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Relationships of Manganese Minerals in the Butte District

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Parent, C. F.

RELATIONSHIPS OF MANGANESE MINERALS IN THE BUTTE DISTRICT

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
Charles F. Parent

Montana School of Mines
Butte, Montana
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TABLE OF CONTENTS

Tables

Plates

RELATIONSHIPS OF MANGANESE MINERALS IN THE BUTTE DISTRICT

by

C. F. Parent

INTRODUCTION

The work for this thesis entailed study of the general occurrence of manganese in Butte and western Montana, and especially the zonal distribution of the primary minerals rhodonite and rhodochrosite in the Butte area and their alteration to the oxides. Petrographic investigations and analyses were made, and theories on genesis postulated to the best of the writer's ability, according to available information.

I wish to thank the members of the faculty of the geology department at the Montana School of Mines, whose assistance made the compilation of necessary data much easier. Dr. E. S. Perry was especially helpful in outlining the work and suggesting methods of procedure, Dr. G. F. Seager was of much help in laboratory work and Dr. L. L. Sloss's aid in the photography of specimens was invaluable.

My sincere appreciation is tendered to the Anaconda Copper Mining Company for their kind permission to visit their properties and especially to the employees at the Emma mine who were most considerate. To the men who showed me around the mine and granted me interviews, namely Messrs. Sam Barker Jr., E. Hungerford, G. McCracken, J. Kolesar, and E. P. Shea, I owe a great deal.

Miss Margie Anderson, who edited and typed the manuscript, also rendered valuable assistance.

IMPORTANCE AND ECONOMICS OF MANGANESE

The term "strategic mineral" is assuming new importance every day due to the complex and ever-shifting international situation. The use of manganese in the steel industry as a deoxidizing and desulfidizing agent makes it a necessity in modern industry, while the various alloy steels using manganese for the quality of toughness are also indispensible. Manganese is also used in the manufacture of such various articles as battery cells, paints, glass and others.

In the Butte district are the largest commercial reserves of manganese in the United States, and although exceeded by Philipsburg at present in production, will probably become the chief producer in the country within the next few years. With foreign sources being shut off, the price of manganese will undoubtedly rise, enabling the Anaconda Copper Mining Company to step up production and mine veins not now commercially minable.

Mr. W. H. Hoover, in an address on the evening of January 14, 1941 at a Butte Chamber of Commerce dinner, made the following pertinent remarks, concerning the importance of the manganese in the area:

"Montana is still the Treasure State. Its significance in the defense program in the production of strategic and other minerals is immense. Here our relation to our state and nation in the matters of preparedness can be more easily visualized.

During the last summer the defense commission at Washington became concerned as to the supply in this country of manganese which is so necessary in the making of certain steels for defense equipment. Manganese in peace times has been supplied largely from Russia. The imports have been greatly curtailed due to lack of shipping facilities and production abroad. For untold generations a deposit of low grade manganese ore has lain dormant thousands of feet under the Butte Hill. For many years in the operation of the Emma mine for zinc this deposit has been known and in more recent years blocked out, to some extent developed, and carefully estimated. For many years no process had been evolved for the treatment of these low grade ores to concentrate them sufficiently for nodulizing, the process which prepares manganese ores for use in steel. No market condition stimulated an investigation of the possibilities of utilization. The defense commission, in considering sources of manganese within our borders, concluded that the Butte hill contains the only presently available supply of manganese ore in the United States in substantial quantities. A contract was negotiated for the sale to the government of as much manganese as the mine can produce over a three-year period of production. This contract involves substantial work at the mine itself, the building of a concentrator and nodulizing plant at Anaconda, the resultant employment of men, and a reasonable assurance of an added production enterprise and industry over the period of the next few years. While not large in comparison with the copper and zinc operation in Montana, its importance in the defense program may not be minimized."

The world production of manganese ore in 1940 was approximately five million long tons, of which over 35% is manganese. The United States produced only 40,000 long tons of 35% manganese in 1940, importing 1,254,588 long tons of battery grade ore, showing the dangerous insufficiency of our production. Foreign producers in order of their importance are Russia, India, Union of South Africa, Gold Coast and Brazil. From our neighboring Americas we import almost their entire production, or 310,000 long tons, and this source is in little danger of being shut off. We have no reserves of mined ore in this country of any importance.*

The domestic production is principally 80 per cent from Arkansas, Montana and Tennessee, with Montana leading by a wide margin. The domestic production of metallurgical manganese ore is only 2.54% of our needs. The reserves at Philipsburg are only 600,000 tons of manganese oxide ore, and at Butte there are between 2 and 5 million tons of commercial rhodochrosite ore at the Emma, Travona, and other mines.

The Anaconda Copper Mining Company has received an order from the United States government for 80,000 tons of nodulized manganese oxide per year for three years, from Butte ores.

The Butte camp is vital to the defense program in the production of many metals, and the manganese occurrence here accentuates this importance greatly. Its history dates back to the first placer gold mining of 1864, when almost $2,000,000 in gold was recovered in three years. Silver mining was inaugerated in 1875, and was successful until the low price of silver caused all mines to close down in 1892. In 1865, copper deposits were discovered in the region, and the mining of this metal is by far the most important today at Butte.

The literature on the Butte District is extremely prolific, and in the bibliography may be seen some of the many references which refer to manganese occurrence. Early writers on Butte included Messrs. Peters and Blake, while the classic reports by Reno Sales, and W. H. Weed, made Butte perhaps the most completely studied area in the world. The extreme complexity of the structures and mineralogy fully justifies past research, nevertheless many problems remain unsolved. J. T. Pardee made a general report on the manganese here, and the research department of the Anaconda Copper Mining Co. is continually adding to the information on the subject.

The physiography of the region is rather simple, the Butte hill lies at the north end of an intermontane valley in the rugged mountains characteristic of the Boulder Batholith. The drainage is to the west down Silver Bow Creek, which eventually reaches the Pacific Ocean. The valley is covered with several hundred feet of alluvium in places. The east wall of the valley is formed by the significant Continental Fault, and to the west is the rhyolitic prominence known as Big Butte, whence the district received its name.

RESUME OF MANGANESE MINERALS

The following (table 1) lists significant information concerning manganese minerals. The element manganese is found in almost every rock in varying amounts, occuring as primary silicates and carbonates and is found as the oxide due to secondary alteration. The oxides are more common and higher in manganese value, and most of the metal is obtained from them. When found occuring with rion oxides, they are smelted together to form the ferro-manganese alloy for steel making.

