5-1942

Mineral Occurences in Certain Pegmatite Dikes in Southwestern Montana

Jacob N. Jovick

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MINERAL OCCURRENCES IN CERTAIN PEGMATITE DIKES
IN SOUTHWESTERN MONTANA

A Thesis Submitted to the Department of Geology
in Partial Fulfillment of the Requirements for the Degree
of Bachelor of Science in Geological Engineering

by

Jacob N. Jovick

Montana School of Mines
Butte, Montana
May, 1942
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MINERAL OCCURRENCES IN CERTAIN PEGMATITE DIKES IN SOUTHWESTERN MONTANA

INTRODUCTION

Pegmatite dikes are rather common in occurrence in parts of southwestern Montana, particularly in a region to the east of the Tobacco Root range 50 to 75 miles southeast of Butte. Although for the most part these dikes are typical coarsely crystalline bodies of quartz and orthoclase, some may contain crystalline masses of white mica which promise to be commercial, and in one or two complex minerals of the pitch blende family have been reported.

The writer became interested in a particular pegmatite dike containing these minerals as well as mica about 3 miles south of the small station of Sappington during the summer of 1941, and this paper is written after field and laboratory studies of the occurrence and mineralogy of this dike.

Especial acknowledgment is given to Dr. E. S. Perry, whose knowledge of the district proved invaluable. The writer is also indebted to Dr. G. F. Seager and Dr. L. L. Sloss for their assistance during the writing of this paper. He also wishes to acknowledge information obtained from Mr. Charles W. Scott, discoverer of the pegmatite dike studied, and from Mr. Roy Earhart of the W. P. A. Mineral Survey, who furnished information concerning the dark rare earth mineral found in the dike.
The term pegmatite was given by Huay (1) in 1822 to the graphic intergrowth of quartz and feldspar. However, by 1850 it was applied to nearly all coarse-grained intrusive rocks, whether the graphic texture was present or not, and this definition still holds today. Landes (4) defines the pegmatite as "an intrusive holocrystalline rock, composed of essentially rock-making minerals, which are developed in part in individuals larger than the grains of the same minerals occurring in the normal plutonic equivalent." However, there are many exceptions to this definition. Many pegmatites may contain an abundance of large crystals of minerals which are not rock-formers, and may not even be a constituent of any other type of rock.

Pegmatites are all shapes and sizes, but occur commonly as tabular masses or dikes. Pegmatites containing economically workable deposits are usually vertical or steeply inclined bodies of elliptical cross-section. All range in size from slivers to enormous bodies, the largest known being 250 feet thick and 4 miles long.

The various advanced theories of origin may be classified as follows:

1. Aqueous
   A. Lateral secretion
      Source of materials is surrounding rock. Ground water is the medium of solutions, transporting and reprecipitation.

   B. Selective solution
      Rocks go into solution under an increase in temperature and pressure, and precipitate when either or both are released.
2. Igneous

A. Viscous magma
Advanced by Charpentier who was the first to describe clearly as igneous origin for pegmatities.

B. Aqueous magma
Pegmatite formed by crystallization from solutions high in volatile constituents, and therefore very fluid in reactions.

C. Hydrothermal replacement
A combination of A and B

Classification

Landes classifies pegmatites as follows:

1. Acid (alaskite, normal granite, alkaline, granite, granodiorite, quartz monzonite, and quartz diorite)
   A. Simple
   B. Complex, with the following phases (aside from albitization): lithium, fluorine, beryllium, boron, phosphate, graphite, rare earth, ore minerals, and vein quartz.

2. Intermediate (syenite, alkaline syenite, monzonite, diorite)
   A. Simple
   B. Complex, with the following phases: rare alkaline mineral, calcite, radioactive mineral, and sulphide.

