THE MINERALOGY OF SOME OF THE GOLD MINES
OF BRITISH COLUMBIA

By

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of
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INTRODUCTION
ACKNOWLEDGMENT

The writer wishes to acknowledge the invaluable instruction and suggestions given to him by Doctor H. V. Warren, of the University of British Columbia, under whom this work was carried out.

The assistance of Mr. E. P. Davis was also greatly appreciated.
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</thead>
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THE MINERALOGY OF SOME OF THE GOLD MINES
OF BRITISH COLUMBIA

INTRODUCTION

The following reports are based on the megascopical and microscopic study of polished sections of ore from some of the gold mines of British Columbia.

The chief objects of the work were to study and determine the mode of occurrence of the gold in various mines and to ascertain any similarities or differences in the mineralogy of the individual mines in each district, and between each district.

Laboratory procedure consisted of cutting, mounting and polishing sections of ore from different mines. These sections were then examined under the microscope, and the various minerals and their relationships were determined. The identification of the minerals was carried out by means of etch tests and microchemistry.

Due to the extreme friability of some ores, such as Zeballos and Cariboo Gold Quartz, a process known as "impregnating" was employed. This consisted of half-submerging the section to be mounted in an impregnating fluid. The section and fluid were then placed under a partial vacuum for about twenty minutes to allow the fluid to penetrate into the interstices of the ore, and then "cooked" in an electric oven.
at 80 degrees centigrade until hard. The section was then ready to mount.

Parageneses for each mine have been suggested, and graphical illustrations given. It must be kept in mind, however, that the breaks between the various periods of mineralization are not necessarily as sharp as is implied by this method. In some deposits it is known that two or more periods of mineralization have occurred, separated by long time intervals, while in others, mineral sequences have been deposited continuously from the same solution over a period of time. Also, movement along a vein may take place at any time, and deposition need not necessarily stop during these periods of stress.

It is the writer's opinion that criteria obtained only from a microscopic examination of polished sections of ore are not sufficient to warrant a conclusion as to whether the deposits are of high, medium or low temperature. A complete study in the field of wall-rock, veins and country-rock as well as a microscopic study of thin sections, is essential for an accurate determination of the temperature conditions existing at the time or times of deposition. Therefore, in the following reports, which are the result of polished section work only, the suggested temperatures of deposition are derived only from the variety and type of minerals present in the sections, and serve only to compare the various deposits.

In most cases, no distinction has been made between gold and the gold-silver alloy "electrum." It is probable that the silver content of some of the gold is high enough for it to be called electrum.
PART A

SHEEP CREEK MINING DISTRICT
PART A: SHEEP CREEK MINING DISTRICT

Description of the District

Location.

The Sheep Creek Mining Camp is located about eight miles southeast of the town of Salmo in the Kootenay district of southeastern British Columbia. A ten mile automobile road connects the mine with the town of Salmo on the Great Northern Railway.

General Geology.

The following table shows the geological formations of the Salmo map-area, British Columbia, as mapped by Walker.¹

<table>
<thead>
<tr>
<th>TABLE OF FORMATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mesozoic</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Late Pre-Cambrian</strong></td>
</tr>
</tbody>
</table>

There are four of these rock formations exposed in the Sheep Creek Mining Camp.

<table>
<thead>
<tr>
<th>Post-Triassic</th>
<th>Nelson Batholith</th>
</tr>
</thead>
<tbody>
<tr>
<td>Late Pre-Cambrian</td>
<td>Pend d'Oreille series.</td>
</tr>
<tr>
<td></td>
<td>Reno formation.</td>
</tr>
<tr>
<td></td>
<td>Quartzite Range formation.</td>
</tr>
</tbody>
</table>

The oldest rocks in the district are those of the Quartzite Range formation which consists essentially of massive, white quartzite in the lower part. Overlying this is 200 feet of argillaceous quartzites and slaty argillites, and above the argillite is more quartzite with a final top member of interbedded quartzites and slates.

The Reno formation varies greatly in character. The lower part is composed of interbedded quartzites, argillites, limestone and schists. The upper part of the formation consists of brittle quartzites.

Above the Reno formation in the table is the Pend d'Oreille series. This is composed chiefly of dark grey to black phillites. In the lower part of the series the phillites grade into beds of dark grey quartzite and four well-defined limestone horizons. Where the phillites have contained carbonaceous matter and are sheared, they give place to graphitic schists.

The portion of the Nelson batholith exposed near the mining camp is porphyritic granite composed mainly of flesh-coloured orthoclase.
Structural Geology.

The four mines studied in this area are all located on the steeply dipping west limb of an asymmetrical anticline. Faults are exposed in some parts. The gold-bearing fissures in the vicinity of Sheep Creek are small fault fissures. Minor faults with displacements of only a few feet are exposed in many of the mine workings. Some larger faults with considerable displacement exist, but are not important in regard to these properties.

Mineralization.

The mineralizing solutions that formed the mineral deposits are believed to have come from a granitic magma at a late stage of differentiation and crystallization. Aplite tongues from it are cut by the mineral veins, and the only igneous rock to cut the mineral occurrences are lamprophyre dykes. Hence, the age of the mineral deposits can be placed as occurring at a late stage in the intrusion of the Nelson batholith of post-Triassic age.

The mineral deposits consist of fissure veins carrying values principally in gold with minor amounts of base metals. The fissures are tight and are not known to be of commercial value where they cut softer rocks such as argillite and limestone, but where they cut the brittle quartzites of the upper Reno formation and Quartzite Range formation, ore-shoots may occur. The formation of ore-shoots is further controlled by a pinching and swelling of the fissures caused by movement along them, both horizontal and vertical.
The original vein matter consisted of quartz, pyrrhotite, pyrite, sphalerite, galena and free gold. Oxidation of the sulphides extends to considerable depths with a certain amount of enrichment an apparent result.

**The Queen Mine**

*(Sheep Creek Mine)*

**Description of the Property.**

**Location.**

The Queen property, owned by E. V. Buckley and associates, includes the Queen, Yellowstone, Hide Away, and Alexandra groups, consisting of fifteen Crown-granted claims, namely: Alexandra, Argyle, Burlington fraction, Bullion, Edward, Hide Away, Lewiston, Mat, Malwaaz, Niagara, Pat, Placer fraction, Queen, Wolf, Yellowstone.

The property lies along the valley of Wolf creek, immediately above its junction with Sheep creek.

**Economic Geology.**

The property lies in rocks of the Pre-Cambrian Reno and Quartzite Range formation.

Four east-west, gold-bearing fissures occur on Queen ground. These are the Yellowstone, Queen and Hide Away, all of which cut rocks of the Reno formation, and the Alexandra, which is in the Quartzite Range formation.

The Yellowstone outcropped low down on the ridge southeast of the junction of Sheep and Wolf creeks. So far as is known, only brown iron oxides and free gold occurred in this fissure at the surface.

The Queen fissure outcrops on the west side of
Wolf creek, parallel to and south of the Yellowstone. This fissure is oxidized down to about the level of Wolf creek.

The Alexandra fissure, on the east side of Wolf creek, outcrops about 1600 feet south of the Queen, and is oxidized to some depth.