A more complete description of the more common oxides follows:

Manganite-($Mn_2O_3.H_2O$) Crystallization:orthorhombic, with long prismatic crystals having deep vertical striations. It occurs in bundles of radiating crystals. It has perfect cleavage in one direction. H-4; G-4.3 Metallic luster. Color is steel gray to iron-black. Has dark to brown streak.

Under the reflecting microscope the color is gray. H.-E . Strongly anisotropic, with four extinctions per revolution, going from white to gray to violet to brown. HCl fumes tarnish brown.

Pyrolusite-($MnO_2.nH_2O$) Crystallization is pseudomorphous after manganite. Structure is commonly fibrous and granular massive. H.-(2-2.5) (soils fingers); G.-4.75. It has a dull metallice luster. Iron-black in color and streak. Splintery fracture.

TABLE I

MANGANESE MINERALS

OPAQUE

Names	Formula	%Mn	Comb. Oxygen	Sp. Gr.	Hardness
Oxides					
Manganosite	MnO	77.46	22.54	5.18	5-6
Manganite	$Mn_2O_3.H_2O$	62.5	27.27	4.2-4.4	4
Polianite	MnO_2	-----	-----	4.8-5	6-6.5
Pyrolusite	MnO_2	63.22	36.78	4.7-4.8	2-5
Heusmanite	Mn_3O_4	72.05	27.95	-------	5-5.5
Braunite	$3Mn_2O_3.MnSiO_2$	63.59	26.43	-------	6-6.5
Psilomelane	$4MnO_2(Mn,Ba,K,Co,N)O$	67.35	32.65	3.7-4.7	5-6
Wad	Mn Oxides	-----	-----	3-4	1-5
Bixbyite	$FeO.MnO_2$	-----	-----	4.95	6-6.5
Pyrophanite	$MnO.TiO_2$	-----	-----	4.54	5-6
Senaite	$(Fe,Pb)O_2(Ti,Mn)O_2$	-----	-----	4.7-5.3	6
Dysluite	$(Zn,Fe,Mn)O.(Al,Fe)_2O_3$	-----	-----	4.6	5-5.8
Franklenite	$(Fe,Zn,Mn)O.(Fe,Mn)_2O_3$	----	-----	5.0-5.2	5.5-6.5
Jacobsite	$(Mn,Mg)O.(Fe,Mn)_2O_3$	----	-----	4.75	6
Chalcophanite	$(Mn,Zn)O.2MnO_2.2H_2O$	----	-----	4.0	2.5
Sulfides					
Alabandite	MnS	-----	----	4.0	3.5-4
Hauerite	MnS_2	-----	----	3.46	4
Tungstates					
Wolframite	$(Fe,Mn)WO_4$	----	----	7.2-7.5	5.5
Hubnerite	$MnWO_4$	----	----	7.2-7.5	5.5
Tantalates, etc.					
Columbite and Tantalite	$(Fe,Mn).(Nb,Ta)_2O_6$	----	-----	5.3-7.3	6

NON-OPAQUE

Names	Formula	%Mn	Comb. Oxygen	Sp. Gr.	Hardness
Rhodonite	$Mn(Ca,Fe)SiO_3$	42.1	---	3.6	6
Rhodochrosite	$MnCO_3$	47.8	---	2.85	3.5

Microscopically it is a very light gray, almost white, similar to hematite. H.-D to E. Strongly anistotropic with 4 extinctions per revolution, showing polarization color from white to black. HCl stains surface brown. Prismatic. Apparent amorphism resolves into interlocking needle crystals.

Psilomelene-(MnO_2, MnO, H_2O) Amorphous. Massive, batryoidal, stalactitic. H.-5 to 6. G.-3.7 to 4.7 Submetallic luster. Black color. Brownish-black streak.

Under the reflecting microscope the color is gray. H.-D-. Some areas appear to be isotropic and others anisotropic, especially where there are radiating fibers. Polarization colors white to black. Four extinctions per revolution. Nitric acit stain is light-brown, fumes tarnish. HCl-brown to black, strong reaction. Concentric banding common.

Braunite-($3Mn_2O_3.MnSiO_3$) Rare. Tetragonal. Under the reflecting microscope, the mineral is gray. Weakly anisotropic. Occurs commonly in pseudo-octahedrons giving nearly equidimensional cross-sections.

Rhodonite and rhodochrosite are described in detail on pages and .

The geneses of all these manganese oxides are very nearly the same; they are all secondary minerals, the result of the oxidation of primary manganese minerals in crystalline igneous rocks or mineral veins, the transportation of the manganese by shallow ground water, and its redeposition as as dendrites and nodules. These minerals are also derived from supergene concentration from manganiferous sedimentary rocks. They are thought to be transported in a colloidal state, as they do not always crystallize upon deposition, due no doubt to some delicate balance in physical-chemical conditions.

GENERAL GEOLOGY OF BUTTE

The Butte ore deposits are in a host rock of quartz monzonite, a part of the Boulder Batholith, a great intrusive body. The ore deposits are concentrated, almost all the rich deposits being in an area two miles square on Anaconda hill. The minerals occur in wide veins which continue to great depths. The veins structure and fault systems are very complex and require constant geologic work to render the mining effective and economical.

The geology of the region has been determined to be the result of a series of geologic events in a definite chronological order, which are given below:*

1. Intrusion of Boulder Batholith.
2. Intrusion of quartz porphyry dikes.
3. Intrusion of aplite and pegmatite dikes.
4. Formation of Anaconda veins.
5. Formation of Blue or Northwest veins.
6. Formation of Steward veins.
7. Development of Mountain View breccia faults.
8. Development of Rarus.

9. Development of Middle fault.

10. Development of Continental fault.

The Anaconda and Blue veins contain the rich producing ore bodies of the district, and the other veins and faults only complicate the mining of these deposits.

The zonal arrangement of Butte has been cited as the perfect example of this phenomenon of mineralization. The mineral areas at Butte have been divided into three zones, each approximately one-half mile wide at the surface, as follows:*

1. A main central copper zone, containing chalcocite, bornite, enargite, etc.

2. An intermediate zone containing copper minerals with sphalerite, rhodonite, and rhodochrosite appearing near the outer edge of this zone.

3. An outer peripheral zone extending indefinately out and containing galena, silver, sphalerite, rhodonite and rhodochrosite.

