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# COLORADO PEGMATITES

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## INTRODUCTION

GENERAL DISTRIBUTION. Pegmatites are found in every county of Colorado along the Front Range of the Rocky Mountains from Larimer County on the Wyoming line to Custer County in the south-central part of the state, and in scattered pre-Cambrian areas to the westward. The various districts are briefly mentioned in the following paragraphs.

The pre-Cambrian schists and granites of Larimer County are cut by numerous pegmatite dikes[1] which have been exploited for mica southwest of Fort Collins.[2] Pegmatite dikes exhibiting an ore mineral phase occur in Boulder County.[3] Jefferson County contains both tourmaline and muscovite pegmatites.[4] Complex pegmatites with a magnetite phase occur in the Georgetown district of Clear Creek County.[5] A pegmatite pocket or cavity measuring 50 feet in length, 2 to 15 feet in width, and 4 feet (average) in depth was

[1] Fuller, M. B., General features of pre-Cambrian structure along the Big Thompson River in Colorado: *Jour Geology*, vol. **32,** pp. 49–63, 1924. Boos, M. F., and Boos, C. M., Granites of the Front Range; the Log Cabin batholith: *Geol. Soc. Am.*, Abstracts 46th Ann. Meeting, p. 16, Dec. 28–30, **1933;** Granites of the Front Range; the Long's Peak-St. Vrain batholith: *Bull. Geol. Soc. Am.*, vol. **45,** pp. 303-332, April 30, 1934. Reed, T. T., Nodular bearing schists near Pearl, Colorado: *Jour. Geology*, vol. **11,** p. 493, 1903.

[2] Sterrett, Douglas B., Mica deposits of the United States: *U. S. Geol. Survey*, Bull. **740,** pp. 59–60, 1923.

[3] Lindgren, W., Some gold and tungsten deposits of Boulder County, Colorado: *Econ. Geology*, vol. **2,** pp. 453–463, 1907. Kirk, Charles T., Tungsten district of Boulder County, Colorado: *Min. and Sci. Press*, vol. **112,** pp. 791–795, May 27, 1916.

[4] Patton, H. B., Tourmaline and tourmaline schists from Belcher Hill, Colorado: *Bull. Geol. Soc. Am.*, vol. **10,** pp. 21–26, 1898. Sterrett, Douglas B., *Op. cit.*, pp. 57–58.

[5] Spurr, J. E., and Garrey, G. H., Preliminary report on the ore deposits in the Georgetown, Colorado, mining district: *U. S. Geol. Survey*, Bull. **260,** pp. 99–120, 1905; *U. S. Geol. Survey*, Prof. Paper **63,** p. 60 et seq.

found on Devil's Head Mountain in southwestern Douglas County about 50 years ago. Within the pocket were crystals of topaz, microcline, cassiterite, and fluorite.[6] Pegmatites with a well developed fluorine phase occur in and associated with the Pike's Peak granite of western El Paso County, Teller County, and eastern Park County. Principal localities are St. Peter's Dome, Crystal Park, Cameron Cone, Pike's Peak, Florissant (Crystal Peaks), and Tarryall.[7] Western Park County contains numerous simple pegmatites.[8] Corundum and dumortierite occur in a pegmatite on Grape Creek in southern Fremont County.[9] Muscovite pegmatites, some with a beryllium phase, occur in three districts in Fremont County: Eight-Mile Park, the vicinity of Micanite (25 miles northwest of Canon City), and 6 miles north of Texas Creek.[10] The crystalline rocks of the Silver Cliff district of Custer County contain simple pegmatite dikes.[11]

Pegmatites likewise occur in central Colorado to the west of the Front Range. Examples are the simple pegmatites in the Montezuma mining district in Summit County,[12] in the Monarch district of Chaffee County,[13] and in the Bonanza district of Saguache

[6] Smith, W. B., Contributions to the mineralogy of the Rocky Mountains: *U. S. Geol. Survey*, Bull. **20,** pp. 73–74, 1885.

[7] Cross, W., and Hillebrand, W. F., Contributions to the mineralogy of the Rocky Mountains: *U. S. Geol. Survey*, Bull. **20,** pp. 221–332, 1885. Finlay, Geo. I., Colorado Springs Folio: *U. S. Geol. Survey*, Folio **203,** 1916. Over, Edwin Jr., Mineral localities of Colorado (El Paso County): *Rocks and Minerals*, vol. **4,** no. 4, pp. 106–107, Dec., 1929. Palache, C., and Over, Edwin Jr., Pegmatites of the Pike's Peak region, Colorado: *Am. Mineral.*, vol. **18,** p. 115, 1933 (Abstract). Smith, W. B., Notes on the crystal beds of Topaz Butte: *Am. Jour. Sci.* (3), vol. **33,** pp. 134–135, 1887; *Proc. Colo. Sci. Soc.*, vol. **2,** pp. 103–115, 1886. Wulff, Willard, W., Topaz in the Tarryall Mountains of Colorado: *Rocks and Minerals*, vol. **9,** no. 4, pp. 45–47, April, 1934.