Between the Queen and Alexandra on the east side of Wolf creek, is the small Hide Away fissure.

These fissures have been filled with quartz and sulphide minerals.

Mineralogy.

**Introduction.**

Thirteen polished sections of ore from the Queen (now Sheep Creek) mine were studied microscopically. These sections were prepared by Mr. J. W. McCammon, whose system of numbering has been maintained by the writer, and is tabulated below.

Sections M1 to M4 consist of ore from the old Queen workings, while Sections M5 to M13 consist of ore from the newer workings.

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>From the 760 level, Stope west.</td>
</tr>
<tr>
<td>M2</td>
<td>From the 810 level, Stope east.</td>
</tr>
<tr>
<td>M3</td>
<td>From the 520 level, Stope west.</td>
</tr>
<tr>
<td>M4</td>
<td>From the west ore-shute No. 2.</td>
</tr>
<tr>
<td>M5</td>
<td>From No. 2 level. 81 vein.</td>
</tr>
<tr>
<td>M6</td>
<td>From No. 2 level. 83 vein.</td>
</tr>
<tr>
<td>M7</td>
<td>From No. 2 level. 92 vein.</td>
</tr>
<tr>
<td>M8</td>
<td>From No. 3 level. Queen vein.</td>
</tr>
<tr>
<td>M9</td>
<td>From No. 5 level. 75 vein.</td>
</tr>
<tr>
<td>M10</td>
<td>From No. 5 level. 76 vein.</td>
</tr>
<tr>
<td>M11</td>
<td>From No. 7 level. 81 vein.</td>
</tr>
<tr>
<td>M12</td>
<td>From No. 7 level. 92 vein.</td>
</tr>
<tr>
<td>M13</td>
<td>From No. 9 level. Queen vein.</td>
</tr>
</tbody>
</table>
The following metallic minerals listed in order of abundance, were determined to be present in the sections.

1. Pyrite,
2. Pyrrhotite,
3. Sphalerite,
4. Galena,
5. Chalcopyrite,

Quartz with minor amounts of calcite were the only gangue minerals recognized.

Description of the Minerals.

**Pyrite.** Two generations of pyrite occur in this ore. The earlier pyrite was probably the first sulphide to be deposited. It occurs as cubic crystals and as anhedral masses. Quartz fills all spaces between the euhedral grains and surrounds the anhedral masses. In places where the pyrite is broken, quartz and other sulphides fill the fractures.

The later generation of pyrite occurs (Section M8) filling a fracture in pyrrhotite, in Section M3 filling a fracture in sphalerite and also in quartz. In all sections, small, rounded inclusions of pyrrhotite occur in the early pyrite.

**Quartz.** Quartz, like the pyrite, occurs as two generations. The first generation, which is fractured, occurs filling fractures in pyrite and filling the spaces between the pyrite crystals. The second generation of quartz occurs filling fractures in sphalerite in Section M3.

**Pyrrhotite.** Pyrrhotite occurs in large masses, and as minute inclusions in pyrite. The mineral is relatively abundant in all sections. It was observed filling fractures in sphalerite and as irregular masses in quartz. Intimate
association with chalcopyrite was also noted.

**Sphalerite.** Sphalerite is abundant in most sections. It occurs as large masses, and in fractures in quartz and pyrite. Chalcopyrite blebs are numerous in the sphalerite and larger masses frequently occur near the boundaries of the sphalerite.

**Galena.** Galena is not as abundant as sphalerite, with which mineral it is quite often in contact. In most cases these two sulphides appear to be contemporaneous, but in Section M6, galena veins the sphalerite. The deposition of galena may have continued longer than that of the sphalerite. Galena was also observed filling fractures in pyrite.

**Chalcopyrite.** Chalcopyrite occurs as blebs in sphalerite, in masses associated with pyrrhotite, in quartz fractures, and to some extent filling fractures in pyrite.

**Gold.** Gold occurs as the gold-silver alloy "electrum." Electrum is relatively abundant in some sections and absent in others. It occurs in the following ways:

1. In fractures in quartz with galena or sphalerite.
2. Included in sphalerite.
3. At quartz-sphalerite contacts and quartz-galena contacts.

**Calcite.** Calcite occurs in small quantities filling fractures in all other minerals and sometimes along the boundaries of two minerals.

**Paragenesis.**

The following paragenes is suggested.

Quartz, pyrite and some pyrrhotite were the first minerals to be deposited. A period of fracturing followed,
during which the pyrite and quartz were considerably shattered. These fractures were then filled by some pyrrhotite and sphalerite, which were also fractured later. The second period of fracturing was followed by the deposition of more pyrite and quartz, together with pyrrhotite, sphalerite, galena, and electrum. Calcite was probably the last mineral to precipitate.

**Graphical representation of paragenesis**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td></td>
</tr>
<tr>
<td>Pyrite</td>
<td></td>
</tr>
<tr>
<td>Pyrrhotite</td>
<td></td>
</tr>
<tr>
<td>Sphalerite</td>
<td></td>
</tr>
<tr>
<td>Galena</td>
<td></td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td></td>
</tr>
<tr>
<td>Electrum</td>
<td></td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
</tr>
</tbody>
</table>

**Distribution and size of gold particles.**

The study of the ore from this mine indicates that the gold was deposited late in the mineralogical sequence. It is irregularly distributed and is associated chiefly with galena and sphalerite, its deposition probably being contemporaneous with, and later than, these two sulphides. The size of the particles varies from 3 microns to 160 microns, with an average of about 20 microns. Most of the grains appear as irregular patches in other minerals or as short veinlets in fractures.

**Description of sections.**

The following is a list of the sections with their constituent minerals. The minerals are separated according to their abundance in each individual section.

**Section N-I:**
- Major -- Pyrite and Quartz.
- Minor -- Chalcopyrite and Pyrrhotite.
- Rare -- Calcite.
Section M-1 (cont.):

Two generations of pyrite occur in this section.

Section M-2: Major — Quartz.
Minor — Pyrrhotite.
Rare — Chalcopyrite and electrum.

Section M-3: Major — Quartz and sphalerite.
Minor — Pyrite and galena.
Rare — Chalcopyrite and electrum.

Two generations of pyrite occur in this section.

Section M-4: Major — Pyrite.
Minor — Quartz and sphalerite.
Rare — Pyrrhotite and chalcopyrite.

Section M-5: Major — Quartz.
Minor — Galena and Pyrite.

Section M-6: Major — Sphalerite.
Minor — Quartz, pyrite and galena.
Rare — Electrum and chalcopyrite.

Electrum is relatively abundant in this section.

Section M-7: Major — Pyrite, quartz and sphalerite.
Minor — Galena and chalcopyrite.

Section M-8: Major — Pyrite, quartz and pyrrhotite.
Minor — Sphalerite.
Rare — Electrum.

Pyrite veins pyrrhotite in this section.

Section M-9: Major — Quartz.
Minor — Quartz, pyrrhotite, sphalerite, galena.
Rare — Chalcopyrite and electrum.

Electrum is relatively abundant in this section.

Sections 10, 11, 12 and 13:
Major — Pyrite and quartz.
Rare — Sphalerite, galena and chalcopyrite.

Conclusions.

