THE GEOLOGICAL SURVEY OF WYOMING

HORACE D. THOMAS, State Geologist

PRELIMINARY REPORT No. 1

THE BIG CREEK PEGMATITE AREA, CARBON COUNTY, WYOMING

by

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Laramie, Wyoming

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Foreword

This is the first of a series of preliminary reports to be issued by the Geological Survey of Wyoming. The preliminary report series is designed to make available to the general public, as soon as possible, summaries of the results of geologic research done at the University of Wyoming in full or partial cooperation with the Geological Survey of Wyoming. The series is to include the work of both staff and students of the University of Wyoming, and emphasis will be placed on publication of results of field studies having economic interest. Each publication will include a geologic map and a brief text describing the general geology and those deposits having economic interest. Suggestions for prospecting may be included. It is our belief that the immediate availability of this type of scientific information will aid those persons interested in the development of the mineral resources of Wyoming.

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THE BIG CREEK PEGMATITE AREA, CARBON COUNTY, WYOMING

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INTRODUCTION

The Big Creek pegmatite area is located in T.13 N., R.81 W., and R.80 W. along the west slope of the Medicine Bow Mountains in southeastern Wyoming. The area covers the northeastern half of T.13 N., R.81 W. and includes five sections along the western edge of T.13 N.,R. 80 W.(Fig. 1.). It is bounded on the east by the North Platte River and on the southwest by Wyoming State Highway 230.

The area is readily accessible from all-weather Highway 230 and is traversed throughout by roads and trails that are best traveled by pick-up truck or four wheel drive vehicle. The nearest railhead is a spur of the Union Pacific Railroad located 20 miles northeast of the area at the town of Encampment, Wyoming.

Mapping was done on enlarged air photographs having a scale of approximately 660 feet to the inch. For the purpose of compiling preliminary maps, data from the photographs were transferred to sheets enlarged from U.S. Geological Survey topographic sheets that had an original scale of one-half inch equals one mile. A good transfer of geologic data could be made in most of the area except that part along the North Platte River.

TOPOGRAPHY

Elevations are in excess of 8,000 feet, but in most of the area relief is not great. The only part that is rugged topographically is that along the North Platte River where the relief is in the order of 1,000 feet, with elevations rising from 7,500 feet to 8,500 feet in less than one mile.

Vegetation is not abundant except along minor streams and the North Platte River. Most of the streams have small groves of aspen along them, and dense forests of coniferous trees and aspen are found along the valley adjacent to the North Platte River. Most of the area is covered by a sparse growth of sage brush and native grass.

Rock outcrops are abundant except in heavily forested areas and along the tops of interstream divides.

GENERAL GEOLOGY

Mapping was confined to the rocks of Precambrian age (Pl. 2), which may be divided into three general units as follows:

1. The layered sequence, consisting of interlayered feldspar-quartz-biotite gneiss and hornblende gneiss and schist;
2. Mafic intrusive rocks consisting principally of rocks of gabbroic composition;
3. Foliated granite.

The layered sequence is found throughout the area and is further subdivided into a unit consisting chiefly of feldspar-quartz-biotite gneiss and a unit consisting chiefly of hornblende gneiss and schist. The mafic intrusive rocks in the northeastern part of the map area are a southern extension of a large body of meta-igneous rock that ranges in composition from norite to quartz diorite. Foliated granite is found in a large body in the northwestern part of the area and in a number of sills and dikes throughout the area.

The layered sequence is folded into a series of northeast-trending folds with nearly vertical limbs. The axes of these folds plunge to the northeast. The folds are displaced along east-west and northeast-trending faults and shear zones.

Tertiary rocks that are part of the North Park formation of late Miocene age occur in the southwestern part of the area. De la Montagne (1955, p. 32-33) states that the North Park formation consists of light-colored highly calcareous siltstone, sandstone, pumicite, and conglomerate. He divides the formation into three facies as follows:

1. The Platte channel facies, consisting of cross-bedded conglomerates and sandstones, is found near the middle of the Saratoga Basin.
2. The back-fill facies, consisting of fine tuffaceous siltstone and claystone, laminated silty shale, marl, and algal limestone, is found on either side of the Platte channel facies.
3. The flank facies, consisting of colluvial deposits containing locally derived fragments of Precambrian rocks cemented by carbonate, is found along the flanks of the Sierra Madre and Medicine Bow Mountains.

