5-1950

The Renova "Syenite" Porphyry Madison County, Montana

James H. Clement

Follow this and additional works at: http://digitalcommons.mtech.edu/bach_theses

Part of the Ceramic Materials Commons, Environmental Engineering Commons, Geology Commons, Geophysics and Seismology Commons, Metallurgy Commons, Other Engineering Commons, and the Other Materials Science and Engineering Commons

Recommended Citation
http://digitalcommons.mtech.edu/bach_theses/317

This Bachelors Thesis is brought to you for free and open access by the Student Scholarship at Digital Commons @ Montana Tech. It has been accepted for inclusion in Bachelors Theses and Reports, 1928 - 1970 by an authorized administrator of Digital Commons @ Montana Tech. For more information, please contact sjuskiewicz@mtech.edu.
THE RENOVA "SYENITE" PORPHYRY
MADISON COUNTY, MONTANA

by
James H. Clement

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

MONTANA SCHOOL OF MINES
BUTTE, MONTANA
May, 1950
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>1</td>
</tr>
<tr>
<td>Introduction</td>
<td>3</td>
</tr>
<tr>
<td>Topography</td>
<td>4</td>
</tr>
<tr>
<td>Relief and Drainage</td>
<td>4</td>
</tr>
<tr>
<td>Physiography and Vegetation</td>
<td>4</td>
</tr>
<tr>
<td>General Geology</td>
<td>6</td>
</tr>
<tr>
<td>General Stratigraphy</td>
<td>6</td>
</tr>
<tr>
<td>Regional Structure</td>
<td>6</td>
</tr>
<tr>
<td>Petrology</td>
<td>8</td>
</tr>
<tr>
<td>Occurrence</td>
<td>8</td>
</tr>
<tr>
<td>Distribution</td>
<td>8</td>
</tr>
<tr>
<td>Weathering Character</td>
<td>9</td>
</tr>
<tr>
<td>Belt Series</td>
<td>10</td>
</tr>
<tr>
<td>Intrusive Porphyry</td>
<td>10</td>
</tr>
<tr>
<td>Megascopic Description</td>
<td>10</td>
</tr>
<tr>
<td>Orthoclase Crystals</td>
<td>11</td>
</tr>
<tr>
<td>Microscopic Description</td>
<td>13</td>
</tr>
<tr>
<td>Heavy Accessory Minerals</td>
<td>14</td>
</tr>
<tr>
<td>Chemical Composition</td>
<td>18</td>
</tr>
<tr>
<td>Contact Rocks</td>
<td>18</td>
</tr>
<tr>
<td>Age and Correlation</td>
<td>21</td>
</tr>
<tr>
<td>Economic Geology</td>
<td>23</td>
</tr>
<tr>
<td>Mineral Deposits</td>
<td>23</td>
</tr>
<tr>
<td>Character of Deposits</td>
<td>23</td>
</tr>
<tr>
<td>Mineralogy</td>
<td>25</td>
</tr>
<tr>
<td>Production</td>
<td>26</td>
</tr>
<tr>
<td>Relation of Mineralization to Renova Porphyry</td>
<td>26</td>
</tr>
<tr>
<td>Conclusions</td>
<td>27</td>
</tr>
</tbody>
</table>
APPENDIX I
PETROGRAPHIC DESCRIPTIONS OF THE RENOVA PORPHYRY
AND BELT GRAYWACKE ................. 28

APPENDIX II
DESCRIPTIONS OF THE HEAVY ACCESSORY MINERALS
OF THE RENOVA PORPHYRY ............. 30

ILLUSTRATIONS

PLATE I .................................... 9
Surface Outcrops of Renova Porphyry

PLATE II .................................. 9
Features of Renova Porphyry

PLATE III ................................. 13
Orthoclase Crystals from Renova Porphyry

PLATE IV .................................. 13
Orthoclase Crystals from Renova Porphyry

PLATE V .................................. 20
Photomicrographs of Renova Porphyry

PLATE VI .................................. 20
Photomicrographs of Renova Porphyry
and Belt Graywacke

PLATE VII .................................. 20
Heavy Minerals of Renova Porphyry

PLATE VIII .................................. 20
Heavy Minerals of Renova Porphyry

PLATE IX .................................. 33
Map of Mining Claims in Renova Area

PLATE X .................................. 33
Geological Map of Renova Area, Montana
<table>
<thead>
<tr>
<th>TABLE</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Modal Analysis of Rock</td>
<td>13</td>
</tr>
<tr>
<td>II</td>
<td>Heavy Accessory Minerals of Renova Porphyry</td>
<td>17</td>
</tr>
<tr>
<td>III</td>
<td>Heavy Accessory Minerals of Orthoclase Crystals</td>
<td>17</td>
</tr>
<tr>
<td>IV</td>
<td>Chemical Analysis of Renova Porphyry</td>
<td>20</td>
</tr>
<tr>
<td>V</td>
<td>Chemical Analysis of Orthoclase Crystals</td>
<td>20</td>
</tr>
</tbody>
</table>
THE RENOVA "SYENITE" PORPHYRY
MADISON COUNTY, MONTANA

By
James H. Clement

ABSTRACT

Unique feldspar porphyries, syenitic in appearance, and granitic in composition, form an unusually thick sill intruding pre-Cambrian Belt graywacke about eight miles south of Whitehall in southwestern Montana. Commercial deposits of gold and silver ores occur nearby, and may possibly be genetically related to the porphyry, although direct association is not evident. The geologic age is believed to be late Cretaceous or early Tertiary, and the sill may be related to the Tobacco Root batholith.

Mineralogically, the porphyry contains about equal amounts of feldspar phenocrysts and groundmass, the albite plagioclase being about twice as abundant as the orthoclase, but much smaller. Perfectly formed orthoclase crystals, which weather free from the rock, are up to 2 inches in diameter. Quartz is minor (perhaps 9 per cent), and occurs as subhedral and rounded grains about 1 mm in diameter. Feric minerals, which are less than 2 per cent of the mass,
are exceedingly fine-grained. Heavy accessory minerals, constituting less than 2 per cent of the rock, are mainly apatite and muscovite, with minor amounts of zircon, magnetite, titanite (sphène), garnet, and epidote. On the basis of the phenocryst content the intrusive is technically classified as a leuco-sodaclase-granodiorite porphyry (Johannsen).
INTRODUCTION

Notably different from most intrusive rocks in Montana, the Renova porphyry has many interesting features. The lack of information about these rocks aroused the interest of the writer, particularly so since the Tobacco Root batholith, about 10 miles distant, together with its related dikes and sills, has been but little studied. Furthermore, widespread commercial metallic mineral deposits appear to be related to these intrusives.