The order of deposition or paragenesis of the Butte minerals is to my mind best determined by Mr. Waldemar Lindgren, who lists them as follows:**

1. Quartz. Continued more or less throughout ore deposition.

2. Pyrite.

3. Sphalerite. Where conditions can be determined it is always later than pyrite.

4. Enargite.

5. Tennantite. Frequently replaces the enargite intricate vein patterns.

6. Bornite. Replacing any of the preceding minerals.

7. Chalcopyrite. More difficult to place than any of the other minerals. Occurs as blebs and rods in sphalerite and as irregular masses in bornite, but also as veinlets cutting across these minerals; also in druses, psuedomorphous after enargite.

8. Galena. Always later than pyrite and sphalerite, bornite and tennantite. Relations to enargite uncertain as they are rarely found together. Relations to chalcopyrite also difficult to establish; probably almost comtemporaneous.

9. Rhodochrosite-Rhodonite-Quartz. After the copper minerals and the galena were deposited there followed a time of brecceation, mostly in what now is the zinc area (in which the full development of the copper minerals is lacking) and then a cementation of the breccias by these two manganese minerals (often very intimately intergrown). This was followed by a renewed deposition of quartz, as is well seen in the Alice, Rainbow, and Magna Charta region, but also in numerous smaller veins and the upper levels of the State vein.

10. A late generation of pyrite occurs in smaller amounts with the manganese minerals, a distinctly later phase than the early pyrite.

11. Chalcopyrite, and perhaps other sulphides including argentite (?), also small amounts in the manganese minerals.

12. Iron, Manganese, Calcium, Magnesium carbonates of the ankerite type, occur mostly in druses of the copper mineralization. Little or no rhodochrosite is found in the copper areas.

13. Dolomite. Clusters of rhombohedrons surmounting the latest sulphides in copper and zinc areas.

14. Calcite. Latest phase of carbonate in druses, occuring in places as large scalenohedrons.

15. Barite. Rare but observed as one of the latest gangue minerals in Colorado No. 2 and in the State vein, at both places in copper areas.

16. Chalcocite. I have placed the hypogene chalcocite as the latest of the sulphide minerals, replacing all of earlier copper minerals.

MANGANESE, MINERALS IN BUTTE

The quartz-monzonite country rock of Butte contains a small amount of manganese throughout, but this is of no value whatsoever. Manganese occurs otherwise only as either the original constituent of vein fillings or as the oxidized alteration product of supergene action.

The rough-and-ready classification used by the Butte miners of the manganese ores, which is sufficient for practical purposes, is simply "black mag" for the oxidized minerals, and "pink mag" for the unoxidized minerals. The black manganese stain is very apparent on the surface at the vein outcropping, and the zone of oxidation for the manganese minerals extends downward to a depth which varies from a few feet to several hundred, averaging close to seventy-five.

The order of frequency of the manganese oxides seems to be:

1. Pyrolusite.
2. Psilomelane.
3. Manganite.
4. Braunite.
5. Wad-(a mixture of oxides).

Most of the manganese oxide has been tentatively classed as pyrolusite because little water was found in it, and the usual hardness was less than psilomelane and greater than wad. Its composition is doubtless unhomogeneous, and no strict classification is possible. The mineral is commonly in prismatic forms or acicular clusters, and occurs as crusts with radial structure, often with enough water to be called manganite. Psilomelane occurs as mammillated crusts and concretions, and its compact aspect and hardness renders it easily identifiable. All soft brown manganese oxides which readily stain the hands are grouped together as "wad".

Hubnerite, or manganese tungstate, is found rarely in the central zone and is of no economic importance.

Rhodonite and rhodochrosite are the primary vein constituent manganese minerals, and the field and laboratory work for the present work was done to determine the occurrence and associations of these two minerals. In view of their importance the following two pages are devoted to a listing of all available pertinent facts regarding their characteristics and properties:

RHODONITE

Composition: Mn(Ca,Fe)SiO_3; Silica-45.9%; Manganese protoxide-54.1%.

Crystallization: Triclinic, tabular, rounded edges, a: b: c= 1.073: 1: 0.721. = $103^{\circ}18'$,B=$108^{\circ}44'$, = $81^{\circ}39'$.

Physical Properties: Cleavage 110, 110, perfect; 001, fair. Brittle. Hackly fracture. H.-6.G.-3.6. Color, flesh-pink. Streak, white. Lustre, vitreous. Translucent when unaltered.

Optical Properties: Optically negative. 2V-76°. p v, weak. Marked cross dispersion. Weak birefringence. Acute bisetrix inclined at angles of $51^{\circ}40'$ and $51^{\circ}47'$ from normals. N =1.730to1.744, N_b=1.726 to 1.740, N_a = 1.721 to 1.733. N - N_a 0.009 to 0.011.

Occurrence: In the northern part of the Butte district this mineral is next to quartz in importance as gangue mineral in silver veins, occuring as crusts and microrhombs alternating with quartz, being same age as quartz and younger than sulfides. Rhodonite is not found to represent in the southern portion of the Butte district.

At Franklin Furnace, New Jersey, the result of recrystallization uder dynamic metamorphism,

Alteration: Sometimes alters to rhodochrosite, or to manganese oxides in the following order:

1. Rhodonite.

2. Formation of intimate mixtures of oxides of manganese and iron.

3. Replacement of psilomelane by pyrolusite.

4. Formation of braunite and wad.

RHODOCHROSITE

Composition: $MnCO_3$, CO_2-38%, MnO-61.7%. (Fe, or sometimes Ca, Mg. Zn, etc. often replaces in part the Mn.)

Crystallization: Hexagonal-rhombohedral.

Physical Properties: Perfect rhombohedral cleavage. H.=3.5 to 4.5. G.=3.70. Vitreous luster. Color, flesh pink to white to brown. F.= 7, decrepitates and turns black.

Optical Properties: Uniaxial. Optically negative with extreme birefringence, which increases with iron content. Colorless.

$N_o=1.818$, $N_e=1.595$, $N_o-N_e=0.223$.

Occurrence: Found as vein filling in silver zone in Butte, pure deposits in Emma and Travona mines. Rhodochrosite is sparce or absent in the northern part of the Butte district, whereas in the southern part it is the only primary manganese mineral.

Alteration: It alters readily to pyrolusite, and is the hypogene alteration product of the decomposition of rhodonite in some cases.