1. The primary ore of the mine consists of pyrite, sphalerite, pyrrhotite, galena, and chalcopyrite.

2. The gold occurs as the gold-silver alloy "electrum."
The gold was probably the last of the metallic minerals to deposit. It is associated with galena, sphalerite, and pyrrhotite.

4. In most cases the electrum was located in fractures in quartz and pyrite with galena or sphalerite.

5. Particles of electrum are more abundant when galena or sphalerite are present.

6. Gold particles are of fair size, but not coarse.

7. The minerals belong to the mesothermal zone of deposition.

The Gold Belt Mine

Description of the Property.

Location.
The property of the Gold Belt Mining Company Limited consists of the following Crown-granted claims, as well as two held on location: Joint, Double Joint, Bluebird, Shamrock, Golden West, Dominion fraction, Sunbeam fraction, Bruce fraction, Nevada.

The Gold Belt property extends northerly from the steep side of Sheep creek valley across the ridge to the more gentle slope of the east side of Reno (Fawn) creek valley.

Access to the property is afforded by a branch road from the Reno Mine road, and the distance from Salmo is about fourteen and one-half miles.

Economic Geology.
The principal showings on Gold Belt ground are easterly striking fissures filled with quartz, sulphides and free gold. They strike across the northerly striking upper
part of the Reno formation.

**Mineralization.**

The ore consists of pyrite, galena, and sphalerite, sparingly distributed through the quartz with free gold visible in some specimens.

Unlike the extensively oxidized condition which prevailed in the upper parts of ore-bodies in other mines of the camp, oxidation is very shallow or entirely absent, primary ore being exposed at the surface.

**Mineralogy.**

**Introduction.**

Five polished sections of ore from the Gold Belt mine were examined. These sections were all prepared by Mr. J. W. McCammon, and his system of numbering is maintained by the writer. They were from various parts of the mine as follows:

- **Section M1** From the 1850 level. No vein specified.
- **Section M2** From the 2100 level. 8000 vein.
- **Section M3** From the 1780 level. 8000 vein.
- **Section M4** From the 1780 level. 8200 vein.
- **Section M5** From the 1975 level. 8200 vein.

The following metallic minerals, listed in order of abundance, were found to be present in the ore:

1. Pyrite.
2. Pyrrhotite.
3. Sphalerite.
4. Galena.
5. Chalcopyrite.

Quartz is abundant and is the only important gangue mineral, although calcite is present.
Description of the Minerals.

**Pyrite.** Pyrite is the predominating sulphide in all five sections. It is badly fractured, and the fractures are filled with quartz, pyrrhotite and some chalcopyrite. The pyrite occurs most commonly in large fractured masses, and to some extent as isolated cubes in quartz.

**Quartz.** Quartz fills fractures in the pyrite and is the principal matrix for the euhedral grains of that mineral. It is fractured, but not as much as is the pyrite. Pyrrhotite, sphalerite, galena and chalcopyrite occur in the fractures.

**Pyrrhotite.** Pyrrhotite occurs in all sections except Section M1. It fills fractures in both pyrite and quartz, but some places were noted where smooth, rounded boundaries existed between pyrrhotite and quartz, which seems to indicate that both minerals solidified at approximately the same time.

**Sphalerite.** Sphalerite is plentiful in Sections M4 and M5. It occurs in small masses and in fractures in quartz. It contains small bodies of pyrrhotite and chalcopyrite.

**Galena.** Galena is present only in Section M5, where it fills fractures in quartz and sphalerite. It is apparently later than all other minerals except calcite.

**Chalcopyrite.** Chalcopyrite is present in all sections, occurring in fractures in pyrite, sphalerite and pyrrhotite, and also along sphalerite-pyrrhotite contacts.

**Electrum.** Electrum is present in Sections M2 and
M5 as minute inclusions in galena, usually near galena-quartz contact. Its intimate association with galena indicates a late deposition, more or less contemporaneous with that mineral.

Calcite. Calcite is later than all the other minerals observed. It occurs veining galena and sphalerite.

**Paragenesis.**

The following paragenesis is suggested.

Pyrite was the first mineral to be deposited. It was later fractured and the fractures filled by quartz. A second period of fracturing then occurred affecting both of these early minerals. Sphalerite was then deposited, and filled some of the fractures in both pyrite and quartz. As pyrrhotite was seen veining sphalerite along a fracture, a third period of stress is indicated. The deposition of pyrrhotite and chalcopyrite took place at about the same time following that of the sphalerite. Galena appears to have come in later, probably accompanied by electrum. The calcite is later than all the other minerals.

**GRAPHICAL REPRESENTATION OF PARAGENESIS**

<table>
<thead>
<tr>
<th>Pyrite</th>
<th>Quartz</th>
<th>Sphalerite</th>
<th>Pyrrhotite</th>
<th>Chalcopyrite</th>
<th>Galena</th>
<th>Electrum</th>
<th>Calcite</th>
</tr>
</thead>
</table>

**Distribution and Size of Gold Particles.**

The gold, as in the other mines from this district, occurs as the gold-silver alloy "electrum." Although in these sections it appeared more finely disseminated than in the
sections from the other mines, its intimate association with galena is typical. Very little electrum is seen where galena is scarce or absent. The average size of the particles in these sections was less than 6 microns.

**Description of Sections.**

**Section M-1:**
- **Major:** Pyrite.
- **Minor:** Quartz.
- **Rare:** Chalcopyrite.

**Section M-2:**
- **Major:** Pyrite and quartz.
- **Minor:** Pyrrhotite.
- **Rare:** Chalcopyrite and calcite.

**Section M-3:**
- **Major:** Pyrite and quartz.
- **Minor:** Pyrrhotite.
- **Rare:** Chalcopyrite and calcite.

**Section M-4:**
- **Major:** Pyrite and quartz.
- **Minor:** Sphalerite and pyrrhotite.
- **Rare:** Chalcopyrite and calcite.

**Section M-5:**
- **Major:** Pyrite, quartz and sphalerite.
- **Minor:** Pyrrhotite and galena.
- **Rare:** Chalcopyrite, electrum and calcite.

The electrum is very fine and can only be seen under very high power. It occurs as small blebs in galena.

**Conclusions.**

1. The primary ore of the mine consists of pyrite, sphalerite, pyrrhotite, chalcopyrite and galena.

2. The gold occurs as the gold-silver alloy "electrum," which is very finely disseminated in the galena.

3. No electrum was seen except in the one section where galena occurred.

4. The electrum is intimately associated with the galena, and was probably the last mineral to be deposited.

5. The minerals belong to the mesothermal zone of deposition.
The Reno Mine

Description of the Property.

Location.

The Reno group, the property of Reno Gold Mines, Limited, consists of the following Crown-granted claims, and a number held on Location: Reno, Blue Stone, Black Stone, Curlew, Donnybrook, Latham, Dandy, Red Rock, Clarence, Clarence fraction, Gartan, Lynx, Manhattan fraction, Triune and Snowdrift.

The workings are at the head of Reno (Fawn) creek, a tributary of Sheep creek, on the west slope of the west peak of Reno mountain. A branch road leaves the Sheep creek road at an elevation of 3,100 feet, and in 5.8 miles climbs to the mine buildings at an elevation of 6,240 feet. The total distance from Salmo is approximately 15 miles.