The Renova "syenite" porphyry crops out as a sill in Madison County, Montana, approximately 8 miles south of Whitehall, in the foothills and lower ranges at the northern end of the Tobacco Root Mountains. These mountains, bisected by the 112th meridian, lie between the parallels 45° and 46°. Although the district is mountainous, it may be traversed by car on well-graveled county roads; moreover, all of the mines in the area are serviced by passable dirt roads.

As no previous studies of the Renova porphyry have been made, the purpose of this study was to classify the intrusive, to determine its structure and origin, to study its petrological nature, and to determine its relationship to the mineralization of the region.

Outcrops were sampled by this writer in December, 1949, and thanks are given to John W. Warren for his assistance in the mapping of the intrusive in September, 1949. Grateful appreciation is extended to Professor Forbes S. Robertson for his invaluable supervisory aid in the selection and completion
of the study, to Dr. Eugene S. Perry for his advice and assistance in the writing of the paper, and to Mr. Robert Pruitt for the valuable information he offered concerning the economic geology of the district.

TOPOGRAPHY

RELIEF AND DRAINAGE

The maximum elevation of the Renova area is approximately 6000 feet with high ridges and outcrops of the Renova porphyry attaining heights of over 5800 feet. (Plate I., A). The lowest elevation of the area is approximately 5200 feet, an altitude falling away to elevations of 5000 feet or less in the Jefferson River valley.

Many intermittent streams dissect the Renova area, and the porphyry has been subjected to intense mechanical weathering. Two small, permanent streams, one on the east side and one on the west side, are present, both of which cut deep valleys in the porphyry and the host rock and, resultantly, expose excellent contacts. They flow northward a distance of two and one-half miles into Jefferson River.

PHYSIOGRAPHY AND VEGETATION

A distinct boundary exists between the enclosing rock and the Renova porphyry sill. Forming ridges trending north and south, the porphyry on the eastern margin of the area, occurs as a high mountain which extends southward for approximately one mile.
Generally, the area is progressively rolling and hilly from northeast to southwest. Although the host rock rises in steep hills to the west, it forms valleys and low-lying hills, deeply eroded by the intermittent streams in the near vicinity of the porphyry sill.

On the north, the area is bounded by Jefferson River, on the west and south by mountainous ridges of Cambrian formations, and on the east by rolling hills of Tertiary lake beds.

Scrub pines and sagebrush are the only vegetation which grows abundantly on the porphyry outcrops. This growth clearly defines the outcrops throughout their length from the grass-covered slopes of the graywacke host rock and Tertiary lake beds. Wild life is abundant in the area, and the region serves as grazing land for domestic livestock.
GENERAL GEOLOGY

GENERAL STRATIGRAPHY

The only formations related significantly to the porphyry sill are the pre-Cambrian Belt graywacke and the Tertiary lake beds.

The Belt sediments are present as a massive thickness of fine-grained, light-brown-to-green graywacke, commonly called arkose. Zones of coarse angular pebbles of milky quartz and gneiss an inch or more in diameter are present throughout the formation. As bedding is well defined in the formation, accurate determinations of the strike and dip adjacent to the sill were easily obtained. Quartz, feldspars, and mica are abundant as angular grains cemented by clay and micaceous material.

Of little importance, the Tertiary lake beds consist of white, soft, earthy chalks and clays and light-gray to green-brown, coarse-grained arkose. The silty material is very fine-grained and contains a large amount of argillaceous material. The arkose contains pebbles and grains of quartz, jasper, mica, feldspar, and varied dark pebbles.

REGIONAL STRUCTURE

The regional structure of the area is a homocline with the formations dipping from 30 to 40 degrees westward. This structure is the western limb of a large anticline whose axis strikes approximately N 20°E. The structure has been extensively faulted by block faults which strike east to
west and north to south, and cut nearly perpendicular. A large reverse fault cutting the Renova porphyry sill has an apparent horizontal movement of about 400 feet, and is mineralized over a distance of 1 mile (Plate X).
PETROLOGY

OCCURRENCE

Cropping out near the base of the pre-Cambrian Belt graywacke, the Renova "syenite" porphyry sill occurs as a simple inclined intrusive which dips 30 to 40 degrees westward and lies parallel to the bedding of the host rock. The sill has a maximum thickness of 1000 feet in Section 3, T. 1S., R. 4W., but is thinner towards the southern end, where it has an estimated thickness of 500 feet. At the southern extremity of the sill, the outcrops dip approximately 65 degrees southwest and strike N 70°W.

The sill, appearing to conform to the regional structure, has been faulted by the same east-to-west faults which cut Paleozoic strata to the west. Many mineralized quartz veins are present in the fault zones (Plate II., A), as well as along the contact of the porphyry and the graywacke.

The contact between the graywacke and the porphyry is sharply defined and is most noticeable at the top of the sill. The margin of the sill is chilled for nearly 3 feet, metamorphosed shales and sandstones being present for 2 feet in the graywacke. Marked by a dark brown and black zone, the contact is well shown by Fig. C of Plate II.

DISTRIBUTION

Compared with its lateral extent, the sill is relatively thin. It crops out in an area of approximately seven
square miles; however, the exposures cover an area of approximately one square mile.

No accurate determination of the distribution or uniformity of the sill beneath the surface is possible; one can judge only on what is suggested by the surface configuration. One shaft, at the Idaho mine, which has been sunk to a depth of 75 feet on the porphyry-graywacke contact, indicates a ragged, but continuous contact at depth. If such is true, the structure may be estimated as shown by section AA' on the Renova geological map (Plate X).

WEATHERING CHARACTER

The porphyry is more resistant to weathering than the enclosing Belt graywacke; consequently the sill stands out in bold blocky outcrops. Joints were noted to strike N 50°E with a dip of 60°S, and N 11°W with a dip of 40°W. The blocky structure and associated jointing are shown in Plate II., Fig. B.

