (pls. 2 and 4,A), and parallel to the normal fault (post-upper Miocene) that forms the eastern boundary of the Ruby Range. _/

_/ Sharp, R. P., Basin-range structure of the Ruby-East Humboldt Range, northeastern Nevada: Geol. Soc. America Bull., vol. 50, p. 900, 1939.

The contacts of the pegmatites with schist and quartzite are generally sharp and even. No evidence of thermal matamorphism was noted. Contacts of granite with pegmatite are gradational and irregular.

All but three small pegmatite dikes are zoned, that is, they are composed of shells of contrasting texture and mineral arrangement, which are parallel to the walls (pl. 4,B). The zones from the contact inward are called the border zone, the wall zone, intermediate zones, and the core. / Only one or two sections across

/ Cameron, E. N., Larrabee, D. M., McNair, A.H., Page, J. J., Shainin, V. E., and Stewart, G. W., Structural and economic characteristics of New England mica deposits: Econ. Geol., vol. 40, no. 6, p. 373, 1945.

a dike show all types of zones because the zones are discontinuous. Three types are most common: The border, wall, and intermediate zones. The border zones, generally less than 2 inches thick, are composed of muscovite grains, a quarter of an inch in maximum diameter, with varying, but generally small, amounts of quartz and plagioclase. The wall zones are composed of one-half to 4-inch grains of muscovite, quartz, and plagioclase (pl. 4,B). The intermediate zones consist of grains as large as 1 inch. Many of the intermediate zones contain 2-to 6-inch clusters of perthite and cleavelandite grains, 1 to 3 inches in diameter. The cores are discontinuous elongated lenses composed of 1-to 6-inch grains of quartz, or quartz and muscovite.

Mineralogy

The minerals in the pegmatites, in order of abundance, are: plagioclase, quartz, muscovite, perthite, garnet, beryl, microcline, apatite, zircon, hematite, biotite, phlogopite, tourmaline (schorlite), and penninite.

Description of individual minerals. The plagioclase is albite (Ab97An03) except in one of the 23 samples taken from six cross sections. At the northernmost pit of the Western dike, the border and outer wall zones contain oligoclase (Ab88An12). The percent of anorthite molecule was determined by measuring the refractive indices of (001) and (010) cleavage flakes, and by applying the refractive index to a curve by Tsuboi, reproduced by Rogers and Kerr. /

/ Rogers, A. F., and Kerr, P. F., Thin section mineralogy, 1st ed., McGraw-Hill, p. 213, 1933.

White to pale yellow albite occurs abundantly in the pegmatite as the ordinary anhedral form and also the tabular form cleavelandite. The typical granitoid textures contain albite, quartz, and muscovite grains 0.2-1.5 mm. in diameter. The cleavelandite plates are about 1.5 mm. in diameter, about 1.5 mm. thick, and as much as 19 mm. long. Polysynthetic albite twins, composed of lamellae varying greatly in width, predominate, but carlsbad twins also occur.

Quartz occurs in the pegmatite as glassy, gray anhedral grains and veinlets. Some of the grains contain streaks of very small rounded inclusions of a composition indeterminable under a microscope.

Pale-green to pale-brown muscovite, generally free from stains and ruled markings, occurs in all zones. It is most abundant in the wall zones, where books as wide as 5 inches show a preferred orientation perpendicular to the zone contacts. Scattered large books occur in or near the cores. In thin section the muscovite grains are rectangular or lath-shaped; a few are simple twins. Some flakes are bent along fractures (pl. 5,A).

Individual crystals and curved layers of red garnet crystals as much as 4 mm. in diameter are scattered throughout the pegmatite (pl. 5,B). The larger crystals are rusty red-brown; the smaller ones are clear red-orange trapezohedrons with small dodecahedral faces. Measurements of specific gravity and index of refraction, supplemented by a qualitative test for manganese indicate that the garnets are of uniform chemical composition. The specific gravity is 4.12 ± 0.01 , the index of refraction 1.82 ± 0.005 , and manganese is present. The composition is therefore 54 percent spessartite, 36 percent almandite, and 10 percent andradite. / Some garnet is

/ Winchell, A. N., Elements of optical mineralogy, vol. II, 3d ed., Wiley, p. 180, 1933.

altered to hematite and penninite.