Outcrops of the North Park formation in the area under discussion are chiefly tuffaceous limestones and calcareous conglomerate of the back-fill facies and flank facies of Montagne.

Pediment gravels of Quaternary age are especially common along the borders of the Precambrian areas, and deposits of alluvium lie along streams and in the valley of Big Creek adjacent to the Big Creek ranch.

Layered Sequence

This unit, the most widespread in the area, is made up of alternating layers of feldspar-quartz-biotite gneiss and amphibole gneiss and schist. In some areas, such as along Big Creek, these two rock types occur in alternating layers 2 to 50 feet in thickness. In general, units composed principally of feldspar-quartz-biotite can be distinguished from units composed principally of amphibole gneiss, a distinction made in mapping (Pl. 2). The area underlain principally by hornblende gneiss is best exposed in the vicinity of the Big Creek mine and the area underlain principally by feldspar-quartz-biotite gneiss is best exposed in the core of an anticlinal structure in the southeastern part of the area.

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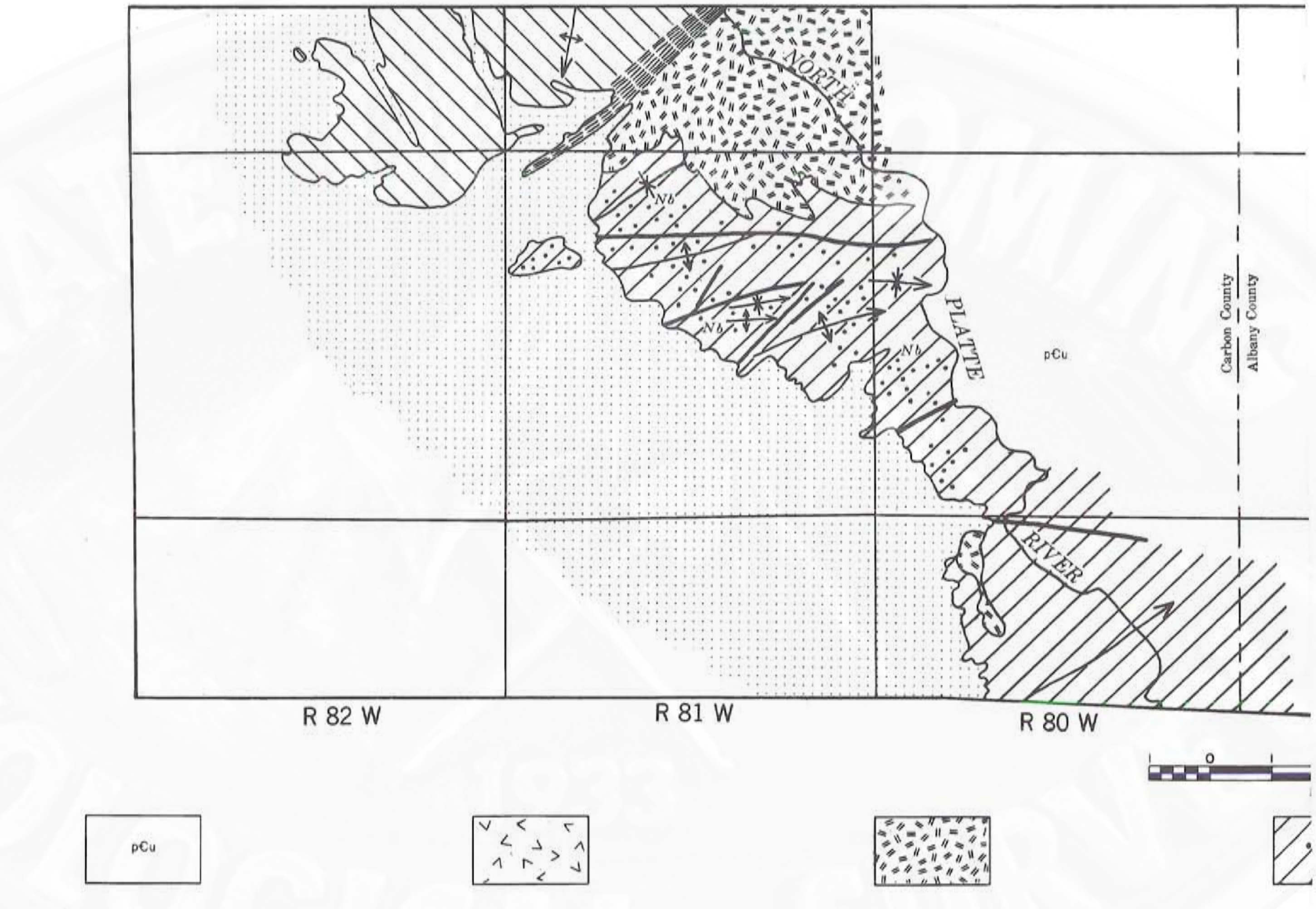