On weathered surfaces, the rock is light-cream-to-dark-brown, with the surface pitted and rough where feldspar phenocrysts have weathered free, or where they stand out relative to the less resistant groundmass. Near the porphyry-graywacke contact, the rock is reddish, having weathered to a dark brown or light pink with many limonite stains. A dark-gray lichen grows with profusion on weathered surfaces. Talus slopes are present on slopes perpendicular to the dip of the sill, and blocks of the porphyry have moved hundreds of feet down slope.
PLATE I

Surface Outcrops of Renova Porphyry

A. Ridge-forming outcrops of Renova porphyry, showing contrast of porphyry to enclosing Belt graywacke. SE cor. SW_{3/4}, Sec. 4, T. 1S., R. 4W.

B. Weathered outcrops of Renova porphyry, showing covered contact and blocky appearance of rock. SW cor. SW_{1/2}, Sec. 34, T. 1N., R. 4W.

C. Outcrops of Renova porphyry, showing parallel structure with bedding of Belt graywacke and general dip westward. SW cor. SW_{1/4}, Sec. 34, T. 1N., R. 4W.
Surface Outcrops of Renova Porphyry
PLATE II

Features of Renova Porphyry

A. Quartz veins in fault zone of the Renova porphyry. Sec. 4, T. 1S., R. 4W.

B. Blocky, jointed porphyry rock, showing weathered surface and conspicuous light phenocrysts, blocks approximately 4 feet square. Sec. 4, T. 1N., R. 4W.

C. Contact of Belt graywacke and Renova porphyry, showing sharply defined metamorphosed contact zone. Sec. 34, T. 1N., R. 4W.
Features of Renova Porphyry
BELT SERIES

A poorly sorted coarse-grained sandstone, the Belt series is commonly called an "arkose". It is characterized by an abundance of subangular rock fragments: quartz (31 per cent), feldspar (25 per cent), feldic minerals (2 per cent), all embedded in a matrix of clay. The matrix constitutes about 40 per cent of the rock. The feldspars are quite fresh and show little alteration. Classified, according to Pettijohn's classification of arenites (9:227), the Belt sandstone is a graywacke.

Detailed petrographic descriptions are given in Appendix I.

INTRUSIVE PORPHYRY

Megascopic Description

The porphyry is very fine-grained and light-gray with abundant phenocrysts. A very dense hard rock, the porphyry is difficult to sample and all sampling was accomplished with dynamite or a heavy sledge.

The groundmass, commonly very fine-grained and somewhat stoney, constitutes approximately 60 per cent of the mass. It is impossible to determine the mineral composition of the matrix in a hand specimen. It weathers to a light-brown or gray, the light feldspars become increasingly conspicuous, and feldic minerals become scarcely discernible or disappear.

Phenocrysts compose about 40 per cent of the rock. The plagioclase crystals, though smaller than the orthoclase crystals, are more abundant and range from less than 1 mm to more
than 8 mm in length. They are white or slightly green, euhedral to subhedral, and are free of inclusions. Often they are enclosed in the larger orthoclase crystals (Plate IV., A & B), but they are most abundant in the groundmass. No zoning is apparent in the plagioclase feldspars, and they appear to be arranged at random in the groundmass. Such an arrangement suggests that the plagioclase feldspars crystalized first, and were included in the orthoclase in the later stages of solidification of the magma. Upon weathering, the plagioclase phenocrysts become bleached by development of kaolinite and sericite.

Although an essential constituent of the rock, the quartz grains are decidedly less abundant than either the orthoclase or plagioclase. Quartz typically forms anhedral to subhedral transparent ill-defined grains. Many of the grains are slightly rounded, but the angular grains are the most abundant.

Some fine grains (less than 1 mm in diameter) of a felsic mineral are scattered through the mass, but their content is almost negligible.

Orthoclase Crystals

One of the most interesting features of the Renova porphyry is the persistent occurrence of large orthoclase crystals. These idiomorphic crystals weather out of the rock and may be found scattered abundantly on weathered slopes. It was noted that crystals of the same type occur abundantly in the same locality. They are dark to light-pink
in color, and, on weathering, appear flesh colored to dark brown. When cut perpendicular to the "c" axis, many crystals show growth lines.

Orthoclase crystals are monoclinic. Usually prismatic in habit, and elongated parallel to the "a" axis, or elongated parallel to the "c" axis, they may be flattened parallel to the clinopinacoid(010) or the prism(110), and they are often modified by small orthodomes and pyramids.

Crystals occurring in the Renova porphyry are twinned according to the Carlsbad(left and right) and the Manebach laws, but many simple forms are found. Crystals twinned according to the Baveno law are rare. In addition to the more perfect crystals, many complex crystal aggregates or clusters are found which apparently follow no definite law of twinning.

Simple crystals, commonly equidimensional, vary in size from $5\text{mm}$ in length and $3\text{mm}$ in width to $3\text{cm}$ in length and $2.5\text{cm}$ in width. All of these crystals are modified by both positive and negative ortho-hemidomes. Small included crystals are present on the basal pinacoids and prism faces as penetration twins (Plate IV., C & D).

Carlsbad twins, both left and right, occur in the porphyry. They range in size from equidimensional crystals approximately $8\text{mm}$ in length to elongated twins $4\text{cm}$ in length and $2\text{cm}$ in width. Right Carlsbad twinning is the most common (Plate III., D), but left twinned crystals are also present (Plate III., C). The crystals are usually elongated parallel to the "c" axis of the penetration twins.
Manebach twins are found ranging in size from 2 cm to 5 cm in length and from 1 cm to 3 cm in width. They are usually terminated by pyramids, and the basal pinacoid acts as the twinning plane (Plate III., A).

Baveno twins are not common in this rock. No crystals twinned according to the Baveno law could be identified by this writer, but Dr. Eugene S. Perry has indicated their presence.

Crystal aggregates, complex and multiply twinned, are common. Composed usually of simple crystals, the aggregates are sometimes groups of Carlsbad twins. The aggregated crystals apparently follow no definite law of twinning and are complex intergrowths of varied orthoclase crystals (Plate III., E & F).

