The Replacement at the Homestake Mine

by

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## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location and History</td>
<td>1</td>
</tr>
<tr>
<td>General Geology</td>
<td>2</td>
</tr>
<tr>
<td>Description of the Deposit</td>
<td>2</td>
</tr>
<tr>
<td>Lower Barite Deposit</td>
<td>3</td>
</tr>
<tr>
<td>Upper Barite Deposit</td>
<td>5</td>
</tr>
<tr>
<td>Structure and Size of Deposit</td>
<td>5</td>
</tr>
<tr>
<td>Paragenesis of the Minerals</td>
<td>7</td>
</tr>
<tr>
<td>Results of Assays and Chemical Analyses</td>
<td>9</td>
</tr>
<tr>
<td>Petrography of the Barite Lodes and the Schist</td>
<td>10</td>
</tr>
<tr>
<td>Chemical Experiments</td>
<td>12</td>
</tr>
<tr>
<td>Origin of the Deposit</td>
<td>16</td>
</tr>
<tr>
<td>Association of Minerals</td>
<td></td>
</tr>
<tr>
<td>Evidence of Epigenesis and Replacement</td>
<td>18</td>
</tr>
<tr>
<td>Origin of the Mineralization</td>
<td>22</td>
</tr>
<tr>
<td>The Evidence as to the General Origin of Barite</td>
<td>24</td>
</tr>
<tr>
<td>Acknowledgments</td>
<td>26</td>
</tr>
<tr>
<td>Bibliography</td>
<td>27</td>
</tr>
</tbody>
</table>

## ILLUSTRATIONS

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Key Map</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Sketch of Mine</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Polished surface of Ore</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Thin Section of Schist</td>
<td>11</td>
</tr>
</tbody>
</table>
THE REPLACEMENT AT THE HOMESTAKE MINE.

Location and History.

The Homestake mine is situated in the Sinmax creek valley, about three miles from Ska-am Bay on Adams lake (fig.1). A trail connects the property with the main wagon road running between Louis Creek and Ska-am Bay.

The first work done on this mine was in 1893-4 when 20 tons of fairly high-grade ore, running 79.2 oz. per ton in silver, were shipped to the smelter at Everett, Wash. Shortly afterwards McAevoy saw the property. (1) At the time of his visit the opening from which the ore had been taken was filled with caved material, but he states that the excavation was on an irregular vein. He also mentions a "bedded rock highly impregnated with barite and galena". This statement no doubt refers to the lower barite replacement, which has been developed since then as the main ore body.

The resident engineers report for 1917 (ii) describes the underground workings as they exist today. Just before his examination the La Rose Mining Co. of Cobalt became interested in the mine, and carried on considerable development. But the Silver values found were apparently low, and the company did not take up the property. Since then no further work has been done.

General Geology.

The formation in which the mine occurs consists of metamorphosed sediments in the form of quartzites, schists and slates, called by Daly the Bastion schists. The type section of this formation is found near Salmon Arm, and the correlation with the Adams lake exposures is solely on the basis of lithological characteristics. The Bastion formation has been traced west to the North Thompson river by W.L. Uglow.

Description of the Deposit.

The Homestake mine is situated on the north side of the Simms creek valley, roughly 800 feet above the road. The principal outcrops are found on the western face of a rock gully, which has been cut by a stream passing just below the mouth of the main tunnel. The rocks dip into the mountain and strike parallel with the general attitude of the hillside. Two main deposits of barite are found in the formation and have the appearance of conformable stratified beds. This resemblance is due to the presence of bands of white and grey barite which are parallel to the general rock structure. The ore outcrops are brown due to a superficial stain of limonite, but this alteration does not extend into the barite, and specimens from the surface contain unaltered pyrite.

The country rock has a general strike of N 60°W and dips from 25-40 NE. It consists mostly of a sericitic schist.

