THE MINERALOGY OF THE BONANZA SILVER DEPOSIT

GREAT BEAR LAKE

N.W.T.

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by

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ABSTRACT

A study of the mineralogy of a suite of specimens, collected by Dr.C.Riley from the Bonanza silver deposit, has been made. Particular attention is paid to the silver mineralization and the origin of the dendritic structure. A brief examination of the wall rock alteration is included.

The mineralogy of the deposit is relatively simple, consisting of the following metallic minerals in their order of abundance: native silver, magnetite, hematite, tetrahedrite, argentite, chalcopyrite, and an unknown mineral. Pitchblende and cobalt-nickel minerals are absent. Magnetite and hematite are restricted to the wall rock and are not associated with the other metallic minerals. The magnetite is believed to be of pyrometasomatic origin and related to a granodiorite intrusion, while the other metallic and gangue minerals, ~~with the exception of sericite~~, are considered to be of hydrothermal origin. The gangue minerals consist of quartz, sericite, and carbonate.

Ninety-five percent of the native silver occurs as dendrites and the other five percent as replacement of tetrahedrite and chalcopyrite. Core replacmment by the silver is well developed. The dendritic structure of the silver is inherited from quartz through replacement. In a quartz gangue this structure appears to be controlled by rows of specially oriented, doubly terminated, quartz prisms, while in a sericitic gangue the euhedral quartz grains, arranged in a rude dendritic pattern, are the controlling factor.

The mineral deposits of the Echo Bay area are compared with similar deposits throughout the world.

INTRODUCTION by DR. C. RILEY

Introduction.

The ores described herewith were collected in June, 1932, by C. Riley from the Bonanza silver prospect. The only work done at that time consisted of one shallow pit on the vein and some stripping. It was therefore not possible to take a complete suite of ores from the deposit. The specimens, however, are probably representative of the main types of vein material. They were taken for the purpose of study and description but opportunity to do such work was not available until Mr. J.K. Diebel undertook the work during the winter of 1947-48.

Location.

The Bonanza vein is situated on Dowdell Point, about six miles south of the Eldorado Radium Mine on the eastern shores of Great Bear Lake. The deposit should not be confused with the El Bonanza prospect which is about one half mile to the east (see Figure I).

History.

The Bonanza vein was discovered in June, 1931, by G.A. La Bine and E.C. St.Paul, prospectors working for Eldorado Mines Ltd. A small amount of surface work was done in 1931, and in 1938 some underground work was done but no record of it has been published. The property has, therefore, been inactive most of the time since its discovery.

Accessibility.

The vein is less than one half mile on easy grade, from a small bay on Great Bear Lake. Otherwise it would be serviced in the same manner as the Eldorado Mine - that is, by river and lake boats, and by air.

Climate.

The climate of the country is severebut not unpleasant. Winters are cold and dry; the snowfall is from three to four feet. Late winter and spring have long, clear and pleasant days. Summer is short and fall commonly dreary. The lake is open for navigation from July to October.

Topography.

The Great Bear Lake district has unusually rugged topography for a pre-Cambrian area. Rocky hills rise about 1200 feet above the lake level. The Bonanza vein is very little higher than the lake but the area immediately to the north is rough and precipitous.

General Mining Conditions.

Exploitation of the Bonanza vein would offer no problems other than those to be expected from the remote location and severe and protracted winter. Timber, however, is sparse and stunted and already made scarcer by the long use of it by the Eldorado Mine. Replacement by growth is slow.

GENERAL GEOLOGY

The general geology of the Echo Bay area has been described by D.F. Kidd (1932), H.S. Robinson (1933), G.M. Furnival (1939), R. Murphy (1946) and others. The following description is a summary of their work.

The general geology is shown in Figure I. The oldest rocks are a complex series of volcanic and sedimentary rocks, and probably intrusive porphyries, known as the "Old Complex". On lithological grounds, these early rocks are divided into two groups; the lower member being called the Echo Bay group and the upper member, the Cameron Bay group.

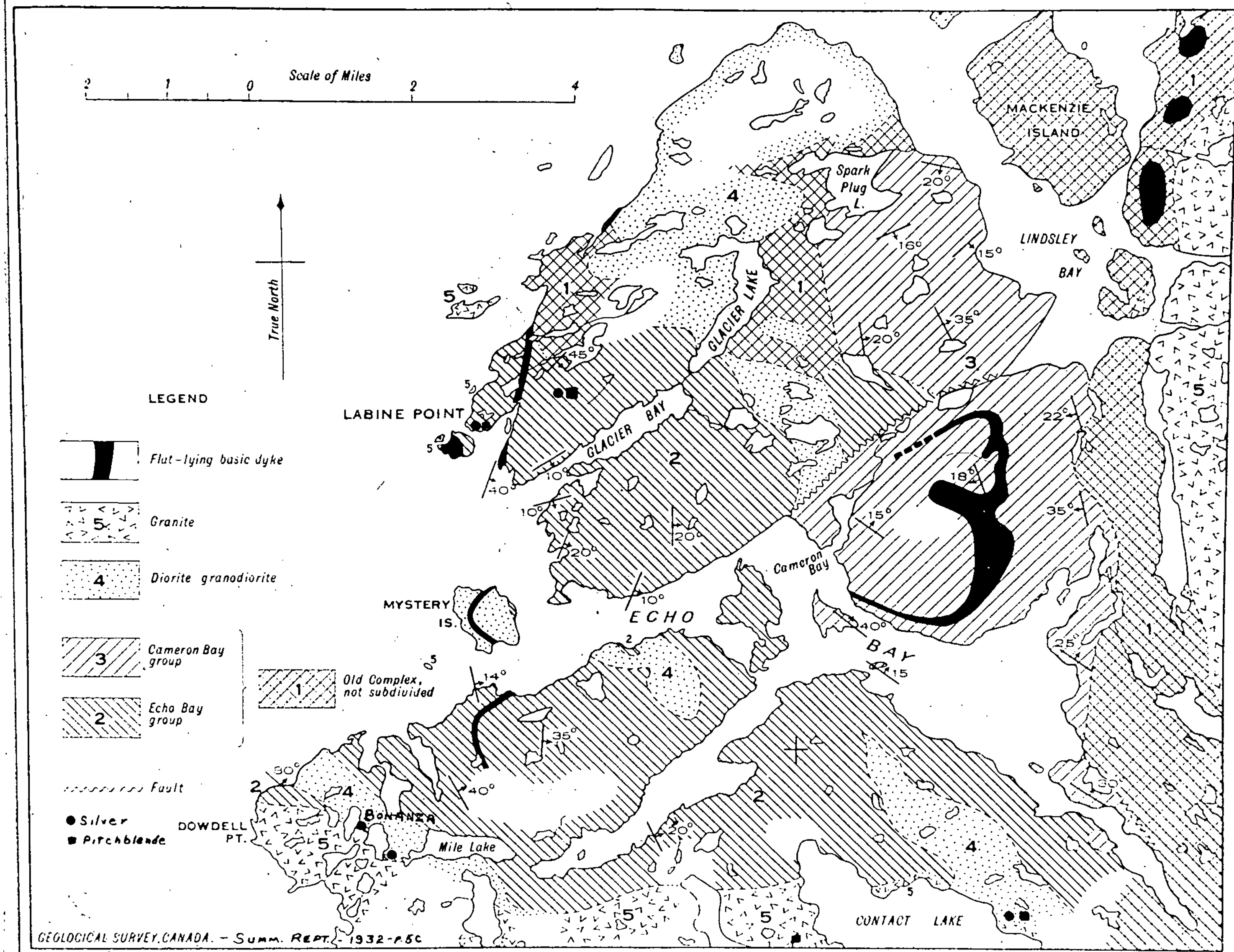


Figure 1. Echo Bay district, Great Bear Lake.

FIGURE 1.

TABLE OF FORMATIONS

Quaternary	Silt, clay, gravel, morainal material
	Unconformity
Precambrian(?)	Basic dykes and sills; large quartz veins
	(Intrusive Contact)
Precambrian(?)	Granite and other acid plutonic rocks
	(Intrusive Contact)
Precambrian	Quartz diorite and granodiorite
	(Intrusive Contact ?)
Precambrian	Sedimentary and volcanic complex subdivided into: (a) Cameron Bay group - conglomerate, tuff, argillite, etc. ----------unconformity---------- (b) Echo Bay group - porphyritic volcanics, tuff, argillite, quartzite, conglomerate, etc.

Echo Bay Group:

In ~~their~~ its upper part, the Echo Bay group consists mainly of porphyries, at some places extrusives, with minor amounts of argillite and tuff. In the lower part of the group siliceous argillite, tuff, quartzite, conglomerate and a little limestone are abundant. The base of the group has not been seen. The rocks have moderate to steep dips and structurally appear to underlie the Cameron Bay group, though the contact has not been observed. The presence in the Cameron Bay conglomerate of abundant pebbles of rocks similar to those in the Echo Bay group, suggests there is an unconformity between the two.