[8] George, R. D., Geology and ore deposits of the Alma district, Park County, Colorado: *Colo. Geol. Survey*, Bull. **3,** 1912. Singewald, J. D., Igneous history of the Buckskin Gulch stock, Colorado: *Am. Jour. Sci.* (5), vol. **24,** pp. 52–67, 1932.

[9] Finlay, Geo. I., On an occurrence of corundum and dumortierite in pegmatite in Colorado: *Jour. Geology*, vol. **12,** pp. 479–484, 1907.

[10] Sterrett, Douglas B., *Op. cit.*, pp. 50–56.

[11] Cross, W., Geology of Silver Cliff and Rosita Hills, Colorado: *U. S. Geol. Survey*, 17th Ann. Rept., Pt. 2, p. 279, **1896.**

[12] Patton, H. B., The Montezuma mining district of Summit County, Colorado: *Colo. Geol. Survey*, First report, pp. 105–144, **1909.**

[13] Crawford, R. D., A preliminary report on the geology of the Monarch mining district, Chaffee County, Colorado: *Colo. Geol. Survey*, Bull. **1** (19), pp. 1–78, 1910.

County.[14] Chaffee County also contains pegmatites with an ore mineral phase,[15] and (in the vicinity of Mount Antero) a well-developed beryllium phase.[16]

Pegmatites are not abundant in western Colorado where crystalline rock outcrops are relatively scarce. Both simple and complex (lithium) pegmatites occur in pre-Cambrian rocks exposed near Ohio City in eastern Gunnison County.[17] Muscovite pegmatites have been exploited in Mesa County, about 8 miles south of Grand Junction.[18] Relatively small dikes of simple pegmatite occur within the pre-Cambrian rocks of the Needles Mountains in southeastern San Juan County.[19]

The writer has visited and made extensive collections from a number of pegmatites in the Pike's Peak region (El Paso and Teller counties), in the valley of the Arkansas (Fremont and Chaffee counties), and in Gunnison County. These deposits are described in this paper.

Field Work and Acknowledgments. The mineral deposits described in the following pages were studied during July in both 1932 and 1933. The field work the first summer was made possible through a grant from the Elizabeth Thompson Science Fund. A similar grant was made by the National Research Council for the 1933 field season. The writer wishes to express his gratitude to these organizations for their assistance. He is also grateful to General Superintendent W. J. Coulter and Chief Engineer Carl Cunningham of the Climax Molybdenite Company for courtesies received at Climax. The writer is indebted to Dr. John W. Vanderwilt for helpful suggestions made during the preparation of a preliminary draft of the manuscript, and to Mr. A. L. Morrow for assistance during the 1933 field season. The Graduate Research

[14] Burbank, W. S., Geology and ore deposits of the Bonanza mining district, Colorado: *U. S. Geol. Survey*, Prof. Paper **169,** pp. 1–166, 1932.

[15] Crawford, R. D., Geology and ore deposits of the Monarch and Tomichi districts, Colorado: *Colo. Geol. Survey,* Bull. **4,** pp. 280–281, 1913.

[16] Over, Edwin, Jr., Mineral localities of Colorado: *Rocks and Minerals,* vol. **3,** no. 4, pp. 110–111, 1928. Penfield, S. L., Some observations on the beryllium minerals from Mt. Antero: *Am. Jour. Sci.* (3), vol. **40,** pp. 488–491, 1890.

[17] Eckel, Edwin B., A new lepidolite deposit in Colorado: *Jour. Am. Ceramic Soc.,* vol. **16,** no. 5, pp. 239–245, May, 1933.

[18] Sterrett, Douglas B., *Op. cit.,* pp. 61–62.

[19] Cross, Whitman, Fluidal gneiss and contemporaneous pegmatites (Abstract): *Science,* n.s., vol. **29,** p. 946, 1909.

Committee of the University of Kansas supplied a refractometer and a sodium light which materially increased the accuracy of the optical data obtained.