(iv) Summary Report, G.S.C., 1921, Part A.
Sketch of Underground Workings at the Homestake Mine

Scale 1" = 30'

B, barite;

S1, Sericitic Quartzite;

S2, Sericitic or Talc Schist;

S3, Schist with Quartz eyes.
containing considerable pyrite. On weathering it becomes reddish yellow in color and breaks into thin plates. There are also several talc partings present in the schist. In the form of small lenses, or in irregular masses associated with pyrite and quartz, barite occurs throughout the schist from a short distance below to a little above the main ore bodies. Near the mine the mountain side is composed of rocky cliffs or slaty talus material, and is only slightly covered by trees or other vegetation.

**Lower Barite Deposit.**

The lower barite deposit contains the metallic minerals pyrite, sphalerite, galena, tetrahedrite and chalcopyrite. Practically all the development done occurs in this body (fig.2). The outcrop is about eight feet in width and can be followed on the surface for a distance of eighty feet. To the west it disappears under surface drift, and the eastern end is buried by creek detritus. Across the stream, about 50 feet from the last exposure, the deposit was not found. However the schist there exposed contains pyrite and barite. It seems probable that a fault follows the creek bed at this point, although no conclusive evidence was found of its presence.

The underground examination showed that faults are numerous in the mine. There is usually gouge of soft laminated nature developed parallel to the fault plane. Where the slip is small, and where the drag is visible, as when quartz veins are cut, the direction of movement may be determined. In all such
cases the faults appeared normal.

Underground it is found that the barite is cut off on the west by a large fault. This was not examined as the drift is tightly timbered and lagged at this point. But there appeared to be a wide zone of gouge similar to that mentioned above. The lamination of this material strikes N 60°E and dips 40°NW.

The examination of the rocks found exposed in the main tunnel showed that these consist mostly of sericitic and talcose schists. Near the end of the tunnel the rock is much less compact, and is probably a more schistose zone which has been altered and softened by surface waters, which drip from the faces at all points underground.

One stratum found in the tunnel is characterized by a surface studded with small eyes of quartz (33, fig.2). A similar rock was found in the drift beyond the fault. If both exposures represent the same bed, the horizontal displacement of the fault is apparent. This feature was not carefully investigated in the field.

Many quartz veins occur in the mine. Most of these appear barren, but in certain places metallic minerals and barite are found in them. In one vein, 18 inches wide, which outcrops in the creek just below the main tunnel mouth, coarsely crystalline galena appears, and in an irregular vein at the end of drift D (fig.2b), barite, pyrite and a small amount of galena were found.
Upper Barite Deposit.

The upper outcrop of barite is 12 feet in width, and is very similar to the lower one. Little of this deposit is exposed, as the outcrop is covered on both sides by drift, and the only development consists of a small crosscut 10 feet in length. At the bottom and end of this opening a large irregular mass of quartz appears.

Just above this barite body is a band of rock about 12 inches thick, containing barite, bornite, chalcopyrite, sphalerite and galena. It is also conformable to the rock structure, and is marked by the copper stain on its weathered surface. Barite is found in diminishing amounts for about 30 feet above this zone, beyond which the rock consists of a sheared pebble conglomerate with some pyrite. Still higher on the hillside unmineralized green schists and black slates appear. These continue for about 200 feet, and above them the ridge apparently consists of the massive grey quartzite common in the Bastion formation.

Structure and Size of Deposit.

When the whole mineralization at the Homestake mine is considered, the shape of the baritic zone appears to be cross-cutting with respect to the country rock. This statement refers to the general shape of the schists that are mineralized, as of course the two main ore bodies, as well as several small similar horizons, are conformable to the attitude of the rocks in the locality.
Measured perpendicular to the strata, the extent of the mineralized schist is at least 200 feet. Barite disappears a short distance above the upper ore body, but from there down was found in varying amounts as low as 30 feet below the main adit, beyond which the rocks were not carefully examined.

The main ore body, which should be as extensive in this direction as any part of the baritic zone, does not continue very far along the strike of the country rock, as it outcrops for only 80 feet. It is probable that this deposit is cut off on both sides by faults, but for certain reasons it does not seem likely that the barite body ever had a great lateral extent. The faults are obviously later than the mineralization, and also of small magnitude, since barite occurs in the schist beyond them. That is, the offset portions of the barite deposit must occur near the mine and carry values. It follows, then, that if they were of large lateral extent, they would no doubt have been discovered and developed. Since there is no record of this, the inference is that the ore bodies beyond the fault are small, probably due to a rapid falling off of the mineralization.