Cameron Bay Group:

The Cameron Bay group shows a uniform deposition of sediments; first a poorly consolidated cobble conglomerate with some interbedded greywacke, followed by coarse grit, arkose and sandstone. One felsite flow is interbedded with the conglomerate. The total thickness is in the vicinity of 3000 feet. Vein quartz pebbles and a single granite pebble indicate that there may have been a period of granitic intrusion prior to the formation of the group.

Intrusives - General:

The Echo Bay and Cameron Bay groups have been intruded by acid and basic rocks. In chronological order from oldest to youngest they are:

1. Granodiorite to diorite

2. Dowdell Point granite and Lindsay Bay granite
3. Diabase Dykes (older)
4. Diabase Dykes and Sills (younger)

Granodiorite:

The granodiorite occurs as irregular elongated stocks intruding the Echo Bay and Cameron Bay groups. A typical specimen of granodiorite is massive, medium-grained, granitic textured and reddish to greenish-brown in colour. In thin section plagioclase (oligoclase to andesine), orthoclase, quartz, augite, biotite and iron oxides are usually present. These rocks have caused an unusually great amount of metamorphism round their borders. At many places, for a width of one-quarter of a mile or more, the intruded rocks are rusty weathering, due to disseminated pyrite, and contain chlorite, magnetite, biotite, epidote, actinolite and red feldspar. The granodiorite is older, at least, than the Dowdell Point granite, because it is cut by the granite.

Granites:

The Dowdell Point granite and the Lindsay Bay granite do not occur in contact with each other; thus their relative age is not known. The Dowdell Point granite is an entirely massive, fresh-looking, coarse-grained, usually somewhat porphyritic, buff to pink, crumbly weathering biotite granite. The Lindsay Bay granite is massive, medium-grained, rather uniform in appearance, with light brown to buff to white to pink feldspars, quartz, biotite and, in some places, hornblende. It is occasionally slightly porphyritic near the borders. Aplite dykes are minor differentiates of both granites. Pegmatites are rare.

Basic Dykes and Sills:

Basic dykes are widespread and cut rocks of all the four groups previously described. A few dykes differ lithologically from the more abundant type in having some red feldspar and are provisionally separated as an older type.

These older dykes have been termed "gabbro" by Robinson (1933, p.618). They are the youngest intrusive that can be definitely shown to be older than the pitchblende-silver mineralization. Kidd (1932D, p.14C) reports that thin sections from two of these dykes show a rock with a medium even grain, also subhedral plagioclase grains (oligoclase to andesine), a little orthoclase, quartz, augite and iron ore.

The more abundant type of basic dyke is widespread, generally steeply dipping and up to 100 feet in width. The trend is variable. They are medium to fine-grained, and greenish-grey to greenish-black in color. In some instances the medium grained parts have a diabasic texture.

A flat-lying dyke (or perhaps more than one) outcrops at many places. It is found as a series of isolated occurrences that may have been one continuous body. It is only 100 to 500 feet thick but of great lateral extent. It is a quartz norite, which in thin section shows conspicuous interstitial micrographic intergrowths of quartz and feldspar. Lithologically this sill, or flat-lying dyke, is similar to the more abundant steeply-dipping basic dykes and probably is part of the same intrusive.

Giant Quartz Veins:

~~Composite~~ Stockworks of large quartz veins are common in the area. These veins are locally known as giant quartz veins. They range in width from 50 to 500 feet and have lengths up to ten miles. They contain no feldspar nor any appreciable quantity of metallic minerals. Their occurrence in faults, which cut nearly all the known igneous rocks, suggests that they are not related to intrusives now exposed.

STRUCTURAL GEOLOGY

In the Echo Bay district the rocks of the "Old Complex" strike north and south at Glacier Bay and swing southeast to strike about S.60°E. north of Contact Lake. They form the western edge of a gentle syncline which has been crumpled against the granite along the shore of Great Bear Lake, north and south of Echo Bay. Except near the granite bodies, the dips are usually less than 45 degrees; much of the Cameron Bay group is only slightly folded. Considering its proximity to so many intrusive bodies this is rather remarkable.

The area is broken by many faults, the majority of which have right-hand offsets and strike about northeast. Little evidence has been found of major vertical movement. There are large quartz veins in several of the faults, and the coincidence in direction between the system of quartz veins and the major faults suggests that many of the veins may occupy faults. As some of the large quartz veins cut the granite, the faulting possibly post-dates the granite.

The most prominent fault in the district is at Cameron Bay (FigureI). Contacts meeting it appear to be displaced about three miles. A large quartz vein lies in the fault.

In addition to the northeast faults, there are suggestions of other structures that trend north and south. These structures may represent jointing and fracturing rather than faulting. They are indicated by north-south dykes of considerable length.

Geology of the Bonanza Claims

General:

The mineralization occurs in banded sedimentary rocks of the Echo Bay group, approximately one-quarter of a mile wide, bordered on the south by the Dowdell Point granite and on the north by a body of granodiorite.

Sedimentary Rocks:

The sedimentary rocks strike west-northwest and dip nearly vertically. They are, in large part, thinly banded cherts, quartzites and argillites, now largely recrystallized. In thin section they consist primarily of very fine-grained, recrystallized quartz with minor amounts of chlorite, green mica or hornblende, some cloudy alteration, possibly a clay mineral, and euhedral grains of magnetite. ~~Certain~~ Some bands contain enough fine, disseminated hematite to give them a reddish colour. The magnetite crystallized late since it cuts into all the other minerals.

Individual bands range from less than 1/16 inch to 1/8 inch in width. The average grain size is less than 0.05 mm.

Some bands, particularly in the mineralized zone, are much softer, weather differentially, and have a dark green colour. They contain a large amount of flaky chlorite and at some places much hematite and magnetite. They are probably altered calcareous beds. The alteration is similar to that caused at other places by the granodiorite. A study of thin sections of these highly altered sedimentary rocks shows widespread development of tabular to fibrous, green, strongly pleochroic, pennine chlorite with anomalous blue interference colours, along with typical greenish to colourless clenochlore(?) chlorite. Iron-stained carbonate predominates in the groundmass. Replacement of the chlorite and carbonate by subhedral grains of magnetite is common. Rosettes and stringers of hematite are scattered throughout much of the rock. In one section the groundmass is composed almost entirely of minute shreds of sericite (or talc?), less than 0.1 mm. in length. Sericite is also present to a minor extent in other thin sections of the altered rock. The sericite has the following optical properties: elongated shreds, parallel extinction, third-order interference colours and a mean index of refraction, determined by means of immersion oils, of 1.572.

Granodiorite:*

The granodiorite is a border phase of a comparatively large intrusive that extends about five miles east. A specimen of this rock, taken close to the sedimentary contact, was a ~~slightly~~ moderately altered, dark, fine-grained rock, well mottled with pink feldspar grains and weathered to a pinkish-white colour for a depth of approximately 1/32 inch on the exposed surface.

* The term granodiorite, as used in this paper, refers to ~~an~~ a rock which ~~intrusive~~, ranging in composition from granodiorite to diorite. Kidd has described as

A thin section of the same specimen indicated it was a ~~grano-~~ quartz ~~diorite~~ monzonite with the following mineral composition:

Mineral	%	Optical properties by which the essential minerals were identified.
Orthoclase	25	index less than balsam; untwinned; biaxial with large 2V
Hornblende	15	green - pleochroic; birefringence = 0.20; maximum extinction angle in longitudinal sections = 13°; biaxial negative with 2V about 70°.
Biotite	15	pleochroism; strongest absorption when the cleavage traces were parallel to the vibration plane of the lower nicol.
Plagioclase (Andesine)	15	maximum extinction angle of albite twins in sections normal to 0/0 = 16°; index greater than balsam; biaxial negative with 2V about 80°.
Quartz	10	uniaxial positive
Chlorite	10	
Magnetite Apatite Sericite Some clay mineral	10	

In thin section the rock is moderately altered. About 80 percent of the feldspar, particularly orthoclase, has altered to sericite and a cloudy alteration product, probably one of the clay minerals. Small, fresh remnants of plagioclase, about 0.1 mm. in diameter, are fairly abundant. All stages of alteration of hornblende to biotite are evident. Some of the biotite has altered to chlorite. Much of the magnetite is along cleavage planes of the biotite thus suggesting it is secondary after the alteration of hornblende. Very little magnetite of possible primary origin was seen. Both hornblende and biotite are conspicuously embayed along their margins by grains of quartz and feldspar, and in addition, commonly contain isolated inclusions of these minerals. The writer has interpreted the above relationships as indicating replacement of the hornblende and biotite by quartz and feldspar. A few seams of chlorite traverse the rock.

The contact between the granodiorite and the sedimentary rocks is very irregular and the intrusive contact appears to dip south at a low angle under the sedimentary rocks; this may account for the extensive alteration of the intruded rock.

Specimens of the Dowdell Point granite were not available and thus no study could be made of the granite and its alteration effects.

Mineralization:

Dr. C. Riley has supplied the following description of the ore zone:

"Bonanza Number 5 showing occurs in a brecciated and sheared zone some 20 feet wide, striking N. 20° W. and dipping vertically. The zone lies within banded sedimentary rocks just at their contact with a granodiorite to the north. The sedimentary rocks strike N. 20° to 25° W. and vary in dip from 65° S.W. to vertical. They consist of banded cherts, quartzites and argillites all highly metamorphosed and fractured."

