1-1-1931

Age Relationships of Ore Deposits of Southwestern Montana (A Microscopic Study)

Charles R. Trueworthy

Trueworthy C.R.

AGE RELATIONSHIPS OF ORE DEPOSITS OF SOUTHWESTERN MONTANA

(A Microscopic Study)

by
CHARLES R. TRUEWORTHY

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

AGE RELATIONSHIPS OF ORE DEPOSITS
OF SOUTHWESTERN MONTANA
(A Microscopic Study)

by
CHARLES R. TRUEWORTHY

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

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

AGE RELATIONSHIPS OF ORE DEPOSITS OF SOUTHWESTERN MONTANA

(A Microscopic Study)

by

CHARLES R. TRUEWORTHY

INTRODUCTION

Although considerable work has been undertaken by some prominent geologists, the best known of which is that of Paul Billingsley and J. A. Grimes[1], in investigating the ore deposits of the Boulder Batholith and surrounding area, there has not been any complete microscopic investigation of these deposits, as a whole, published in the literature. With this in mind it was suggested to the writer by Professor Paul A. Schafer, of the Montana School of Mines, that a microscopic study of the ores of this region would be a worthwhile geologic problem. On the basis of this suggestion it was chosen as a Thesis, in partial fulfillment of the requirements for the degree of Bachelor of Science in Geological Engineering.

It was thought that the mineral association, and the mode of mineral occurrence might afford methods of classifying these deposits so that they could be correlated with the age relationships worked out by Billingsley and Grimes.

The time alloted for this work in the curriculum was one afternoon each week of the first semester and two afternoons each week during the second semester of the 1934-35 school year. It must be realized that in such a limited time it would be impossible to make a complete micro-study of all the ore deposits of this area; however, the specimens studied and reported on in this thesis are fairly representative of the deposits which were investigated and those deposits, in turn, were representive of all the deposits in the general area.

This report suggests certain practical possibilities which arise from the use of the microscope. It also points out several definite facts concerning the microscopic occurrence of the minerals and their relationships in several of the districts.

LOCATION OF AREA

All of the deposits from which mineral specimens were investigated, except one, lie within one-hundred miles of Butte, Montana and in or near the Boulder Batholith--a large body of quartz-monzonite which extends from near Anaconda to within a few miles of Helena, a distance of about one-hundred miles. The Neihart district is the only region very far from the Boulder Batholith, from which specimens were studied. Included in this report is microscopic data from the following districts near Helena: Rimini, Wickes, Boulder, Basin, Elkhorn, Emery; and the following districts near Butte: Lowland Creek and Silver Star. Specimens from the Neihart district, south of Great Falls, were also studied.

PREVIOUS WORK

Geological work on these deposits has been done by Billingsley and Grimes[1], Adolph Knoph[2], Pardee and Schrader[3],

METHODS OF WORK

Work on this problem has been carried on in the laboratory of the Geological Department of the Montana School of Mines under the supervision of Dr. E. S. Perry and Professor Paul A. Schafer.

COLLECTION OF SPECIMENS

Mineral specimens were obtained from the collection at the Montana School of Mines. By no means did this collection represent a complete mineral suite from every district discussed in this report. I was unsuccessful in obtaining specimens from all the mines of this area and there were some entire districts from which specimens were not available. It would have been impossible, in the time spent on this work, to polish and investigate a complete collection from each mine in the Boulder Batholith. This report represents work on about one-hundred specimens which were immediately available.

GRINDING AND POLISHING

Grinding and polishing of the specimens was performed with the apparatus available in the Geological Department. Coarse grinding was done on a twelve-inch, glass topped, horizontal wheel with carborundum as an abrassive. Stationary glass plates with four-hundred mesh, six-hundred mesh, and levigated alumina as successive abrassives were used for fine grinding.

A polish was obtained on a cloth-covered brass wheel on which suspensions in water and in soap solutions of levigated alumina, rouge, zinc oxide, and tin oxide were used at different times. A thick paste of tin oxide and water on a flannel cloth gave the best results in polishing.

MINERAL DETERMINATIONS

Microscopic determinations of minerals were made by methods used by Short[4]. No satisfactory test was found for distinguishing tennantite from tetrahedrite. It was attempted to distinguish between these minerals by staining with chromic acid, as was suggested by members of the Ore Dressing Department of the Montana School of Mines, but this was not entirely successful.