COLLECTION AND INVESTIGATION OF SAMPLES

The field work in connection with this report was necessarily extensive, as representive samples of the entire Butte district were needed to work out the zones of occurrence of the minerals. The principal problem under investigation was the distribution of the primary manganese ores, rhodonite and rhodochrosite; and as most of the mines in the peripheral zone are shut down sampling was limited to the waste dumps except at the Emma. The Orphan Girl, Lexington and Anselmo mines have manganese minerals, but underground studies were not made at these places.

The fallacy in dump sampling for critical work is obbious, for neither the vertical nor lateral position of the mineral collected is known, and some of the mines have stopes over a mile from the haulage shaft. However, for the purpose of locating the general areas of occurence of each of the minerals, this type of sampling was adequate.

As previously stated rhodonite occurs exclusively in the northern part of the Butte district, and rhodochrosite occurs exclusively in the southern part. Extensive sampling at the junction of the two zones would of course be desirable, but on the west side it is covered with a rhyolite flow, and on the east side, by a deep alluvial mantle. A few dumps occur in the western part of the district with both minerals being about equal in occurrence, as for example around the Walkerville reservoir. In the Meaderville region there are numerous dumps with small amounts of both minerals. A cursory examinations was made of the dumps across the valley near the foot of East Ridge, and in these dumps both minerals were seen in an oxidized state. The veins containing rhodochrosite extend to the west past Rocker, where they gradually pinch out.

In sampling the dumps, the name of the mine which yielded the material was sometimes not known, and thus a system of coordinates has been used. Thus every dump has been given a coordinate designation for east-west and from north-south, which indicates the source of each sample in the following tabulation.

To study these samples with the petrographic microscope there was the choice of oil immersions or thin-sections. Due to the very large number of samples to be studied, the making of thin-sections of each one would be impracticable, and as quantitative analyses were desired, nothing would have been achieved from thin-section that could not be done with oil immersion which are quickly and easily made and involve slight expense.

The samples were powdered in a small iron crushing device and were sized with screens.

As the size - 80 100 is the one which most closely conforms to the thickness of the thin-section, this was the sieve size used in almost all of the examinations. Care was taken to thourghly cleanse the iron cup after each grinding to avoid contamination of the sample.

In choosing oils, it was found that 1.544 oil (Canada balsam) gave excellent relief differences so as to facilitate the study and this was adopted as standard practice. After a few analyses were made, the minerals were easily identified and the percentage estimated.

Four thin-sections of rhodonite and rhodochrosite occuring alone and together were studied for paragenetic and alteration relations. A great number of oil immersions were studied and are tabulated below.

Some question has seemed to exist as to whether the rhodonites to the north were not actually a microscopic intergrowth of rhodochrosite and quartz. However, chemical analyses and petrographic studies show that this is not the case, and such a theory seems implausible to the present writer.

In petrographic examinations of the rhodonite, the good cleavage in both directions, weak birefringence, high 2V, and negative sign all checked with the recorded data on rhodonite The angle of extinction varied widely, between 45° and 55°, probably due to the presence of iron and calcium in the rhodonite molecules. Its high relief in bslsam and opacity, combined with its massive structure serve to easily distinguish it from quartz and rhodochrosite, as is shown by the various photographs in the back of the report.

In several cases, the rhodonite seemed to have altered to rhodochrosite along cleavage faces and fractures, and perhaps this gave rise to the microscopic intergrowth theory. The powdered rhodochrosite is indeed characteristic and easily identified.

Chemical analyses of the Butte rhodonite show it to be over 90% $MnSiO_3$ with varying amounts of alumina, iron, sulfur and calcite.

An interesting mineral found both with rhodonite and rhodochrosite is fluorite, which was determined by using successive oil immersions and observing Becke line to calculate index of refraction.

Franklin Furnace rhodonite was also studied, and is shown in photomicrographs accompanying this report for purposes of comparison.

The following table shows in tabular form the results of analyses made, and is arranged to show that in the north zone there is no rhodochrosite and in the south no rhodonite, while in the intermediate zone both minerals grade into each other. Many dumps were examined in the central zone, but as the results were negative for primary manganese minerals, they are not tabulated. Many dumps in the peripheral zone were sampled, but not one exception to the zonal arrangement was observed.