Beryl occurs in the pegmatite as pale-green to white euhedral crystals generally less than a millimeter but as much as 5 mm. in diameter. Most of the crystals are tapering hexagonal prisms, rounded at the larger ends and terminated at the smaller by pyramids (pl. 6,A). 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. A variation in alkali content from zone to zone is shown in the Western pegmatite that was adequately sampled. The refractive index of the ordinary ray (No) ranges from 1.580 in the wall zone to 1.576 in the core and indicates a range of 1.25 to 0.8 percent in total alkali content respectively. / This variation is the reverse of normal pegmatites.

/ Winchell, A. N., Elements of optical mineralogy, vol. II, 3d ed., Wiley, p. 213, 1933.

The interference figures of the beryl are characteristically indistinct; most optic axis figures show a blurred cross, with a gray center.

Microcline occurs only in small veins in the wall zone of the Western dike and in the intermediate zone of the Northwestern dike. The microcline veinlets in the wall zone of the Western dike taper and end in large albite grains (pl. 6,B). At the northern end of the Northwestern dike, the intermediate zone, composed of plagioclase, quartz, and muscovite contains veinlets of microcline that cut across albite (cleavelandite) grains (pl. 7,A). The microcline in both the Western and Northwestern dikes is cloudy and shows faint quadrille twinning under the microscope (pl. 7,B).

Apatite is present in all zones as small pale blue-green rods enclosed in quartz and albite (pl. 8,A). Most of the rods are shorter than 0.2 mm., although one, 0.9 mm. long, occurs in albite parallel to the twinning. The accessory mineral, zircon, forms clusters of minute angular grains and, rarely, small tetragonal bipyramids (pl. 8,b). Hematite rims and fills fractures in altered garnet (pl. 9,A). Two isolated cubes of hematite are probably pseudomorphs after pyrite. Biotite occurs mostly near contacts with schist, although it also is found in the center of the Northwestern pegmatite (pl. 2) near altered garnet. A few grains of phlogopite were identified in the hanging-wall part of the Northwestern pegmatite. The phlogopite is colorless and except for a smaller optic angle is similar to muscovite. Black tourmaline is present sparingly as small irregular grains near the footwall contact of the Northwestern pegmatite.

Paragenesis. The sequence of crystallization of these minerals has been determined on the basis of two kinds of evidence. First, assuming that the pegmatite fluid crystallized from the border zone inward to the core without subsequent replacement, the zonal position of the minerals in the pegmatite should indicate the relative ages. Second, vein minerals are younger than the host.

Schorlite occurs only at the footwall contact of the Northwestern dike exposed at the open pit. It could have crystallized early or late. No fractures in the pegmatite or adjacent schist were noted, and no evidence of replacement at the contact ^{was} observed; therefore the schorlite is believed to be one of the first minerals to have solidified. The zonal position of biotite is the only evidence of its age relationship, and the evidence is conflicting. One grain of biotite is found in contact with hematite adjacent to a garnet crystal near the center of the Northwestern dike. Three biotite flakes occur in muscovite near the footwall contact of the Northwestern dike with schist. A biotite grain is in a garnet grain at the eastern contact of the Eastern dike with quartzite (pl. 9,A). Probably the biotite near the contacts of pegmatite with schist and quartzite came from the schist and quartzite. The biotite in garnet is believed to have formed earlier than the garnet. Apatite and zircon occur as small inclusions in albite, quartz (pl. 8,A), and beryl (pl. 9,B); therefore, apatite and zircon crystallized either earlier than albite, quartz, and beryl or at the same time. Oligoclase is found in the border and outer wall zone of the Western dike, and albite occurs in the inner zones. Thus, by zonal position, oligoclase crystallized before albite. This sequence conforms with the normal crystallization of plagioclase. /

/ Bowen, N. L., Melting phenomena of the plagioclase feldspars: Am. Jour. Sci., 4th ser., vol. 35, p. 583, 1913.

Beryl occurs as subhedral crystals with albite, muscovite, and quartz (pls. 6,A and 9,B), as lobate anhedral grains in albite (pls. 8,B and 10,A), and as anhedral inclusions in muscovite (pls. 10,B and 11,A), garnet (pl. 11,B), and albite (pl. 8,A). The grain relationships of beryl and albite indicate simultaneous growth or microscopic replacement. The only inclusion found in the beryl is a small rod of apatite (pl. 9,B). The beryl is believed to have begun crystallization of albite, muscovite, quartz, and garnet. Landes / and Gedney /

/ Landes, K.K., Origin and classification of pegmatites: Am. Mineralogist, vol. 18, p. 97, 1933.