DETERMINATION OF SEQUENCE

Considerable of the criteria which has previously been used for determining sequence of mineralization by many geologists have not been used in this report, mostly because of the facts concerning replacement of minerals, brought out by C. Schouten[5] in his article "Structures and Textures of Synthetic Replacements". It is shown in this reference that much of the criteria which has been used as "standard" evidence of sequence of mineralization may be entirely incorrect. It was, therefore, thought advisable not to use some of the "standard" methods.

ACKNOWLEDGMENTS

I have greatly appreciated the help given by Dr. E. S. Perry and Professor Paul A. Schafer in collecting the material on which this report is based. Discussions with fellow students Clarence A. Wendell and Edwin Johnson, concerning the determination of minerals and sequences have been of great value.

AGE RELATIONSHIPS

The following quotation from Billingsley and Grimes explains the basis of their paper. "It appears that the majority of ore deposits (Boulder Batholith) are genetically related to one another of the igneous periods of the region; that when grouped according to this relationship they display resemblances and contrasts that can be traced with certainty to the conditions of their origin and that common laws governing the deviation of their varying character can be reasonably deduced." In knowing that the different deposits, according to age, have certain definite characteristics it is thought that there perhaps exists some relationship between sequence of mineralization and the age of the deposit, which could be brought to light by a microscopic study.

The authors of this pervious quotation recognized the following igneous periods and their phases.

I Andesite Period

II Granitic Period

A. Diorite phase
B. Quartz-monzonite phase
C. Aplite phase
D. Quartz porphyry phase
E. Quartz veins

III Rhyolite Period

A. Early phase
B. Late phase (Dacite)

They also worked out the following classification of the ore deposits according to their age relationships:

I. Andesite Period

All types of deposits (contact replacement, segregations and disseminations, fissure veins) are found in the following districts: Emery, Elliston, S. Baldy, Elkhorn, Radersburg.

II. Granite Period

1. Segregations and Disseminations

Helena, Sheridan, Elkhorn, Whitehall, Heddleston, Red Rock Creek.

2. Contact replacement deposits

French Gulch, Highland, Argenta, Bannock, Blue Wing, Philipsburg.

3. Fissure vein deposits

Twenty seven districts including Pony, Garnet, Marysville, Norris, Mammoth, Argenta.

B. Aplite Phase

1. Segregations and Disseminations

Red Lion, Basin, Rimini.

2. Contact replacement deposits

Bryant, Elkhorn, Philipsburg

3. Fissure type deposits

Helena, Basin, Comet, Wickes, Butte.

C. Quartz-Porphyry phase.

1&2. Segregations and disseminations and contact types are lacking.

3. Fissure veins

Several ages of fissuring connected with mineralization of this phase at Butte and possibly Philipsburg.

III. Rhyolite Period

A. Early Rhyolite phase

1. Disseminations, contact, and fissure impregnations found only near Rimini

B. Late (Dacite) phase

1. Contact and fissure

Clancy, Warm Springs, Lowland Creek.

MICROSCOPIC DATA

CRITERIA FOR DETERMINATION OF SEQUENCE

It was necessary to be careful in choosing evidence which would be accepted as proof of sequence of mineralization. "Common sense" interpretation of the evidence has been attempted according to the physical appearance of the minerals, in place of "set" rules for determining mineral relationships. Where some evidence seemed doubtful, other, more definite proof was always sought.

Smooth boundaries were not considered as evidence which would prove that two minerals were of contemporaneous deposition. If the borders were round and smooth, other evidence on which relationships could be based were sought in the same specimen or from specimens from the same mine.

If the borders between two minerals were straight and smooth a cleavage control of replacement of one mineral upon the other was looked for. In case it was found that the cleavage of one mineral controlled the direction of the border between the minerals that one whose cleavage was the controlling factor was always considered to be of the earlier age. Such a phenomenon was very marked in some specimens, from the Neihart district especially, in which galena cleavage controlled the direction of the contact between this mineral and both sphalerite and chalcopyrite, as is shown in Fig. 1 and Fig. 2, Plate I.

Jagged boundaries and corrosion effect was thought to be acceptable in some instances. It was noticed that in some specimens, pyrite which was deposited early, was often corroded by later minerals, while some grains in the same specimen would have straight uncorroded boundaries and contained remnants of some other mineral. In the latter case the pyrite was considered to be of a later age, than the surrounding minerals. Remnants of one mineral in another was not considered as good evidence unless they were contained in straight bordered pyrite. Figure 3, Plate II shows late pyrite with specks of chalcocite within the crystal.