**Microscopic Description**

Microscopically, the rock is typically porphyritic. It is characterized by abundant phenocrysts of light feldspars embedded in a dark aphanitic groundmass.

**TABLE I**

<table>
<thead>
<tr>
<th>Mosaic Analysis of Rock</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td></td>
</tr>
<tr>
<td>Orthoclase</td>
<td>8.75 %</td>
</tr>
<tr>
<td>Plagioclase</td>
<td></td>
</tr>
<tr>
<td>(Albite Ab97-An3)</td>
<td>14.19 %</td>
</tr>
<tr>
<td>Orthorombic pyroxene</td>
<td></td>
</tr>
<tr>
<td>Groundmass</td>
<td>26.61 %</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Orhoclase</td>
<td>1.13 %</td>
</tr>
<tr>
<td>Groundmass</td>
<td>49.30 %</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>99.98 %</td>
</tr>
</tbody>
</table>

Orthoclase occurs in euhedral to subhedral crystals which are much larger than the albite crystals. They
PLATE III

Orthoclase Crystals from Renova Porphyry

A. Manebach crystals.
B. Top and side view of simple crystals.
C. Left Carlsbad penetration twinned crystals.
D. Right Carlsbad penetration twinned crystals.
E. Multiple-twinned crystal aggregates.
F. Multiple-twinned crystal aggregates.
Orthoclase Crystals from Renova Porphyry
PLATE IV

Orthoclase Crystals from Renova Porphyry

A. Polished sections of simple crystals cut parallel to the "c" axis, showing inclusions of albite plagioclase.

B. Polished section of simple crystal cut perpendicular to the "c" axis, showing inclusions of albite plagioclase.

C. Simple crystals, showing included penetration twins on the basal pinacoid.

D. Simple crystal, showing included penetration twin on the prism face.

E. Unidentified twinned crystal.
Orthoclase Crystals from Renova Porphyry
contain inclusions of albite in varying amounts from 17 to 29 per cent (Plate VI., A). Quartz is present as clear angular to rounded grains. Femic mineral are almost entirely absent, but definite identification of the minerals was difficult because of the alteration and small size; however, petrographic data indicate them to be an orthorhombic pyroxene, probably hypersthene, altered to fibrous amphibole and sericite.

Accessory minerals are discussed separately in this paper. The alteration products are sericite, kaolinite, and minor chlorite. Alteration of the albite and pyroxene is the most conspicuous, with orthoclase being only slightly altered.

Texturally, the porphyry is micro-granular with a holocrystalline groundmass (Plate VI., B).

As no exact determination of the minerals in the groundmass was possible, although it appears to contain a large amount of quartz, classification of the porphyry was made on the basis of the relative percentages of the phenocryst minerals according to Johannsen's Quantitative Mineralogical Classification (4:227). The percentages of the minerals was calculated after seven traverses were made across each thin section with a Wentworth Traveling Stage. The porphyry is technically classified, according to Johannsen (5:317-331, 361), as a leuco-sodaclase-granodiorite porphyry.

Heavy Accessory Minerals

A heavy mineral study of the Renova leuco-sodaclase-granodiorite porphyry was made to determine the heavy accessory
minerals present, and to make a qualitative comparison of these minerals with those found in other sills which emanate from the Tobacco Root batholith.

Separation of the heavy minerals was made by the heavy-media sink-float process described by Wahlstrom (16:44). The heavy media employed was bromoform with a specific gravity of 2.86 and approximately 100-gram samples were used with a particle size of eighty-115 mesh were used. No separation of the magnetic fractions was made.

Microscopic slides were prepared by mounting several hundred grains of the heavy fractions in Lakeside cement, and the minerals were determined with the use of the index, form, cleavage, relief, refractive index, pleochroism, birefringence, extinction, interference figure, and optic sign of the minerals. Calculation of the percentages was made by counting approximately 300 hundred grains on each slide with the aid of a grid ocular. The index figure, percentage of heavy minerals exceeding the specific gravity of bromoform, was calculated for the fractions separated.

Heavy minerals were found to constitute 1.28 per cent by weight of the rock, which constitutes an index figure for such measurements. Minerals identified in the heavy fractions include apatite, muscovite, zircon, magnetite, titanite (sphene), epidote, garnet, and pyrite. A summarized table of the minerals is given in Table II.

Apatite, the most abundant mineral in the heavy fractions (57 per cent), is present in colorless, euhedral to subhedral, and hexagonal or pseudo-hexagonal grains (Plate VII). Many
of the grains appear to be fragments, and much of the apatite is the biaxial variety podolite.

Muscovite is present in colorless to pale green, well rounded, tabular, and elongated grains. Inclusions of apatite and zircon are common in many grains; however, many are masked by dark tan and green chloritic material (Plate VII., E).

Garnet is present as deep red to black, massive, irregular grains. The mineral is believed to be the black variety, melanite, of andradite, the type of garnet commonly found in pegmatites and soda-rich rocks.

Irregular and octahedral grains of magnetite, granular grains of epidote with high interference colors and high relief, stubby, normal zircons, and irregular titanite (sphene) grains are present in minor amounts. Pyrite, of which only a few grains were found, is a minor constituent, amounting to less than 0.5 per cent of the heavy fractions.

Ten large orthoclase crystals, differing in size and form, were crushed and the heavy minerals separated. Heavy minerals were found to constitute only 0.40 per cent by weight of the crystals, a figure representing approximately 0.12 per cent by weight of the total rock, and nearly 10 per cent of the total heavy mineral content of the mass, all of which indicates that most of the heavy minerals are contained in the groundmass. The heavy accessory minerals present and the respective percentages are given in Table III.