## Pike's Peak Region

St. Peter's Dome Cryolite Locality. Several pegmatite veins containing cryolite and associated fluorides occur on the north flank of St. Peter's Dome. This is one of the very few cryolite localities of the world. The deposit visited by the writer is a short distance north of the east portal of a tunnel on the Corley Mountain

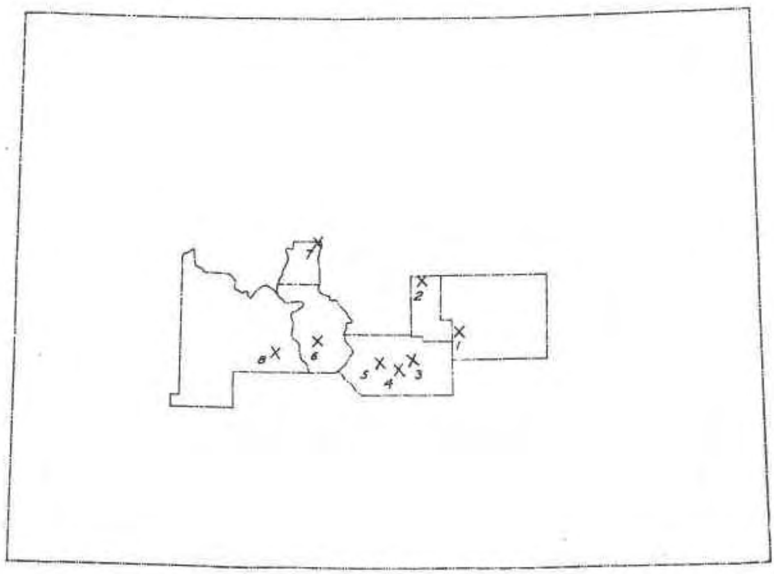

Fig. 1. Outline map of Colorado, showing location of deposits described in this paper. Key to numbers: (1) St. Peter's Dome (El Paso County), (2) Florissant (Teller County), (3) 8-mile Park (Fremont County), (4) "Pegmatite" (Fremont County), (5) Texas Creek (Fremont County), (6) Mt. Antero (Chaffee County), (7) Climax (Lake County), (8) Ohio City (Gunnison County).

toll road. This tunnel, which cuts through a northward-trending spur of St. Peter's Dome, is shown on the Manitou topographic sheet as a tunnel on the Cripple Creek railroad. It is 10.3 miles above the first toll gate out of Colorado Springs.

The pegmatite was opened up many years ago by a tunnel which has since caved. Most of the writer's collecting was done on the dump. The pegmatite strikes north and south and dips steeply into the hill (west). It is about 3 feet thick at the outcrop. The dominant minerals are white bull quartz, microcline in large masses, and long prismatic crystals of riebeckite. The fluorides, which are white in color except where purple fluorite is abundant, are decidedly subordinate quantitatively, occupying but a small part of the pegmatite. Aplite, consisting mainly of quartz, feldspar, and riebeckite, occupies a narrow zone along the footwall of the pegmatite. The country rock is the Pike's Peak granite, a coarse rock composed of greenish feldspar, quartz, and biotite.

The following paragraphs describe the minerals occurring in the pegmatite.

The *feldspar* is entirely microcline, except for a subordinate amount of perthitically intergrown albite. The microcline varies in color from pink to dark-red. Cleavage faces 10 cm. long are common. The contact between the microcline and the fluorides in some specimens is a smooth plane parallel to one of the cleavage directions of the feldspar; in others the fluoride-depositing solutions have attacked the feldspar, forming deep reentrants into it and in a few cases completely cutting through a microcline crystal. The *quartz* is milky. One quartz specimen collected exhibits a remarkably good cleavage (for this mineral), and the surrounding and encroaching fluorides have preserved the cleavage in "ghost" form. A black prismatic mineral which occurs completely surrounded by fluorides is probably *riebeckite*. It is so weathered as to be practically opaque, but the prismatic characteristic of the amphiboles is still recognizable.