The well known graphic structures were considered in some instances as indicative of difference of age of two minerals. I believe that in some cases graphic structures may be interpreted either way--that the "host" mineral is earlier than the "guest", or visa versa, unless the "guest" mineral shows a graphic structure along what is definitely known to be the cleavage of the other mineral. If this is well shown the "guest" can be called the later mineral.

Only when the concentric outer border mineral entirely, or almost entirely, surrounded another mineral, and the contact of the border was marked definitely, was concentric banding used in determining age relationships. Fig. 3, PlateI shows galena bordering a field of sphalerite almost entirely. In this case galena was considered to be younger than the zinc mineral.

Crosscutting structure was in most cases used in determining which of two minerals was later; however, unless a mineral cut the grain from border to border or cut irregularly through the grain the evidence was not thought to be conclusive enough to prove that the veining mineral was the later. Figure 4, Plate I illustrates one case where galena was believed to be later than sphalerite and probably of a different generation, owing to the fact that sphalerite seems to have been brecciated.

PLATE I

Fig. 1

Fig.2

Fig. 3

Fig. 4

Figure 1 - Neihart, Minute Man. Showing gal. cleavage controlling boundaries with sphalerite. (X276)

Figure 2 - Neihart, Minute Man. Showing gal. cleavage control of replacement by Cp. (X276)

Figure 3 - Basin, Gray Eagle. Displaying ring of gal. around sphal. Gal. considered to be later. (X276)

Figure 4 - Neihart, Hegener. Sph. appears to have been brecciated and then followed by another generation of mineralization during which gal. was deposited. (X276)

SEQUENCE OF MINERALIZATION AND CHARACTERISTIC OCCURRENCE OF MINERALS

It may be observed in the following data, that minerals which are reported by other writers, as occurring in some districts, are not listed in the sequence of mineralization. This is no indication that these minerals are not present in the ores of the district in which they have been previously reported, but only that they were not found in the specimens studied.

WICKES DISTRICT

The Wickes district surrounds the town bearing the same name, which is situated about twenty miles south of Helena. Included in this area are the towns of Corbin, Jefferson, Gregory and Comet.

Atlas Mine.

Minerals occur in the following order, as was determined from the specimens studied: quartz, pyrite, tennantite, chalcocite, sphalerite, galena, chalcopyrite and late pyrite. Chalcopyrite occurs as veinlets cutting several other minerals and in the characteristic exsolution form which was common throughout many of the districts studied. Late pyrite, which is distinguished from early pyrite by its straight uncorroded

PLATE II

Fig. 1

Fig. 2

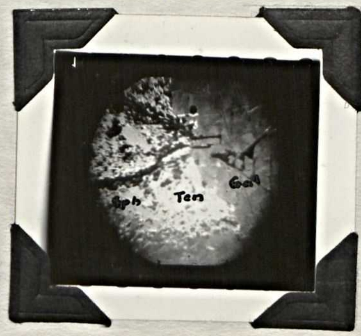

Fig. 3

Fig. 4

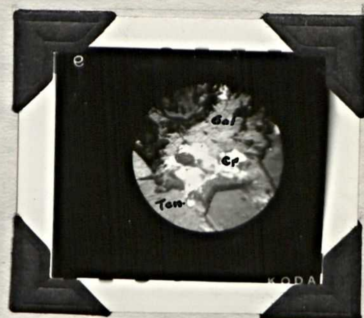

Figure 1 - Basin, Comet. Showing chalcopyrite in graphic structure in Sph. (X276)

Figure 2 - Basin, Comet. Tenn. cuts Sph. and is replacing gal. (X230)

Figure 3 - Basin, Atlas. Displays late py. with remnants of cc stained with chromic acid. (X276)

Figure 4 - Wickes, Atlas. Tenn. Gal and Cp. relationship $FeCl_3$ stain. (X276)

boundaries and by remnants of chalcocite within the crystals, was noticeable in many specimens. Although there was not enough evidence to include it in the sequence, there were several indications that there may have been a second generation of sphalerite in this deposit. Figs. 3, 4, Plate II and Figs. 1, 2, Plate III show some of the mineral relationships and manner of occurrence.