For a detailed description of the optical and identifying properties of the minerals, the reader is referred to Appendix II.
### TABLE II

**Heavy Accessory Minerals of Renova Porphyry**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Per Cent of Total Heavies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apatite</td>
<td>57.0%</td>
</tr>
<tr>
<td>Muscovite</td>
<td>28.5%</td>
</tr>
<tr>
<td>Zircon</td>
<td>1.7%</td>
</tr>
<tr>
<td>Magnetite</td>
<td>3.6%</td>
</tr>
<tr>
<td>Epidote</td>
<td>2.0%</td>
</tr>
<tr>
<td>Titanite (sphene)</td>
<td>2.3%</td>
</tr>
<tr>
<td>Garnet</td>
<td>4.9%</td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
</tr>
</tbody>
</table>

Total ...100.0%

Per Cent by weight of rock: 1.28%

---

### TABLE III

**Heavy Accessory Minerals of Orthoclase Crystals**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Per Cent of Total Heavies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apatite</td>
<td>45.1%</td>
</tr>
<tr>
<td>Muscovite</td>
<td>22.4%</td>
</tr>
<tr>
<td>Zircon</td>
<td>6.1%</td>
</tr>
<tr>
<td>Magnetite</td>
<td>4.2%</td>
</tr>
<tr>
<td>Epidote</td>
<td>3.7%</td>
</tr>
<tr>
<td>Titanite (sphene)</td>
<td>2.4%</td>
</tr>
<tr>
<td>Garnet</td>
<td>14.0%</td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
</tr>
</tbody>
</table>

Total ... 99.9%

Per cent by weight of crystals ... 0.40%

Per cent by weight of rocks ...... 0.12%
Chemical Composition

A chemical analysis of the Renova porphyry makes possible classification of the rock on the basis of the CIPW system. Analyses of the porphyry and the orthoclase crystals are given in Tables IV and V. As classified according to the CIPW system, as presented by Wahlstrom (16:226), the Renova porphyry is a kallerudose porphyry.

CONTACT ROCKS

The altered graywacke zone at the contact is approximately 2 feet thick. This contact rock is a thin series of highly metamorphosed shales and sandstones, dark brown or black and slatey, with a high content of quartz, clay, and fine dark minerals. The rock is fine-grained, most of the minerals being too fine to be recognizable. On weathered surfaces, the metamorphosed graywacke is dark brown, having a hard smooth surface. As a rule, the bedding of the shales and sandstones is well preserved.

When examined microscopically, the graywacke contact rock is fine-grained and holocrystalline. The rock contains an abundance of quartz, orthoclase and plagioclase feldspars, and clay; the grain size ranges from about 4 mm to particles submicroscopic, and the fine-grained material is that classified as clay.

The rock on the porphyry side of the contact is a dark-brown, fine-grained porphyry, 1 foot thick, which is highly sericitized and lacks the abundant large orthoclase crystals so common in the main mass of the porphyry. On weathering, the rock becomes dark brown or tan, and is stained limonitic-
brown and pink.

Microscopically, the rock has a micro-sutural texture. Abundant feldspar phenocrysts are present, but all are highly altered, bent, and fractured in subhedral to anhedral grains (Plate VII and VIII). The albite crystals in thin sections of the contact rock have irregular boundaries. These irregular boundaries, the bent and fractured grains, and also the fine-grain size, suggest mechanical abrasion and crushing of the phenocrysts in a partially crystallized magma during intrusion of the magma between the beds of host rock. Chilling of the margin is indicated by the fine-grain size and holocrystalline groundmass.
### TABLE IV

**Chemical Analysis of Renova Porphyry**

<table>
<thead>
<tr>
<th>Compound</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>66.2%</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>16.2%</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>2.3%</td>
</tr>
<tr>
<td>CaO</td>
<td>0.4%</td>
</tr>
<tr>
<td>MgO</td>
<td>Trace</td>
</tr>
<tr>
<td>Na₂O</td>
<td>5.7%</td>
</tr>
<tr>
<td>K₂O</td>
<td>2.2%</td>
</tr>
<tr>
<td>TiO₂</td>
<td>0.22%</td>
</tr>
<tr>
<td>Loss on ignition</td>
<td>1.6%</td>
</tr>
</tbody>
</table>

Total: 94.82%

**CIPW Normative Minerals:**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illmenite</td>
<td>0.41%</td>
</tr>
<tr>
<td>Hematite</td>
<td>2.24%</td>
</tr>
<tr>
<td>Orthoclase</td>
<td>12.80%</td>
</tr>
<tr>
<td>Albite</td>
<td>48.20%</td>
</tr>
<tr>
<td>Anorthite</td>
<td>2.00%</td>
</tr>
<tr>
<td>Corundum</td>
<td>3.78%</td>
</tr>
<tr>
<td>Quartz</td>
<td>24.60%</td>
</tr>
<tr>
<td>Ignition Loss</td>
<td>1.60%</td>
</tr>
</tbody>
</table>

Total: 95.63%

Albite-Anorthite ratio: Ab₉₀₆-An₄₄

### TABLE V

**Chemical Analysis of Orthoclase Crystals**

<table>
<thead>
<tr>
<th>Compound</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>58.8%</td>
</tr>
<tr>
<td>CaO</td>
<td>0.4%</td>
</tr>
<tr>
<td>Na₂O</td>
<td>6.1%</td>
</tr>
<tr>
<td>K₂O</td>
<td>8.9%</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>0.4%</td>
</tr>
</tbody>
</table>

Total: 74.6%

(Analyses by C.J. Bartzan)
Photomicrographs of Renova Porphyry
(Crossed-Nicols)

A. Micro-granular textured groundmass and albite crystal, showing albite and pericline twinning, (slide 12-1-1), x18.

B. Bent and fractured albite crystal in Renova porphyry contact rock, (slide 2-11-3), x70.

C. Micro-granular groundmass, rounded quartz, and albite, (slide 12-1-1), x18.

D. Albite, showing brecciation and holocrystalline groundmass in contact porphyry, (slide 2-11-4), x18.

E. Albite in large orthoclase crystal, showing albite twinning, (slide 2-10-2), x18.

F. Holocrystalline groundmass, bent and fractured albite crystal, and pericline twinned crystal, (slide 2-11-3), x18.
Photomicrographs of Renova Porphyry
A. Oriented albite crystals in large orthoclase crystal, showing irregular boundaries and alteration, (slide 2-10-11), x18.

B. Holocrystalline groundmass of Renova porphyry, (slide 2-11-3), x70.

C. Normal zircon in holocrystalline groundmass of Renova porphyry, (slide 2-11-3), x70.

D. Elongated orthorombic pyroxene in holocrystalline groundmass of Renova porphyry, showing alteration of pyroxene and fibrous appearance, (slide 2-11-2), x70.