The fluorides will be described in the order in which they were formed. The solutions from which each of the fluorides were precipitated first followed fractures and other directions of easy penetrability and then worked outward into and replacing the older minerals. The fluorides, with the exception of fluorite, are white in color and not readily distinguishable. Only a small proportion of the white material collected proved to be *cryolite*. The freshest specimens of cryolite are pale-gray and translucent. Alteration along cleavage planes gives this mineral a banded appearance which aids in its identification. Crushed fragments of the fresh cryolite show beautiful polysynthetic twinning under the microscope. Most of the cryolite collected is severely kaolinized and ranges in color from white to pink. Other fluorides are almost invariably associated. The commonest of these, and the most abundant mineral in the pegmatite other than feldspar and quartz, is *pachnolite*, $NaF\cdot CaF_2\cdot AlF_3\cdot H_2O$. This mineral is white (rarely pale-green) and opaque in the hand specimen. Crushed fragments gave the following optical data under the microscope: biaxial positive; $\alpha=1.407\pm.003$; $\gamma=1.418\pm.003$; cleavage indistinct. Polysynthetic and even gridiron twinning are visible in a few grains. All stages of hydrothermal replacement between pure cryolite and completely pachnolitized cryolite were found among the specimens collected. Where replacement is partial only the specimen is translucent; where complete it is chalky. The contact between the cryolite and the feldspar is especially liable to be occupied by pachnolite (and fluorite) veins. The pachnolite is partially kaolinized in many of the specimens collected.

*Prosopite*, $CaF_2\cdot 2Al(F, OH)_3$, ordinarily occurs in glassy colorless blades, exhibiting a good cleavage parallel to the blade surface. Optical data follow: biaxial positive, $n=1.50$; birefringence $=.009$. This material occurs as scattered blades or bundles of blades in the earlier fluorides, or in veins which either follow the contact between the earlier fluorides and feldspar or cut through the cryolite and pachnolite. A small amount of prosopite appears in very dense translucent masses. The color is white unless impurities are present. Scattered minute fluorite grains may give the mass a light-purplish color. Iron oxide has stained some of the prosopite red. Part of a microcline crystal in one specimen has been replaced by prosopite, the latter, exhibiting the cleavage of the feldspar in ghost form. In this instance the red color of the prosopite appears to be residual from the microcline. The prosopite is remarkably free from supergene alteration.

*Fluorite* occurs both finely disseminated and in veins. The latter are especially abundant along contacts, such as those between the fluoride masses and the feldspar, but fluorite veins also occur cutting cryolite and pachnolite. One such vein is over a centimeter thick. In most cases the fluorite is purple, but one specimen of fluoritized cryolite is pale greenish-white in color.

Siliceous solutions have caused the replacement of some of the fluorides by *chalcedony*, producing a very hard sugary mass. The host minerals to the chalcedony were in most cases prosopite and cryolite, but in one specimen a fluorite-prosopite aggregate has been silicified. All stages may be found between incipient and complete chalcedonization of the prosopite and cryolite. Kaolinization has affected the microcline, cryolite, and pachnolite. Cryolite is in the majority of specimens more kaolinized than the pachnolite. A very thin vein of *kaolinite* cuts a vein of fluorite in one specimen. The mean index of refraction of this kaolinite was 1.564.

The fluorides are distinctly later than the feldspar and quartz, penetrating the latter in veins and wedge-shaped masses in several specimens. The smooth contacts between the fluorides and the microcline (parallel to a cleavage direction in the latter mineral) seen on some specimens may be due to dissolution along planes of weakness in the feldspar. Additional evidence of the later deposition of the fluorides lies in the concentration of this material in "shoots" which occupy but a small proportion of the total volume of the pegmatite.

The writer concludes that first the feldspar, quartz, and probably the riebeckite crystallized from a pegmatite magma which was an offshoot of the Pike's Peak batholith. After the solidification of this primary pegmatite, hydrothermal solutions rich in fluorine released from deeper crystallizing magma travelled up through the pegmatite and replaced a part of the earlier minerals with fluorides. The fluorides were deposited in the following order: cryolite, pachnolite, prosopite, and fluorite. A small amount of silicification closed the period of hydrothermal mineralization. The kaolinization was caused by supergene solutions.

That more than one period of mineralization is involved in the St. Peter's Dome fluoride pegmatites was recognized by Cross and Hillebrand[20] in 1885: "Some of these veins have certainly had two periods of secretion, as is shown in the Eureka tunnel, St. Peter's Dome."

There must have been an abundance of fluorine in the Pike's Peak granite magma. The fluorides occurring in the pegmatite just described and in others in the immediate vicinity are one manifestation of this. Another is the presence of fluorite in nearly solid veins at several places on the east flank of St. Peter's Dome. And of greatest importance is the presence of fluorite as an accessory mineral in the Pike's Peak granite itself.[21] One result of the presence

[20] Cross, W., and Hillebrand, W. F., Contributions to the mineralogy of the Rocky Mountains: *U. S. Geol. Survey*, Bull. **20,** p. 42, 1885.