/ Gedney, E.K., Beryllium ores of New England: Am. Mineralogist, vol. 15, p. 120, 1930.

believe that most common beryl is magmatic and that some is hydrothermal.

The garnet crystals in the pegmatite enclose grains of beryl, albite, and biotite (pls. 9,A; 11,B; and 12,A). A garnet crystal is embayed by a quartz grain (pl. 12,B). The refractive indices and specific gravities indicate that the composition of the garnets in the pegmatite is 54 percent spessartite molecule, 36 percent almandite molecule, and 10 percent andradite molecule. The garnets of the schist contain 65 percent almandite molecule, 18 percent andradite molecule, and 17 percent pyrope molecule. The garnets of the pegmatite contain inclusions of albite and beryl and differ in chemical composition from the garnets of the surrounding schist. These facts point to a magmatic origin of garnets in the pegmatite.

Quartz, muscovite, and microcline fill fractures in albite and are therefore younger (pls. 6,B; 7,A; 7,B; 9,B). The relationship of these three vein-filling minerals to each other was observed in only a few thin sections. Quartz fills fractures between microcline and muscovite (pl. 6,B); thus some quartz crystallized before microcline or muscovite. The sequence of albite preceding microcline is the reverse of the order of crystallization of feldspars in pegmatite as given by Schaller / and Switzer. / Landes / also

/ Schaller, W. T., Mineral replacements in pegmatites: Am. Mineralogist, vol. 12, p. 61, 1926.

/ Switzer, G., Paragenesis of the Center Stafford, N.H., pegmatite: Am. Mineralogist, vol. 23, p. 812, 1938.

/ Landes, K. K., Origin and classification of pegmatites: Am. Mineralogist, vol. 18, p. 98, 1933.

noted that albite commonly replaces earlier potassium feldspars.

Hematite and penninite, products of the alteration of garnet, crystallized last.

Genesis

The origin of pegmatites by injection of granitic material was first proposed by Charpentier / in 1823. Later this idea was modi-

/ von Charpentier, J. T., *Essai sur la constitution geognostique des Pyrenees*, p. 158, 1823.

fied to the aqueous magma theory by Elie de Beaumont. / In 1915

/ de Beaumont, Elie, *Sur les emanations volcaniques et metalliferes*: Soc. geol. France Bull. vol. II, p. 12, 1847.

that is, after the pegmatite has partly or wholly crystallized, solutions moving along the walls or fractures replace the earlier minerals. As very little or no replacement of pre-existing pegmatite is evident in the pegmatites of the Errington-Thiel mine, the pegmatites are, according to the classification of Landes, / simple rather than complex.

/ Landes, K. K., *Origin and classification of pegmatites*: Am. Mineralogist, vol. 18, p. 95, 1933.

The only probably evidence of hydrothermal action is altered garnet, and a few grains of microcline doubtfully replacing albite (pls. 6,B; and 7,B). Replacement on a microscopic scale during the pegmatitic stage is shown by albite and beryl textures (pls. 8,B; and 10,A).

The pegmatites of the Errington-Thiel mine probably were derived from solutions expelled during the last stages of crystallization of the adjacent granite stock. Irregular and gradational boundaries between granite and pegmatite suggest a close genetic relationship.

The eastern outcrop of muscovite granite, less than 100 yards from the pegmatite dikes and sills (pl. 2), contains bands and lenses of quartz and feldspar ranging in texture from fine-grained granite to pegmatite. Both the granite and the pegmatite contain plagioclase, quartz, muscovite, and garnet. It is believed that as the granite crystallized, H_2O , Na_2O , K_2O , SiO_2 , and BeO were concentrated in the residual fluid and assisted in keeping the magma mobile at comparatively low temperatures. / This residual fluid was injected into

/ Smith, F. G., Transport and deposition of the non-sulfide vein minerals, III phase relations at the pegmatitic stage: Econ. Geol., vol. 43, p. 536, 1948.

fractures in previously metamorphosed schist and quartzite. The fractures probably were formed by the regional forces associated with the folding of the rocks in the Dawley Canyon area. The regional nature of the fracturing is indicated by the fact that all the 200 to 250 dikes in the Dawley Canyon map area strike northward and are parallel to joints in the schist and quartzite. If it is assumed that the pegmatite crystallized from the residual fluid of the granite stock, the fracturing must have occurred earlier than the eastern boundary fault (post-upper Miocene). Sharp states that "The folding occurred after the deposition of the Permian (?) Upper limestone and before or contemporaneously with intrusion of the late Jurassic or early Tertiary igneous rocks." /

/ Sharp, R. P., Basin-range structure of the Ruby-East Humboldt Range, northeastern Nevada: Geol. Soc. America Bull. vol. 50, p. 890, 1939.