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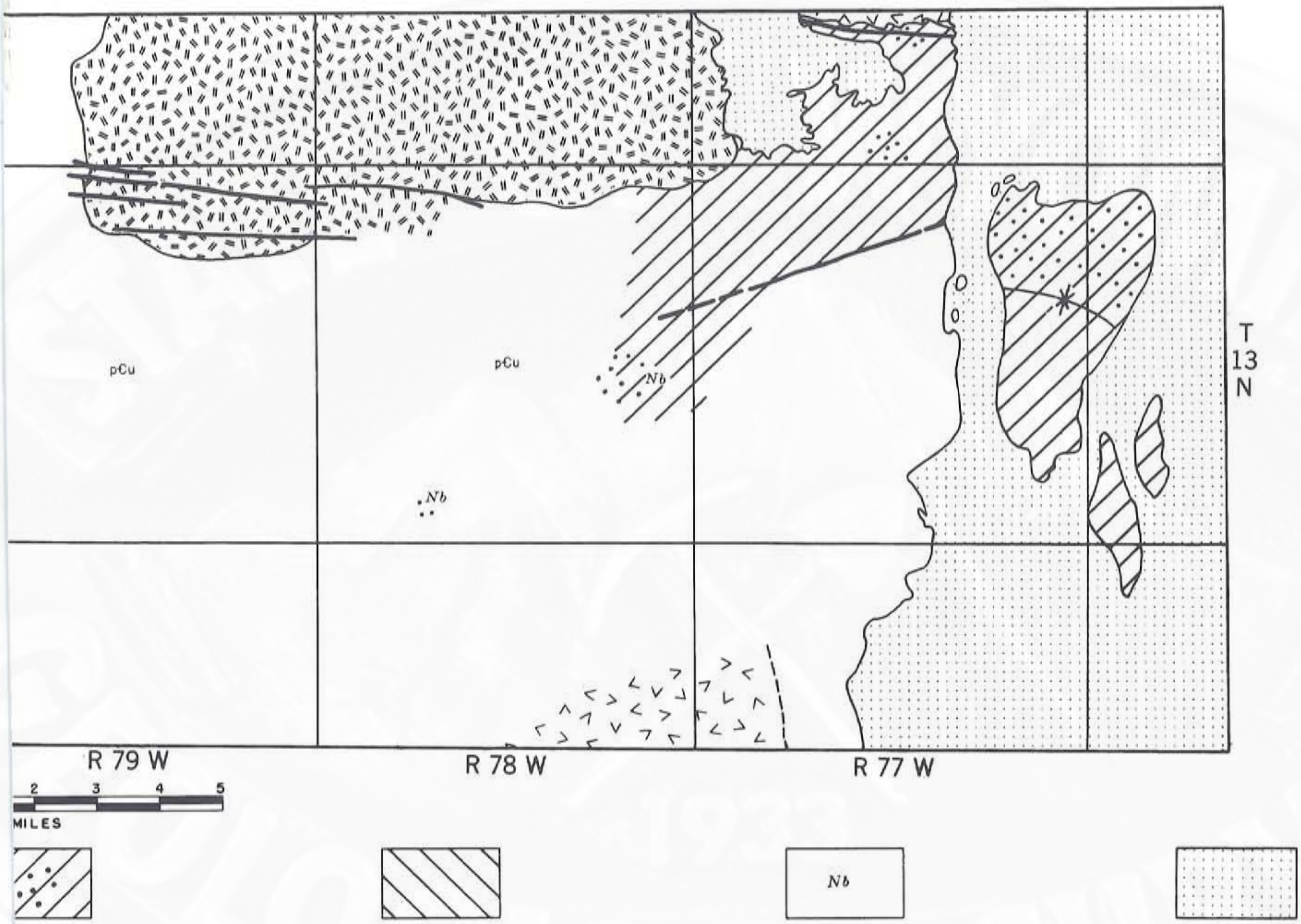