Mt. Washington Mine.

The sequence of mineralization at this mine was quartz, tennantite and chalcopyrite which is followed by a carbonate gangue. Supergene chalcocite was noticeable in the specimens observed.

Blue Bird Mine.

A very limited number of specimens were available from this property, but those studied showed that pyrite, the earliest mineral present, was followed by the deposition of tennantite which was being replaced by primary, unaltered chalcocite.

BASIN AND BOULDER DISTRICTS

The town of Basin is about forty miles from Butte on the Great Northern Railway toward Helena. Boulder is about ten miles northeast of Basin. The Gray Eagle and Comet are the most prominent mines of the area; the Comet is usually considered to be in the Wickes district but is thought to be a faulted portion of the same vein on which the Gray Eagle is located. For the sake of contrast, it is placed in the Basin district for this report.

GRAY EAGLE MINE

The minerals of this deposit were found in the following sequence: quartz, pyrite, sphalerite, galena, chalcopyrite, pyrite and a late carbonate grangue which was probably rhodochrosite. There is some doubt as to whether or not there was pyrite deposited later than the other sulfide minerals but the indications were fairly distinct that this was the case. There was no doubt that rhodochrosite was the latest mineral deposited.

Of all the specimens studied only in those from this mine was galena found to be bordering sphalerite as is shown in Fig. 3, Plate I. Exsolution chalcopyrite in sphalerite was one of the common features of this group of specimens.

Figs. 3 and 4, Plate III display characteristic features of the mineral relationships of this deposit.

COMET MINE

Although the Comet deposit is supposed to be of the same origin and part of the same vein in which the Gray

Eagle is located, the presence of arsenopyrite in the Comet specimens showed a considerable contrast with those of the Gray Eagle. It is highly possible that the depth at which the specimens were collected was the reason for the presence of arsenopyrite in one deposit and not in the other.

The order of mineralization was pyrite, arsenopyrite, sphalerite, galena, tennantite, arsenopyrite and late quartz.

Tennantite is associated with galena and the relationship between these two minerals is not any too definite.

Other Mines

In a specimen from an unknown mine of this district tennantite was found to be later than the galena and sphalerite, but earlier than the chalcopyrite.

A specimen from the crystal mine showed the same general sequence as the Comet and Gray Eagle. The galena had been oxidized along its cleavage to some other lead mineral, probably pyromorphite or cerrusite. The other minerals did not appear to be oxidized when observed under the microscope.

A specimen from the Jackman mine in the Boulder district showed the occurrence of pyrrhotite, which was later than quartz and earlier than chalcopyrite. This was the

PLATE III

Fig. 1

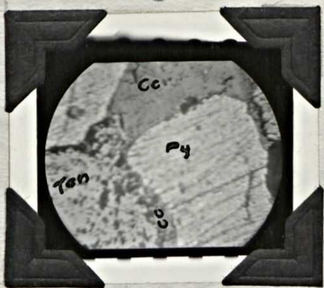

Fig. 2

Fig. 3

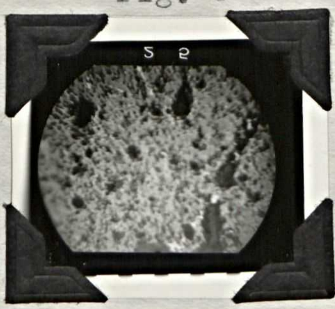

Fig. 4

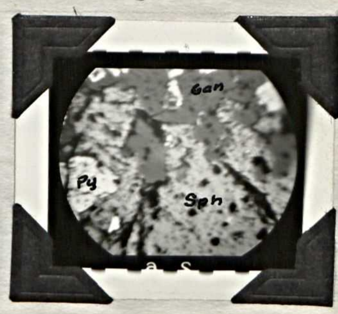

Figure 1 - Wickes, Atlas. Shows Cc. filling around Py. and the contact with tenn (Chromic acid stain) (X276)

Figure 2.- Wickes, Atlas. Showing a typical Tenn-gal. relationship. (X276)

Figure 3 - Basin, Gray Eagle. Displaying exsolution Cp. in Sph. (X276)

Figure 4 - Basin, Gray Eagle. A late gangue mineral, quartz or calcite cutting Sph. and Py. (X192)

only available piece of ore from this district and was only worth noting because of the occurrence of pyrrhotite.