[21] Boos, Margaret Fuller, Granites of the Front Range; the heavy minerals: (Abstract) *Proc. Geol. Soc. Am.*, **1933,** p. 67.

of this fluorine-rich rock in the drainage basin contiguous to Colorado Springs is the prevalence of "mottled enamel," a disfiguring disease of the teeth caused by fluorine in the drinking water, among the children of that city.

Another element present in greater than average amount in the original magma was zirconium. A zircon-quartz pegmatite occurs a few hundred yards to the southeast of the fluoride pegmatite, and zircon is a fairly common mineral in the rocks of this region. The origin of the zircon has been discussed by Palache and Over[22] and a paper on the subject is anticipated.

FLORISSANT. A group of pegmatites lies about 8 miles (by road) north of Florissant. This is the locality known in the early literature as "Topaz Butte" and "Crystal Peaks,"[23] and now locally referred to as the "Gem Mines." Mr. A. B. Whitmore has opened up several of the pegmatites from which he obtains quartz and amazonstone crystals which he sells to visitors.

According to W. B. Smith crystal-bearing pegmatites are abundant over a rectangle which measures 3 miles east and west and 6 miles north and south, and has its southern edge about 5 miles due north of Florissant. The Crystal Peaks, a group of bare granite peaks, lie within this rectangle. A dominant feature of the pegmatites is the common occurrence within them of pockets or cavities which are invariably lined with quartz and microcline crystals and, more rarely, phenacite and topaz. A crystal quarry near Whitmore's cabin affords an excellent opportunity to observe the field relationships. The country rock is a severely disintegrated granite which is cut by small and erratic pegmatite stringers. Within the latter are cavities up to 30 feet in length which are lined with drusy microcline and quartz crystals. Some of the pockets pinch completely shut and then open up again farther along the same plane. A zonal arrangement was noted in these pegmatites. Immediately adjacent to the disintegrated granite walls are bands of graphic granite about 8 inches across. These are succeeded (toward the center of the pegmatite) by zones from 2 to 4 inches wide of massive feldspar and quartz with a few small books of muscovite. Crystals on the inside walls of this zone project into the cavity which occupies the center of the pegmatite.

[22] Palache, C., and Over, Edwin, Jr., Pegmatites of the Pike's Peak region, Colorado: (Abstract) *Am. Mineral.*, vol. **18**, p. 115, 1933.

[23] Smith, W. B., Notes on the crystal beds of Topaz Butte: *Am. Jour. Sci.* (3), vol. **33**, pp. 134–135, 1887.

No amazonstone was observed in the graphic granite or massive spar zones except near a cavity wall. The *microcline* in the "primary" pegmatite is white or pink and the *quartz* is milky. The microcline crystals lining the vug walls are dominantly amazonstone, but white and cream-colored crystals are likewise present. A very small amount of *albite* (cleavelandite) was found replacing amazonstone. The drusy quartz is colorless, milky, smoky, and (rarely) amethystine. A few very minute colorless and reddish *phenacite* crystals were found perched upon rhombohedral faces of quartz crystals. One large milky quartz crystal is in part coated by a minutely reniform black crust of *manganite*.

Unusually fine specimens of graphic granite are obtainable from these pegmatites. In one specimen collected by the writer the feldspar has been etched out to a depth of 1 to 3 mm., leaving the quartz hieroglyphs in a bas-relief. The quartz occurs in crystals which are euhedral but severely distorted, in many cases flattened parallel to a pair of rhomb faces. A wide variety of shapes is exhibited by the hieroglyphs. The quartz crystals vary in maximum dimension from 1 to 23 mm. Over relatively large portions of the specimen the faces on the quartz crystals are parallel (but in different planes) so that light is simultaneously reflected from each individual among a mass of hieroglyphs. In one part of the specimen rhomb faces of the quartz crystals are approximately parallel to the etched surface of the microcline, in another part prism faces parallel this surface. The feldspar is too badly weathered to permit determination of its orientation, but it appears to be a single individual with a dominant cleavage parallel to the general surface of the specimen. Apparently the atomic structure of the feldspar had a dominating control on the position and orientation of the quartz "guests."

The writer suggests the following sequence of mineralization for the Florissant pegmatites:

1. Intrusion of the primary pegmatite magma into the granite country rock.

2. Cooling and crystallization of this magma, producing white or pink microcline, milky quartz, and muscovite (in very minor amounts). The quartz did not commence to crystallize until some of the feldspar had already been precipitated in the border zones. This microcline was replaced in part by quartz, forming graphic granite. Farther toward the center of the pegmatites the crystal-

lization of the two dominant minerals overlapped, resulting in a mixture of anhedral crystals.