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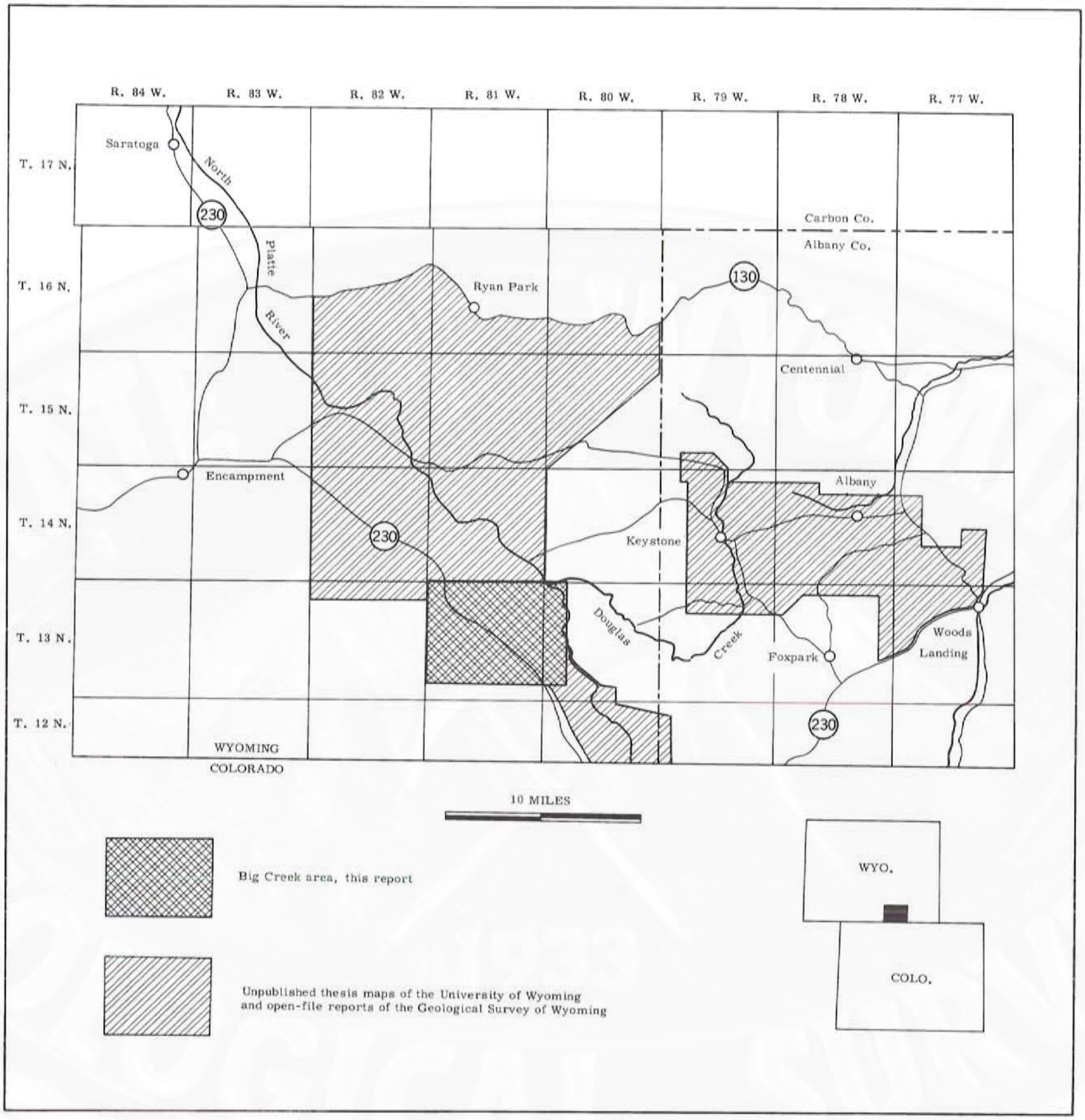