"The granodiorite is altered in the same manner."

"The chief mineral in the vein is native silver in quartz and calcite lenses and stringers. Locally, the silver forms 25 percent of the lenses and stringers. Magnetite and hematite are abundant gangue minerals and appear to be earlier than the silver."

"Some distance to the south of the zone, coarse-grained, pink granite is intrusive into the sedimentary rocks along a clearly defined contact."

MINERAL DEPOSITS

General.

The mineralization of economic interest in the Echo Bay district ~~are~~ is silver and pitchblende. The principal deposits are shown in Figure I.

Pitchblende occurs in the area at Labine Point and Contact Lake and also at Hottah Lake, 110 miles to the south. It is frequently in botryoidal, colloform or dendritic forms. Magnetite, cobalt and nickel minerals, native bismuth, argentite, chalcopyrite, tetrahedrite, galena, and native silver are commonly associated with the pitchblende.

Silver occurs at most of the pitchblende deposits and at Camsell River, 35 miles to the south. It is usually in the native state in the form of dendrites or fine wires. Tetrahedrite, cobalt and nickel minerals, and argentite are closely associated with the native silver.

Copper is widespread in the area but of no economic importance. It is found in all deposits, usually as chalcopyrite, bornite, chalcocite, tetrahedrite or covellite.

Like copper, the cobalt and nickel minerals are of widespread occurrence but of little direct economic importance. They are found as smaltite-chloanthite, skutterudite, cobaltite, niccolite, and gersdorffite.

The more important deposits occur in brecciated and sheared zones. The gangue minerals comprise quartz, barite, and calcite. Much of the carbonate is manganiferous.

Mineralogy of the Bonanza Group

General Statement:

Microscopic study was made of 20 polished sections and 16 thin sections from the Bonanza group. Physical and optical characteristics coupled with etch reactions were used for mineral determinations. All the metallic minerals, except for native silver, hematite and magnetite, were considered too small to be isolated into pure samples large enough for spectroscopic or micro-chemical analysis. Two spectroscopic analyses were made of native silver.

Magnetite (Fe_3O_4):

The magnetite is abundant in the altered wall rock and the banded sedimentary rocks but is conspicuously lacking in the veins or stringers of quartz or calcite. It occurs as euhedral to subhedral grains and as irregular stringers or massive patches replacing the country rock. Remnants of carbonate, quartz, chlorite, and sericite are found in the massive magnetite. In some cases the massive magnetite has irregular disseminations of tabular pennine chlorite grains in it, giving a texture similar in appearance to "diabasic". The magnetite is commonly rimmed and cut by stringers of hematite. In thin sections of the fine-grained, banded sedimentary rocks, magnetite is found as scattered, small, euhedral grains cutting into the recrystallized siliceous groundmass.

In all cases examined the magnetite is later than the country rock alteration but is the earliest metallic mineral present. It is generally accepted that the majority of the magnetite is related to the granodiorite intrusion. Dr. C. Riley[(1)] states that in the Echo Bay district, and also immediately to the south, it is more the rule than the exception, to find magnetite as disseminations, patches or veins adjacent to the granodiorite contact but in the intruded rock.

(1) Riley, C.: Oral Communication, 1948.

Hematite (Fe_2O_3):

Hematite is widespread in the deposit but not as abundant as some of the hand specimens might indicate. These specimens have a reddish tone suggesting a large proportion of hematite, but when they are examined carefully the reddish tone is found to be due to the dominating red colour of a few narrow hematite stringers whose powder has covered the surface of the specimen.

Hematite commonly occurs as tiny irregular seams, up to 1/16 inch in width, cutting or rimming the magnetite. Where the rock is brecciated it is common for the angular pieces to be cemented by carbonate containing much finely-divided hematite. The altered rock usually contains finely disseminated hematite, or rosettes of the same mineral, along fractures or interstitial to the mineral grains. Chert and carbonate veinlets commonly contain enough disseminated hematite "dust" to give them a reddish colour. The same applies for some of the siliceous bands in the fine-grained, banded sedimentary rocks.

Hematite was not found to be associated with any of the metallic minerals other than magnetite; any chert or carbonate that contained hematite was usually void of metallics. This fact, however, may not have much significance as Kidd and Haycock (1935, p. 905), and Furnival (1939, p.751) found that hematite was quite commonly associated at Labine Point and at Contact Lake with various copper and silver minerals.

The hematite is definitely later than the magnetite and appears to be earlier than the native silver since the veins containing silver cut hematitic country rock. It is possible that the hematite may be of two generations, the first one filling fractures in the magnetite and altered rock and acting as a cement along with carbonate for the brecciated material, and the second generation appearing with the chert and carbonate stringers. However, since no direct evidence was found substantiating the theory of two generations of hematite, it is probably best to assume one generation later than the magnetite and earlier than the silver.

The best evidence for hydrothermal origin of the hematite in the area is presented by Murphy (1946, p.436) in the following passage: "The alteration of the rocks and veins in the vicinity of the Eldorado mine is prominent, and the 'baked' appearance of all formations, except the later diabase, has been frequently remarked. In both rocks and veins, the alteration has given rise to widespread discolouration by hematite and the obliteration of original textures. This so-called red alteration, undoubtedly related to the quartz-hematite period of mineralization, affects the quartzose rocks most severely, but, where alteration is intense, there is little selectivity. The rocks are then reduced to a dense, reddish 'jasperoid'. The exact nature of the alteration has not been determined, but quartz, hematite, magnetite, sericite, chlorite, and carbonate are obvious constituents.

"Going away from the mine, the degree of alteration falls off, but the mineralization is so pervasive that in no case can it be said that examination has been carried beyond the zone of alteration. The distribution of the alteration points to the mine as being a centre of mineralization in the district, and indicates that the veins and alteration have a common hydrothermal source. In a geophysical examination of the area, Brant has noted an unusually high magnetite content of the rocks on Labine Point. The percentage of magnetite decreases away from the mine, thus giving further evidence as to the locus of mineralization."

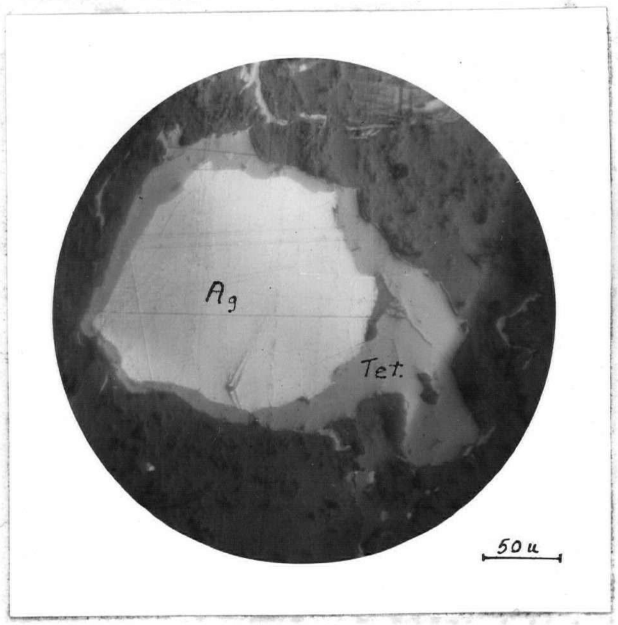
The above description is comparable to the situation at Bonanza mine and thus it is logical to assume that the hematite at Bonanza is also hydrothermal.

Tetrahedrite ($5Cu_2S.2(CuFe)S.2Sb_2S_3$):
Tennantite ($5Cu_2S.2(CuFe)S.2As_2S_3$):

The physical and chemical properties of tetrahedrite and tennantite are so similar that chemical or spectrographic analysis must be resorted to in order to distinguish between them. Although tetrahedrite (or tennantite) is widespread in the polished sections, it was never found in sufficient quantity to enable a spectrographic sample to be isolated. In the remaining part of this paper this mineral shall be called tetrahedrite, with the understanding that it may be tennantite.

Tetrahedrite appears in more than 50 percent of the polished sections, but only as sparsely disseminated small grains. Usually the mineral could barely be distinguished under low power and was revealed only by high power or oil of immersion lenses. The largest single piece of tetrahedrite is shown in Plate I, where the width of the mineral is about 0.5 mm. Tetrahedrite is closely associated primarily with native silver and argentite, and to a minor extent with chalcopyrite and an unknown pinkish-cream mineral. With the exception of chalcopyrite, it is older than all the metallic minerals with which it is associated. Argentite consistently replaces tetrahedrite and, invariably, irregular islands of the mineral are found within argentite, as illustrated in Plates II and III. The argentite replacement most commonly starts on the borders of the tetrahedrite, and advances very rapidly along easiest channels, such as fractures.