E. Subangular grains in clay material; mostly quartz and feldspar; all in Belt graywacke, (slide 2-11-7), x18.

F. Quartz, orthoclase, and unusually fresh plagioclase grains in Belt graywacke, (slide 2-11-7), x18.
Photomicrographs of Renova Porphyry and Belt Graywacke
PLATE VII

Heavy Minerals of Renova Porphyry
(Plane Polarized Light, x85)

A. Normal zircon of the long, clear variety, showing inclusions. From Renova porphyry rock as a whole.

B. Normal zircon of the long, clear variety from Renova porphyry rock as a whole.

C. Heavy mineral assemblage from Renova porphyry rock as a whole. Light, clear, stubby grains are apatite (podolite); dark grain is garnet; medium dark, granular grain is epidote.

D. Euhedral grain, probably fluorapatite, from Renova porphyry orthoclase crystals.

E. Heavy mineral assemblage from Renova porphyry rock as a whole. Light, clear grain is apatite; grains with inclusions are muscovite; and dark grain is magnetite.

F. Elongated muscovite grain and dark euhedral garnet from Renova porphyry orthoclase crystals.
Heavy Minerals of Renova Porphyry
PLATE VIII

Heavy Minerals of Renova Porphyry
(Plane Polarized Light)

A. Normal zircon, clouded muscovite, and clear corner of apatite from heavy mineral assemblage of the Renova porphyry rock as a whole, x85.

B. Long, clear normal zircon grain and stubby barrel-shaped apatite from Renova porphyry rock as a whole, x85.

C. Heavy mineral assemblage from Renova porphyry orthoclase crystals. Light, roundish, clouded muscovite, with long clear zircon grain, x25.

D. Heavy mineral assemblage from Renova porphyry orthoclase crystals. Granular appearing grains are epidote; dark grains are garnet and magnetite, x85.

E. Wedge-shaped fragment of titanite from Renova porphyry orthoclase crystals, x85.
Heavy Minerals of Renova Porphyry
As quantitative determinations of the heavy minerals of the main Tobacco Root batholith are lacking, correlation of the Renova porphyry with that batholith on the basis of heavy mineral similarities is not feasible. Yet, the general character of the batholithic body and of its accessory minerals is indicative of a common origin.

The main mass of the batholith is a medium-grained quartz monzonite containing about equal proportions of quartz, orthoclase, and plagioclase, with hornblende and biotite. Although the rock is not a true granite in most instances, it does grade into true granite in some locales. It has a pink color and the most common accessory mineral is apatite. Dikes and sills which emanate from the granite are very numerous, but have been little studied. A sill, similar to the Renova sill, which emanates from the main batholith body is described by Tansley, Schaffer, and Hart as follows (15:16):

"The rock is a porphyry with phenocrysts of white feldspar varying from one eighth to three eighths of an inch in length, and frequently showing twinning, embedded in a fine-grained groundmass of reddish-brown color .......... Under the microscope, the texture is porphyritic holocrystalline. Large crystals of idiomorphic crystals of orthoclase are enclosed in a fine-textured groundmass of feldspar and quartz. The composition is orthoclase (59%), quartz (40%), the remainder being made up of accessory apatite, magnetite, pyrite, and secondary white mica."

From the foregoing descriptions, and from the content of this paper, one can see that although there is a noticeable difference in the composition of the sills and the To-
bacco Root batholith, and between the sills themselves, there is a resemblance in the types of feldspars present in each body; and the similarity of the accessory minerals is suggestive that the Renova leuco-sodaclase-granodiorite porphyry sill and the Tobacco Root batholith are genetically related.

The age of the Tobacco Root batholith is commonly considered late Cretaceous or early Tertiary (Eocene), having been intruded during the later stages of the Laramide Revolution. Therefore, it is believed that the age of the Renova leuco-sodaclase-granodiorite porphyry is also late Cretaceous or early Tertiary.

Paleozoic formations on the western margin of the Renova area have been complexly faulted, as have Mesozoic formations in adjoining areas. The faults are nearly vertical and represent the adjustment of rock layers to the sharp folding of Paleozoic rocks in the northern end of the Tobacco Root Mountains. Faulting of the underlying Belt graywacke is also indicated to be of the same age (Plate X). In late Cretaceous or early Tertiary times, following this extensive faulting, or probably associated with the deformation, intrusion occurred, implacing the Tobacco Root batholith and probably the Renova porphyry sill. Data such as this are not conclusive and are offered only as suggestive of the age of the intrusive body.
For over 50 years the Renova district has been an intermittent producer of gold and silver. The Renova porphyry sill lies within one mile of the well-known Gold Hill mines, (Plate IX), and some ore has been mined along the contact zones and in the fissures related to the fault zones of the sill. Each vein occurs in a strong fissure zone cutting the Belt graywacke, and these veins constitute the only known ore deposits related to the Belt sediments in this region.

The Gold Hill mine was discovered in 1894 by Frank Pruitt. Discoveries were made along the faults and the quartz-filled fissures of this area. Pruitt located the Gold Hill and Colorado lodes in 1894, with many other lodes being located since that time. A map of the patented mining claims of the area is presented in Plate IX.

All of the claims of the area have been operated intermittently since their discovery; the following lodes are being operated at the present time:

Benedict lode ...... by Emil Datres and Percy Renz.

Blue Bird, Colorado, and Mary Ingabar lodes ... by Robert Pruitt and Lloyd Thompson.

Idaho lode .......... by Harry Lux.

CHARACTER OF DEPOSITS

The veins are probably the result of mineralization along fault fissures in the Belt graywacke. Present oper-
ators describe two periods of faulting, one pre-mineralization and one post-mineralization. The first period of faulting resulted in a series of large complex but uniform faults, which trend from east to west and dip from 70 to 85 degrees south. Following this faulting, mineralization occurred in the fissures. A second period of faulting followed, the result being a series of small faults which strike nearly north and south and which offset the mineralized fissures. The north-south faults are not mineralized except where they cut the porphyry-graywacke contact and apparently fault the east-west trending veins. No ore has been found at the fault intersections except where drag material is included.