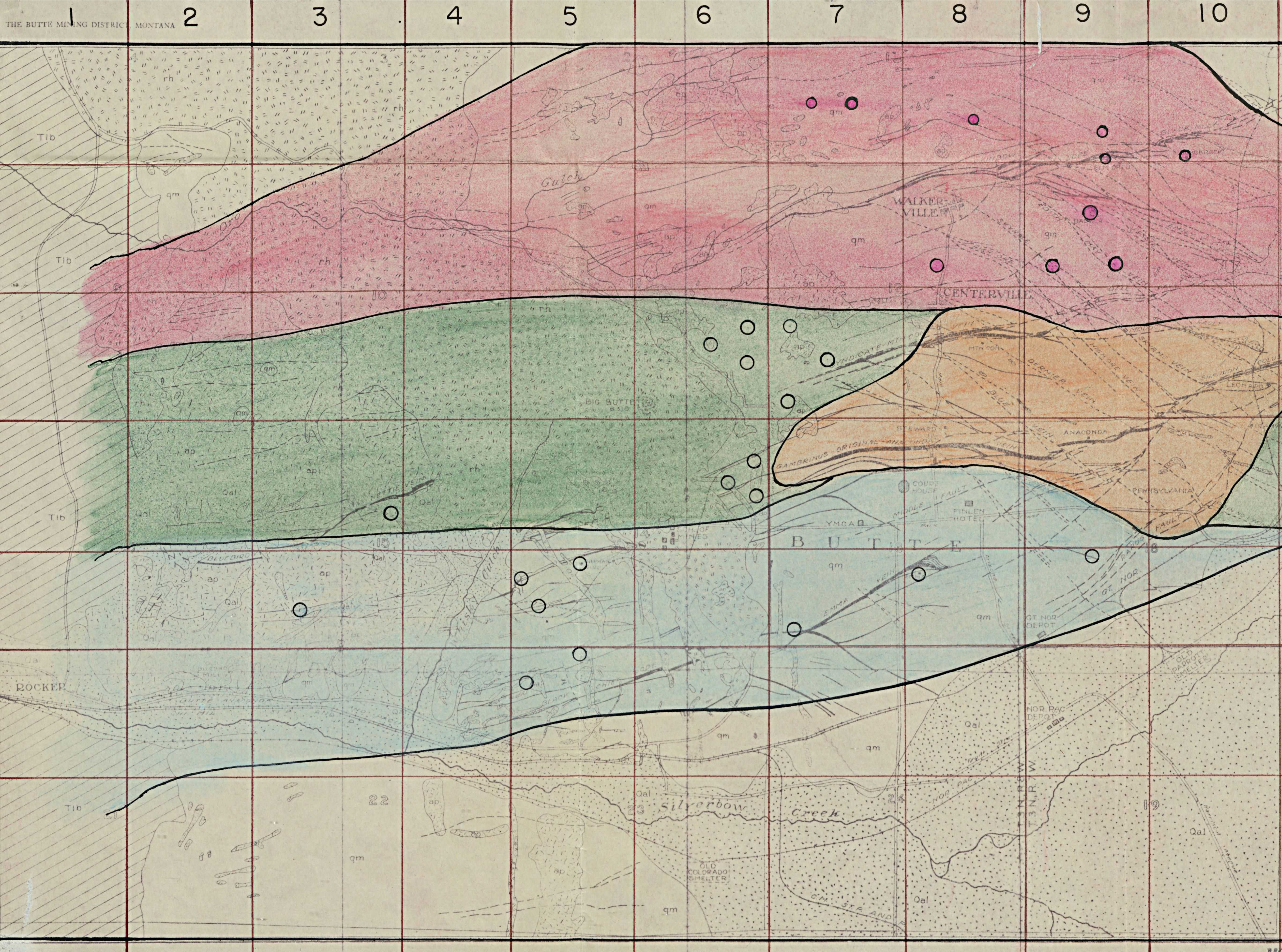
Results of Petrographic Analyses

Of Samples Collected in the Butte District

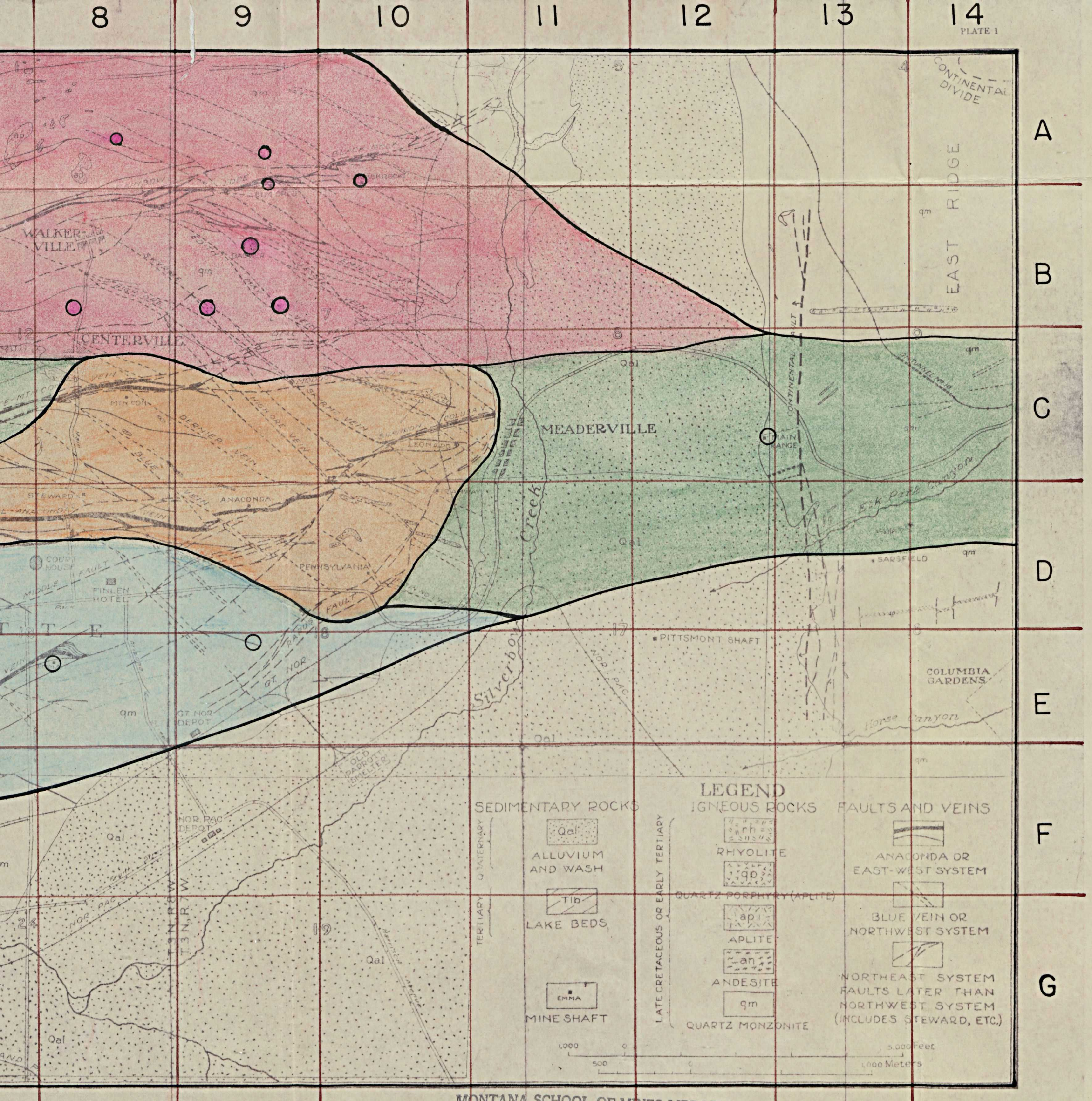
	No.	No. of Samp.	Mine Name	Coords. N.	Coords. E.	Rhodonite	Rhodochrosite	Quartz	Remarks
NORTHERN	1	8*	Alice	A	8	+++	----	+++	
	2	5*	Lexington	B	8	+++	----	++	
	3	3	Elm Orlu	B	9	+++	----	++	
	4	5	Black Rock	A	10	++	----	++	
	5	4	Badger	B	9	++	-----	++	
	6	3	Magna Charta	B	9	+++	----	++	
	7	4	Amy	A	7	+++	----	++	
	8	9*	Moulton	A	7	+++	----	++	
	9	6	Valdemere	A	9	+++	----	++	
	10	9	Corra	B	9	+++	----	++	
CENTRAL	11	7	????	D	6	+++	+++	++	Both minerals.
	12	6	????	D	6	++	+	+	"
	13	4	????	D	6	+	+++	+	"
	14	5	????	C	7	++	++	+	"
	15	4	????	C	7	+++	++	+	"
	16	6	????	C	7	++	+	+	"
	17	7	Main Range	C	12	++	++	+	"
	18	7*	????	C	6	++	++	+	"
	19	5*	????	C	6	++	++	+	"
	20	5*	Reservoir	C	6	++	++	+	"
SOUTHERN	21	17*	Emma	E	8	----	+++	+	
	22	11*	Orphan Girl	E	5	----	+++	+	
	23	9*	Travona	E	7	----	+++	+	
	24	5	Minnie Jane	E	5	----	+++	+	
	25	7	Hibernia	D	4	----	+++	+	
	26	6	????	E	9	----	+++	+	
	27	8	Nettie	E	3	----	+++	+	
	28	7	????	F	5	----	++	+	
	29	6	?????	F	5	----	+	+	
	30	8	?????	E	5	----	+++	+	