3. The cavity stage. Either the not yet solidified magma in the center of the pegmatites drained on out of certain portions leaving flattened lens-like openings or else subsequent corroding hydrothermal solutions used this part of the mineral deposit as a channelway. In either case very narrow and elongate cavities resulted.

4. Hydrothermal replacement phase. In most pegmatites this phase is dominated by deposition of soda feldspar. At Florissant, however, the residual pegmatitic solutions were unusually high in potash, so that crystals of microcline (much of it the green amazonstone) were deposited along the cavity walls, in part replacing the pegmatite wall rock. At the same time variously colored quartz crystals were deposited. Some of these root into the walls in rods which give certain sections of the cavity wall rock a graphic texture, much poorer in quality, however, than that of the outer graphic granite zone. During later stages of this phase a little albite was deposited, replacing amazonstone, and the phenacite crystals were precipitated on the quartz faces.

5. Supergene phase. Ground waters have deposited manganite, and the feldspars have been partially kaolinized.

## Arkansas River Valley

Eight-Mile Park. Eight-Mile Park lies immediately north of the Royal Gorge of Arkansas River, about 8 miles by road from Canon City. The Arkansas River flows through sedimentary rocks both above and below Royal Gorge, but at the Gorge the river cuts through an up-pushed mass of pre-Cambrian granite.[24] Eight-Mile Park is the wooded rolling eroded surface of this crystalline rock mass. Pegmatites are abundant in the Park. Most are simple in composition and small in size, but two are sufficiently large to have been opened up for mica and feldspar. These are the Myers-Halstead quarry and the Mica Hill deposit. Both are reached by a road which runs south from U. S. Highway 50 from a point about 1½ miles east of the Royal Gorge airport. Mica Hill lies a few hundred yards west of the Myers-Halstead quarry and overlooks the Priest Canyon road from the Gorge rim to Canon City.

Feldspar is the dominant constituent of both pegmatites, form-

[24] Campbell, M. R., Guidebook of the Western United States, Part E, the Denver and Rio Grande Western route: *U. S. Geol. Survey*, Bull. **707**, pp. 79–80, 1922.

ing masses (but not single crystals) 40 to 50 feet across. Quartz is second in order of abundance. It appears in masses of irregular shape; most of which measure but a few inches across, but some are several feet in maximum dimension. Muscovite is present in sufficient amount to yield commercial mica. It occurs in books of relatively small size, but these books form aggregates of pure mica as much as 10 feet across. A small amount of beryl was found in the Myers-Halstead pegmatite, but none was observed at Mica Hill. The latter deposit contained a small amount of malachite. As no primary copper minerals were found in the pegmatite, it is possible that the country rock was the source of the copper.

Two varieties of feldspar, microcline and albite, are present in the Myers-Halstead pegmatite. The *microcline* occurs in large red subhedral crystals. It is perthitic, but the albite lamellae are very thin and decidedly subordinate. Post-perthite *albite* is very abundant in some parts of the quarry. This albite is pink, and can be readily distinguished from the microcline by its lighter shade. Two generations of *quartz* are present; the earlier is massive, while the later generation occurs in rods, veins, and subhedrons. Both types are milky in color. The *muscovite* is silvery, and tends to form wedge and fan-shaped aggregates. A light yellowish-green sericitic mica is also present. *Beryl* varies from cream to light-green in color. It is invariably in small prismatic crystals, which may group together into slightly radiating bundles. *Tourmaline* is decidedly subordinate. It occurs in very dark-blue crystals and is opaque in the hand specimen.

The outstanding feature in the paragenetic history of these pegmatites was albitization. This followed the magmatic phase during which muscovite, tourmaline, microcline, and first generation quartz crystallized out. Between the magmatic phase and the albitization a small amount of beryl was deposited. Post-albitization mineralization was confined to hydrothermal deposition of a second generation of quartz, and last of all, the precipitation of sericite. In places the quartz so replaces the albite as to produce graphic texture. Some of the quartz rods are subhedral, exhibiting striated prism faces. Such rods are not elongated parallel to a crystallographic axis, but may be parallel to the rhombohedral face edges, which have not been developed. Both the elongated crystals and the quartz veins tend to follow cleavage directions in the host feldspar.