Veins average 5 feet in width, but veins have been mined with widths as great as 22 feet; moreover, a fault zone was encountered with a width of 32 feet. Having a definite pattern, the veins are constant in dip and strike; but contrary to the statements of A.N. Winchell (18:100), they are highly faulted. The wall rocks are altered and mineralized. Assays of the wall rock indicate a varying gold content from 0.5 to 0.8 ounces of gold per ton. Mineralization and alteration of the wall rock extend about 18 to 20 inches. Winchell (18:100) indicates that,

"...the high-grade ores are on the footwall in the oxidized zone, and on the hanging wall in the sulphide zone. The ores decrease in value from the surface to the lower part of the oxidized zone, and the upper part of the sulphide zone is richer than the overlying part of the oxidized zone. In the Gold Hill property the sulphide ores, pyrite, chalcopyrite, and galena, come within 30 feet of the surface."

Enrichment in silver and gold extends to the base of
the oxidized zone which is approximately 60 feet deep, but the gold is less concentrated than the silver. Sulphide ores occur below the oxidized zone, but mining of the ores has been unsuccessful because they are of too low a grade to be worked profitably. Shafts have been sunk to depths of over 300 feet in the ore bodies-- the Mary Ingabar (310 feet), the Colorado (200 feet), and the Blue Bird (268 feet).

MINERALOGY

The mineralogy of the deposits was not studied by this writer, but the following information was gathered from the present operators and A.N. Winchell (18:100).

The ore at the surface is free gold in limonite, hematite, quartz and jasper. Some silver is also found in this oxidized material which is clayey, reddish to black, and quite soft except where considerable jasper and quartz are encountered.

Copper is found in the area as malachite, cuprite, chalcopyrite, and native copper. Most of the copper ore is found along the porphyry-graywacke contact, and is associated with the quartz veins in the fault zones. Malachite and cuprite are present in the oxidized zones of the mines with chalcopyrite occurring in the sulphide zone.

Pyrite and galena have also been found in the sulphide zones of most of the mines. The gangue in the sulphide zone is largely calcite, dolomite, and siderite.

The average tenor of the ore in the past was estimated by Robert Pruitt at 2 ounces of gold per ton, but at present is much lower. Assays on the Benedict claim indicate values
ranging from 0.5 ounces to 1 ounce in the veins being mined, and in the wall rock of worked out stopes.

PRODUCTION
Although production from the district has been erratic, Robert Pruitt estimated that minerals valued at over $800,000 have been produced. Approximate estimates given by Pruitt indicate that the Gold Hill lode has yielded $310,000, the Colorado $250,000, and the Blue Bird $40,000.

Definite data on shipments made from the district were found only for one year, 1914 (19).

"181 tons shipped, produced by 6 operators, $7,383 gold, 925 ounces silver, 2,070 pounds copper, principal producers were the Bonanza, the Colorado, the Last Chance, the Gold Hill, and the O.K. claims."

At present development work is being carried on in old workings and shafts, with shipments to be made in the summer of 1950.

RELATION OF MINERALIZATION TO RENOVA PORPHYRY
Although some ore has been mined along the margin of the porphyry sill, there appears to be no direct relationship of the igneous rocks and the mineralization. Intrusion of the sill was probably completed before mineralization of the area occurred. This theory is substantiated by the distinct break between the mineralization and the faulting of the sill, and by the fact that no ore has been found in the main mass of the porphyry body. Detailed study of the mineralization of the area would be needed before any conclusion could be reached as to the future of the district.
CONCLUSIONS

Apparently an off-shoot from one of the batholithic masses of Montana, the Tobacco Root batholith, the Renova leuco-sodaclase-granodiorite porphyry is syenitic in character, but differs from true syenite by being composed of more than 5 per cent quartz, less than 2 per cent feric minerals, and dominant sodic plagioclase. It differs from most intrusive masses in Montana, but may have, as do many of the intrusive bodies of the state, some relationship to metallic mineral deposits commonly occurring in the same vicinity. However, no direct relationship to the ore deposits of the Renova district was observed.
APPENDIX I

PETROGRAPHIC DESCRIPTIONS OF THE RENOVA PORPHYRY
AND BELT GRAYWACKE

To supplement the material presented in the section under petrology, separate petrographic descriptions of some of the samples collected are given here. Points from which the samples were taken are shown on the accompanying map (Plate X), and are marked by an identifying number such as 2-11-1; "2" refers to this writer's field book, "11" refers to the page in the field book, and "1" denotes a specific sample on that page.

12-1-1 (Renova Porphyry) Texturally, this sample of nearly fresh rock is micro-porphyritic with a holocrystalline groundmass. Minerals identified and the percentages of each are: quartz 8.7 per cent, orthoclase 14.2 per cent, plagioclase (albite Ab\textsubscript{97}An\textsubscript{3}) 26.6 per cent, and orthorombic pyroxene (probably hypersthene) 1.2 per cent. The holocrystalline groundmass constitutes 49.3 per cent of the total rock. The plagioclase is highly altered in some instances, but only slightly in others. The pyroxene is partially altered to fibrous amphibole. Excellent twinning, albite and pericline, is exhibited by all of the albite grains. Accessory minerals are difficult to distinguish, but a few rare grains of apatite were noted.

Grain sizes are: quartz 1.1 mm, orthoclase 3.5 mm, plagioclase 2.25 mm, orthorombic pyroxene 0.6 mm. (Plate V., A&C).

By Johannesen's classification this rock is a leucosodaclase-granodiorite porphyry.

Megascopically, this rock is a green-gray porphyry with large pink idiomorphic orthoclase crystals and smaller, more abundant plagioclase phenocrysts.

2-11-2 (Renova Porphyry) This specimen is micro-porphyritic with a holocrystalline groundmass, although some of the matrix appears shardy or glassy. Minerals identified were: quartz 3.5 per cent, orthoclase 17.9 per cent, plagioclase (albite Ab\textsubscript{6}An\textsubscript{4}) 30.8 per cent, orthorombic pyroxene 1.5 per cent. The groundmass constitutes approximately 48 per cent of the total rock. The plagioclase crystals are shattered, bent, and highly altered as is the orthorombic pyroxene. Sericite and kaolin are present as secondary alteration products and limonite is present in the fractures and around the large phenocryst boundaries. Some magnetite is also visible.