No evidence was available as to the extent of the baritic zone in the direction of the dip of the country rock. However, from the indications above, it is probable that the shape of the whole mineralized mass is irregular, and not conformable to the structure of the rock formation.
(7)

Paragenesis of the Minerals.

Polished specimens of average ore were examined and found to contain sphalerite, pyrite, galena, tetrahedrite and chalcopyrite. The size of grain is small, and usually the total content of metallic minerals is under 10%. Barite from the small mineralized zone above the upper barite deposit was found to contain bornite, chalcopyrite, galena, sphalerite and pyrite, and the amount of the copper-bearing minerals is much greater than in the main ore bodies.

The metallic minerals usually occur in reticulate form between the grains of barite, and have a very irregular outline. Separate particles do not appear elongated parallel to any one direction in the barite. However, the metallic as a whole are concentrated in certain zones which are conformable to the apparent stratification of the ore.

The paragenesis is hard to determine, as the small amount of the metallic minerals has allowed them to be widely disseminated. There is no evidence of any mineral, or group of minerals, having been introduced distinctly later than the rest, or from a different source. On the contrary, the metallic minerals appear rather evenly distributed in all the ore examined, and no marked replacement of one mineral by another was observed. However, it seems probable from the examination that the minerals were deposited in regular order, probably from different phases of mineralization of solutions from the same source. (The
FIGURE 3
Polished Surface of Baritic Ore.

MAG 500 DIAM

G, galena,
S, sphalerite,
P, pyrite,
T, tetrahedrite.

Black, barite and pitting.
above statements refer only to relations between the metallic minerals, as there is evidence to show that this group as a whole is later than the barite. This feature will be discussed later). The evidence on which the succession of the metallic minerals is based is the occurrence of small projections of one mineral in another.

On this evidence, the following order of deposition was determined, (beginning with the oldest mineral), pyrite, sphalerite, galena and tetrahedrite. Pyrite tends to be rather equidimensional and has no distinct veinlets in the barite. Sphalerite is more irregular and in places projections of this mineral almost surround barite. Galena is found completely enclosing barite, and is characterized by its fine reticulate structure. It occurs in veinlets cutting the barite. Tetrahedrite, where present, is usually found at the edges of galena grains, with small projections into that mineral. (These features can be seen in the camera lucida reproduction shown in figure 3). Chalcopyrite in the average ore is present in amounts less than 0.3%, (calculated from a quantitative chemical analysis, with allowance being made for the copper in tetrahedrite). Its time relation to the other metallic minerals is not clear.

The metallic minerals appear to be of later deposition than the barite. This is shown by the description given above, and by the fact that the metallic minerals appear concentrated along certain planes in the barite, suggesting that their
Deposition was from solutions working along channels in the barite.

Certain other relations, which will be found described later under their proper headings, will be used here to complete the statement of the paragenesis. In a polished section pyrite was found in a regular network of veins apparently along cleavage planes in the barite. In certain thick sections quartz was found which is of contemporaneous deposition with the barite. However, most of the quartz appears to have been deposited from the last stages of the mineralisation, since it is so common as veins cutting the ore bodies.

Leaving quartz out of the list, the paragenesis of the main ore minerals is: barite, pyrite, sphalerite, galena and tetrahedrite.

**Results of Assays and Chemical Analyses.**

The analysis of a typical specimen of baritic ore is:

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag</td>
<td>0.03</td>
</tr>
<tr>
<td>Fe</td>
<td>0.70</td>
</tr>
<tr>
<td>Mn</td>
<td>5.30</td>
</tr>
<tr>
<td>Cu</td>
<td>0.30</td>
</tr>
<tr>
<td>Zn</td>
<td>1.00</td>
</tr>
<tr>
<td>As</td>
<td>0.20</td>
</tr>
<tr>
<td>Sb</td>
<td>0.10</td>
</tr>
<tr>
<td>S (in sulphides)</td>
<td>2.40</td>
</tr>
<tr>
<td>SiO₂</td>
<td>5.00</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>2.10</td>
</tr>
<tr>
<td>Na₂O</td>
<td>55.00</td>
</tr>
<tr>
<td>SO₃</td>
<td>27.10</td>
</tr>
<tr>
<td>CaO</td>
<td>0.80</td>
</tr>
<tr>
<td>MgO</td>
<td>0.60</td>
</tr>
<tr>
<td>O &amp; undetermined</td>
<td>1.37</td>
</tr>
<tr>
<td></td>
<td>100.00</td>
</tr>
</tbody>
</table>
Fire assays for silver were run on several specimens. It was found that those, which, under the microscope, were seen to contain the largest amount of tetrahedrite, also carry the highest silver values. That the content of galena or sphalerite has little relation to the amount of silver present is shown by the following comparison.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Ag (oz. per ton)</th>
<th>Pb (%)</th>
<th>Zn (%)</th>
<th>Tetrahedrite (app.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H14</td>
<td>19.8</td>
<td>0.5</td>
<td>3.1</td>
<td>1.5%</td>
</tr>
<tr>
<td>H10</td>
<td>4.0</td>
<td>7.0</td>
<td>15.0</td>
<td>very little</td>
</tr>
</tbody>
</table>

A small piece of more or less pure tetrahedrite broken from a specimen ran 160 oz. per ton in silver. Galena similarly analysed only carried 30 oz. The conclusion is, therefore, that the silver value of the ore is determined by the amount of tetrahedrite present.

**Petrography of the Barite Lodges and the Schist.**

Both calcite and quartz were present in all the specimens of sericitic schist examined in thin section. In general there is an arrangement into areas of almost pure calcite and those of dominant quartz. Calcite occurs mostly in zones of large interlocking grains with secondary twinning well developed. The quartz grains show the same pattern but are individually much smaller. With them can be seen a little calcite and a large amount of sericite, (which is poorly developed in the zones of calcite). A few crystals of orthoclase, of about the same size as the calcite grains, are associated with the quartz. These are considerably altered to sericite, but
FIGURE 4

Thin Section of

SERICITIC SCHIST

Mag. 125 diam.

Pyrite, black.
Calcite, yellow.
Sericite, shred-like.
Quartz, white.
their outline is still distinct, and the Carlsbad twinning plane can be clearly seen. A few grains of plagioclase were also seen in the rock, and are fresh in appearance.

Pyrite is present in considerable quantity and is distinctly a replacement of the schist. Square and triangular sections are common, and these truncate indifferently grains of calcite, quartz and sericite. Figure 4 shows a crystal of pyrite in the schist which contains a quartz remnant at its center.

The schists were probably formed from beds of sandstone containing impurities of clay and calcareous material. The amount of original ferruginous matter was probably small, since the metamorphism produced sericite and talc, both of which are deficient in iron. The difference in size between the grains of calcite and quartz is to be expected, since under deformation quartz granulates whereas calcite takes up the strain by internal, molecular rearrangement, and also since recrystallization is more marked with calcite than with quartz. A comparison of the average texture of quartzites and marbles that have been subjected to the same stress shows the effect of this difference in development. The metamorphism that produced the schistosity was of such a nature as to form sericite from the clay and sand, but not severe enough to cause the formation of lime silicates.

In the thin sections of the baritic ore only a few grains of calcite were found, and these are all in one slide. Quartz occurs in all the specimens examined, but in small amounts.
The grains are small, about the same size as those of quartz in the schist, and occur in little groups, with sometimes a few shreds of sericite in close association. Where there was sufficient mica to get two particles near enough to one another for comparison, they were found to be in more or less parallel orientation.

The barite is in medium-sized grains, which are well interlocked and show no twinning. The size of the barite grains is very nearly the same as those of the calcite in the schist. The grains of barite are of very uniform size, and show no zonal distribution, either according to size or crystallographic orientation. A few minute inclusions were found in the barite. Their interference color is usually high, and they are similar to calcite in many ways. They are therefore thought to consist of that mineral.