"Pegmatite." On the Denver and Rio Grande railroad above the Royal Gorge and 2½ miles below the station of Echo is the abandoned station of Pegmatite. The mineral deposit which gave the station its name is situated near the top of a high hill south of the river, and is reached by a trail which leads from a group of buildings along the highway. The deposit consists of lit-par-lit injections of pegmatite into schist. A 500-foot tunnel has been driven into the hill, cutting through several bands of pegmatite of variable thickness. These bands consist mainly of white and pink feldspar with scattered small books of mica. Quartz is subordinate.

The paragenesis at "Pegmatite" is relatively simple. However, the relationship between the *microcline* and the *quartz* is interesting. All stages are present between graphic granite and quartz-veined feldspar. One specimen collected by the writer is a large cleavage fragment of flesh-colored microcline which is cut by many thin parallel quartz veins. These range mostly from one-half to 1 mm. in thickness, and the maximum is 3 mm. Some veins disappear completely, others taper out and reappear again. These veins are roughly parallel to the brachypinacoidal cleavage. They do not follow exact planes; minor irregularities in direction occur, and in a few instances one vein branches out from another for a short distance and then follows a parallel course. In other specimens the quartz veins were much less consistent in length, and more apt to turn and follow some other molecular plane, such as the direction of prismatic cleavage. The result, when viewed on the basal cleavage, is a graphic texture. In the writer's opinion, the most plausible explanation of this phenomenon is that the microcline crystallized first and that the quartz-depositing solutions followed planes of weakness in the microcline.[25] It must be remembered that graphic structures are viewed in two dimensions only and when the third dimension is examined the quartz is usually found to be decidedly elongated.

Both *biotite* and *muscovite* are present in minor amounts in this deposit. Some of the muscovite is light greenish-yellow in color, occurring in very fine scales and flakes.

Texas Creek. This deposit lies about 6 miles north of Texas Creek, a station on the Denver and Rio Grande railroad between

[25] Schaller, W. T., Mineral replacement in pegmatites: *Am. Mineral.*, vol. **12,** p. 61, 1927. Landes, K. K., The Baringer Hill, Texas, pegmatite: *Am. Mineral.*, vol **17,** p. 383, 1932.

Canon City and Salida. A trail runs from the mine to Texas Creek, and a secondary road connects the ore bins below the mine with Echo station. The pegmatite crops near the top of a hill about 300 feet above the floor of East Gulch. It has been mined to a small extent and a tram connects the open cut with the bottom of the gulch.

The Texas Creek pegmatite is composed mainly of pale-pink feldspar. Quartz, both milky and rose, is present in large isolated masses. Sterrett[26] reports one of these as 150 feet long and 20 feet high. Muscovite aggregates are present in streaks and masses up to 4 feet across. *Beryl* and *tourmaline* are accessory minerals.

The principal feldspar is *microcline*. It ranges in color from white to red, but pale salmon pink predominates. Most of the microcline is perthitic, with the albite percentage varying between 10 and 30. The microcline encroaches upon the muscovite. Later albitization has been an important process in the history of the Texas Creek pegmatite. A part of the perthite is extensively replaced, and thin veins of *albite* extend out beyond the replaced portions into the older feldspar. Books of *muscovite* are likewise invaded by albite veins which both parallel and cut across the mica sheets. The albite is the cleavelandite variety. Albitization was accompanied by the precipitation of silvery sericitic mica along cleavage planes in the earlier minerals. *Quartz* also appears in two generations. Most of it occurs in large anhedral masses of milky or rose color which are cut by veins of albite. The later (hydrothermal) quartz forms thin veins which traverse all of the other minerals including the cleavelandite.

Mineralization during the magmatic phase included the precipitation of tourmaline and muscovite followed by microcline (perthite) and quartz. Beryl is probably early hydrothermal. Its formation was followed by albitization and minor sericitization. Vein quartz was the last mineral to be deposited.

Mount Antero. Since 1887 Mt. Antero has been known as a source of fine aquamarine gems occurring in pegmatites. Associated with the aquamarines are phenacite, bertrandite, and fluorite. These minerals are found at a number of points at high elevation on Mt. Antero and on Mt. White, one of its spurs.[27]

[26] *Op. cit.*, p. 56.