The pegmatites of the Errington-Thiel mine crystallized as thin, straight-walled dikes and sills from the residual fluid of a late Jurassic or early Tertiary granite stock. The dikes and sills pushed apart and filled parallel fractures that were formed by forces associated with regional folding. Various degrees of zoning occur in the dikes. The component minerals, other than the common plagioclase, quartz, and muscovite, include early beryl and garnet. Microcline has crystallized after albite, the reverse of the usual order.

Description of individual pegmatite dikes

Western dike. The westernmost of the two longest pegmatite dikes shown on plate 2 is designated the Western pegmatite. It is about 8 feet wide and 290 feet long. It strikes N. 10° W. and dips about 70° E. into schist, granite, and quartzite. Most of the contacts with the schist and quartzite are even and distinct, but the pegmatite grades into the muscovite granite. Two small irregularities in this tabular pegmatite body are exposed at the northern pit (pl. 3,B) and above the adit.

The Western dike can be divided into five zones; however, only four 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. Inside the border zone is the wall zone, 2 feet thick, that is composed of coarse-grained muscovite, quartz, albite, and garnet. The muscovite is in 3 by 4 inch clear, pale-green books that are fractured, perhaps by blasting. In thin sections, small microcline veinlets can be seen cutting albite. 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 northern open pit (pl. 4,B).

In 1944 the Columbia Mica Corporation, under lease from the owners, Mrs. A. T. Errington and Mr. Oscar W. Thiel, excavated about 80 feet of underground workings (pls. 2 and 13). 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. Production data were not available. The average piece of muscovite on the sump from the adit is 2 inches by 3 inches.

Table I contains data on the beryl content of each zone as measured on a micrometer stage by the Rosiwal method. The length of beryl grains ranging in size from 0.2 to 5 mm. and the total length of all other grains were measured by traverses across 21 thin sections of three pegmatites. The weight percent of beryl was calculated without any correction for specific gravity as the range of specific gravity of beryl approximates that of pegmatite. Beryl is absent from thin sections of the wall zone at the footwall of the Northwestern pegmatite and from the intermediate zone of the Eastern pegmatite. Beryl ranges up to 1.62 percent of other zones.

Northwestern dike. The Northwestern pegmatite is the dike farthest to the northwest. It is 11 feet thick, strikes roughly north, and dips about 36° E. It is exposed for about 100 feet (pl. 2). Although the same minerals occur in this pegmatite as in the Western dike, they are not grouped into such distinct zones. 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 present in the pegmatite, but most of it is in the border zone (see table 1). Black tourmaline occurs as a few small, flattened and broken grains at the footwall contact with schist in the bottom of the open pit.

Eastern dike. The Eastern dike, one of the two longest pegmatites, is 8 feet wide and about 350 feet long (pl. 2). It strikes north and dips 50° - 80° E. Two small dikes branch off the larger one and extend into the surrounding schist. Two sills, each about a foot thick, crop out in quartzite at the cliff in the northeastern part of the map area. One of these sills is visible in a photograph (pl. 4,A). 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, and muscovite, plus a few beryl crystals as large as 5 mm. in diameter. A distinctive feature of the Eastern dike is garnet occurring in wavy bands and streamers (pl. 5,B). Thin layers of small, rusty garnet crystals separate the intermediate zone from the wall zone and from the core. The intermediate zone consists of fine-grained albite and quartz with scattered clusters of crystals 2 to 4 inches long in coarse-grained quartz, muscovite, and albite. The core is typically discontinuous and is composed of coarse-grained quartz and muscovite. The dike is broken by three small faults of slight displacement that probably formed during cooling.

Plate 1

Plate 1. Photograph of the north slope of Hawley Canyon. The high point, at right, composed of schist and granite, is cut by pegmatite. Granite is at left.

Plate 3-A. Photograph of a quartzite-schist xenolith in granite, southwest edge of the muscovite granite. Altitude 7920 feet.

Plate 3-B. Photograph of a roll of the Western dike in the northern pit. This roll is about 10 feet south of the wall zone shown in plate 4-B.

Plate 4

Plate 4-A. Photograph of the northeast face of the "pegmatite" hill. Pegmatite dike and sill cut quartzite and schist.