3. Basic (gabbro, diabase, anorthosite, and pyroxenite)
   A. Simple
   B. Complex (calcite-apatite-phlogopite-phase)

Mineralogy

The mineralogy of pegmatites is very complex. Rare earth minerals, when found, usually occur in pegmatites. The following minerals are characteristically associated with pegmatites: (1)
LOCATION OF THE PEGMATITE

Scale: 1" = 2000'
<table>
<thead>
<tr>
<th>Mineral</th>
<th>Mineral</th>
<th>Mineral</th>
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</thead>
<tbody>
<tr>
<td>acmite</td>
<td>danburite</td>
<td>phenacite</td>
</tr>
<tr>
<td>allanite</td>
<td>diopside</td>
<td>pyrite</td>
</tr>
<tr>
<td>apatite</td>
<td>emerald</td>
<td>pyrrhotite</td>
</tr>
<tr>
<td>amphiboles</td>
<td>euxenite</td>
<td>quartz</td>
</tr>
<tr>
<td>andalusite</td>
<td>feldspar</td>
<td>rutile</td>
</tr>
<tr>
<td>anatase</td>
<td>fluorite</td>
<td>samarskite</td>
</tr>
<tr>
<td>anorthite</td>
<td>gadolinite</td>
<td>spodumene</td>
</tr>
<tr>
<td>aquamarine</td>
<td>galena</td>
<td>spinel</td>
</tr>
<tr>
<td>arsenopyrite</td>
<td>garnet</td>
<td>stannite</td>
</tr>
<tr>
<td>augite</td>
<td>gold</td>
<td>sphene</td>
</tr>
<tr>
<td>axinite</td>
<td>hornblende</td>
<td>schreibite</td>
</tr>
<tr>
<td>beryl</td>
<td>hubnerite</td>
<td>sphalerite</td>
</tr>
<tr>
<td>biotite</td>
<td>illmenite</td>
<td>tourmaline</td>
</tr>
<tr>
<td>bismuth</td>
<td>lepidolite</td>
<td>tantaite</td>
</tr>
<tr>
<td>bismuthinite</td>
<td>lollingite</td>
<td>thorite</td>
</tr>
<tr>
<td>bornite</td>
<td>leucopyrite</td>
<td>titane</td>
</tr>
<tr>
<td>cassiterite</td>
<td>magnetite</td>
<td>topaz</td>
</tr>
<tr>
<td>chalcedite</td>
<td>molybdenite</td>
<td>triphylite</td>
</tr>
<tr>
<td>chalcopyrite</td>
<td>monazite</td>
<td>triplite</td>
</tr>
<tr>
<td>columbite</td>
<td>moonstone</td>
<td>wolframite</td>
</tr>
<tr>
<td>cordierite</td>
<td>muscovite</td>
<td>yttroline</td>
</tr>
<tr>
<td>corundum</td>
<td>microcline</td>
<td>zircon</td>
</tr>
<tr>
<td>(ruby)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(sapphire)</td>
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</tbody>
</table>

The following minerals have been found in pegmatites in Montana:(1)

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Mineral</th>
<th>Mineral</th>
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</thead>
<tbody>
<tr>
<td>andalusite</td>
<td>hubnerite</td>
<td>quartz</td>
</tr>
<tr>
<td>apatite</td>
<td>muscovite</td>
<td>samarskite</td>
</tr>
<tr>
<td>arsenopyrite</td>
<td>magnetite</td>
<td>sapphire</td>
</tr>
<tr>
<td>biotite</td>
<td>molybdenite</td>
<td>sphalerite</td>
</tr>
<tr>
<td>chalcopyrite</td>
<td>orthoclase-microcline</td>
<td>scheelite</td>
</tr>
<tr>
<td>galena</td>
<td>plagioclase</td>
<td>tourmaline</td>
</tr>
<tr>
<td>gold</td>
<td>pyrite</td>
<td></td>
</tr>
<tr>
<td>hornblende</td>
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</table>

Muscovite, magnetite, tourmaline, and biotite are found as common accessory minerals in pegmatites.

The following paragraphs are descriptive of pegmatites:(2)

(1) Characteristically coarse-grained, but variable, some may be settled in gravitationally settled bands, and a few may be trachitoid. Many of them grade into rocks with granitoid textures, but porphyry textures do not occur in pegmatites.

(2) There is commonly graphic intergrowth of quartz and feldspar, and some intergrowths of quartz and tourmaline, and also
other minerals. Perthite is common.

(3) Most pegmatites are dikes; some are segregations, pipe-like or irregular; many intrude schists 'lit-par-lit'.