The silver replacement of tetrahedrite generally begins at the core of the mineral and advances towards the rim. In many cases remnant rims of tetrahedrite, partially rimmed by argentite, can be seen bordering silver (Plates I and IV). Edwards (1947, p. 97) cites core replacement by silver as occurring at Cobalt, Ontario, Königsberg, Norway and Contact Lake in the Echo Bay district. ~~Silver replacement of the tetrahedrite seems to begin wherever a hole or a fracture appears in the tetrahedrite, suggesting that these may act as a nucleus from which the core replacement commences.~~ Occasionally under high power, silver can be seen replacing tetrahedrite from the



x 204

Plate I

Core replacement of tetrahedrite by silver in a sericitic gangue.

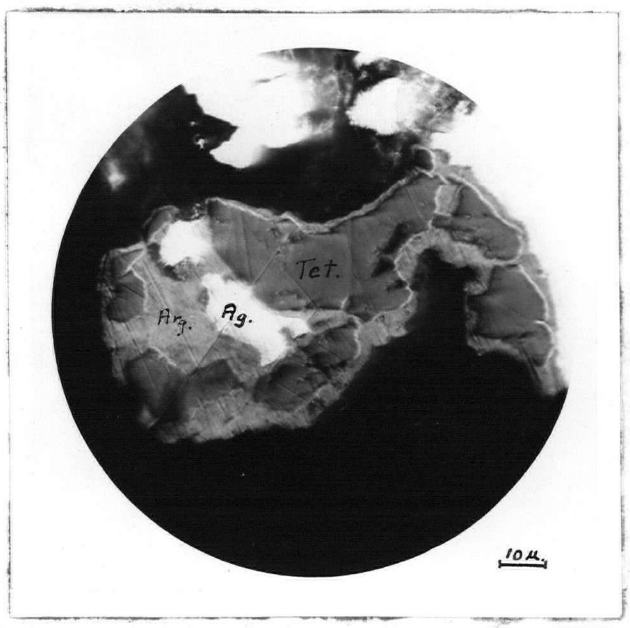


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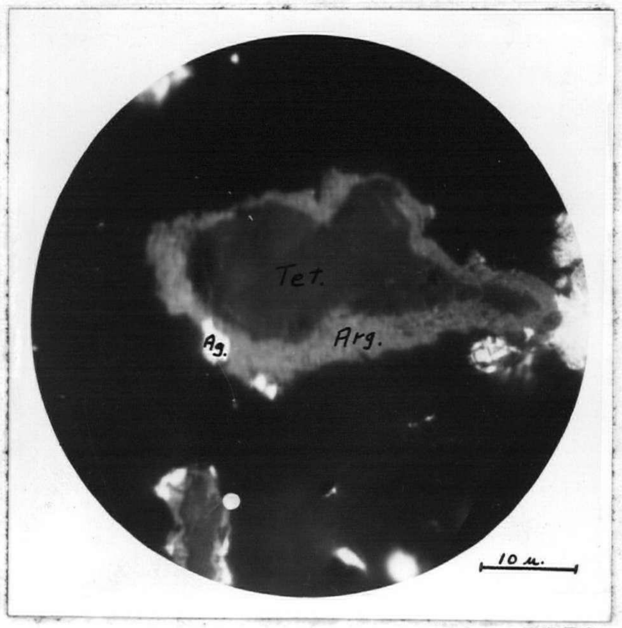
Plate II

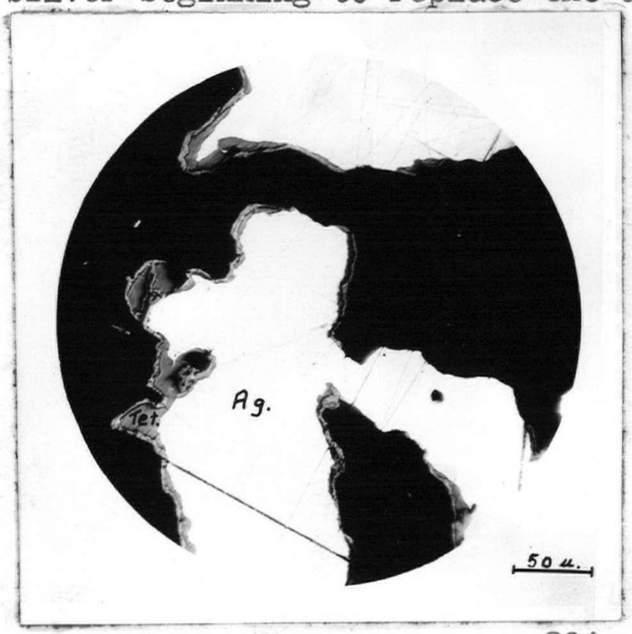
Islands of tetrahedrite and silver in argentite. The gangue is mostly sericite.



x 1250

Plate III

Argentite replacing tetrahedrite. Note the silver beginning to replace the argentite.



x 204

Plate IV

Silver rimmed by tetrahedrite (dark gray) and argentite (light gray). This is thought to be an advanced stage of core replacement.

outer borders in much the same manner as the argentite does. A few small remnants of tetrahedrite were found in silver in several of the polished sections.

Tiny 'snake-like' veinlets of tetrahedrite were found, in one polished section, with their borders being replaced by a pinkish-cream, unknown mineral and, occasionally, by argentite (Plate V).

Intimate association of chalcopyrite and tetrahedrite was seen in only one section. The chalcopyrite has been definitely replaced by tetrahedrite. The grey mineral rims the chalcopyrite with the replacing front advancing into the chalcopyrite along the easiest channels, very similar to the replacement of tetrahedrite by argentite. A poor example of this is shown in the upper part of Plate VI.

Tetrahedrite occurs in the same gangues as silver, namely, carbonate, quartz and sericite.

The following is a summary of the tests used to identify tetrahedrite:

Colour (in polished section): Steel grey.

Hardness: C +.

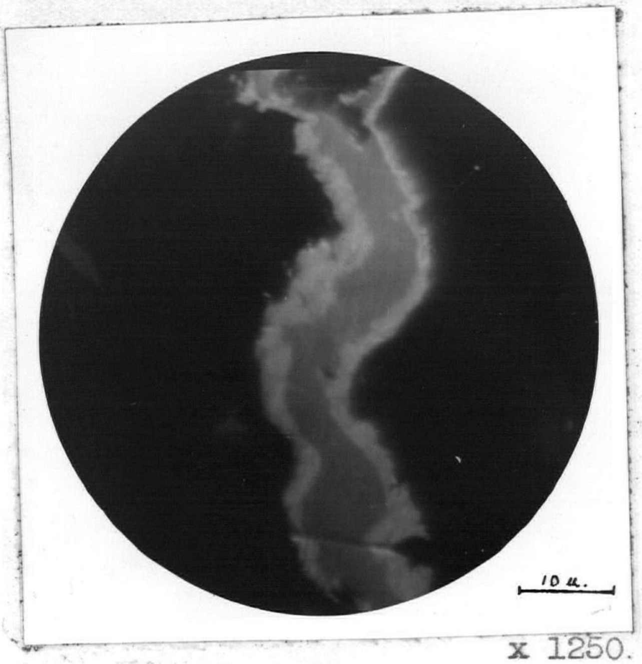
Crossed Nicols: Isotropic.

Etch Tests: HNO_3, HCl, $FeCl_3$, KOH, KCN, and $HgCl_2$ all negative.

Miscellaneous: Triangular pits in some of the mineral.

Argentite (Ag_2S):

Argentite is intimately associated with, but not quite so



x 1250

Plate V

A "Snake-like" stringer of tetrahedrite rimmed by the unknown mineral in a sericitic gangue.

x 204

Plate VI

Chalcopyrite ~~being~~ partly replaced by silver and tetrahedrite (dark gray). The dark background is the quartz gangue.

abundant as tetrahedrite. The two minerals have practically the same occurrence, and their relationships have already been described.

Silver and argentite have much the same relationships as silver and tetrahedrite except that the silver is more commonly associated with the latter; however, this may be because of the relative abundance of the two minerals. Plate II shows silver replacing argentite from the core outwards, and Plate III shows it replacing argentite from the border inwards. Argentite, with imbedded islands of tetrahedrite, occasionally is completely rimmed by silver.

In some instances argentite is found with chalcopyrite but in these cases tetrahedrite is usually present also. Some replacement of the chalcopyrite by argentite may have taken place but the invariable presence of tetrahedrite as well suggests that a good deal of the argentite replaced tetrahedrite and not chalcopyrite. The unknown pinkish-cream mineral was not found associated with argentite.

It is possible that some of the argentite is supergene though positive evidence on this point was not found.

The tests by which argentite was identified are as follows:

Colour (in polished section): Light grey.

Hardness: B - .

Crossed Nicols: Isotropic.