Economic Geology.

Two east-west fissures occur on Reno ground, cutting strata of the Reno formation. These are the Reno and the Donnybrook.

The southerly, or Reno fissure, strikes about 70 degrees, dips almost vertically, and cuts quartzites, argillaceous quartzites, and siliceous argillites of the upper part of the Reno formation. The fissure appears to die out as it approaches the contact of the Reno formation with the less competent Pend d'Oreille series to the west and the lower part of the Reno formation to the east.

The Donnybrook, nor northerly fissure is of little importance with respect to gold values.
Mineralization.

The mineralization consists of vein quartz, pyrrhotite, pyrite, galena, sphalerite, and a little chalcopyrite. It extends outwards from the fissure into the crushed country rock. Well-defined walls to the vein are not common, the width of ore being determined by the extent to which mineralization can be seen to have spread from the fissure, and by sampling. This width varies from nothing up to five feet; the average being about two feet. Reported values in gold range from a trace to as high as 21 ounces across one foot.

Oxidation has completely removed the primary sulphide mineralization from the Reno fissure for some distance from the surface.

Mineralogy.

Introduction.

Five sections of ore from the Reno mine were examined. These sections were prepared by Mr. J. W. McCammon, and his system of numbering is maintained by the writer.

The following metallic minerals in order of abundance were identified microscopically:

1. Pyrrhotite.
2. Sphalerite.
3. Galena.
5. Electrum.

Quartz is the only gangue mineral in these sections.

Description of the Minerals.

Pyrrhotite. Pyrrhotite is rather abundant in these sections. It occurs in fractures in quartz, and in fractures in sphalerite (Section 2). Contacts between pyrrhotite and
sphalerite were not numerous, but where seen, the pyrrhotite appears to be later than the sphalerite.

**Sphalerite.** Sphalerite is not as abundant as pyrrhotite. It occurs in small irregular masses, and in fractures in quartz. It is slightly fractured in places, and these fractures are filled with pyrrhotite and sometimes galena.

**Galena.** Galena occurs sparingly and has the same general distribution as sphalerite. In general the galena-pyrrhotite contacts are smooth and regular, indicating contemporaneous deposition. However, galena was observed to fill fractures in sphalerite as well as in pyrrhotite. The deposition of galena probably overlapped that of pyrrhotite, and was later than that of sphalerite.

**Chalcopyrite.** Chalcopyrite is not abundant and occurs mainly in small blebs or irregular masses with pyrrhotite and sphalerite. It is commonly seen with pyrrhotite in fractures in pyrite.

**Quartz.** Quartz appears to be the first mineral to be deposited. It occurs in all sections, and is considerably fractured. Pyrrhotite, sphalerite, and galena fill these fractures.

**Electrum.** Electrum occurs in sections 1.A, 1.B and 2. It occurs in quartz fractures with pyrrhotite, sphalerite and galena, and along boundaries between quartz and the sulphides. Minor amounts occur as isolated particles in quartz fractures, but the most common association is with galena. Electrum, therefore, was probably deposited at a late
stage with galena.

**Paragenesis.**

The following paragenesis is suggested.

Quartz was the first mineral to be deposited. It was then fractured and the fractures healed by sphalerite. Another period of fracturing occurred causing cracks in the sphalerite, which in turn were filled by pyrrhotite, chalcopyrite, galena and electrum.

**GRAPHICAL REPRESENTATION OF PARAGENESIS**

| Quartz | Sphalerite | Pyrrhotite | Galena | Chalcopyrite | Electrum |

**Distribution and Size of Gold Particles.**

The gold occurs as the gold-silver alloy "electrum", and is intimately associated with galena, and to a lesser extent with pyrrhotite, sphalerite and chalcopyrite. In these sections a variation in colour was noticed from a very pale to deeper gold. This is probably due to a change in the gold-silver ratio. In size the particles vary from 5 microns to 84 microns, with an average of about 25 microns.

**Description of Sections.**

The following is a list of the sections with their constituent minerals. The minerals are separated according to their abundance in each individual section.

**Section 1-A:** Major -- Pyrrhotite and quartz.  
Minor -- Chalcopyrite.  
Rare -- Electrum.

**Section 1-B:** Major -- Pyrrhotite and quartz.  
Rare -- Chalcopyrite and electrum.

**Section 2:** Major -- Quartz.
Section 2 (cont.) Minor — Pyrrhotite and galena. Rare — Sphalerite and electrum.

Electrum is relatively plentiful in this section.

Section 7-A: Major — Quartz. Minor — Pyrrhotite. Rare — Chalcopyrite.

Section 7-B: Major — Quartz. Minor — Sphalerite and galena.

Conclusions.

1. The gold occurs as the gold-silver alloy "electrum."

2. The electrum is intimately associated with galena in fractures in quartz.

3. Most of the electrum observed was associated with galena.

4. The minerals present suggest that deposition occurred under conditions between mesothermal and hypothermal.

The Kootenay Belle Mine

Description of the Property.

Location.
This property is owned by Kootenay Belle Gold Mines, and consists of the following Crown-granted claims: Batt fraction, Pasadena, Rio Tinto, Rio Tinto fraction, Sultana, Yosemite, Yosemite fraction.

The property is on the south side of Sheep Creek, about a quarter of a mile above the junction with Wolf creek.

Economic Geology.
Two gold-bearing fissures cut rocks of the Quartzite Range formation that strike approximately north and dip from 50 to 75 degrees east. No. 1 fissure strikes on an average 60 degrees and dips south at angles of 69 to 76
degrees. No. 2 fissure, south of No. 1, strikes on an average 64 degrees south. The two strike along the hillside and dip into it. The two fissures either join or cross. Four ore-shoots outcropped, two on each fissure. Ore consists of quartz, pyrite, sphalerite, galena and gold.

Mineralogy.

Introduction.

Three polished sections of ore from the Kootenay Belle mine were examined microscopically. The sections were prepared by Mr. J. W. McCammon, and his system of numbering has been used by the writer.

Section M-1 From the 6th level east.
Section M-2 From the 303 stope.
Section M-3 From the 303 raise.

The following metallic minerals, listed in order of abundance were determined in the sections.

1. Sphalerite.
2. Galena.
3. Pyrite.
5. Pyrrhotite.

Quartz is the chief gangue mineral, but small amounts of calcite were noted.

Description of the Minerals.

Pyrite. Pyrite is not very abundant in these sections. It occurs as euhedral grains or small masses usually surrounded by quartz, but sometimes scattered through sphalerite and galena. Pyrite was probably the first mineral to be deposited, as it contains fractures and embayments which are now filled with quartz, galena, or sphalerite.
Quartz. Quartz is relatively abundant. It occurs filling fractures and cavities in pyrite. The quartz in turn is fractured, and these fractures are filled with sphalerite, and a few blebs of chalcopyrite.

Sphalerite. Sphalerite is common in the sections, but not as plentiful as galena. It usually occurs in quartz fractures, and where in contact with galena, shows mainly smooth, intimate, rounded boundaries. Occasionally, the galena veins into the sphalerite.

Pyrrhotite. Pyrrhotite is very rare. It was seen as small rounded blebs in galena and sphalerite.