In several slides quartz was noticed of larger size than the ordinary grains of that mineral found in the ore. Moreover it is not found associated with them in the little groups in which they usually appear. The outline of this vein quartz, as it is considered to be, is very irregular, and it was found intergrown with several small barite grains, which extinguished at the same time, giving the appearance of micropogmatitic structure. This quartz was therefore probably deposited simultaneously with the barite.

**Chemical Experiments.**

An effort was made to find some method of differentially
staining or marking barite and quartz, which are the principal gangue minerals in the mine. The object of this endeavor was to learn the time relationship existing between these minerals.

By treating a precipitate of barium sulphate, the following facts were learned.

1. Barium sulphate is practically insoluble in all the common acids, including hydrofluoric.

2. In a hot, concentrated solution of potassium carbonate, barium sulphate is completely changed to barium carbonate in a few hours.

3. Under similar conditions, silica remains unchanged.

4. A hot, concentrated solution of potassium chromate does not attack barite to any appreciable extent.

Two methods of selectively treating barite in the presence of quartz follow from the above facts.

1. Since hydrofluoric acid attacks quartz and not barite, the surface of the former mineral can be roughened without marring the polish of the barite. The reaction proceeds at the most desirable rate when the specimen is just warm. The acid may be dropped on the surface directly, if it is not too large, and can easily be made to form a thin film over the specimen. After a certain time, usually about 30 seconds but depending on the temperature of the specimen, the surface can be washed free from the acid, and will be found to be etched over the quartz. If the dried surface is now rubbed with a cloth on which some rouge, yellow ochre, or other colored powder has been placed, the quartz will become colored, whereas the smooth surface of
the barite is unchanged.

By heating a specimen in a hot, concentrated solution of potassium carbonate, barite will be attacked and not quartz. The barium carbonate formed can then be removed with hydrochloric acid, leaving a roughened surface on the barite. Or the barium carbonate can be changed to yellow barium chromate by placing the specimen in a solution of potassium chromate to which a few drops of hydrochloric acid have been added. The difficulty here is that the carbon dioxide formed may shift the barium chromate, which does not adhere to the surface of the specimen. The disadvantage of the whole method is that, whereas the reaction between a hot solution of potassium carbonate and a finely-divided precipitate of barium sulphate proceeds rapidly, a polished surface of barite is decomposed slowly and unevenly. However as barite is attacked with great violence by molten potassium carbonate, it would no doubt be possible to change that mineral to any required extent by placing the specimen in a solution of potassium carbonate at high temperature. This temperature could be obtained by heating the solution under pressure, and by increasing the concentration of the potassium carbonate.

A method of staining, the possibilities of which were drawn to the attention of the writer by Dr. Winchell of the University of Wisconsin, involves the use of selenium oxychloride, which is said to have the property of preferentially wetting barite. This substance is a yellow liquid, which fumes on exposure to air, and is decomposed by water. It crystallizes
Selenium oxychloride was prepared by the writer according to the method introduced by Cameron and Macallan. (v) A large glass tube with three down-bends in it was used. In the first two of these were placed selenium and salt, respectively, in the ratio given by the equation:

\[ 2\text{SeO}_2 + 2\text{NaCl} = \text{SeOCl}_2 + \text{Na}_2\text{SeO}_3 \]

The bend containing the selenium was connected to an oxygen tank through a drier of pumice and sulphuric acid. The other end of the glass opened to the air through a drier of calcium chloride. On being intensely heated in the stream of oxygen, the selenium burned with a blue flame to selenium oxide, which deposited as slender white crystals in the cool part of the tube. After all the selenium had been converted to the oxide, this was driven over into the salt with the flame. On heating the mixture in the second down-bend selenium oxychloride was formed, which was distilled from the sodium selenate into the third down-bend of the glass tube. To keep the selenium oxychloride absolutely dry, the part of the tube containing it was cut off with the flame, sealing the ends at the same time.