Etch Tests:

HNO_3 - definite bluish-green tarnish

HCl - commonly negative; occasional tarnish

KCN - stains brown

$FeCl_3$- dark stain

$HgCl_2$- definite irridescent stain

KOH - negative

<u>Chalcopyrite ($CuFeS_2$):</u>

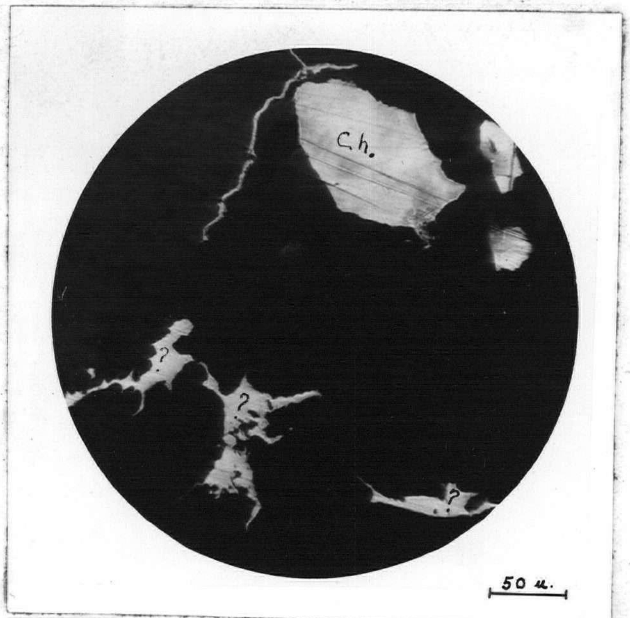
Chalcopyrite is rather scarce in the polished sections. It appears in only three out of the 20 sections and in only one of these is it ~~in sufficient abundance~~ possible to determine its associations and relative age.

Generally the chalcopyrite occurs as isolated small grains, about 0.1 mm. in diameter, scattered throughout the gangue and not particularly associated with any of the other metallic minerals. Whenever chalcopyrite does occur with the other metallics it is decidedly, and in some instances extensively, replaced by them, especially by tetrahedrite. Silver occasionally replaces the chalcopyrite as core replacement (see Plate VI). Three irregular grains of chalcopyrite are shown in Plate VII with three patches of unknown pinkish-cream mineral at the bottom of the photomicrograph.

Chalcopyrite was identified by the following means:

Colour (in polished section): Brass yellow.

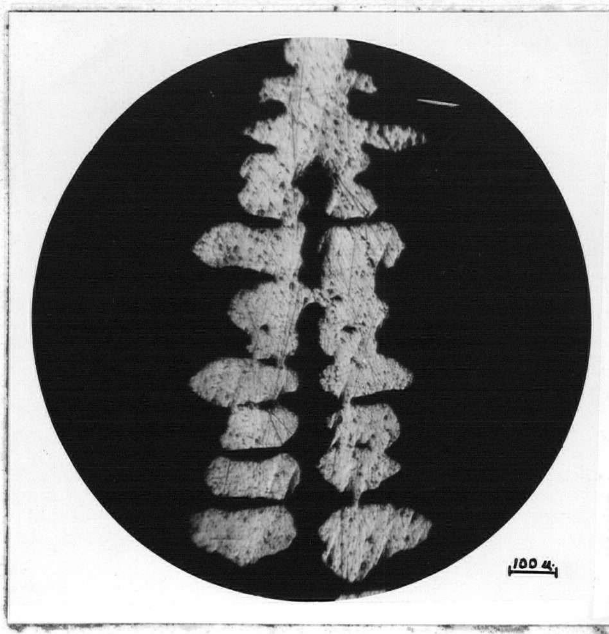
Hardness: C .



x 204

Plate VII

Chalcopyrite and the unknown mineral in a sericitic gangue.



x 65

Plate VIII

A typical silver dendrite in a quartz gangue.

Crossed Nicols: Slightly anisotropic.

Etch Tests:

HNO_3 - irridescent tarnish

KCN - very light tarnish

HCl, $FeCl_3$, KOH and $HgCl_2$ - negative.

Unknown Pinkish-Cream Mineral:

An unknown pinkish-cream mineral occurs sparsely in two of the polished sections. As already mentioned its relationships are:

(1) as replacement rims on tetrahedrite (see Plate V).

(2) as isolated blebs scattered throughout the section (see Plate VII).

All that can be said of the unknown's relative age is that it is younger than tetrahedrite.

Properties of the unknown mineral are:

Colour (in polished section): Pinkish-cream.

Hardness: C .

Crossed Nicols: Isotropic.

Etch Tests:

HNO_3, $FeCl_3$, $HgCl_2$ - very light tarnish.

HCl, KCN, KOH - all negative.

Native Silver (Ag.):

Native silver is the most abundant and widespread metallic mineral in the polished sections and hand specimens. It is found in all sections of the vein material. With the exception of hematite and magnetite, it is the only metallic mineral that can be seen in megascopic examination. Ninety-five percent of the silver occurs either as individual dendrites or in a dendritic pattern. The other five percent appears as isolated blebs and seams, and as replacements of tetrahedrite, argentite or chalcopyrite. The gangue minerals, in order of abundance, comprise quartz, sericite and carbonate.

The dendritic pattern is most widely developed in a quartz gangue. The individual dendrites, one of which is illustrated in Plate VIII, are up to 1/4 inch in length with a decided branching tendency. Locally, the dendrites appear to be oriented in one of three directions, intimating rhombic control; however when the specimen is viewed generally the dendrites have a random orientation and no control is suggested. A poor dendritic pattern is shown in Plate IX. The origin of the dendritic pattern will be discussed fully with the gangue minerals. Silver is invariably associated with tetrahedrite, argentite and to a minor extent with chalcopyrite, whenever these minerals are present. These associations have already been described (see Plates I, II, III, IV and V). Two spectrographic analyses of what was believed to be pure silver gave the following results:

Silver	:	strong
Copper	:	strong
Mercury	:	weak to moderate
Bismuth	:	weak to moderate

Cobalt : nil

Nickel : Nil

Arsenic : nil

Antimony: nil

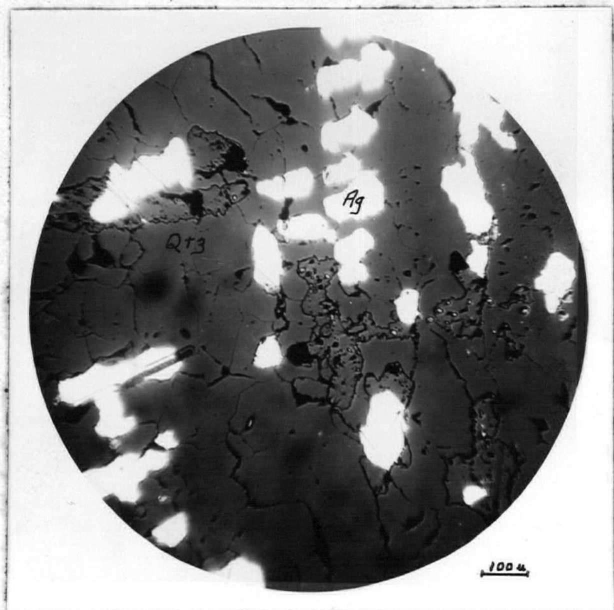
The copper could be due to admixed tetrahedrite or chalcopyrite but since no mercury or bismuth minerals were found in any of the polished sections it is only logical to assume that these elements are alloyed with the silver. It is interesting to note that Furnival (1939, p.763) found mercury alloyed with silver at Contact Lake and that Knight (1924, p.35) reported the same at Cobalt.

Native silver is the youngest metallic mineral in the deposit and with the possible exception of some of the late barren carbonate veins, is the last mineral to be deposited. Kidd and Haycock (1935, p. 925) state that the silver is the last hypogene mineral to form at Labine Point (Eldorado).

From the small scope that the specimens offer it is rather difficult to determine positively whether the silver is supergene or hypogene; however, by comparison with other deposits in the area and considering the negative evidence it is concluded that the greater part of the silver is hypogene. A summary of the points in favour of hypogene silver follows:

(1) The notable absence of supergene ~~minerals such as~~ covellite and chalcocite.

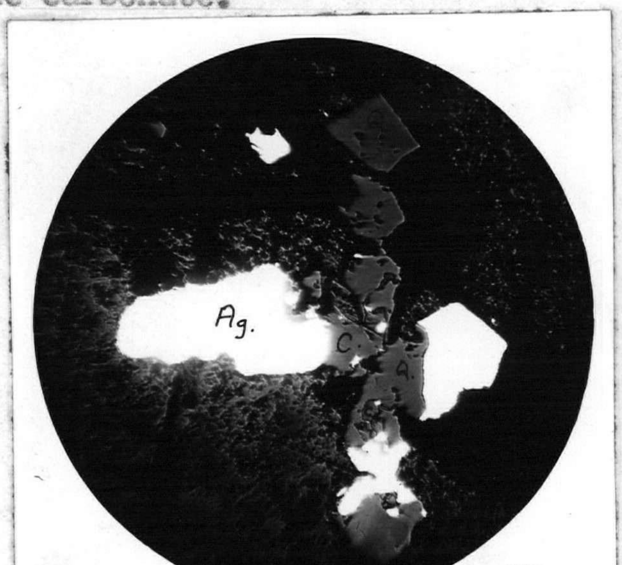
(2) The presence of mercury and bismuth in the silver.



x 65

Plate IX

Silver replacing dendrites of carbonate in a quartz gangue. Note the specks of silver in the carbonate.



x 65

Plate X

Quartz, in a rude dendritic pattern, ~~being~~ partly replaced by silver and carbonate. The ~~gangue~~ matrix is mostly sericite.