Chalcopyrite. Chalcopyrite, like pyrrhotite is very scarce in these sections. It occurs as small patches in quartz fractures, and as blebs in sphalerite.

Galena. Galena is fairly abundant. It occurs in irregular masses associated with sphalerite and quartz. Often it is found filling fractures in quartz and less commonly is seen as veins in sphalerite.

Electrum. Gold occurs in sections M-1, M-2 and M-4, as the gold-silver alloy "electrum." This is intimately associated with galena, and occurs most commonly as inclusions in the galena. A minor amount of electrum occurred in fractures in quartz. It was noted that sections containing a large percentage of galena also contained the largest amount of electrum.

Calcite. Calcite was observed in small quantities in Sections M-2 and M-3. It always occurs in small fractures
Paragenesis.
The following paragenesis is suggested.

Pyrite was the first mineral to be deposited. This mineral was then fractured, and the fractures filled with quartz. A second period of fracturing shattered both pyrite and quartz, and in these later fractures were deposited sphalerite, pyrrhotite, chalcopyrite, galena and electrum. Sphalerite apparently solidified first as it is veined by pyrrhotite, galena and chalcopyrite. Galena, in places veins pyrrhotite, and at other places appears to be contemporaneous with it. This suggests that the galena was deposited with, and later than, the pyrrhotite. Chalcopyrite is intimately associated with pyrrhotite, and to some extent with sphalerite. It is reasonable, therefore, to assume that the deposition of chalcopyrite occurred with, and probably overlapped that of these two sulphides.

As has been previously stated, by far the greater proportion of the electrum is closely associated with galena. Some, however, occurs isolated in quartz fractures. These criteria indicate that electrum was precipitated contemporaneously with, and later than, the galena. The calcite is probably a much later mineral.

GRAPHICAL REPRESENTATION OF PARAGENESIS

<table>
<thead>
<tr>
<th>Pyrite</th>
<th>Quartz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sphalerite</td>
<td>Pyrrhotite</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td></td>
</tr>
<tr>
<td>Galena</td>
<td>Electrum</td>
</tr>
<tr>
<td>Calcite</td>
<td></td>
</tr>
</tbody>
</table>
Distribution and Size of Gold Particles.

The study of sections from this mine shows that the gold was probably the last mineral to be deposited from the mineralizing solutions. It is found irregularly distributed as inclusions in galena and in fractures in quartz. The most important association is with galena, as the quantity of electrum appears to vary with the amount of galena in the ore. The particles range in size from 5 microns to 40 microns, with an average of 27 microns.

Description of Sections.

Section M-1: Major -- Pyrite, quartz and galena.
Minor -- Sphalerite.
Rare -- Chalcopyrite, pyrrhotite and electrum.

Section M-2: Major -- Pyrite, quartz and galena.
Minor -- Sphalerite.
Rare -- Chalcopyrite, pyrrhotite, electrum and calcite.

Section M-3: Major -- Pyrite and quartz.
Minor -- Sphalerite and galena.
Rare -- Chalcopyrite and calcite.

Conclusions.

1. The primary ore of the mine consists of pyrite, sphalerite, pyrrhotite, chalcopyrite and galena.

2. The gold occurs as the gold-silver alloy "electrum".

3. The electrum is intimately associated with galena in which mineral it usually occurs as inclusions.

4. The sections containing visible electrum had galena as a major constituent.

5. The minerals belong to the mesothermal zone of deposition.
<table>
<thead>
<tr>
<th>Mesh</th>
<th>Gold in quartz with sulphides, but no enclosed by them. Percent</th>
<th>In Pyrite</th>
<th>Gold in Sulphides</th>
<th>Totals Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Along fractures Percent</td>
<td>In dense pyrite Percent</td>
<td>In dense arsenopyrite Percent</td>
</tr>
<tr>
<td>-100</td>
<td></td>
<td>6.66</td>
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<td>6.66</td>
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<tr>
<td>-3200</td>
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<td>6.66</td>
</tr>
<tr>
<td>Totals Percent</td>
<td>13.22</td>
<td>13.22</td>
<td>33.30</td>
<td>26.64</td>
</tr>
</tbody>
</table>
PART B

THE ZEBALLOS MINING DISTRICT
PART B: THE ZEBALLOS MINING DISTRICT

Description of the District

Location.

Zeballos River mining camp is located on the west coast of Vancouver Island, approximately 195 nautical miles northwestward from Victoria, B.C. At present, the area is comprised of the valley of the river and its watersheds, including the valleys of Van Isle, Spud, and Goldvalley creeks.

Zeballos is reached either by Canadian Pacific steamships, which maintain a tri-monthly service from Vancouver and Victoria, or by aeroplane.

General Geology.

The following table shows the geological formations of the Zeballos mining area.

<table>
<thead>
<tr>
<th>TABLE OF FORMATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Jurassic</strong></td>
</tr>
<tr>
<td>Intrusive Contact</td>
</tr>
<tr>
<td>Mesozoic</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
</tbody>
</table>
The main feature of the geology is a northwesterly trending belt of granitic rocks which have been called the Zeballos batholith. Rock types, in this intrusion, range from gabbro through quartz-diorite to quartz monzonite. Within the smaller area of present mining operations, the prevailing type is quartz-diorite. The granitic rocks have intruded Mesozoic volcanics and sediments of the Vancouver group.

The Vancouver group has been divided into three members:

1. Karmutsen volcanics, a lower assemblage of volcanic rocks lying northeast of the batholith.
2. Quatsino limestone, or middle member, lies above the Karmutsen volcanics.
3. Bonanza member, southwest of the batholith, which consists of interbedded volcanics and sediments.

Dykes are numerous near the intrusion, and are all premineral in age.

**Structural Geology.**

In the Zeballos mineral area the prevailing dip of the sediments is to the southwest. Pre-mineral faulting and fracturing cut the folded rocks and batholith in such a way as to develop major shears along northwest-southeast lines. The majority of the gold-bearing veins on Vancouver Island strike northwest-southeast, and these are well-defined in the Zeballos district.
Mineralogy:

The ore deposits of the Zeballos area may be classified into three groups:

1. High-temperature replacement deposits.
2. High-temperature veins.

The high temperature replacement deposits are lenticular replacements in limy sediments. Typical minerals of this type of deposit are: pyrrhotite, chalcopyrite, and molybdenite.

High-temperature veins are not common, but where found are characterized by an abundance of pyrrhotite, chalcopyrite, and sphalerite.

The main deposits of the area are gold-bearing quartz-sulphide veins occupying fault fissures. The form, texture and mineralogy indicate conditions of deposition between those prevailing for medium and high temperature veins.

The veins occupy well-defined fissures that maintain a fairly uniform strike and dip over considerable length. Comb textures are common in the veins, which suggests the filling of open fissures.

The sulphide minerals in the veins include: pyrite, sphalerite, arsenopyrite, galena, chalcopyrite and pyrrhotite. Quartz and a little calcite are the only gangue minerals.

The mineral deposits are related to the Zeballos batholith, and their age is probably late upper Jurassic.
The Privateer Mine

Description of the Property.