Of the three schemes, two for etching and one for staining, the treatment with hydrofluoric acid was found most satisfactory. Specimens of the vein material and of the mineralized schist were examined by use of this method. It was found that in certain places quartz surrounds barite, and occurs as

small veinlets cutting through masses in the rock which consist largely of barite and pyrite. However in other specimens the intergrowth between barite and quartz suggests contemporaneous deposition. In one specimen of the mineralized schist pyrite appears in a regular network of veinlets which appear to follow the cleavage planes in the barite.

These facts indicate that pyrite is later than the barite, and also show that quartz was present in probably all the stages of the mineralization. For quartz was found which was apparently deposited at the same time as the barite, both in slides and polished surfaces, and in other places quartz appears with pyrite in veinlets cutting barite. There is also a large amount of quartz in veins which cut all the other introduced minerals.

Origin of the Deposit.

Association of Minerals.

The relations found seem to show that all the minerals of the ore came from the same immediate source. The evidence is as follows.

1. Barite, quartz and pyrite appear together all through the schist. Quartz, in different places, appears contemporaneous in deposition with both pyrite and barite. Also in the ore pyrite is closely associated with the other metallic minerals, and in certain veins barite, quartz, pyrite and galena all appear closely intergrown. Although there appears to be a general order of deposition such as mentioned under paragenesis,
the minerals, especially quartz, seem to overlap one another in their time relations. This suggests a common source for all the minerals.

2. All the baritic ore contains the metallic minerals in very even distribution, and no barite was found which did not contain some of them. This indicates that all of the mineralization came from the same center of distribution.

3. The way in which the metallic minerals are uniformly scattered among one another shows their close relationship.

4. The metallic minerals occur in certain zones parallel to the banding in the barite, which shows that they were deposited from solutions that worked along one set of channels. It does not seem probable that the metallics replaced impurities in the barite, as the shape of the minerals and the occurrence of small grains of quartz in the zones of metallic minerals suggests that the solutions had followed the paths provided by the presence of unreplaced sandy laminae in the original stratum. If any one of the metallic minerals were from a different source than the rest, a relative concentration of this mineral would be expected in some locality. Since this is not the case it seems clear that the same conditions must have prevailed while all were being deposited, which suggests their common source.

Opposed to this evidence is the occurrence of the relatively pure barite bodies that compose the main ore deposits, and the numerous barren quartz veins which cut these deposits and the country rock. But these facts are not incapable of an
explanation by an hypothesis which postulates only one source of mineralization. For it is known that, in replacement, the walls of the channels may to one substance and not to another. Moreover, silica appears to be one of the substances largely confined to the walls of the vein. (vi) That is, in the case of the Homestake mine, the first mineralizing solutions may have been poor in silica, which was mostly kept within the fissure. Later the solutions contained much quartz, as shown by the occurrence of pure veins of that mineral. However a little galena, pyrite and barite were still present, as they are found in some of these veins. Such an hypothesis would account for the traces of vein quartz in the baritic ore, and also for the large amount of quartz intergrown with barite and pyrite in the schist, where deposition was probably not so much by metasomatic action as by the filling of fissures and formation of lenticular masses in the schist through the force of crystallization and the pressure of the solutions.

Evidence of Epigenesis and Replacement.

The foregoing discussion has presumed that the minerals of the ore have been introduced into the position they now occupy since the rocks were formed, and also that the main ore bodies are replacements. The evidence leading to this assumption will now be given.

Concerning the epigenetic nature of the deposit little proof seems necessary. The field examination showed that the

mineralized zone as a whole is irregular, and does not correspond to any broad baritic horizon in the rock formation. This of course indicates that the barite is not epigenetic. The facts given below to show that barite is a replacement will also prove it is epigenetic. As pyrite is clearly a replacement of the schist, its introduction is obvious, and there can be no doubt about the epigenetic origin of the rest of the metallic minerals.

The facts showing that the barite ore bodies are replacements are as follows:-

1. The mere fact that certain relations can be readily explained by presuming that replacement has occurred is in itself evidence of the truth of the supposition.

2. The texture of the barite, which consists of crystalline grains perfectly interlocked, is typical of metasomatic action. There is no tendency to the crustification common in cavity fillings.