*Many more hand specimens examined.

THE BUTTE MINING DISTRICT, MONTANA



GEOLOGIC MAP OF THE BUTTE DISTRICT, MONTANA, SHOWING PRINCIPAL VEINS AND FAULTS



TANA, SHOWING PRINCIPAL VEINS AND FAULTS

Explanation

● Rhodonite Dump

○ Mixed Mineral Dump

○ Rhodochrosite Dump

🟧 Copper Zone

🟥 Rhodonite Zone

🟩 Intermediate Zone

🟦 Rhodochrosite Zone

THEORY ON GENESIS

The source at Butte of the primary manganese minerals, rhodonite and rhodochrosite, was undoubtedly some phase of batholithic intrusion. Magmatic emanations in the form of heated gases and waters containing metals in solution percolated upward through the fractured and brecciated rocks to form the vein systems, where the ore minerals were deposited. The zoning was the result of higher temperatures in the central zone, which decreased toward the peripheral areas.

As both rhodonite and rhodochrosite, may be seen intergrown together in specimens, the solutions which deposited each one must have been essentially contemporaneous. The difference in composition is best explained by the theory that in the north the waters were acidic and of only moderately low temperature, while to the south the waters were alkaline and definitely of lower temperature. The manganese solutions are definitely later than those which deposited the copper minerals, and as rhodochrosite occurs in druses on sphalerite and galena in the Emma mine, it is of course also later than these minerals. The manganese solutions appear to be very close to the last if not the last of the mineralizing waters.

The occurrence of both rhodonite and rhocochrosite together is only to be expected where the two solutions merged, and the contemporaniety of the solutions is unquestioned.

Later alteration and oxidation caused the formation of the oxide minerals toward the surface, and the rhodonite in the northern portion of the area altered to rhodochrosite in small amounts, due to action of carbonic waters.

(1) The occurrence of rhodochrosite in vugs and druses with beautifully formed crystals below the 2800 levels of the Anselmo and Steward mines, in the high temperature copper zone, is a phenomenon which is apparently contradictory to the commonly accepted zonal arrangement of ores at Butte. This has been explained by the theory that the source of these waters may not be the original batholiths.

(2) The occurrence of crystals of the manganese minerals in vugs and breccias indicates a very late period of deposition Some observers believe that a late surge of mineralizing water carrying manganese may have accompanied the rhyolitic extrusions, and that these waters may be responsible for this late manganese mineralization. It is the writer's belief that the extrusion of the rhyolite, which is post-mineralzation, caused fracturing and faulting, which formed voids in the copper veins. Hot mineral-bearing solutions from the rhyolite magma percolated through these voids and deposited the manganese from alkaline solutions of lower temperature.

MANGANESE AT THE EMMA MINE

Two trips underground were made at the Emma mine in addition to several trips to the large waste dump of the mine. Here the manganese veins were observed first-hand, and many samples taken. Photographs of hand specimens and microscopic grains accompany this report. No rhodonite is to be observed anywhere in the Emma mine, although in places the silica content in the form of quartz of the veins is very high.

The principal manganese-bearing veins are in the Emma system and are members of the Anaconda or east-west vein system. They always dip to thesouth, the angles ranging between wide limits but averaging about 60°. Intersecting these veins are northwest or "Blue" veins, which have a similar dip to the Anaconda system. The "northwesters" are harder and more silicious, and the manganese ore within them is of a lower grade. Two post-mineral faults are encountered, the Rarus and the Middle, and they displace all manganese veins. The rhodochrosite occurs throughout the vein, and no appreciable pinching out of the veins has yet been observed within the limits of this mine.

In depth, however, all good commercial veins are above the 1400 level, although pockets of good mineable manganese are found down to the 2100 level. The manganese grades into sphalerite, galena and silver ores with depth.

Sphalerite is almost always found associated with the rhodochrosite in veins. It occurs in parallel bands, usually on the hanging wall. In the mining of manganese, the sphalerite is regarded as waste, and great care is taken to avoid "contamination", because it is bothersome in flotation and nodulization.

All manganese veins on the 1400 level and below are flatlying "northwesters", and yield low grade manganese ore.

The manganese ore at the mine is divided into (1) low grade and (2) high grade, on the basis of treatment after mining. Manganese ore higher than 37% manganese is high grade, and is sent directly to the nodulizing kiln, whereas the low grade ore at present is stock-piled to be put through a flotation process for concentration of the manganese at some future time.

The projected development work at the Emma mine comprises approximately five miles of drifts, crosscuts, and raises. The Anaconda plant now under construction will be prepared to put through by flotation process 1000 tons of ore per day, and the mine's output is expected to meet this tonnage.

A favorable aspect of the situation here is that all development so far has turned out much better than anticipated. Three years fullfillment of the government orders requires 240,000 tons of manganese concentrates, and this means that approximately one million tons of crude ore must be mined to fill the order.

On the 1800 level a vein is being mined where neither the foot-wall nor the hanging-wall has yet been reached within a width of approximately 75 feet, and as the veins extend indefinitely longitudinally, the reserves of manganese ore at the Emma should be ample to meet any production for many years to come.

MANGANESE DEPOSITS AT PHILIPSBURG

The Philipsburg occurrence has been the chief manganese producer of the United States in recent years, and as such merits a brief description in the present report. The production is entirely from the oxide minerals, although rhodochrosite found at depth may be utilized at a later date.