Location.
The Privateer property, owned by the Privateer Mine Limited, includes the following claims: Privateer Nos. 1 to 4 inclusive, Privateer No. 7, Progress Nos. 1 to 4 inclusive, and the Ray fraction.

The camp is on the southwest side of Spud creek at an elevation of approximately 430 feet, and is reached by 4½ miles of road up the Zeballos valley from the town of Zeballos.

Economic Geology.
The property is crossed by the southwestern contact of the Zeballos batholith and the Vancouver volcanics. The main vein is a fissure vein filled with quartz and sulphides. It strikes north 65 degrees east, dips 87 degrees northwest, and averages 6 inches in width.

Mineralogy.

Introduction.
Megascopically the ore consists of bands of sulphides in a translucent quartz gangue.

Pyrite, aresenopyrite, and small amounts of sphalerite and galena are visible in the ore.

Six polished sections of ore from this property were prepared and studied microscopically.

The following metallic minerals were determined
by microscopic examination to be present in the ore. They are listed in order of abundance.

1. Pyrite.
2. Arsenopyrite.
3. Galena.
4. Sphalerite.
5. Chalcopyrite.
6. Pyrrhotite.
7. Gold.
8. Unknown.

Friable quartz and calcite were the only gangue minerals observed.

Description of the Minerals.

Pyrite. Pyrite is the major sulphide mineral in the ore, and constitutes well over half of the sulphides present in the sections studied. It is exceedingly broken and fractured, and occurs mainly as anhedral masses, but occasionally shows crystal form against later sulphides. Where arsenopyrite is in contact with the pyrite, the boundaries are very smooth. Some arsenopyrite is included in the masses of pyrite. The major interstices between grains, and the larger fractures in the pyrite are filled with quartz, sphalerite, galena, and sometimes chalcopyrite. Smaller fractures are filled by a later generation of quartz, which is darker than the first.

Arsenopyrite. In the sections studied, arsenopyrite is fairly abundant. It occurs as small anhedral masses, but generally shows a more or less crystalline form. Inclusions in pyrite are triangular or rhombohedral in outline, as are many isolated patches and grains in quartz. Like the pyrite, the arsenopyrite is also badly fractured, and the fractures filled with quartz, sphalerite and galena.
Galena. Galena occurs in massive, anhedral patches. It forms irregular contacts with pyrite and arsenopyrite, and in some cases fills fractures in these minerals. The boundaries between pyrite and galena are seldom mutual, the two being separated by stringers of late quartz. Where galena and sphalerite are in contact, the boundaries are smooth and mutual. No case was observed where either of these sulphides veined into the other. The same smooth mutual boundaries exist between galena and gold, showing that the gold was closely associated with the deposition of the galena.

Sphalerite. Sphalerite is not as abundant as the galena. It occurs like galena in massive patches, and in fractures in pyrite and arsenopyrite. The sphalerite-galena boundaries are smooth and mutual, but the pyrite-sphalerite boundaries are very irregular. Late quartz stringers separate the sphalerite from pyrite in most cases.

Chalcopyrite. Chalcopyrite is present only in small amounts. It occurs as minute blebs in sphalerite; as minute, rounded or elongated blebs in the pyrite; as long, narrow, veinlets in the pyrite and arsenopyrite fractures; and rarely as larger irregular masses in quartz. Boundaries between chalcopyrite, galena and sphalerite are mutual and smooth; while those between chalcopyrite and pyrite are irregular.

Pyrrhotite. In the sections, pyrrhotite occurs only as minute rounded blebs in the pyrite, and occasionally in the arsenopyrite. In many cases pyrrhotite and chalcopyrite occur together in one bleb indicating a close relationship. Pyrrhotite was not observed to occur in any other way in
these sections, but has been previously reported in small masses in quartz.

**Quartz.** Quartz is the only important gangue mineral observed. There appear to be two generations of quartz in the ore, the second one being darker than the first. The earlier generation fills interstices between the pyrite and arsenopyrite masses, but does not vein the later sulphides. The later, or dark, quartz fills small fractures in pyrite and arsenopyrite, veins between the later sulphides and pyrite, and fills irregularities in galena, sphalerite and chalcopyrite. It would seem that the deposition of the later quartz was contemporaneous with or overlapped the deposition of galena, sphalerite and chalcopyrite.

**Gold.** The gold occurs in different ways in this ore, as follows:

1. Isolated in quartz.
2. At contacts between galena and pyrite.
3. At contacts between arsenopyrite and pyrite.
4. Rarely as inclusions in pyrite.

Its boundaries with galena are mutual, but are irregular with pyrite and arsenopyrite.

**Calcite.** Calcite was observed in small quantities in quartz fractures.

**Unknown.** This mineral occurred very sparingly in pyrite as minute specks, and was often seen near blebs of pyrrhotite or chalcopyrite. The colour is dark-grey with a decided purple tinge, but due to the extremely small size of the particles, its identity could not be determined.
Paragenesis.
The following paragenesis is suggested.

Pyrite was the first sulphide mineral to be deposited. The deposition of arsenopyrite and pyrrhotite probably overlapped that of the pyrite. Some gold was also deposited at this time. The pyrite and arsenopyrite were fractured, and the fractures filled by the first generation quartz. It is thought that this first generation quartz may have started to deposit with the pyrite and arsenopyrite. A second period of fracturing, in which all the early minerals were shattered, was followed by the deposition of sphalerite, galena, chalcopyrite and gold. Also about this time, a second generation of quartz was introduced. Calcite is thought to have been deposited at a much later time, as it may be seen filling small fractures in the later sulphides.

**GRAPHICAL REPRESENTATION OF PARAGENESIS**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Quartz</th>
<th>Pyrite</th>
<th>Arsenopyrite</th>
<th>Pyrrhotite</th>
<th>Gold</th>
<th>Sphalerite</th>
<th>Galena</th>
<th>Chalcopyrite</th>
</tr>
</thead>
</table>

**Distribution and Size of Gold Particles.**

In some sections of the Privateer ore very little gold was seen, while in others it was very abundant. It was observed to be mainly associated with the later sulphides, although a small quantity was found as inclusions in pyrite.

The gold particles vary in size from 3 microns to grains of megascopic size, about one quarter of an inch in
length. The finer particles were generally those included in the pyrite, while the coarser grains were associated with galena, sphalerite and chalcopyrite.

Description of the Sections.

Section No. 1: Major -- Pyrite, arsenopyrite and quartz.
Minor -- Chalcopyrite, sphalerite and galena.
Rare -- Gold and pyrrhotite.

Section No. 2: Major -- Pyrite, arsenopyrite and quartz.
Minor -- Chalcopyrite.
Rare -- Pyrrhotite, gold and unknown.

Section No. 3: Major -- Pyrite.
Minor -- Arsenopyrite.
Rare -- Chalcopyrite and pyrrhotite.

Section No. 4: Major -- Pyrite, and arsenopyrite.
Rare -- Pyrrhotite and chalcopyrite.

Section No. 5: Major -- All quartz.
Rare -- Gold and sphalerite.

Section No. 6: Major -- Quartz.
Rare -- Gold.

Section No. 7: -- Headley Section No. 1.
Major -- Pyrite, arsenopyrite and quartz.
Minor -- Galena and sphalerite.
Rare -- Pyrrhotite, chalcopyrite and gold.