(4) Pegmatites occur near the margins of large igneous masses mostly granite, at least as much on the outside as inside the masses.

(5) Granite pegmatites and aplites grade into quartz veins on one hand, and into syenite pegmatite on the other. A granite composition is assumed for pegmatites unless otherwise specified.

(6) The temperature of transformation of quartz form the alpha to the beta variety is 573°C. Both of these forms are present, but none of the others. Thus, pegmatites are believed to have been formed at approximately that temperature.

(7) The order of crystalline is erratic, usually normal in the mass, and reversed in miarolitic cavities.

(8) Replacement is very common.

(9) Pegmatites are more silicious than the parent magma.

(10) There are notable concentrations of rare elements, the "earths", and mineralizers such as boron, beryllium, lithium, and fluorine.

(11) There is evidence of an abundance of water in the pegmatite magma. This varies from 10 to 70 per cent.

GENERAL INFORMATION CONCERNING THE SAPPINGTON DIKE

The dike was discovered by Mr. Charles W. Scott on the property of Mr. Charles Sappington. Interest was aroused in the dike because of the presence of muscovite mica, and Mr. Sappington immediately staked out a claim. The mica observed at the surface was much speckled with impurities, and had the characteristic
Views of Workings on the Sappington Pegmatite
(Looking North)
"herringbone structure", a product of crystal growth peculiar to some localities. This mica is commercially valuable only as scrap, and if it is too badly speckled it may have no value at all. To prospect the deposit further a pit was driven into the south side of the dike in hopes of finding mica of better grade at depth.

While excavating for the mica, a peculiar brownish-black mineral was found. This mineral, first believed to be pitchblende, was later identified as fergusonite. However, the writer found through detailed laboratory study that the mineral is an intermediate between fergusonite, \( R_f(Nb,Ta)O_4 \), and samarskite, \( R'_2R'_3(Nb,Ta)_6O_{21} \), where \( R'=Y, \text{Er}, \text{Ce} \), and \( R''=\text{Fe}, \text{Ca}, \text{UO}_2 \), etc.

No development work has been done on the dike since the fall of 1941.

METHODS OF STUDY

The information contained in this paper was revealed through both field and laboratory work. In obtaining field data, two trips were made to the dike, one in the fall of 1941, and one in the spring of 1942. During these trips specimen material was collected, desired dimensions were taken, and such things as dip, strike, and photographs obtained. The laboratory work consisted mainly of working with the petrographic and reflecting microscopes. The electroscope was also employed in working with the brownish-black radioactive mineral. Binoculars and magnetized needles were used in identifying magnetite. Chemical tests were made where necessary. Reference has been made to other papers concerning pegmatites, especially those in Montana, so that all known facts could be employed in obtaining the desired information.
The topography adjacent to the area studied is gently rolling, except to the north where resistant ledges of Paleozoic rocks have caused ridges with intervening valleys. Rugged mountains may be seen far to the southwest on the horizon. Drainage is to the east for a way, then it turns in a northerly direction. The dike, at the outcrop where the open cut or pit was driven is 110 feet thick, has a horizontal width of 105 feet, and its length along the strike is approximately 150 feet. Another smaller pit was started 15 feet west of the main workings. There is another exposure of the dike 500 feet east (Plate IV-B), and here still another smaller pit was begun. Still further east is a third exposure of the dike (Plate IV-B). To the west several outcrops of the dike may be observed, and at a distance of about half a mile in that direction an extension of the dike is crossed by a similar one which can be seen about 500 feet south of the large pit (Plate IV-A). These outcrops appear as white patches of "bull" quartz. It is possible that these outcrops of the dike are connected in depth, although at the surface they appear to be separated.

The average strike of the dike is approximately N.70°E., and its dip varies from 32° to 36° N.W. It is curved in its course through the country rock, and at the point where the main pit was driven, the deflection from a straight line is 25°.