3. The stratified appearance of the ore, which is mostly due to the banding of the barite into white and grey layers parallel to the bedding of the country rock, is no doubt a structure preserved by replacement, since the barite of the veins is white. The even size and uniform distribution of the grains of barite shows that the banding is not due to the crystallization of that mineral, but to a difference in color which is independent of the texture of the ore. This fact confirms the supposition that the banding is a preserved structure.
4. The occurrence of isolated grains of quartz and sericite indicates replacement, since these remnants would obviously be unsupported under any other form of deposition. The orientation of the shreds of mica, and the size and grouping of the quartz grains show a pattern very similar to that displayed by these minerals in the country rock.

5. Particles occur in some of the barite grains which are probably unreplaced kernels.

Conclusive evidence on the matter of replacement would result from the examination of a suite of specimens showing the gradation from ore to country rock. Unfortunately such a perfectly graded set of samples was not obtained. However, one of the ore specimens seems to represent an intermediate stage. This shows a few grains of calcite in the areas characterized by the presence of quartz and sericite. By a further replacement of the calcite, the texture would become that of the ordinary baritic ore.

This occurrence, and the relations set forth above, make it reasonably certain that the main ore bodies are replacements.

Concerning the probable character of the stratum in which the deposition occurred, the following facts are of importance.

1. The examination of thin sections showed that the barite grains are of approximately the same size as the calcite constituents of the country rock. In the metasomatism of fossils the organic structure is often preserved by a variation in the
dimensions of the replacing grains, which show that it is possible for the size of the replaced grains to affect that of the metasomes. Where the replacement has taken the form of a disseminated deposit, this is not the case, as the pyrite crystals in the rock are often much larger than the original constituents of the rock. But where replacement advances more or less as a wave, as was probably the case with the barite, the number of centers of crystallization would no doubt be considerably affected by the texture of the substance replaced. The fact that the texture of the barite resembles that of the calcite found in the country rock, and not that of the quartz, is therefore an indication that a bed of limestone has been replaced.

2. The small amount of sericite in the ore suggests that a relatively pure stratum was the host, as it is hardly likely that this mineral was replaced to any great extent.

3. The kernels found in certain grains of barite resembled calcite and not quartz.

4. The specimen of ore, mentioned above as being a case of incomplete replacement, will only constitute an intermediate stage to the typical ore on the hypothesis of a preferential replacement of calcite with regard to quartz. The adoption of an hypothesis that posulates the replacement of quartz in such a sample would develop an ore containing calcite and no quartz. As just the opposite is true, the preferential replacement of calcite is indicated.

Again the absence of a gradational set of specimens renders the case inconclusive. It is of interest, however, to
note that the outward appearance of the baritic ore greatly resembles the grey limestone found elsewhere in this formation. On the whole it seems most likely that a relatively pure bed of crystalline limestone was replaced. The well known susceptibility of this type of rock to metasomatic action makes this supposition probable. Also such an hypothesis readily accounts for the bedded appearance of the main ore bodies and the smaller highly mineralized horizons.

**Origin of the Mineralization.**

The origin of the mineralizing solutions is not clear. It has been stated above that all the minerals seem to have come from the same immediate source, but certain facts discovered are hard to reconcile to the hypothesis of a common ultimate origin.

No field relations were found that would indicate the source of the mineralizing solutions. However two general features may serve as suggestions. Certain structural relations show the possibility of a younger granite underlying the district. Also there is not known in the locality any deposit of pure barite, or baritic sediments, from which that mineral might have been dissolved by surface waters.

The nature of the ore itself suggests deposition at moderately high temperature and pressure. The absence of crustification or any open cavities, the even texture of the ore, and extent of metasomatic action all indicate that the deposit was not formed by meteoric waters at low pressure.

The mineral composition of the ore gives evidence of
Beth Bypegene end sapergene origin, A comparison of the lead ores of the Slocan district with those of Missouri and Wisconsin shows that in hypogene deposits of this type high silver values and black sphalerite are common, whereas in ore bodies formed by meteoric waters the galena is very low in silver and light-colored resin sine blende is the rule. Hence the presence of galena and tetrahedrite, both rich in silver, and black sphalerite suggests deposition from solutions of magmatic origin. But, on the other hand, barite is considered by most authors to be only of supergene origin.