Fig. 1. Index map showing location of the Big Creek pegmatite area

The feldspar-quartz-biotite gneiss is the more resistant of the two units and occurs as low ridges and subdued hillocks. Fresh outcrops are gray; weathered surfaces are pink or reddish. The rock weathers into gravel composed of crystals of feldspar and quartz. Mineralogical and textural variations of this rock can be recognized in hand specimens. The most common type is composed of plagioclase, quartz, biotite, and microcline. Layering, caused by alternations of light-colored minerals and biotite, is poorly developed, but a distinct alignment of biotite crystals gives the rock a well-developed foliation. Locally the feldspar-quartz-biotite gneiss is massive in appearance. A different textural variety of the gneiss is an augen gneiss found along the northwestern border of the area. This gneiss is characterized by large eye-shaped potash feldspar crystals in a fine-grained biotite-rich matrix. It has gradational contacts with foliated granite and may be an intermediate phase between amphibole gneiss and foliated granite.

The amphibole gneiss and schist is bluish gray to black depending on the percentage of dark-colored minerals in the rock. It ranges from types rich in amphibole that contain minor amounts of quartz and plagioclase and best classified as amphibole schist or amphibolite, to layered types composed of alternating plagioclase-quartz layers and amphibole-rich layers.

The structural relationship between the two rock types of the layered sequence is conformable. The units cannot be followed for long distances in single outcrops, but in limited exposures the attitude of the foliation and the attitude of the contacts between the two different rock types are parallel. Contacts between the two units are generally sharp. Replacement of the amphibole-rich unit by more felsic constituents is common. The transformation is toward a biotite-rich microcline gneiss, and it is difficult or impossible to be certain how much of the felsic gneiss was formed by transformation of amphibole gneiss and how much was primary, especially in areas where the felsic gneiss is the principal rock type.

Mafic Igneous Rock Series

The mafic igneous rock series crops out in the northern part of the area. It consists of a variety of mafic igneous rocks that may or may not be related to each other in space and time. Only a small part of this rock series is exposed in the Big Creek area. The series extends for a distance of approximately three miles north of the Big Creek area and for an undetermined distance in an easterly direction.

Rocks of the mafic series are dark colored and fairly resistant to erosion. They underlie low rounded hills for the most part. Soil developed from these rocks is dark colored, making it possible to distinguish the unit readily on air photographs.

The southern border of the mafic rock series in the Big Creek area is underlain by diorite, but northwest trending outcrops of norite, gabbro, and related rocks are present in the northwestern part of the area. The relationship between the different types of mafic rocks has not been established, but the variation in grain size, texture, and degree of metamorphism suggests that they have been emplaced at different times.

Foliated Granite

The largest outcrop of foliated granite is in the northwestern part of the area where it underlies approximately one square mile. It is also found in northeasterly trending sills in the layered sequence in the southeastern part of the area and as cross-cutting bodies in the mafic rock series.

The foliated granite is similar to the feldspar-quartz-biotite gneiss in color and resistance to erosion. It does not have the layering that is common in the gneiss, however, and it is not as well foliated as the gneiss. It is composed chiefly of quartz, microcline, and biotite and is, in general, a coarse-grained rock.

The foliated granite of the northwestern part of the area grades into augen gneiss that is in turn gradational into hornblende gneiss. Contacts of this type are especially common along the northwestern border of this body. In this area the granite has well developed jointing that strikes in two directions roughly parallel to and perpendicular to the strike of the foliation. Many of these joints are filled with quartz, and quartz veins of this type can be considered characteristic of the rock.

The foliated granite sills are similar in mineralogy and texture to the larger unit, but are finer grained. These units are relatively narrow bodies with a thickness of 2 to 50 feet, but they commonly extend for long distances along strike. They are very similar in appearance to the layers of feldspar-quartz-biotite gneiss but are not banded and do not contain as much biotite as this unit. These sills may or may not be of igneous origin. They are in sharp contact with units of the layered series, but they do not have stringers or veinlets cutting the host rock.

The foliated granite dikes in the mafic igneous rock series are unquestionably cross-cutting igneous rock. These dikes are found in part in joint spaces in the mafic igneous rock and have interconnected stringers and veinlets cutting the country rock. They are composed of microcline, quartz, and biotite and are similar in texture to the granite sills. Many of the dikes are more highly foliated than the mafic units that they cut, and were it not for the stringers of granite cutting the mafic rock in contact with them, they might be considered inclusions of felsic gneiss.