The waste dump is about 60 feet south of where the open pit was begun. Its width varies from 12 to 25 feet, and it is approximately 80 feet long, and 25 feet high at its widest part. On one portion of the dump is the mica saved, which approximates
Photographs Showing General Character of Surface in the Outcrop Area of the Sappington Pegmatite Dike
Photographs Showing General Character of Surface in the Outcrop Area of the Sappington Pegmatite Dike
A. View Looking South
(Showing Mica Pile)

B. View Looking North

Photographs of the Main Workings on the Sappington Pegmatite Dike
10 tons (Plate V-A). This is about 2 per cent of the total mica-bearing rock excavated.

GENERAL GEOLOGY OF THE PEGMATITES

Where the dike has been developed for mica it was intruded into a pre-Cambrian metamorphic rock known as Pony gneiss, which is a member of the Pony series, and which is composed of gneisses and schists of quartz, feldspar, biotite, and hornblende. In this particular locality the main constituents are hornblende and feldspar, with minor amounts of quartz. It is the general belief that these rocks are of Archeozoic age (lower pre-Cambrian), or the oldest rocks in Montana.

About 50 miles southward other pre-Cambrian rocks known as the Cherry Creek formation are believed to lie on top of the Pony. The typical Cherry Creek section consists of quartz-feldspar gneiss, quartz-mica schist, marble quartzite, and hornblende-biotite schists. The sedimentary origin of the typical Cherry Creek is unquestionable, but the origin of the Pony series has been an unsettled problem. However, Mr. John C. Rabbit, who received his M. S. degree in Geology in 1937, and who is now working on this problem in acquiring his Ph. D. degree at Harvard University is of the opinion that the Pony gneiss is also sedimentary in origin, and merely a variation in lithologic facies of the Cherry Creek. About a half a mile to the west the dike cuts the Flathead quartzite (lowermost Paleozoic formation in Montana). To the north for a distance of about 2 miles is a nearly complete Montana section of Paleozoic and Mesozoic sediments. To the south the surface is covered by Quarternary and Tertiary alluvium and
lake beds (Plate I). Near the dike the gneiss is twisted and
folded, some of which may be from the force of intrusion.

The dike is acidic in character. The lower 50 feet is composed
essentially of plagioclase feldspar stained red by iron. Lying
on top of this is a portion 45 feet thick composed of an inter-
growth of quartz and feldspar, which may be classed as alaskite.
This is capped by 15 feet of massive, glassy and milky quartz
commonly called "bull quartz" by prospectors. This quartz
fingers in places into the rocks below for distances as great
as 15 feet. Vugs or miarolitic cavities are found in the alaskite
and feldspar, and throughout the dike are scattered small local
segregations of the radioactive mineral.

These dikes are truncated by the erosion surface upon which
Eocene lake beds rest, and we know of no intense igneous activity
from Cambrian to Cretaceous times. Therefore, because we associate
this type of dike with intense igneous activity we are inclined
to believe that the dike was intruded between Cretaceous and
Eocene times; and since the minerals in the dike show no evidence
of having been subjected to regional metamorphism, they must have
occurred after the Laramide orogeny or about middle Eocene time.

MINERALOGY

The important minerals found in this dike are not numerous,
however, all are definitely typical of pegmatites. The most
important are feldspar, both plagioclase (andesine), and ortho-
clase (microcline), mica, and a mineral that chemically and
physically showed the properties of both fergusonite and sam-
arskite. Because this mineral seems to show more of the proper-
ties of the latter, it is referred to by that name in this paper.
A. White, massive, "bull" quartz

B. Red, iron-stained plagioclase feldspar showing cleavage (a) and vug (b)
Plate VII

A. Pony gneiss; composed of hornblende, feldspar, and some quartz.

B. A portion of the alaskite showing feldspar (a), quartz (b) and samarskite (c)
The feldspar constitutes about 65% of the dike with plagioclase predominating by such a large margin as to make the orthoclase insignificant. Quartz is second in abundance; making up about 30%. The dike is also composed of about 3%-3½% mica, 1½% samarskite, and the remaining ½% tourmaline, magnetite, and minute amounts of some secondary carbonate or carbonates. This carbonate was not detected under either microscope, however, there was a slight effervescence when hydrochloric acid was introduced into some of the vugs.

Films of a white mineral found between the leaves of the mica proved to be oligoclase. With this oligoclase is another mineral that is present in crystal clusters. Dr. Seager said that it might be a zeolite, but probably is quartz. However, the crystals were too small to give any optical information.