It is very unlikely that these elements would appear in supergene silver, especially since no mercury mineralization has been noted in the area.

(3) Furnival (1939, p 763) found a homogeneous, coarse, recrystallized structure in silver at Contact Lake, which, according to Edwards (1947, p.6) is indicative of hypogene silver.

(4) Kidd and Haycock (1935, p.926) state that the silver at Labine Point is older than supergene manganese oxides and after careful study concluded that the greater percentage of the silver was hypogene.

One point which makes supergene origin for the silver feasible is the fact that the specimens were taken from within a few feet of the surface.

Gangue Minerals:

Quartz- Quartz is the most abundant gangue mineral. It constitutes 90 percent of the gangue in 60 percent of the specimens and in the remainder it is conspicuous as dendritic inclusions. The quartz is a fine to medium grained, white, crystalline variety with interlocking, more or less equidimensional, anhedral grains and displays a vuggy character in some of the specimens. The vuggy quartz contains no silver mineralization though it is immediately adjacent to crystalline quartz carrying up to 25 percent silver. This implies that the vuggy quartz is later than the silver mineralization and could be a result of secondary deposition by circulating ground waters.

Bands of "jasper-like" chert, up to 1/4 inch wide, containing cryptocrystalline quartz with finely disseminated, blotchy hematite, frequently occur at the contact of the quartz veins and the country rock. They carry little or no silver mineralization and are considered to be later than the silver. It is thought that the chert bands, because of their very fine grained character, were deposited from colloidal suspension near the close of the silver mineralization. On the basis that the hematite in the deposit is of hypogene origin and that it is not uncommon to get colloidal silica deposited in the late stages of mineralization, it is assumed that the chert is of hypogene origin.

The quartz bodies have sharp, frozen contacts. No one specimen showed both walls but from descriptions by Kidd (1932b, p.27c), Lord (1941, p.49) and Dr. C. Riley (1) the quartz appears as lenses up to eight inches by 30 inches in brecciated and sheared zones. In thin section the quartz frequently contains interstitial fine grained sericite indicating that at least some of it is replacement of the sericitic rock in or near the shear zone.

Two ages of quartz are evident in the sericitic gangue. One appears as altered irregular remnants, that have been extensively replaced by sericite; the other is a fresh euhedral

(1) Riley, C.: Oral Communication, 1948.

quartz displaying a poor dendritic pattern, with minor replacement by carbonate. The dendritic pattern is largely inherited by the silver. (See Plate X).

In a quartz gangue the silver has a strong tendency to be interstitial to the quartz grains and to replace carbonate (Plates IX and XI). Even in cases where no carbonate appears to be present, slight effervescence can frequently be observed along the margins of silver grains when a drop of dilute hydrochloric acid is applied to the area, suggesting that the silver may have replaced carbonate. In thin section silver dendrites are often surrounded by a narrow rim, less than 1 mm. wide, of cryptocrystalline quartz that is much finer than the fine to medium-grained groundmass. This could be due to either excessive quartz entering solution at the time of silver replacement and being redeposited in situ as a cryptocrystalline rim around the silver, or to an introduction of cherty quartz with the silver. Of the two proposals the first one seems to be more plausible as it does not involve introduction of siliceous material and as the cryptocrystalline quartz has a tendency to grade into the quartz gangue. The fact that some of the rims have a slightly cloudy appearance somewhat resembling some of the chert bands may support the latter proposal.

All the quartz is definitely older than the silver mineralization, excepting possibly of course, the chert bands, the vuggy quartz and the rims around the silver dendrites.

Sericitic Gangue - Sericite is next in abundance to quartz as a gangue mineral in the specimens studied. It is composed of a mass of small fibres or flakes of sericite less than 0.2 mm. in length, with minor amounts of carbonates, and a few remnant grains of quartz that have been largely replaced by the sericite. Euhedral grains of quartz in a poor dendritic pattern, some carbonate and the metallic ore minerals are all younger than the gangue. The sericite, as determined by means of immersion oils, has a mean index of about 1.572, thus indicating that it is close to pure muscovite in composition (Winchell, 1946, p.268).

Carbonate Gangue - Most of the carbonate in the specimens is present in barren calcite stringers up to 1/4 inch wide, that cut indiscriminately through the altered rock. These stringers commonly have narrow seams of chert along their contacts, and are usually devoid of any mineralization. The only carbonate which is consistently related to the silver is that replaced by the silver and associated with quartz (Plates X and XI).

Kidd (1932b, p.27c) and Lord (1941, p.49) give the impression that most of the silver is in carbonate veins or lenses rather than quartz; thus, it appears that carbonate is considerably more important as a gangue in the deposit than the available specimens indicate. Kidd (1936, p.40) reported the following analysis of white carbonate with silver from the Bonanza deposit:

		Percent
Insoluble	-	10.96
Metals	-	1.14
Fe_2O_3	-	3.06
Al_2O_3	-	2.76
FeO	-	0.29
MnO	-	3.18
CaO	-	41.50
MgO	-	0.56
CO_2	-	35.38
		98.83
Equivalent to		
$FeCO_3$	-	0.61
$MnCO_3$	-	5.51
$CaCO_3$	-	74.11
$MgCO_3$	-	1.18

All the carbonate effervesces readily with cold dilute hydrochloric acid indicating that it is largely calcite.

Origin of the Dendritic Form of Silver:

There is little doubt that the dendritic form of the silver has been inherited from either the quartz or carbonate. Plate X shows partial replacement of dendritic quartz by carbonate and silver and though it is not illustrated the dendrite of silver in Plate VIII changes abruptly to carbonate outside the field of the photomicrograph. The problem then is: "the origin of the dendrites of carbonate and quartz".

In the case of the carbonate dendrites in the quartz gangue (Plates IX and XI) the carbonate is mainly interstitial to the grains of quartz with the silver following the pattern of the carbonate when it is present. Thin section study of this material was rather disheartening in that very little carbonate was seen in the sections; nevertheless, it is apparent that the silver dendrites have replaced a dendritic structure in the quartz gangue caused by a special arrangement of certain quartz grains. For example, in one thin section several doubly terminated quartz prisms lie side by side in a row with their ends terminating in rude pyramids. Silver has replaced these prisms resulting in the dendritic pattern. In Plate VIII the arms of the silver dendrite could easily represent replacement of rude prisms of quartz lying side by side; as a matter of fact, under the existing circumstances it is difficult to explain them by any other means. In polished section, silver is seen to have frequently replaced dendrites of carbonate in a quartz matrix. In this case the carbonate evidently has replaced the dendritically arranged quartz and, in turn, is replaced by silver.

The doubly terminated quartz prisms must have formed in a medium that did not seriously obstruct their growth and, in addition, permitted them to grow in two directions. This type of medium might be provided by:

(1) replacement of a gangue, such as a carbonate, which offers little resistance to the replacing solutions and the

growth of crystals. The growth of the doubly terminated quartz prisms could have started along minute fractures or joints in the carbonate. This would explain the random orientation of the dendrites and in addition would help to explain the rhombic control which is suggested by some of the dendritic patterns. The objection to this theory is that there is no evidence that the quartz is a replacement of carbonate.

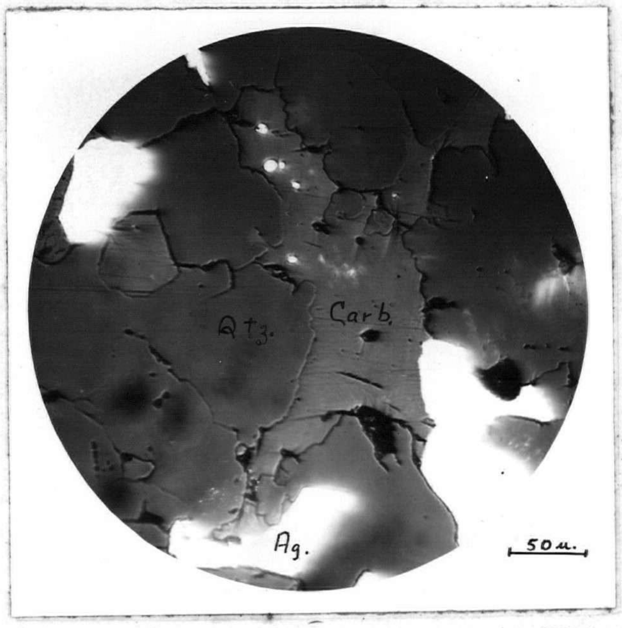
(2) the quartz crystallizing in an open fissure. Although it might be possible to have doubly terminated quartz prisms developed in open fissures, it is difficult to visualize how the decided random orientation of the dendrites could be produced by this means. In addition, there is no evidence in the deposit of fissure filling.

In summary, no definite conclusion has been arrived at as to the origin of the rows of doubly terminated quartz prisms. Two theories have been suggested but both of these lack substantiating evidence. The origin of the dendritic structure certainly warrants further study and as an approach to this the writer suggests the study of thin sections cut to give various orientations of the quartz prisms. At the same time the problem of the selective replacement of the rows of quartz prisms by the silver, or carbonate, in preference to the unoriented quartz gangue might be investigated.