Pegmatite

Granite pegmatites are found throughout the area. They are especially abundant in the amphibole gneiss and schist unit of the layered sequence, are less abundant in the felsic gneiss, and are uncommon in the foliated granite. The most common type of pegmatite is unzoned feldspar-quartz pegmatite that is approximately conformable in strike and dip with the country rock. These pegmatites are not much over 10 feet wide and probably average less, but they may extend for distances 5 to 10 times their width along strike, with some of them being over one-half mile long. They have sharp contacts with the country rock but do not show a decrease in grain size at the contact. They are characterized by simple mineralogy and contain chiefly feldspar with minor quartz and accessory biotite, garnet, muscovite, magnetite, and ilmenite.

A second type of pegmatite has cross-cutting relationships with the country rock and is generally more elliptical in plan. The length of these pegmatites may average three times their width. These pegmatites also have sharp contacts with the country rock and do not show a decrease in grain size at the contact, but they may have poorly developed zoning such as a concentration of quartz pods near the center of the pegmatite or a poorly developed quartz core and a graphic granite outer border. They are generally more complicated mineralogically and, in addition to feldspar and quartz, contain such minerals as garnet, tourmaline, biotite, muscovite, fluorite, and rarely monazite, allanite, euxenite, and columbite.

This basic distinction between pegmatites is arbitrary, and there are gradations between the two types. For example, the Big Creek mine is in a pegmatite containing a unique assemblage of copper minerals and a relatively complex mineralogy, but it is basically a conformable pegmatite.

Most of the pegmatites are strongly sheared. Many of the conformable pegmatites have a crude foliation caused by closely spaced joints that cut all minerals in the rock. This extensive fracturing may indicate that the pegmatites were folded along with the rocks in which they were emplaced, or at least subjected to a period of stress after emplacement.

STRUCTURE

The layered sequence has been folded into a series of northeast trending folds. The limbs are steep and the axes plunge northeast. These folds have been displaced along east-west and northeast trending faults and shear zones. In an area of this sort where key beds or marker beds are lacking, and where no definite stratigraphic succession has been established, it is very difficult to interpret the structure. The faults and shear zones have been established by recognition of abrupt changes in foliation, by extensively sheared, silicified, crenulated, or brecciated zones, and by photo-geologic evidence. It is possible that the folds are the result of drag along the fault systems or that the faults displace previously formed folds. The latter interpretation is favored because northeast-trending folds in similar rocks have been established in less deformed rocks to the south (Myers, 1958) and because the axes of most of the minor folds plunge northeastward.

Foliation of the rocks is a combination of a preferred orientation of platy minerals and compositional layering. In general there is no divergence in strike and dip between mineral foliation or compositional layering and the contacts between the units of the layered sequence. On the other hand, isolated exposures of highly deformed hornblende gneiss have been found, especially where this unit is the dominant one, that have very complex minor folds developed in the compositional layering. The gneiss has been folded into tight chevron folds with an amplitude of one inch and a wave length of one and one-half inches. The limbs of many of the folds have been faulted, and the planes of the faults are parallel to the axial planes of the folds. The attitude of amphibole crystals is parallel to the axial planes of the folds rather than to the compositional layering. This type of structure suggests that the compositional layering may have originally been bedding and that the minerals were oriented during deformation parallel to the axial planes of the folds. The attitude of the minerals would then define an axial plane foliation, and as this type of foliation is folded along with the rest of the units it may be considered folded axial plane foliation.

Linear features of three types have been recorded (Pl. 2): (1) plunge of the axes of minor folds, (2) plunge of biotite streaks in the plane of foliation, and (3) plunge of amphibole crystals.

The attitude of the axes of minor folds is parallel to those of the major folds, but the attitude of the biotite streaks and amphibole crystals is generally inclined to these two structural features.

A satisfactory integration of all of the structural features has not been made, but certain of the features observed suggest that the rocks may have been subjected to more than one period of folding. These are:

1. The evidence of folded axial plane foliation in the amphibole gneiss.
2. The lack of a consistent direction of plunge of mineral lineation, which may mean an older established trend has been refolded.
3. The sheared nature of most of the pegmatites suggests that they have been deformed after emplacement and probably folded with the layered sequence in a final stage of deformation.