 Except for the presence of barite, all the indications point to the hypogene origin of the deposits. The existence of this mineral in the ore could be explained by two hypotheses which do not require its origin to be hypogene. Barite might have been leached by the ascending solutions in their journey through the rocks, or a mingling of barite-bearing surface waters with the magmatic solutions might have occurred. Since barite is appreciably soluble only in solutions containing a large amount of alkaline carbonates and an excess of carbon dioxide, the leaching by ascending solutions is more probable, as their composition is more commonly of the alkaline nature required for the reaction. However this hypothesis must be considered unlikely, as there are no beds of barite known in the district which would provide the source for such leaching. (Such a supposition would require a more or less concentrated deposit of barite in the path of the magmatic solutions, as these are not thought to wander very far in their journey upwards, but to
be rather confined to the channel walls). The possibility of
the mingling of different solutions from above and below is also
to be dispensed with, since, in addition to reducing the temper-
ature, the presence of meteoric waters would necessitate low
pressure at the time of deposition. For it is clear that in
surface waters, (which usually contain no great amount of alkal-
ine carbonates nor a big excess of carbon dioxide), the solubil-
ity of barite is small, and free channels would therefore be
necessary for the rapid circulation of the large amount of
meteoric water required to provide the barite. To put the case
briefly, it is hard to reconcile deposition at high pressure,
which seems to be the condition at the Homestake mine, with the
presence of a large supply of circulating meteoric water.

The Evidence as to the General Origin of Barite.

Lindgren states that barite is not a mineral of igneous
origin, and that it is not found in contact metamorphic deposits.
(vii) Since the relations at the Homestake mine seem to show
that it is there of hypogene origin, it might be advisable to
carefully examine the evidence advanced to show that barite can-
not be of igneous origin.

This evidence may be said to consist of two general
arguments. One is based on field relations, the other on
chemical data.

The field relations in the majority of the barite
deposits described in the literature show that this mineral is
of supergene origin. However it is probable that the greater part of the reports are concerned with commercial deposits, which must necessarily be very pure. The amount of the barite which occurs as gangue in metallic ores is no doubt greater than that of the valuable deposits, but because of its contamination with sulphides, its usual occurrence away from industrial centers, and a variety of other reasons, it is not commonly of commercial value. Owing to the wide distribution of this type of barite, it seems unlikely that all if it could have been derived from the strata traversed by the solutions. A few specific instances may be given in which the barite appears to be definitely of igneous origin. S.J. Schofield found barite apparently as a replacement of part of a mass of slate that had been engulfed in an igneous intrusive at the Britannia mines.

(viii) T.C. Holland describes a network of veins of quartz and barite which he regards as magmatic differentiates. (ix) Hanson, of the Geological Survey of Canada, believes that the barite at the Dolly Varden mine is hypogene. (x)

The chemical evidence put forward to show that barite cannot be of magmatic origin is the fact that barite and quartz cannot exist together in a rock melt, as barium silicate and sulphuric oxides are formed. (xi) It seems clear that barite

(viii) Personal Communication.
(x) Personal Communication.
and quartz can exist together in solutions at fairly high temperature, and also that the elements composing these minerals do occur in magmas. The chemical composition of the magma would largely determine the order of crystallization of the minerals. If conditions were such that part of the barium content would remain in the unsolidified portion of the magma, the nature of the minerals in this liquid remnant would be greatly affected by the conditions of temperature and pressure, and the presence of mineralizers, especially water, since silica appears to be not as active in aqueous solutions as in dry melts, and the ordinary acids are not effective without the presence of water. It seems probable that results found from experiments with rock melts cannot be directly applied to magmas, as it is known that siderite, for instance, occurs in veins of igneous origin, and yet if iron carbonate is melted with silica, iron silicate and carbon dioxide will be formed.

The above discussion shows that there is no definite grounds on which the hypogene origin of barite can be excluded. Since the relations at the Homestake mine strongly suggest a deep seated source for all the mineralization, there appears to be no cause for not accepting this interpretation.

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