Quartz grains are about 1 mm in diameter, orthoclase grains about 4 mm, plagioclase grains about 1.1 mm, and pyroxene 0.6 mm. In hand specimen this sample is porphyritic and was collected about 3 inches from the contact. It apparently lacks
the abundant orthoclase crystals so common in the main porphyry mass. The rock has a light-to-dark gray color with many limonite stains.

2-11-3 (Renova Porphyry Contact Rock) This specimen was obtained from the contact approximately 2 inches from the sharply defined contact line. Minerals identified in this micro-porphyritic rock were: quartz 5.5 per cent, orthoclase 14.6 per cent, plagioclase (albite Ab97An3) 18.5 per cent, pyroxene (altered hypersthene) 1.3 per cent. The groundmass is holocrystalline, (Plate VI., B), and appears to contain a great deal of quartz and shattered feldspar. Essentially, the rock is much like 2-11-2, but the grain size is smaller, decreasing in large orthoclase crystals, but becoming more crystalline in texture. Limonite is abundant and alteration of the feldics and the plagioclase is well developed.

Grain sizes are: quartz 0.9 mm, orthoclase 2 mm, plagioclase 0.7 mm, orthorombic pyroxene 0.3 mm. All measurements represent the lengths of grains.

Megascopically, the specimen is a fine-grained porphyritic rock, light-gray in color, but highly stained by limonite and bleached by kaolin and sericite.

2-11-4 (Porphyry-Graywacke Contact) This specimen is partially porphyritic and partially metamorphosed graywacke. It is an excellent section of the sharp contact. Minerals identified are: quartz, orthoclase, plagioclase (albite Ab96An4), pyroxene, limonite, and clay. Grain size of the constituent minerals was difficult to obtain, but all of the grains average about 0.1 mm in length.

Megascopically, the rock is the contact point between the light-gray porphyry and the dark brown graywacke. This contact line is approximately one-half inch thick. The rock is fine-grained and highly altered and micro-crystalline.

2-11-7 (Belt Graywacke) This sandstone appears to be poorly sorted and contains quartz 31.8 per cent, orthoclase 23 per cent, plagioclase 3.1 per cent, feldic minerals 2.2 per cent, and clays 40.4 per cent. All of the grains are nearly subangular and unusually fresh feldspar grains are present in the rock (Plate VI., E & F).

Megascopically, the rock has a dark-brown to greenish color and weathers a deep ruddy brown. Classified according to Pettijohn's classification of arenites (9:227), this sandstone is a graywacke.
APPENDIX II

DESCRIPTIONS OF THE HEAVY ACCESSORY MINERALS OF THE RENOVA PORPHYRY

A more detailed description of the heavy accessory minerals found in the Renova leuco-sodaclase-granodiorite porphyry, with their optical and identifying properties is presented in the following paragraphs.

**Apatite** --- The apatite in the heavy mineral fractions occurs as colorless, euhedral to subhedral, barrel-shaped grains. Many of the grains appear to be hexagonal or pseudo-hexagonal in form and may be fragments of larger grains. Most of the grains have moderate relief (podolite has a slightly higher relief than the common apatite) and have interference colors ranging from first order grays and yellows to second order blues, greens, and yellows. All of the apatite has parallel extinction. Elongate grains are length-fast. The distinctive features of the apatite are: colorless grains, parallel extinction, low birefringence, tabular to hexagonal crystals. Inclusions of a very light yellowish material are present in some of the more irregular grains.

**Muscovite** --- The muscovite found in the heavy fractions occurs as colorless to pale green, rounded to elongate grains. The mineral has a vitreous luster and shows perfect basal cleavage under the binocular microscope. The grains have low relief, and interference colors ranging from first order grays to second order yellows. Biaxial negative optic figures were obtained with 2V equal 30°. The grains are commonly rounded to sub-tabular or elongate. The distinctive features of the muscovite are: pale green color, 2V equal 25°-30°, rounded to elongate grains, altered boundaries, cloudy or masked appearance of all grains (Plate VII., E). Inclusions are abundant in the mineral, including apatite, zircon, and a brownish chloritic material which is present in most grains, and in many instances completely masks the grains.

**Zircon** --- Normal zircons are found in the heavy accessory suites of the Renova porphyry. They are present as colorless to light-brown, short, prismatic crystals. All of the zircons have high relief and interference colors ranging from second to fourth orders. The grains have parallel extinction and are length-slow. Uniaxial positive figures were obtained on the few grains noted. Grains are commonly euhedral prismatic crystals terminated by simple pyramids. The distinctive features are: tetragonal habit, high relief, length-slow grains, parallel extinction. Inclusions of small grains were noted in several of the zircon crystals (Plate VII., A).
Garnet --- Grains of garnet present in the heavy mineral suites are unusually dark, and appear to be nearly reddish-black in color. The mineral occurs as irregular grains and masses. It has high relief, a rough surface, and is distinguished from magnetite by its reddish color, rough surface, lack of metallic luster, and the presence of small fractures. The garnet is possibly the black melanite variety common to pegmatites and soda-rich rocks.

Magnetite --- Grains of magnetite in the heavy mineral fractions are easily recognized by their black color and metallic luster. They are commonly massive and irregular, but some octahedral grains were observed. In many instances, it was difficult to distinguish between the magnetite grains and the dark garnet grains (Plate VIII., D).

Epidote --- By far the most difficult mineral to identify, epidote grains are found as colorless to slightly greenish, irregular grains. The grains have high relief and high birefringence (high second and third order colors). Distinctive features of the epidote are: high relief, strong birefringence, granular appearance. The grains are irregular and all have the characteristic granular appearance (Plate VIII., D).

Pyrite --- The pyrite grains of the heavy mineral fractions are typically brass colored with metallic luster in reflected light. The grains occur in irregular grains and masses, with only one euhedral cubical grain noted. It is distinguished by its brassy color in reflected light and its opaqueness.
BIBLIOGRAPHY


11. Reyner, M.L., Geology of the Tidal Wave Mining District, Madison County, Montana, Montana School of Mines.


MAP of MINING CLAIMS
in RENOVA AREA
after LAND MANAGEMENT BUREAU MAPS
SCALE: 1" = 1300'
19 RENOGA SYENITE