The mica was found throughout the dike, however, it seemed to be concentrated at the contact of the plagioclase and alaskite. The mica is speckled throughout with grains of magnetite. Magnetite is also present in places in the feldspars as dendrites, both in the plagioclase zone and in the alaskite.

The samarskite is found predominantly in the plagioclase zone, and appears as masses here and there within the dike. Where these masses appear, the iron stain in the plagioclase becomes a deep red, and the mica appears to be much more speckled with magnetite than mica from other parts of the dike.

The quartz as mentioned before shows at the outcrops of the dike as massive milky or "bull" quartz. It also appears as clear glassy quartz in the alaskite portion. The milky quartz was given a spectographic analysis for beryllium, since
A. Mica, showing the "herring-bone" structure and the minerals oligioolase (a) and magnetite (b).

B. Samarskite (black mineral) occurring with plagioclase (a)
A. A specimen from the alaskite showing mica (a), feldspar (b), dendrites of magnetite (c), oligoclase (d), and samarskite (e).

B. Enlarged view of A, showing feldspar (a), dendrites of magnetite (b), mica (c), and samarskite (d).
A. A specimen from the alaskite showing glassy quartz (a), feldspar with dendrites of magnetite (b), and black tourmaline (c)

B. A similar specimen showing glassy quartz (a), feldspar with dendrites of magnetite (b), and black tourmaline (c)
beryl sometimes occurs in this manner and very much resembles this mineral. However, the spectograph showed no beryllium.

The tourmaline was found only in the alaskite portion of the dike and is of the black variety.

At first the magnetite was thought to be an oxide manganese and a chemical test was made for the element. The test showed only traces of manganese present, and this is probably of secondary origin.

ECONOMIC ASPECTS

The only minerals that might be considered of economic importance are the mica, and the samarskite. However, the plagioclase is rather pure and might bring some profit if excavated in sufficient quantities.

Mica (5), (6)

The annual production of muscovite or potash mica (theoretical formula $\text{H}_2\text{KAl}_3(\text{SiO}_3)_2$) is small, but its special physical properties keep it in great demand especially with electrical companies. Chemically it is of little value. Mica has low thermal conductivity (3.6), and high dielectric strength. These properties, coupled with high heat resistance, toughness, flexibility, resilience, and ability to be split into thin sheets, gives it outstanding value as electrical insulating material. Besides being punched or cut for use as electrical insulator, mica is also used as windows in furnaces and kilns, as lamp chimneys, canopies and shields, and as lenses of goggles, smoke helmets, and similar apparatus.
If the mineral is crushed, and not large enough to be used for the purposes mentioned above, it is called "scrap" mica. In such form it may be ground up and used as a lubricant. Some other uses of the mineral in this form are in the making of building blocks, wall paper for decorative purposes, and in the making of synthetic resins, gums, asphalt, rubber, silicate cement, lead borate, and in the annealing of steel.

Production and Consumption of Mica

The United States is the largest consumer of mica, although not the largest producer, and together with Great Britain, Germany, France, and Italy, consumes the major part of world production.

The annual production of sheet mica in the United States in the 15-year period of 1920 to 1934, has ranged from a peak of 2,172,159 pounds, valued at $400,134.00 (about 18¢ per pound average) in 1926 to a low of 338,997 pounds, valued at at $45,822.00 (about 13¢ per pound average) in 1932. During the 11-year period 1920 to 1930, the annual production only once (in 1921) dropped below the million-pound mark, and in 3 years exceeded the two-million pound mark. Consumption trends for the period 1926 to 1935 are shown in Figure I.

The annual production of scrap mica for the 15-year period 1920 to 1934 ranged from 2577 short tons, valued at $56,849.00 (about $22.00 per ton) in 1921, to 9659 tons, valued at $173,537.00 (about $18.00 per ton) in 1925. The average for the 10-year period 1925 to 1934 was about 7,000 tons.
India is the world's chief source of mica. Other important producers are the United States, Canada, Madagascar, Argentina and Brazil. Small amounts are produced in Guatemala, Korea, Ceylon, Australia, and many places in Africa. In the United States important mica deposits are found in Alabama, Connecticut, Georgia, Maine, New Hampshire, New Mexico, North Carolina, South Dakota, and Virginia.