ECONOMIC GEOLOGY

Pegmatites contain all the minerals of economic value that have been found in this area. From an economic viewpoint, two types of pegmatites occur--a copper-bearing type and a rare earth-bearing type. The rare earth pegmatite contains such minerals as euxenite, columbite, and monazite in addition to common pegmatite minerals. Five pegmatites containing one or more of these minerals have been noted in the field and others are probably present, but the only pegmatite that contains these minerals in economic quantities is the Platt pegmatite.

The Platt pegmatite is a zoned cross-cutting type that is 70 feet wide and 160 feet long. The central part of the pegmatite is a quartz-mica-feldspar-rare earth mineral pegmatite, and the outer part is feldspar pegmatite. The rare earth minerals occur as large individual crystals and crystal aggregates in the central part of the pegmatite and in gash fractures, some of which are filled with mica and rare earth minerals and some with quartz and rare earth minerals. Euxenite is the most abundant rare earth mineral, monazite is second, and columbite is least abundant.

X-ray fluorescence studies of euxenite show that the mineral contains, in order of abundance, niobium, yttrium, iron, tantalum, uranium, and zirconium, as well as minor amounts of lead, manganese, zinc, erbium, europium, actinium, holmium, titanium, thorium, samarium, and radon. Compared to normal euxenite (Palache, Berman, and Frondel, 1944, p. 789) this mineral is low in titanium and cerium and perhaps high in iron. It is metamict and does not give an X-ray diffraction pattern. Samples fired to 1,100 degrees centigrade give an X-ray pattern that is closer to yttrotantalite than euxenite, and the general chemical composition of the mineral is closer to yttrotantalite, but inasmuch as the name euxenite has been generally applied to the mineral, it will be used here until more detailed studies have been made.

X-ray fluorescence studies of monazite from the Platt mine show that it contains, in order of abundance, cerium, neodymium, yttrium, thorium and lanthanum, as well as minor amounts of praseodymium, samarium, and gadolinium. This type of analysis does not show the presence of phosphorus which is undoubtedly present as a major constituent.

The Platt mine is in a pegmatite exceptionally rich in the rare earth minerals. From 1956 to 1958 approximately 10,000 pounds of euxenite were recovered from this relatively small pegmatite by the part-time mining operations of two men during the winter months.

The Big Creek mine is in a copper-bearing pegmatite. This pegmatite conforms in strike and dip to the surrounding country rock and is exposed continuously on the surface for a distance of 2,400 feet, averaging approximately 15 to 20 feet in width. Surface exposures, with one exception, are feldspar pegmatite without any evidence of copper mineralization. A cross section of this pegmatite is exposed along Big Creek at the eastern limit of the body, however, and at a depth of about 70 feet below the canyon rim the pegmatite contains numerous gash veins composed of quartz and chalcopyrite. Locally, the chalcopyrite is replaced by secondary copper minerals, including bornite, chalcocite, malachite, and chrysocolla. These minerals are also found in veinlets in brecciated pegmatite and in brecciated country rock adjacent to the pegmatite. The quartz and sulphide mineralization is invariably later than the pegmatite, but it could be a late stage of pegmatite mineralization. Adits driven into the pegmatite from along the canyon of Big Creek extend for a distance of 400 feet to the west and are in mineralized pegmatite most of the distance.

SUGGESTIONS FOR PROSPECTING

The geology of the Medicine Bow Mountains is not completely known, but recent surveys made as part of the Precambrian program of the Geological Survey of Wyoming and previous investigations by students of the University of Wyoming indicate that the area roughly south of the line between T.13 N. and T.14 N. is underlain primarily by rocks similar to those of the layered sequence.

These rock types appear to be the preferred hosts for pegmatite mineralization. Pegmatites have been mapped or reported throughout this southern area, and several outside of the Big Creek area are known to contain niobium bearing minerals (Pl. 1).

Current knowledge of the Medicine Bow Mountains indicates that this southern area would be the best one in which to prospect for pegmatite minerals. There may be several generations of pegmatites in this area:

1. A replacement type found chiefly in the North Park fluorspar district (Steven, 1957).
2. Conformable pegmatites that are later than the host rock.
3. Cross-cutting pegmatites.