EMERY (ZOSELL) DISTRICT

Emery is situated about eight miles southeast of Deer Lodge and includes an area of about four square miles on the slope of the Continental Divide.

Blue Eyed Maggie Mine

Specimens from the Blue Eyed Maggie in this district were observed and studied. These specimens showed that quartz and pyrite were deposited in a first generation and were followed by chalcocite. Chalcopyrite appeared to have been deposited both before and after enargite but later than the chalcocite. Pyrrhotite followed the deposition of enargite, and probably ended this generation. A mineral which was thought to have been jamesonite appeared in prismatic like shapes throughout pyrrhotite, enargite and quartz. A late carbonate gangue mineral was deposited later than jamesonite thus finishing the following sequence: quartz, pyrite, chalcocite, chalcopyrite, enargite, chalcopyrite, pyrrhotite, quartz, jamesonite and carbonate gangue.

Fig. 3, Plate V displays the jamesonite in a mass of quartz. Fig. 4, Plate V showed jamesonite later than enargite but being cut and broken by a carbonate gangue mineral. The carbonate is probably filling after brecciation as a small speck of the jamesonite remains within the carbonate veinlet.

It is worth while to note at this time a megascopic observation of a mineral specimen from the Emery district, which, by chance, was made after the work for this report was finished. In a galena specimen from this district a late carbonate gangue mineral veined the galena and in it was found an almost perfect crystal of pyrite. Pyrite in the galena was altered and corroded, while that in the carbonate was absolutely unaltered. This, I believe, supports the assumption, previously made, that straight boundaried, uncorroded pyrite grains may be considered as occurring late in the sequence of mineralization.

NEIHART DISTRICT

The Neihart district lies about fifty-five miles southwest of Great Falls in the Little Belt mountains. The study of this district has formed a worthwhile basis for a comparison of the sequences of mineralization of the Boulder Batholith deposits and a deposit outside of the batholith.

This district presents the only remarkable contrast of sequence found during this study. It was noticed in

PLATE IV

Fig. 1

Fig. 2

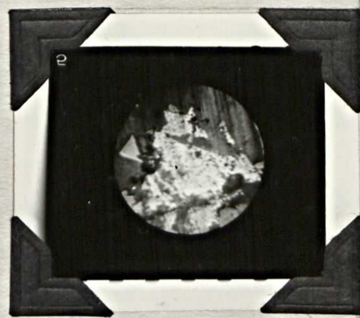

Fig. 3

Fig. 4

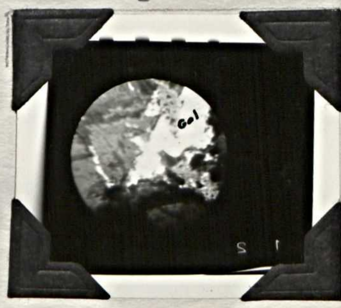

Figure 1 - Neihart, Ripple. Calcite-gal. and sphalerite-gal. borders controlled by gal. cleavage. (X276)

Figure 2 - Neihart, Hegener. Galena appears in small particles throughout the Tenn. (X276)

Figure 3 - Neihart, Ripple. Displaying a late gangue through Cp. and Gal. (X192)

Figure 4 - Neihart, Ripple. A galena, Cp., Py., Qtz. relationship. Galena oxidized along cleavage is not very distinct. (X276)

the specimens from the other districts that sphalerite was earlier than galena except in a few cases where the reverse may have been true; however, in the neihart district it was found that the sphalerite was later than the galena and that the zinc mineral nearly always replaced the galena along the cleavage. It was also noticed that the chalcopyrite-galena borders often had their direction along the galena cleavage showing that this mineral was also deposited later than the galena. It appears as if sphalerite and chalcopyrite are both replacing the lead mineral.

Hegener Mine

In this mine as in most of the mines of this district sphalerite was later than the galena and followed along its cleavages. In one specimen galena appeared to be later than sphalerite as is shown in Fig. 4, Plate I, which indicates a second generation of sphalerite.

Galena is disseminated throughout tennantite and it is considered that galena is the earlier mineral of these two. This is illustrated in Fig. 2, Plate IV, in which the galena has been stained with FeCl to appear darker than the tennantite. Chalcopyrite veins galena and tennantite and also appears in the exsolution form. Argentite was also present in the ores of this district.