Conclusions.

1. The primary ore of the mine consists of pyrite, arsenopyrite, pyrrhotite, chalcopyrite, sphalerite and galena.

2. The minerals belong typically to the mesothermal zone of deposition.

3. The greater part of the gold is associated with the later sulphides, particularly galena.

4. A very small amount of gold appears to have been deposited with the pyrite, but the bulk of the metal was probably one of the last to solidify.
There is a decided tendency of the gold to occur in fractures in pyrite, arsenopyrite or quartz, usually with galena, but often alone.

**The Trites Mine**

**Description of the Property.**

**Location.**

The North Star group is owned by A. B. Trites interests of Vancouver, and consists of the following mineral claims: Golden Key, Golden Nugget, Zero fraction, North Star No. 2, North Star, Don fraction, Golden Stray, Nod fraction, Golden Rocket and Golden Lode.

The group is situated between elevations of 2,425 feet and 2,615 feet, on a steep mountain side sloping south-westward into the headwaters of Goldvalley creek. The workings are reached by the Goldvalley trail, which leaves the creek bottom at an elevation of 1,640 feet and climbs steeply to the camp.

**Economic Geology.**

This property is in typical granodiorite, which is traversed by four north-easterly striking shear zones. Much weathering has taken place in the upper parts, but fresh, unoxidized material occurs in the lower cuts.

**Mineralogy.**

**Introduction.**

The ore from the Trites property is very similar to that from the Privateer, though in the sections studied the sulphides are rather more disseminated. Pyrite, arsenopyrite
and galena are visible megascopically.

The following metallic minerals were identified in the sections. They are listed in order of abundance.

1. Pyrite.
2. Arsenopyrite.
3. Sphalerite.
4. Galena.
5. Chalcopyrite.
7. Pyrrhotite.

Quartz is the only gangue mineral in these sections.

Description of the Minerals.

Pyrite. Pyrite is the most abundant sulphide in the ore. It is fractured and occurs as both massive and crystalline. Inclusions of pyrrhotite and chalcopyrite, although not as numerous as in the Privateer sections, are present to some extent, as are also euhedral inclusions of arsenopyrite. Quartz, galena, sphalerite and chalcopyrite occur filling the fractures in pyrite and arsenopyrite. Gold occurs as inclusions in both pyrite and arsenopyrite.

Arsenopyrite. Arsenopyrite is not as abundant as pyrite and does not occur in large masses. Where it is seen in quantity, it is in swarms of small fragments, usually showing crystalline form. Pyrite-arsenopyrite boundaries are smooth and mutual, indicating deposition at about the same time.

Sphalerite. Sphalerite occurs in masses in quartz, and veining pyrite. The usual specks of evolved chalcopyrite were observed in the sphalerite. Generally these show no orientation.
Some gold evidently accompanied the deposition of these minerals, as it occurs as inclusions in pyrite and arsenopyrite. The deposition of quartz must have continued longer than the others as it fills fractures in pyrite and arsenopyrite, and also fills the interstices between masses. Following a shattering of these earlier minerals, sphalerite, chalcopyrite, galena and gold were deposited. The gold was probably one of the latest minerals to be deposited.

**GRAPHICAL REPRESENTATION OF PARAGENESIS**

<table>
<thead>
<tr>
<th>Quartz</th>
<th>Pyrite</th>
<th>Arsenopyrite</th>
<th>Pyrrhotite</th>
<th>Gold</th>
<th>Sphalerite</th>
<th>Galena</th>
<th>Chalcopyrite</th>
</tr>
</thead>
</table>

**Distribution and Size of Gold Particles.**

Most of the gold particles seen in these sections occurred as inclusions in either pyrite or arsenopyrite, but a few were observed in fractures in these two minerals. It is, therefore, evident that the gold was deposited at the same time and later than the pyrite and arsenopyrite.

The particles vary in size from 2 microns to 12.5 microns, with an average size of 4 microns. It will be seen that this gold is finer than that in the Privateer sections. And again, as in the Privateer sections, the finer particles are found in pyrite and arsenopyrite as inclusions. Those grains in pyrite and arsenopyrite are more or less round, while those occurring in fractures are irregular or elongated.
Galena. Galena is present in about the same amount as sphalerite. It occurs as masses and veins in quartz fractures, and as veinlets in pyrite fractures. In all sections it appears to be contemporaneous with sphalerite.

Chalcopyrite. Chalcopyrite is present as masses in quartz, as veinlets in pyrite and arsenopyrite, as small, rounded blebs in pyrite, and as minute specks in sphalerite.

Gold. Gold occurs associated with pyrite, arsenopyrite and chalcopyrite. In these sections no gold was observed with galena or sphalerite, although some particles occurred in fractures in pyrite and arsenopyrite.

Pyrrhotite. Pyrrhotite is very scarce in these sections. Only one or two tiny specks were seen as inclusions in pyrite and arsenopyrite.

Quartz. Quartz is abundant in these two sections. It occurs filling fractures in pyrite and arsenopyrite. Some of the fractures in the quartz are filled with galena, sphalerite and chalcopyrite.

Paragenesis.

The following paragenesis is suggested.

The order of deposition of the minerals in the Trites ore appears to be identical with that in the Privateer sections. The only difference noted was the absence of a late generation of quartz, the absence of calcite and the absence of the unidentified, purple mineral in the Trites sections.

Quartz, pyrite, arsenopyrite, with minor amounts of chalcopyrite and pyrrhotite were the first minerals to solidify.
Description of Sections.

Section No. 1: Major -- Pyrite and quartz.
           Minor -- Arsenopyrite.
           Rare -- Chalcopyrite and pyrrhotite.

Section No. 2: Major -- Pyrite and quartz.
                  Minor -- Galena, sphalerite and chalcopyrite.
                  Rare -- Gold.

Conclusions.

1. The primary ore of the mine consists of pyrite, arsenopyrite, pyrrhotite, chalcopyrite, sphalerite and galena.
2. The minerals belong mainly to the mesothermal zone of deposition.
3. The gold particles seen in these sections occurred as inclusions in pyrite and arsenopyrite, and in fractures in these minerals. Very little galena or sphalerite occurs in the sections, and neither of these minerals was seen associated with any of the gold.
4. The gold particles are fine. Apparently the coarser particles of gold occur with or near galena and sphalerite.
5. The gold appears to have been deposited at two periods during the solidification of the sulphide minerals.

The Rey Oro Mine

Description of the Property.

Location.
The Lone Star claim is owned by the Rey Oro Gold Mining Company, Limited. The workings are located on the north-east bank of Goldvalley creek between elevations of 1300 feet and 1,420 feet.

Economic Geology.
The deposits are in joints or in crushed zones in the prevailing granodiorite.
Mineralogy:

Introduction.
The samples of Rey Oro ore which were studied are similar to that from the Trites property, and are, like most of the ore from the district, extremely friable.

The following metallic minerals were determined by microscopic examination to be present in the ore. They are listed in order of abundance.

1. Pyrite.
2. Sphalerite.
3. Galena.
4. Arsenopyrite.
5. Chalcopyrite.
6. Pyrrhotite.
7. Gold.

Quartz was the only gangue mineral seen in the sections.