![Graph]

Figure I. Trends in imports of splittings and of both imports and domestic production of the better grades of sheet mica, 1926-1935, United States.

Mining Methods

Whether a mining proposition is going to be profitable or not is largely a matter of prices versus costs, and before any mining method is selected the cost of road building and upkeep, transportation, general tools and other preliminary essentials
must first be taken into consideration, as well as market conditions. The life of the mine must also be considered. The Sappington deposit at present shows some possibility of being worked at a profit. Of course, there is a possibility that in depth the pockets of mica may die out entirely; however, it is also possible that rich deposits may develop as greater depths are reached, and this, together with the possible connection in depth of the pegmatite bodies of this region make the prospect of investment in development a more exciting one.

Mica mines may be divided into three groups: (1) small mines which are generally operated intermittently with little or no mechanical equipment; (2) medium-sized mines which have been successful in a small way, and have increased in size and are equipped with some machinery; and (3) large, well-equipped mines operated according to systematic mining methods.

In the first method selective mining is used. The workings are very irregular, and follow the mica occurrences in a pegmatite from one pocket to another. Only waste rock that must be removed is taken out.

At present the Sappington deposit belongs in this group, however, with proper development, provided mineral is present, it might develop into a larger class mine.

Prices (5)

The present price of white, ground, 70 mesh, scrap mica is from $60.00 to $80.00 per ton or from 3¢ to 4¢ per pound.
Further information concerning mica prices can be obtained from the A. I. M. E. publication, "Industrial Minerals and Rocks", (1937, pp 455-482).

**Samaraskite**

All uranium minerals contain a small amount of radium, and radium is not known to occur in any mineral that does not contain uranium. However only six of the many minerals known to contain uranium have been used as commercial sources of radium and uranium: carnotite, a hydrated vanadate of uranium and potassium; uraninite, a uranate of uranyl; autunite, a hydrous uranium-calcium phosphate; torbernite, a hydrous uranium-copper phosphate; and samarskite, a niobate and tantalate (columbate) of uranium, iron, members of the yttrium and cerium groups, etc.

Uranium quotations are based upon the amount of U₃O₈ contained in ores and concentrates. Ore containing less than two per cent U₃O₈ is called "mill ore". Ore containing two per cent of U₃O₈ is marketable and is referred to as "shipping ore". "Good ore" contains five to ten per cent of U₃O₈ and "high grade" ore runs better than ten per cent U₃O₈.
According to these figures the concentrate found in the Sappington pegmatite would lie on the border between "good ore" and "high grade ore".

Explanation of the Method Used in Quoting the Price of Uranium

As stated above uranium quotations are always based on the amount of U₃O₈ contained in ore and concentrates. If a certain ore or concentrate contains five per cent of U₃O₈, it will contain 100 pounds of this substance per ton of two thousand pounds. If, then, the current price of uranium ore or concentrate of $3.50 per pound of U₃O₈ contained therein, the product mentioned will be worth $350 per ton.

Mining

In spite of the fact that the samarskite is high grade, it probably could be extracted only by selective mining, since when found it occurs only as small local masses within the dike. However, the more perfect pieces taken out would probably bring a better price sold as specimens, since the mineral is comparatively rare; while the rest could be sold as uranium ore.

Feldspar

Feldspar is used chiefly in the ceramic industry. It is also used as a soft abrasive. In the dike, the feldspar is rather pure except in some spots where dendrites of magnetite are disseminated through the mineral. In several places, where the mineral has been exposed to weathering in the out-
crops, it has a more or less mealy feel. The ground-up mineral at present varies in price from $11.00 to $19.00 per ton.

COMPARISONS WITH OTHER PEGMATITES OF SOUTHWESTERN MONTANA

In southwestern Montana pegmatites are found in the following areas: Lost Creek, Potosi, Lower Hot Springs Mining District, Timber Butte, Cook City District, Rochester District, Tobacco Root Mountains, Haystack Stock Region, Dillon Region, Marysville, Laurin, and Horse Creek, as well as elsewhere.