The general sequence is as follows: quartz, pyrite, sphalerite, galena, tennantite, sphalerite, enargite, argentite, chalcopyrite and carbonate gangue.

Fig. 2, Plate IV and Fig. 2, Plate V show some of these relationships.

Ripple Mine

The sequence of mineralization at the Ripple showed the following minerals: Py, galena, sphalerite, tennantite, chalcopyrite and gangue. There did not seem to be any sphalerite of the first generation. Chalcopyrite and sphalerite both followed the galena cleavage in replacing this mineral. Galena was being oxidized in these specimens to cerrusite or pyromorphite.

Figures 1,3,4, Plate IV; Fig. 1, Plate V display some of the characteristic relationships of some of the minerals in the ores of this mine.

OTHER MINES

The Minute, Man, Big Seven and Silver Hill ores showed the same characteristics as the specimens from the Hegener and Ripple mines.

PLATE V

Fig. 1

Fig. 2

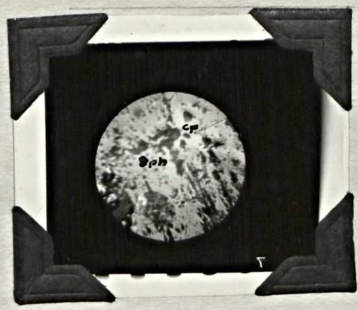

Fig. 3

Fig. 4

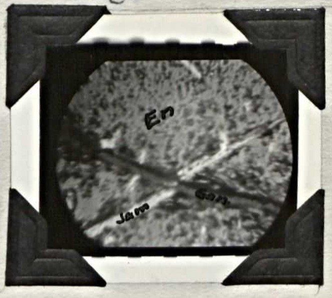

Figure 1 - Neihart, Ripple. Galena is earlier than two different gangue minerals and has been altered along the edge of the contact with one of them. (X552)

Figure 2 - Neihart, Hegener. Cp. veining sphalerite in a mass of tenn. (X276)

Figure 3 - Emery, Blue Eyed Maggie. Illustrating the appearance of Jamesonite in quartz. (X192)

Figure 4 - Emery, Blue Eyed Maggie. Jamesonite and enargite being cut by a late carbonate gangue mineral. (X230)

LOWLAND CREEK DISTRICT

This district contains some of the deposits of the late rhyolite phase. Only low grade specimens were obtained from the Ruby mine and from these not much information could be obtained. They showed a late quartz filling carrying pyrite to be later than a gangue mineral which had been brecciated. The pyrite probably carries the gold in these deposits but none of it was discovered, so it cannot be said that this is true.

OTHER DISTRICTS

A few specimens from other districts--Rimini, Melrose, Elkhorn, Elliston--were studied but no conclusions could be drawn concerning the mineral sequence because of the lack of sufficient minerals in them.

CONCLUSIONS

It may be noticed that the sequence of mineralization in the deposits in and near the Boulder Batholith are generally similiar and that these contrast with the sequence at Neihart, the only district studied which lies any great distance from the Batholith. This fact may have some significance but there have not been enough specimens studied to warrant any such broad conclusions as would be necessary if they were based on the comparison of the entire areas.

There does not seem to be any noticeable contrasts between the microscopic properties of the ores in which a correlation of the districts or mines could be made and compared with the age relationships of Billingsley and Grimes.

BIBLIOGRAPHY

1. Paul Billingsley and J. A. Grimes, Ore Deposits of the Boulder Batholith of Montana: Trans. A.I.M.E., Vol. 58, 1917-1918.

2. Adolph Knoph, Ore Deposits of the Helena Mining Region, Montana: U.S.G.S., Bul. 527.

3. Pardee and Schrader, Greater Helena Mining Dist., U.S.G.S., Bull.

4. Short, M. N., Microscopic Determination of Ore Minerals: U.S.G.S., Bul. 825 (1931)

5. C. Schouten, Structures and Textures of Synthetic Replacements: Econ. Geol., Vol. 29, No. 7, Nov. 1934.

6. Fairbanks, E. E., The Laboratory Investigation of Ores, New York, McGrow-Hill, 1928

7. Lindgren, Waldemar, The Nature of Replacements, Econ. Geol., Vol. 7, p.p.521-535, 1912

8. Hill, J. M., The Mining Districts of Western United States, U.S.G.S., Bul. 507 (1912)