In the sericitic gangue the silver inherits its dendritic form from fresh euhedral quartz arranged in a dendritic pattern (Plate XI). The explanation here is not so difficult.

The quartz in an individual dendrite all has the same orientation and from its fresh appearance, as compared to the corroded remnants of older quartz in the same gangue, and its strongly euhedral shape it is believed that it has replaced the sericitic gangue. Here again there is discordance between the polished and thin sections. In the polished sections one gets the impression that silver invariably replaced carbonate after quartz, while in thin section carbonate is less abundant and the majority of the silver replaced quartz directly, in the absence of carbonate. In view of the fact that approximately twice as many polished sections were studied containing dendritic silver as thin sections, the writer concludes that the majority of the silver is a replacement of carbonate after quartz, but that direct replacement of quartz by silver is more prevalent than indicated by polished section. There is little doubt that the silver prefers carbonate to quartz as indicated by the conspicuous specks of silver in the carbonate and the equally noticeable absence of silver in the quartz in Plates IX, and X /XII.

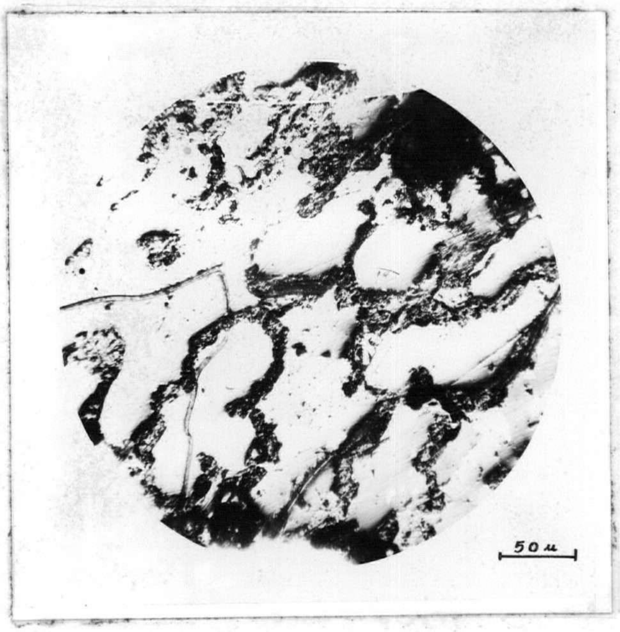
No detailed study was made of dendritic silver in a carbonate gangue but one instance was noted of a dendritic structure in carbonate due to differential polishing (Plate XII) similar to that reported by Kidd and Haycock (1935, p.956). Kidd and Haycock interpreted this as being two carbonates of different hardness with the silver preferring the softer.



x 204

Plate XI

Carbonate being replaced by silver in a quartz gangue.



x 204

Plate XII

Differential polishing in a carbonate gangue.

Summary of Mineralogy:

The mineralogy of Bonanza is very similar to that described by Kidd and Haycock (1935) and Furnival (1939) at Labine Point and Contact Lake, except that far fewer minerals were identified at Bonanza; however, it must be kept in mind that no more than 15 specimens were examined by the writer compared to the hundreds examined by Kidd, Haycock, and Furnival. It is interesting to note that Kidd and Haycock (1935, p.888) identified chalcopyrite, bornite, sphalerite, tetrahedrite, covellite, and erythrite on the Bonanza claims, and R.B. Scott[1] found several radioactive specimens in the Bonanza dump in 1945.

(1) Scott, R.B.: Oral Communication.

PARAGENESIS

Kidd and Haycock (1935, p. 931) have divided the mineralization of the Echo Bay district into three main stages:

(1) pyrometasomatic stage

(2) hydrothermal stage

(3) supergene stage.

This same classification is well suited for the Bonanza deposit.

The pyrometasomatic stage, at Dowdell Point, is connected with the granodiorite intrusion, and is concerned primarily with the introduction of magnetite and the alteration of the banded sedimentary rocks, characterized by widespread development of chlorite, sericite and carbonate. It is the earliest of the three stages.

The hydrothermal stage is the most important as far as the economic aspects of the deposit are concerned. The quartz and carbonate gangues and all the metallic minerals, excepting magnetite, are confined to the hydrothermal period.

Little information was obtained concerning the relative age of the hematite; it is undoubtedly early, as it cements part of the brecciated zone. On the other hand, it occurs in minor amounts in the chert bands which are regarded as being late. Murphy (1946, p.432) ties the major part of the hematite in with the quartz and it is reasonable to assume that the same relationship holds at Dowdell Point, with minor surges of hematite following later.

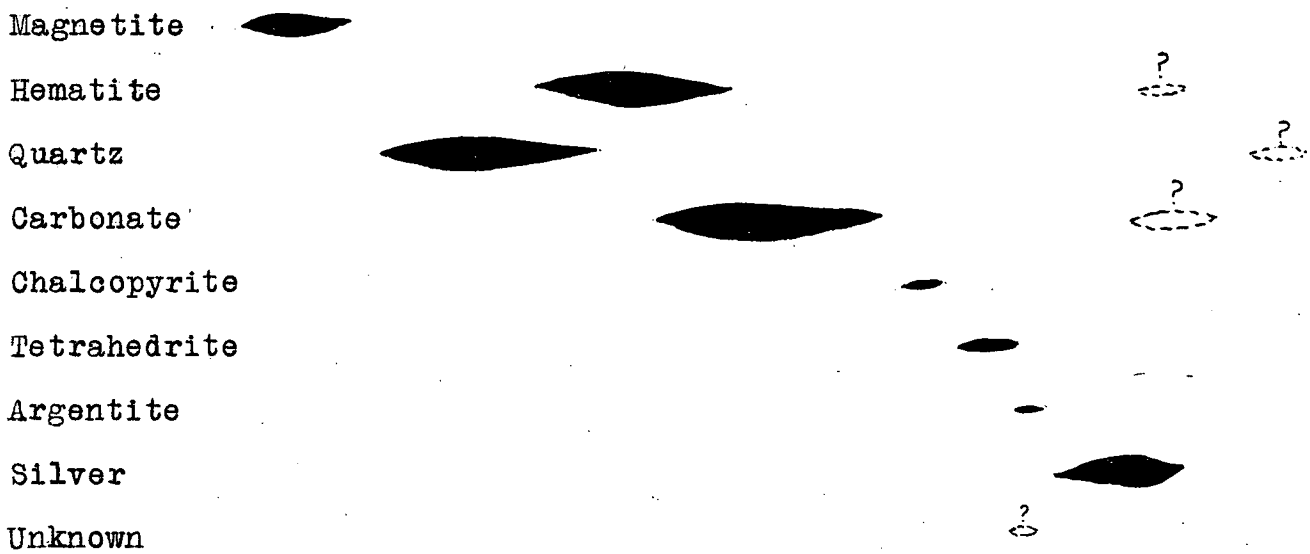
Where carbonate is present in direct association with silver it is unquestionably the older of the two, but in the case of the barren carbonate stringers some uncertainty arises. These stringers contain no mineralization and are often associated with chert bands. The fact that the stringers are in a mineralized zone and are barren and, in addition, are associated with late chert bands suggests that they are late. Furnival (1939, p.768) recognized much the same phenomena at Contact Lake but in his case the carbonate was mineralized.

Though the sulphide mineralization does follow a definite sequence it is very sparse. In no instance was it abundant enough to be seen with the naked eye. These sulphides appear to be the forerunners of the silver mineralization with the early tricklings being copper-iron sulphides, followed by copper, and antimony or arsenic sulphides, then by the silver sulphide and finally by the great surge of silver mineralization.

At the Bonanza property the supergene stage is negligible in that no supergene minerals were identified.

Table I gives the suggested paragenesis for the mineralization at Bonanza.

TABLE I.



TEMPERATURE OF FORMATION

No definite criterion could be found in the suite of specimens studied that might be used as a geological thermometer. The occurrence of chert bands might indicate epithermal temperatures, but is not conclusive. The vuggy quartz suggests low pressure but, as was mentioned, it could be supergene. None of the other minerals, textures or structures can be considered diagnostic of any particular temperature.

At other deposits in the Echo Bay district however, more definite evidence of the temperature of deposition of the silver has been found. Furnival (1939, p.770) found a coarse, homogeneous, recrystallized texture in the silver indicating it had been deposited above its recrystallization temperature of 200°C; Furnival (1939) and Kidd and Haycock (1935) identified native bismuth, which is earlier than the silver, suggesting a temperature of silver deposition of less than 271°C. Kidd and Haycock (1935, p.932) remark that field evidence indicates a low pressure but give no further explanation.

Although direct supporting evidence is lacking, the Bonanza deposit is provisionally placed in the epithermal to mesothermal group in view of the following points:

(1) The investigations of Furnival, Kidd and Haycock at Contact Lake and Labine Point (Eldorado) suggest a silver deposition temperature of between 200 and 271°C -- possibly accompanied by a low pressure.

(2) Silver is a mineral typically deposited under epithermal to mesothermal conditions.