Plate 4-B. Photograph of the coarse-grained wall zone, W, 6 inches thick, finer-grained intermediate zone, I, and coarse-grained core, C, northern pit, Western dike.

Plate 5-A. Photomicrograph of muscovite veins, M, in albite, Ab, and quartz, Q, wall zone at footwall of Northeastern dike. 31X, crossed nicols.

Plate 5-B. Photograph of the Eastern dike. Note the bands of garnet, G, in plagioclase, quartz, and muscovite.

Plate 6-A. Photomicrograph of a beryl crystal, B, in contact with garnet, G. Wall zone, at hanging wall, Northwestern dike. Albite, Ab; quartz, Q. 31X, crossed nicols.

Plate 6-B. Photomicrograph of microcline, Mi, and quartz, Q, veinlets in albite, Ab, wall zone of Western dike. 31X, crossed nicols.

Plate 7-A. Photomicrograph of microcline, Mi, and muscovite, M, veinlets in albite, Ab, central zone, Northwestern dike. 31 X, crossed nicols.

Plate 7-B. Photomicrograph of microcline veinlets, Mi, in albite, Ab. Border zone at the hanging wall, Western dike. 31X, crossed nicols.

Plate 6-A. Photomicrograph of albite, Ab, enclosing quartz, Q, apatite, A. Border zone at east side of Eastern dike. 72X, crossed nicols.

Plate 6-B. Photomicrograph of beryl, B, in albite, Ab, quartz, Q, muscovite, M, and zircon, Z. Wall zone, at hanging wall, Northwestern dike. 31X, crossed nicols.

Plate 9-A. Photomicrograph of garnet, G, enclosing beryl, B, biotite, Bi, and veinlets of hematite, H. Quartz, Q, muscovite, M, and zircon, Z, are adjacent to the garnet. Border zone at east side of Eastern dike. 72X, plane-polarized light.

Plate 9-B. Photomicrograph of apatite inclusion, A, in beryl, B, muscovite, M, quartz, Q, border zone at hanging wall of Northwestern dike. 159X, crossed nicols.

Plate 10-A. Photomicrograph of beryl, *B*, in albite, *Ab*. Quartz, *Q*. Border zone at footwall, Northwestern dike. 31X, crossed nicols.

Plate 10-B. Photomicrograph of inclusions of beryl, *B*, and quartz, *Q*, in muscovite, *M*. Albite, *Ab*. Wall zone at footwall of the Northeastern dike. 31X crossed nicols.

Plate 11-A. Photomicrograph of muscovite, *M*, enclosing quartz, *Q*, and beryl, *B*. Border zone at footwall of Western dike. 31X, crossed nicols.

Plate 11-B. Photomicrograph of garnet, *G*, enclosing muscovite, *M*, quartz, *Q*, beryl, *B*, and veinlets of hematite, *H*. Wall zone at footwall of Northwestern dike. 72X, plane-polarised light.

Plate 12-1. Photomicrograph of albite, Ab, muscovite, M, and apatite, A, inclusions in garnet, G. Border zone of hanging wall, Northwestern dike. 15X, plane-polarized light.

Plate 12-2. Photomicrograph of garnet, G, encayed by quartz, Q. Albite, Ab, muscovite, M. Wall zone at footwall of Northwestern dike. 30X, crossed nicols.

Plate 13

Plate 13. Photograph of the edit and the Western dike.

Fig. 1.-- Index map of Nevada. The Errington-Thiel mine is marked by an X.

Figure 2

Fig. 2.-- Graph of mineral paragenesis

Table 1. Micrometric analysis for beryl.

Location of thin section	Total length of traverses millimeters	Number of thin sections	Millimeters	Beryl weight percent
Northwestern				
0.5 ft. foot border	117.08	2	1.02	0.87
2.- ft. footwall	54.88	1	0.00	0.00
6.- ft. central	101.83	2	0.28	0.28
2.- ft. hanging wall	54.27	1	0.56	1.03
0.5 ft. hanging border	197.56	3	0.90	0.46
Western				
0.3 ft. foot border	107.43	1	1.29	1.20
1.- ft. wall	84.85	1	0.97	1.14
4.- ft. central	92.04	1	1.29	1.40
4.- ft. intermed.	64.96	1	1.05	1.62
0.3 ft. hanging border	131.02	2	0.40	0.30
Eastern				
0.3 ft. border (east)	92.06	1		
1.- ft. east wall	218.41	3	0.96	1.04
4.- ft. intermed.	143.46	2	0.43	0.20
			0.00	0.00