The Philipsburg district is an irregular area comprising seven or eight square miles on the west slope of Flint Creek range, 45 miles northwest of Butte; the producing area, however, is a tract of two square miles just east of the town of Philipsburg.

Mining in this region began in 1864 with the discovery of very rich silver veins, and flourished until the decline of silver in 1892. Production was resumed on a small scale in 1916, when World War I caused a shortage of manganese in this country. In 1918 a high in production was reached with 127,415 tons of high-grade manganese oxide ore being shipped. After the war it was found unprofitable to compete with the foreign metallurgical manganese, but being peculiarly desirable for batteries, an annual production of between 5,000 and 28,000 tons was shipped for this prupose. The total production up to Oct. 31, 1939 was 477,040 long tons of high grade ore and concentrates, 116,363 long tons of 20% manganese tailings, and 2,376 long tons of 20% low grade manganese ore.

The geology of the district is rather simple in its broader aspects. The Philipsburg arch of Paleozoic limestones has been cut and deformed on the east and south sides by a small granodiorite batholith, the magmatic emanations of which were no doubt the source of the mineralization.

The manganese ore deposits occur in and adjacent to east and northwest trending vein fissures. They are largely irregular tabular replacement bodies in the limestone. The quantity of ore in the actual vein is small, and it is in the replaced country rock that the mineable deposits occur.

The ore minerals of the silver and zinc-lead deposits are sphalerite, galena, tennantite, enargite, pyrite, chalcopyrite, and the ruby silvers. Quartz is the chief gangue mineral, along with rhodochrosite, ancherite, barite, and calcite.

The manganese oxides are the result of the alteration of the primary rhodochrosite, and the minerals found in the order of their abundance are pyrolusite, psilomelane, braunite, manganite and wad. The gangue consists of quartz and silicified limestone. The primary rhodochrosite seems to be definitely the result of the action of hydrothermal magmatic solutions emanating from the granodiorite batholith. The depth of oxidation varies from 100 to 700 feet with the average between 500 and 600 feet.

The size of the individual ore bodies is almost always below 10,000 tons, and they range from 50 to 200 feet in length, from 30 to 150 feet in breadth, and from 10 to 60 feet in thickness. The grade ranges from 30 to 38 percent matallic manganese.

Ore reserves are of the order of 700,000 tons of oxide ore and unknown reserves of carbonate ore, due to lack of exploratory work.

It is evident that at present rate of production the oxide ores will be worked out, and unless the carbonate deposits prove to be better than present indications show, the district will be dormant before many more years.

SUMMARY AND CONCLUSIONS

As a result of studies made the following conclusions were made:

1. That on the north side of the Butte district there is a peripheral zone containing large amounts of rhodonite and little or no rhodochrosite.

2. That on the south side of the Butte district there is a peripheral zone containing large bodies of rhodochrosite and very little or no rhodonite.

3. Where these zones come together, both rhodochrosite and rhodonite are found in the same specimen in nearly equal amounts.

4. This north and south zoning was due to the fact that in the north the magmatic waters were moderately hot and acidic, while to the south the waters were definitely alkaline and of lower temperature.

5. That the mineral rhodonite does occur, and that any microscopic intergrowth of rhodochrosite and quartz in the northern area is indeed rare and the result of alteration of rhodonite to rhodochrosite along fractures due to supergene carbonic acid waters in a reducing environment.

6. That the reserves of the carbonate ore of manganese in Butte are immense, and though the rhodonite is not now commercial, there are large reserves of this ore.

BIBLIOGRAPHY

1. Agar, W. M., Minerals of the Intermediate zone, Butte, Montana. Econ. Geol. Vol. 21, pp. 695-707, 1926.

2. Bacorn, F. W., An admendment to Sale's theory of ore deposition: Am. Inst. Min. Eng. Trans., vol. 49, pp. 697-740, 1916.

3. Bard, D. C. and Gidel, M. H., Mineral associations at Butte, Montana: Am. Inst. Min. Eng. Trans., vol. 46, pp. 123-127, 1914.

4. Brown, R. G., The ore deposits of Butte City: Am. Ist. Min. Eng. Trans. vol. 24, pp. 543-558, 1915.

5. Ford, W. E., Dana's Manuel of Mineralogy, John Wiley & Sons.

6. Lindgren, Waldemar, Paragenesis of minerals in the Butte vein: Econ. Geology, vol. 22, pp. 304-307, 1927.

7. Miers, E. M., Mineralogy, John Wiley & Sons.

8. Pardee, J. T., Manganese at Butte, Montana, Bull. 690-E.

9. Ray, J. C., Paragenesis of the ore minerals in the Butte District, Montana: Econ. Geology, vol. 9, pp. 463-481, 1914.

10. Rogers and Kerr, Principles of Petrography, McGraw-Hill Book Company.

11. Sales, R. H., The localization of values in ore bodies and the occurrence of shoots in metalliferous deposits; ore shoots at Butte, Montana: Econ. Geology, vol. 3, pp. 326-331, 1908; Eng. and Min. Jour., vol. 86, pp. 226-227, 1908.

12. Sales, R. H., Superficial alteration of the Butte Veins;

Econ. Geology, vol. 5, pp. 15-21, 1910.

13. Sales, R. H., Ore deposits at Butte, Montana: Am. Inst. Min. Eng. Trans., vol. 46, pp. 3-109, 1914.

14. U. S. Bureau of Mines Yearbook, 1940.

15. U. S. Dept. of Interiou, Mineral Markets Report, Manganese Ore Industry in 1940, Advance Summary.

16. U. S. Geol. Survey Bulletin 922-G, Manganese Deposits at Philipsburg, Montana: U. S. Geol. Survey.

17. Weed, W. H., Geology and ore deposits of the Butte district, Montana: U. S. Geol. Survey Prof. Paper 74, 262 pp., 1912.

18. Winchell, W. R., Elements of Optical Mineralogy, Part II, McGraw, Hill & Company.

EXPLANATION OF PLATE LL

A. Shows an oil immersion in 1.544 oil of rhodonite from Franklin Furnace, N. J. Mesh size -80 100 . Note the typical triclinic cleavage and rounded edges of the grains. #30 objective Magnification 25 diameters.

B. Shows an oil immersions in 1.544 oil of rhodochrosite from the Emma Mine in Butte. Mesh size -80 100. Note perfect rhombohedral cleavage. #3 objective. Magnification 25 diameters.