No definite age relationships between the different types of pegmatite have been established because they have not been found in contact with each other, but certain differences between them suggest they may have had a different source. The replacement type has gradational contacts with the country rock, is not exceptionally coarse grained, is uneven texturally, is unzoned, and is characterized by simple mineralogy. According to Steven (1957, p. 350-351) most of these pegmatites are simple aggregates of quartz and feldspar and are not mineralized. The conformable type of pegmatite has sharp contacts with the country rock, and a few pegmatites of this type have poorly developed zoning and may have a complex accessory mineral suite including some rare earth minerals, but, in general, they have a simple mineralogy similar to that of the replacement type. The cross-cutting pegmatites noted in the Big Creek area generally are zoned and contain a more complex accessory mineral suite, including rare earth minerals.

It seems possible that the cross-cutting type and perhaps some of the conformable type may be the youngest pegmatites in the area because they have certain characteristics in common with the pegmatites of the Pikes Peak type granite, which is the youngest Precambrian igneous rock in the southern Medicine Bow Mountains. The Pikes Peak type granite is a pink coarse-grained microcline granite found in the Front Range of Colorado, in the southern Laramie Range of Wyoming, along the eastern and southern borders of the Medicine Bow Range of Wyoming, and in the southern Sierra Madre Range of Wyoming. Workers in Colorado have stated that pegmatites of the Pikes Peak type granite are noted for rare-earth minerals and are well-zoned (Boos, M.F., and Boos, C.M., 1957, p.2616; Lovering, T.S., and Goddard, E.N., 1950, p. 28-29). It would be logical to assume, then, that the later cross-cutting pegmatites, that may be related to the Pikes Peak type granite, would be the best sort to investigate for rare earth minerals. This type of pegmatite may occur along the borders of the areas underlain by Pikes Peak type granite and Plate 1 shows the distribution of this granite in the southern Medicine Bow Mountains, according to the best information available at this time.

The following references may be useful to anyone seeking further information on the geology of the southern Medicine Bow Mountains:

Currey, D.R., 1959, Geology of the Keystone area, Albany County, Wyoming: unpublished Master's thesis, University of Wyoming, 64 p.

Darton, N.H., Blackwelder, Eliot, and Stienbenthal, C.E., 1910, Description of the Laramie-Sherman quadrangles, Wyoming: U.S. Geol. Survey Geol. Atlas, Folio No. 173, 18 p.

Hanley, J.B., Heinrich, E. Wm., and Page, L.R., 1950, Pegmatite investigations in Colorado, Wyoming, and Utah, 1942-1944: U.S. Geol. Survey Prof. Paper No. 227, p. 107-108.

Michaleck, D.D., 1952, Pre-Cambrian geology of Jelm Mountain, Albany County, Wyoming, unpublished Master's thesis, Univ. of Wyoming, 53 p.

Myers, W.G., 1958, Geology of the Sixmile Gap area, Albany and Carbon counties, Wyoming: Unpublished Master's thesis, Univ. of Wyoming, 74 p.

Orback, C.O., 1959, Geology of the Fox Creek area, Albany County, Wyoming: unpublished Master's thesis, Univ. of Wyoming, 57 p.

Steven, T.A., 1957, Metamorphism and the origin of the granitic rocks, Northgate district, Colorado: U.S. Geol. Survey Prof. Paper No. 274-M, p. 335-375.

REFERENCES CITED

Boos, C.M., and Boos, M.F., 1957, Tectonics of eastern flank of the foothills of Front Range, Colorado: Am. Assoc. of Petrol. Geol. Bull., Vol. 41, p. 2603-2676.

De la Montagne, John, 1955, Cenozoic history of the Saratoga Valley area, Wyoming and Colorado: unpublished Ph.D. thesis, Univ. of Wyoming, 140 p.

Lovering, T.S., and Goddard, E.N., 1950, Geology and ore deposits of the Front Range, Colorado: U.S. Geol. Survey Prof. Paper No. 223, 319 p.

Myers, W.G., 1958, Geology of the Sixmile Gap area, Albany and Carbon counties, Wyoming: unpublished Master's thesis, Univ. of Wyoming, 74 p.

Palache, Charles, Berman, Harry, and Frondel, Clifford, 1944, The System of Mineralogy: 7th Ed., New York, John Wiley and Sons, Inc.

Steven, T.A., 1957, Metamorphism and the origin of granitic rocks, Northgate District, Colorado: U.S. Geol. Survey Prof. Paper No. 274-M, p. 335-375.

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