The following table was prepared so that the reader might readily see the differences and similarities in pegmatites in southwestern Montana.

<table>
<thead>
<tr>
<th>Dike</th>
<th>Mineralogy</th>
<th>Minerals of Possible Economic Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Lost Creek</td>
<td>biotite, magnetite, muscovite, plagioclase, quartz, black tourmaline</td>
<td></td>
</tr>
<tr>
<td>2) Potosi (Late Cretaceous or early Tertiary)</td>
<td>cerargyrite, fluorite, native gold, hubnerite, limonite, molybdenite, orthoclase feldspar, pyrite, pyrolusite, quartz</td>
<td>hubnerite (tungsten)</td>
</tr>
</tbody>
</table>

17.
Plate XI

MAP OF WESTERN MONTANA

Scale: 1" = 48 miles

1. Lost Creek
2. Potosil
3. Timber Butte
4. Cooke City
5. Rochester District
7. Haystack Stock
8. Dillon
9. Marysville
10. Laurin
11. Horse Creek
12. Lower Hot Springs District

INDEX MAP to Montana pegmatites mentioned (courtesy C. Rostad)
<table>
<thead>
<tr>
<th>Dike</th>
<th>Mineralogy</th>
<th>Minerals of Possible Economic Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>3) Lower Hot Springs</td>
<td>chalcopyrite, hematite, muscovite, sodic plagioclase, pyrite, quartz</td>
<td></td>
</tr>
<tr>
<td>(early Tertiary)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) Timber Butte</td>
<td>albite, biotite, magnetite, orthoclase, quartz (smoky and clear), tourmaline (black)</td>
<td></td>
</tr>
<tr>
<td>5) Cock City</td>
<td>albite, apatite, biotite, chalcopyrite, magnetite, muscovite, orthoclase</td>
<td>chalcopyrite (copper)</td>
</tr>
<tr>
<td>(Tertiary)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6) Rochester District</td>
<td>feldspar, quartz, tourmaline (black), oxidized copper minerals (small amounts)</td>
<td>feldspar (ceramic material)</td>
</tr>
<tr>
<td>(late Cretaceous or early Tertiary)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7) Tobacco Root</td>
<td>orthoclase feldspars, quartz</td>
<td></td>
</tr>
<tr>
<td>(late Cretaceous or early Tertiary)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8) Haystack Stock Region</td>
<td>feldspar, mica, quartz</td>
<td></td>
</tr>
<tr>
<td>(pre-Cambrian)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9) Dillon</td>
<td>feldspar, graphite, quartz</td>
<td>graphite</td>
</tr>
<tr>
<td>10) Marysville</td>
<td>feldspar, quartz</td>
<td>placer gold radioactive minerals (rare earths)</td>
</tr>
<tr>
<td>(late Cretaceous or early Tertiary)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11) Laurin</td>
<td>gold, radioactive minerals</td>
<td></td>
</tr>
</tbody>
</table>
Concerning the economic possibilities of the pegmatites of southwestern Montana, Mr. Rostad has the following to say:

The Potosi tungsten deposit is marginal because of the irregular and lens-like distribution of the ore, but may be opened and mined if the prices and conditions indicate that a profit may be made. The Laurin pegmatite has not been found; but if it is, it may become a producer of gold and rare earth metals. The Cooke City and Dillon deposits are not being worked and not sufficient information has been gathered by the writer to state whether or not they may be worked with a profit. Feldspar pegmatites are dependent upon the local development of the ceramic industry for exploitation. Specimens of sheet muscovite (mica) of pegmatite origin are received from time to time by the Montana School of Mines. Although some sheets may be five inches or more in diameter, they are generally defective due to imperfect crystal growth. However it is quite possible that some of the mica-bearing pegmatites may be of commercial character.

**CONCLUSIONS**

Mineralogically the dike is typical of Montana pegmatites. However, it seems to contain rare earth elements in greater quantities than those studied.

Economically the dike is a "border line" project. Whether the feldspar, mica, and samarskite can be worked at a profit is a matter of market, market prices, development, equipment, and many other details. The possibility of the economic minerals either petering out or becoming more abundant in depth would make the project an interesting one.
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