C. Shows an oil immersion in 1.544 oil of rhodonite from the Alice Mine in Walkerville. Mesh size -80 100. Note the very dark color, due to some alteration and presence of other elements in the rhodonite crystal. To the eye these crystals have a definite reddish tinge. #3 objective. Magnification 25 diameters.

D. Shows an oil immersion in 1.544 oil of a mixture of rhodochrosite from the Emma and rhodonite from the Alice. Mesh size for both -80 100. It is readily seen that they are very easily distinguishable, and render petrographic analyses quite simple. #3 objective. Magnification 25 diameters.

PLATE II

A

B

C

D

EXPLANATION OF PLATE III

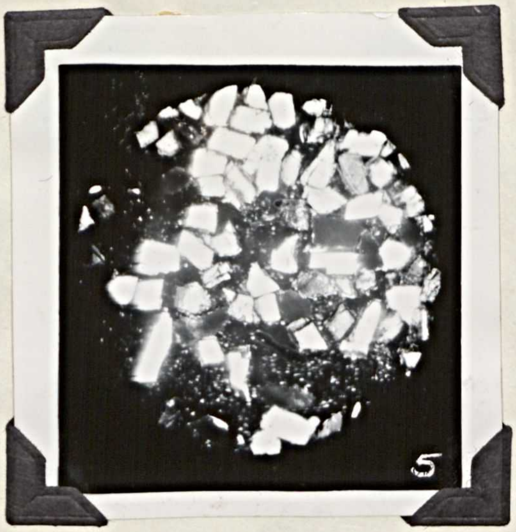
A. This is the same view as in figure D of plate II under crossed nicols. Notice the high order whites of the rhodochrosite and the low tints for the rhodonite, which photographs black. As determinations are easier without crossed nicols, the upper nicol was left out where examining the numerous samples.

B. Shows an oil immersion of mixed rhodonite from Franklin Furnace and rhodonite from the Alice. The two are strikingly different here, the Butte specimen being discolored by impurities. Mesh size 80 100. #3 objective. Magnification 25 diameters.

C. Shows an oil immersion in 1.544 oil of rhodochrosite from the Emma mine, with several grains of quartz. To the eye the quartz is much more easily distinquishable. Mesh size 80 100. #3 objective. Magnification 25 diameters.

D. Shows a thin section of rhodochrosite with rhodonite. The two occur in almost equal proportions and seem to be essentially contemporaneous.

PLATE III



A

B

C

D

EXPLANATION OF PLATE IV

A. Shows a thin section of rhodochrosite under crossed nicols. A perfect example of a euhedral rhombic crystal of rhodochrosite in a groundmass of quartz. #5 objective. Magnification 70 diameters.

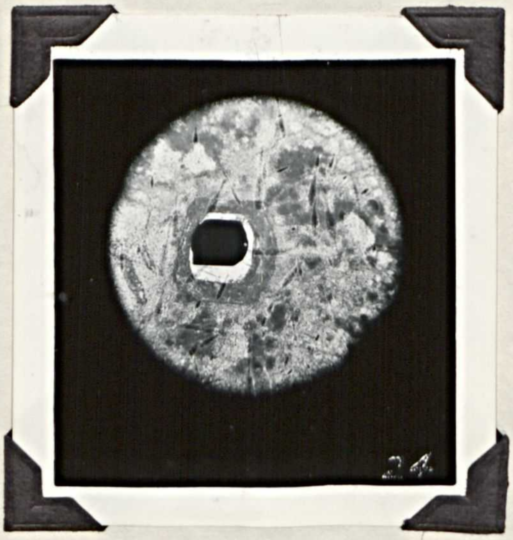
B. Shows a thin section of rhodonite with quartz filling the interstices between the euhedral triclinic crystals. The nicols were crossed. #50 objective. Magnification 70 diameters.

C. Here is shown a euhedral sulfide mineral with zones of quartz and rhodochrosite around it. #5 objective. Magnification 70 diameters.

PLATE IV

A

B



C

EXPLANATION OF PLATE V

A. Shows an oil immersion of rhodochrosite from the Emma mine in 1.544 oil. This sample was collected on the 500 level. Mesh size minus 80 100. Due to the high silicate content, rhodonite was expected, but did not occur. Most grains are quartz with a little rhodochrosite. #3 objective. Magnification 24 diameters.

B. Shows an oil immersion from the same level as above, and they are almost identical.

C. This immersion in 1.544 oil shows a sample from the 400 level and grains of rhodochrosite are easily seen, with the typical rhombic cleavage. Mesh size minus 80 100. #3 objective. Magnification 24 diameters.

D. Shows an immersion in 1.544 oil of a sample of rhodochrosite from the 300 level, and well-defined crystals of rhodochrosite are readily apparent.

PLATE V

A

B

C

D

EXPLANATION OF PLATE VI

A. Shows a hand specimen of rhodochrosite with excellently formed rhombic crystals; the slender acicular crystals are also rhodochrosite which crystallized differently. Magnification 1/6.

B. Shows a hand specimen of fragmentary wall-rock covered with a druse of cystals of rhodochrosite in which the rhombic cleavage is not apparent. Magnification 1/8.

C. Shows an unusually fine example of banding of rhodochrosite. This shows the way the mineral occurs in the veins, and is the result of changes in the character of the mineralizing solutions. The colors of the bands ranges from a definite pink to a dirty white. Magnification 1/5.

D. This hand specimen shows rhodochrosite and bull quartz intergrown, with sulphides disseminated throughout. Magnification 1/7.

PLATE VI

A

B

C

D

EXPLANATION OF PLATE VII

A. This hand specimen was collected on the 300 level of the Emma mine. The vein contained little quartz, and the specimen was almost pure rhodochrosite. Magnification 1/5.

B. This hand specimen was collected on the 500 level of the Emma mine and due to its high silica content was at first believed to be rhodonite, but microscopic examination proved it to be quartz plus rhodochrosite. The commercial value of these veins was much lower than those of the upper levels. Magnification 1/5.

C. These three specimens show rhodochrosite from the 400 level. With inclusions of sphalerite and pyrite present throughout the specimen, it can readily be seen that the sulphides were later than the rhodochrosite. Magnification 1/5.

D. This specimen shows blebs of quartz in rhodochrosite from the 400 level. X 1/5.

PLATE VII

A

B

C

D