ORIGIN OF THE SOLUTIONS

Much has been written on the origin of the silver bearing solutions in the Echo Bay district, with the result that two different hypotheses have developed regarding their origin. Kidd and Haycock (1935), after their detailed work on the Eldorado Ores, prefer the granite as the origin for the silver, while Furnival (1939) and Murphy (1946) show preference for the diabase sill.

A brief summary of the evidence supporting both hypotheses is made below.

I. Evidence favouring the granite as the origin of the silver mineralization.

(1) The areal distribution of the known silver deposits is adjacent to the Dowdell Point granite or its equivalent.

(2) The close association of the pitchblende and silver mineralization, with the pitchblende believed to be genetically related to the granite.

(3) The presence of a little fluorite in both the Bonanza deposit and the Dowdell Point granite. None of the other intrusives in the area have been found to contain fluorite.

II. Evidence supporting the diabase sill as the origin of the silver mineralization.

(1) Silver has been found in the sill.

(2) The silver is later than the youngest acid intrusive.

(3) The close areal association of diabase sills or dykes and the silver deposits.

(4) The silver veins at Cobalt, Ontario, both above and below the Nipissing diabase sill, are generally regarded as being genetically related to the parent magma of the sill.

As can be seen, the evidence on both sides is rather flimsy and certainly far from conclusive. Associations are strongly emphasized, but in no single case is anything approaching positive evidence cited. The writer feels he is in no position to choose either hypothesis and is of the opinion that the silver may be genetically related to either the diabase sillor the granite.

COMPARISON OF THE BONANZA DEPOSIT WITH OTHER DEPOSITS

GENERAL

In the comparison of the Bonanza deposit with other deposits, it should be kept in mind that only a limited number of specimens were examined, and thus it is possible that the complete picture of the mineralization of the Bonanza property has not been determined. In order to make the comparison more complete the writer has first compared the Bonanza deposit with the other deposits in the Echo Bay district and has then compared these as a unit with similar deposits throughout the world.

The major discrepancies between the Bonanza mineralization and the Echo Bay district as a unit are:

(1) The pitchblende and cobalt-nickel minerals are absent at Bonanza. In addition, other minerals such as native bismuth, bornite, molybdenite, stromeyerite and jalpaite, which are common in the district, have not been identified in the specimens examined.

(2) Dendritic silver is more abundant at Bonanza and the dendritic structure is inherited from the quartz, whereas at the other properties the dendritic structure

of the silver is commonly inherited from dendritic pitchblende or dendritic cobalt-nickel minerals.

In summary, the Bonanza deposit is similar to the other deposits of the Echo Bay district only in the silver mineralization, wall rock alteration, and relationship to intrusive bodies. The absence of pitchblende and cobalt-nickel minerals make the deposit unique in the area.

A summarization of the main characteristics of the Echo Bay district is as follows:

The mineralization consists primarily of early pitchblende, followed by cobalt-nickel minerals, some sulphides, and finally native silver. Copper minerals are widespread and abundant. Characteristic minerals found are magnetite, hematite, pitchblende, cobalt-nickel arsenides and sulpharsenides, native bismuth, chalcopyrite, galena, sphalerite, argentite, native silver, and mercury alloyed with the silver. Gangue minerals comprise quartz, calcite, manganiferous carbonate, and barite.

The pitchblende is thought to be genetically related to a granite intrusive while the silver is believed related either to the granite or to a diabase sill. The deposits are classified as lower epithermal to upper mesothermal and are believed to be of Pre-Cambrian age.

COMPARISON WITH THE SILVER DEPOSITS AT COBALT, ONTARIO

The assemblage of minerals at Cobalt, Ontario ~~are~~ is very similar to those of the Echo Bay district. The cobalt-nickel arsenides and sulpharsenides, the character and manner of replacement of the silver, the gangues, and the presence of mercury in the silver are practically identical with the Great Bear Lake deposits. On the other hand, no pitchblende, hematite, or magnetite has been reported at Cobalt and in addition, chalcopyrite is not so widespread nor so abundant at the Ontario locality. At Cobalt the deposits are generally accepted as being genetically related to a diabase dyke whereas in the Echo Bay district there is some doubt whether the silver mineralization is related to a diabase. Both deposits are thought to be late Pre-Cambrian age.

COMPARISON WITH THE ERZGEBIRGE DEPOSITS OF SAXONY AND CZECHOSLOVAKIA IN CENTRAL EUROPE

The deposits of pitchblende, cobalt-nickel minerals, and silver in the Erzgebirge area most closely resemble those of the Echo Bay district. Bastin (1917,pp.121-122) has summarized these deposits from the original works of Müller (1860); Step, Josef and F.Becke (1904), and Viebig (1905).

The Erzgebirge deposits occur as veins in and near intrusive masses of late Palaeozoic granite, with which the deposits may be genetically connected. Müller (1860) has classified the deposits as follows:

A. Older ore forming period.
    1. Veins of tin type
    2. Veins of pyritic lead-zinc type

B. Younger ore forming period.
   3. Veins of the Cobalt-Silver type with pitchblende
   4. Veins of the iron and manganese type.

It is with the deposits of type B3 that we are particularly concerned. Notable deposits of this type occur at Jaachimsthal in Bohemia, and at Schneeberg, Annaberg, and Johanngeorgenstadt in Saxony. Reid (1932, p 65) has competently described the mineralogy in the following quotation: "Veins of type 3 vary somewhat in different localities, but in general carry the following minerals: pitchblende, silver, both native and as sulphosalts, arsenides and sulpharsenides of cobalt, nickel and iron, native bismuth, antimonial minerals, including tetrahedrite, stibnite, and berthierite, sulphides, pyrite, chalcopyrite and sphalerite. Gangue minerals comprise quartz, siderite, manganosiderite, calcite, dolomite, barite, and fluorite. Pitchblende is later than the cobalt-nickel minerals but earlier than the silver ores. In the Annaberg district of the Saxon Erzgebirge, the cobalt-silver veins in many places cut and displace the earlier tin, copper and pyritic lead-zinc veins." In addition to Reid's summary it is worth noting that at Schneeberg bismuth is prevalent enough to become the major ore mineral.

From the above description, it is evident that the Erzgebirge deposits and those of the Echo Bay district, if considered collectively, are similar both geologically and mineralogically. The major discrepancies are:

(1) The association of the Erzgebirge deposits with tin minerals.

(2) At Erzgebirge the cobalt-nickel minerals are considered to be older than the pitchblende while at Great Bear Lake the pitchblende is considered the older.

COMPARISON WITH MISCELLANEOUS DEPOSITS

There are other deposits that deserve brief mention in this comparison. These are:

(1) Tin deposits of Cornwall (Pearce, 1875).

(2) Silver Islet property near Port Arthur, Ont.(Ingall, 1887).

(3) Native Silver Ores near Wickenburg, Arizona (Bastin, 1922).

(4) Silver deposits at Sabinal, Mexico (Krieger, 1935).

(5) Silver deposits at Königsberg, Norway (Beyschlag, Vogt and Krusch, 1915).

The deposits of Cornwall are notably tin and copper lodes associated with granitic intrusives. Pitchblende has been found at several localities associated with copper, cobalt, nickel, bismuth, and lead ores; at only one locality was silver found. According to Pearce (1875), the pitchblende and associated minerals, commonly occur as small veins crossing the tin lodes.

The deposits at Silver Islet, Ontario, Sabinal, Mexico, and Wickenburg, Arizona are similar enough to the cobalt deposits to warrant no further comparison.

The deposits at Konigsberg, Norway are mainly silver, believed to be supergene, and contain no pitchblende or cobalt-nickel minerals. They can hardly be compared with the Echo Bay deposits.

CONCLUSIONS

The suite of specimens studied is rather a limited collection and may not be a genuine representation of the Bonanza deposit; therefore, in evaluating the following conclusions this point should be borne in mind.

1. The magnetite is of pyrometasomatic origin and is related to the granodiorite intrusion, while all the other metallic and gangue minerals, excepting sericite, are of hydrothermal origin.

2. The order of deposition of the minerals is believed to be magnetite, quartz, hematite, carbonate, chalcopyrite, tetrahedrite, argentite, and native silver. Late hematite, quartz and carbonate may also be present in minor amounts. The exact relative age of the unknown mineral could not be determined.

3. Evidence suggests that the native silver is of hypogene origin. It occurs primarily as dendrites, but occasionally core replacements, by silver, of tetrahedrite, argentite, and chalcopyrite are also well developed.

4. The dendritic structure of the silver is inherited from rows of doubly terminated quartz prisms in a quartz gangue, or

from a rude dendritic pattern of euhedral quartz grains in a sericitic gangue. Two hypotheses have been advanced for the origin of the doubly terminated quartz prisms but both lack sustaining evidence. The rude dendritic pattern of euhedral quartz grains is thought to be replacement of the sericitic gangue.

5. The Bonanza deposit is similar to other deposits in the Echo Bay district only in the silver mineralization, wall rock alteration and relationship to intrusive bodies. The absence of pitchblende and cobalt-nickel minerals differentiates it from other deposits in the area.

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