[27] Cross, R. G., Notes on aquamarine from Mt. Antero: *Am. Jour. Sci.* (3), vol. **33**, pp. 161–162, 1887. Smith, V. G., Mineralogical notes—Nos. 1, 2 and 3;

The writer in attempting to find these pegmatites, was misdirected to an abandoned molybdenite mine situated in the headwaters amphitheatre of Browns Creek, a tributary of the Arkansas which drains the southern slopes of Mount Antero. This molybdenite deposit proved very interesting and has been described in a separate paper.[28] *Molybdenite* and *beryl* (some of which is aquamarine) occur together in a *quartz* vein. In all likelihood the deposition of the beryl-molybdenite vein and the formation of the beryl-phenacite-bertrandite pegmatites of Mount Antero belong to the same general period of mineralization. Beryllium was present among the "fugitive" elements of a near-by crystallizing magma in unusual proportions, so appears as an essential constituent in minerals present in both the pegmatites and in hydrothermal veins which were formed during the expiring phases of the igneous activity.

CLIMAX. The Climax molybdenite property at Climax, Colorado, was visited during the 1933 field season. This trip was made because two writers[29] have classified the Climax deposit as a pegmatite. However, neither the field study nor the examination of rock and mineral specimens collected bear out this contention. The mineral grains in the Climax ore body are very small. Furthermore, a magmatic phase is absent; the mineralization was accomplished entirely by hydrothermal solutions. The presence of orthoclase, muscovite, and topaz in the Climax deposit is no more indicative of pegmatites than of hydrothermal veins. Butler and Vanderwilt,[30] who have intensively studied this deposit, consider that it was formed under conditions which were transitional between hypothermal and mesothermal.

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*Proc. Colo. Sci. Soc.*, vol. **2,** pp. 177–179, 1887. Penfield, S. L., Phenacite from Colorado: *Am. Jour. Sci.* (3), vol. **33,** pp. 131–134, 1887; Bertrandite from Mt. Antero: *Am. Jour. Sci.* (3), vol. **26,** pp. 52–55, 1888; Some observations on the beryllium minerals from Mt. Antero: *Am. Jour. Sci.* (3), vol. **40,** pp. 488–491, 1890. Penfield, S. L., and Sperry, E. S., Mineralogical notes: *Am. Jour. Sci.* (3), vol. **26,** p. 32, 1888. Over, Edwin, Jr., Mineral localities of Colorado: *Rocks and Minerals*, vol. **3,** pp. 110–111, 1928.

[28] Landes, Kenneth K., The beryl-molybdenite deposit of Chaffee County, Colorado: *Econ. Geology*, vol. **29,** pp. 697–702, 1934.

[29] Locke, A., Review of paper written by Butler and Vanderwilt: *Econ. Geology*, vol. **27,** no. 1, pp. 99–102, 1932. Lindgren, W., *Mineral Deposits*, 4th ed., p. 770, **1933.**

[30] Butler, B. S., and Vanderwilt, J. W., The Climax molybdenite deposit of Colorado: *Proc. Colo. Sci. Soc.*, vol. **12,** no. 10, pp. 309–353, 1931. *U. S. Geol. Survey*, Bull. **846–C,** pp. 195–237, 1933.

## Gunnison County

Ohio City. The most interesting of the Colorado pegmatites visited by the writer are in the valley of the Gunnison about 2 miles southwest of Ohio City. These have been recently described by Eckel.[31] Three parallel pegmatite dikes, each about 11 feet in width, constitute the main group. The country rock is pre-Cambrian schist, but intrusive granite, which Eckel suggests is genetically related to the pegmatites, outcrops a short distance to the southwest. Other pegmatite dikes, most of them simple in type, occur in the vicinity.

The main (Brown Derby) pegmatites are complex, with a strong lithium base. The principal minerals are *quartz*, *albite* (cleavelandite variety), *lepidolite*, *topaz*, and *beryl*. *Microcline* and *tourmaline* are subordinate. *Columbite* and *samarskite* are minor accessory minerals. The lepidolite occurs both in fine-grained masses and in lilac-colored books measuring several inches across. Topaz is unusually abundant, appearing in large rough milky crystals. Beryl likewise occurs in relatively large crystals and masses. The color varies from pink to aquamarine. Two varieties of tourmaline are present: common black, and the pink rubellite. The latter is probably lithium bearing.

Abundant evidence of hydrothermal replacement is present in the Brown Derby pegmatites. The replacement of the primary minerals of the pegmatites by albite took place on such a large scale that but little microcline is left in the main dikes. The introduction of the rare element minerals and a second generation of tourmaline (the rubellite) accompanied the albitization. Eckel[32] expects to publish a detailed account of the paragenesis of these pegmatites at a later date.

[31] Eckel, Edwin B., A new lepidolite deposit in Colorado: *Jour. Am. Ceramic Soc.*, vol. **16**, no. 5, pp. 239–245, 1933.

[32] Eckel, Edwin B., Letter to the writer dated June 22, 1933.