Description of Minerals.

Pyrite. Pyrite is present as small masses and grains, some of which show a crystalline form. It is considerably fractured, and these fractures are filled with quartz. Small blebs of chalcopyrite occur as inclusions in the pyrite.

Arsenopyrite. Arsenopyrite is not as abundant in these sections as it is in those of privateer and Trites ore. It occurs mainly as masses of small euhedral particles surrounded by quartz. One grain only was seen included in pyrite.

Sphalerite. Sphalerite is relatively abundant in the sections. In most cases it occurs as small, irregular masses, but occasionally it fills fractures in quartz and pyrite. A few scattered blebs of chalcopyrite are usually included in the sphalerite masses.
Galena. Galena is rather scarce, but occurs like sphalerite in small masses and veinlets in quartz, pyrite and arsenopyrite. In one place galena was observed veining sphalerite, suggesting deposition later than the sphalerite.

Chalcopyrite. Chalcopyrite is rare, and occurs only as minute inclusions in pyrite and arsenopyrite, and as exsolved blebs in sphalerite.

Pyrrhotite. Pyrrhotite is exceedingly rare in these two sections. Two small blebs were observed in pyrite.

Gold. Gold is observed to occur in the following ways:

1. In fractures in quartz.
2. In fractures in arsenopyrite.
3. Along the contact of pyrite and arsenopyrite.

No intimate association of the gold with galena and sphalerite was observed. The gold occurs in fractures in the early sulphides or quartz, and tends to be in elongated blebs or veinlets.

Paragenesis.
The following paragenesis is suggested.

Pyrite, arsenopyrite and quartz were the first minerals to be deposited. The quartz continued to deposit after the pyrite and arsenopyrite had solidified, and been fractured, as it is seen filling these fractures. Continued movement caused shattering of both quartz and sulphides with subsequent deposition of sphalerite, galena, chalcopyrite and gold.
Distribution and Size of Gold Particles.

In the two sections of Rey Oro ore which were studied, the gold occurs only in fractures in either quartz, pyrite or arsenopyrite. It is not intimately associated with either galena or sphalerite, although both of these minerals occur near to the gold. The gold particles vary in size from 12 microns to 420 microns with an average of 30 microns.

Description of Sections.

| Section No. 1 | Major  | Quartz. |
|               | Minor  | Pyrite, chalcopyrite and sphalerite. |
|               | Rare   | Gold. |
| Section No. 2 | Major  | Quartz. |
|               | Minor  | Sphalerite, galena and arsenopyrite. |
|               | Rare   | Gold. |

Conclusions.

1. The primary ore of the mine consists of pyrite, arsenopyrite, pyrrhotite, chalcopyrite, sphalerite and galena.

2. The minerals belong to the mesothermal zone of deposition.

3. The gold occurs in fractures in pyrite, arsenopyrite and quartz, and therefore must be later than these minerals.

4. No gold was seen in contact with sphalerite or galena, although both of these minerals are present in the vicinity of the gold.

5. The gold particles are generally rather coarse.
DISTRIBUTION OF THE GOLD PARTICLES IN ZEBALLOS ORE

<table>
<thead>
<tr>
<th>Mesh</th>
<th>Gold in quartz with sulphides, but not enclosed by them. Percent</th>
<th>In Pyrite</th>
<th>Gold in Sulphides</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Along fractures Percent</td>
<td>In dense pyrite Percent</td>
</tr>
<tr>
<td>4:35</td>
<td>5.0</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>3:54</td>
<td>5.0</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>4:48</td>
<td>5.0</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>6:54</td>
<td>5.0</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>10:6</td>
<td>5.0</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>15:0</td>
<td>5.0</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>20:1</td>
<td>5.0</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>28:1</td>
<td>5.0</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>40:1</td>
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<td></td>
</tr>
<tr>
<td>56:1</td>
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</tr>
<tr>
<td>80:1</td>
<td>5.0</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>11:0</td>
<td>5.0</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>16:0</td>
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<td>5.0</td>
<td></td>
</tr>
<tr>
<td>23:0</td>
<td>5.0</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>32:0</td>
<td>5.0</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>20.0</td>
<td>50.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>
PART C

THE CARIBOO MINING DISTRICT
PART C: THE CARIBOO MINING DISTRICT

Description of the District

Location.

The Barkerville area embraces approximately 210 square miles, and is part of the Cariboo district of central British Columbia. This area is in the plateau region of British Columbia, and is bounded on the west by the Coast range and on the east by the Cariboo and other mountain ranges.

The three mines studied from this area are readily accessible by road from the towns of Quesnel and Barkerville. Quesnel is on the Cariboo highway from Vancouver, and is also the northern terminus of the Pacific Great Eastern railway.

General Geology.

The following table shows the geological formations of the Cariboo district:

<table>
<thead>
<tr>
<th>TABLE OF FORMATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tertiary</td>
</tr>
<tr>
<td>Unconformity</td>
</tr>
<tr>
<td>Mesozoic</td>
</tr>
<tr>
<td>Jurassic</td>
</tr>
<tr>
<td>Mount Murry</td>
</tr>
<tr>
<td>sills and dykes.</td>
</tr>
<tr>
<td>Quesnel river group</td>
</tr>
<tr>
<td>Diabase, gabbro</td>
</tr>
<tr>
<td>diorite.</td>
</tr>
<tr>
<td>Argillite and basalt</td>
</tr>
</tbody>
</table>

(Continued on next page)
The oldest rocks of the Cariboo district are known as the Cariboo series. The rocks are not fossiliferous, but from their structural position, degree of metamorphism, and their similarity to Pre-Cambrian rocks farther south, they are believed to be of Pre-Cambrian age. This series consists of quartzites, argillites, and limestones, slightly to strongly sheared and having a total thickness of many thousand feet.

The series has been folded into a northwesterly trending anticline. The medial part of the anticline is exposed for a width of fifteen miles, and a length of more than fifty miles.
Intruding the Cariboo series are a few dykes and sills of quartz porphyry and allied acid rock types. They are called the Proserpine intrusives and are believed to be pre-Mississippian, and possibly pre-Cambrian in age.

Unconformably overlying the northeastern limb of the anticline is the Slide Mountain series of upper Palaeozoic age, consisting of conglomerate, crinoidal limestone, banded cherts, argillite and basaltic lavas. The upper part of the series is cut by many gabbroic dykes. The general dip of the series is northeast.

Overlying the southwestern limb of the anticline, unconformably, are Jurassic argillites and basalts called the Quesnel River group. The sediments of the group dip southwest.

The Cariboo series is of special interest for in it are all the known lode gold deposits of the district. In the Barkerville map-area the series has been divided into three formations:

1. Pleasant Valley formation.
2. Barkerville formation.
3. Richfield formation.

The Richfield formation, the lowest exposed formation of the Cariboo series, consists mainly of quartzite, but includes as well limestone, black argillite, and other rock types gradational between the three named.

The Barkerville formation overlies the Richfield formation conformably, and consists mainly of bluish-grey limestone, black limy argillite, and quartzite.
The Pleasant Valley formation overlies the Barkerville and consists mainly of black argillite.

**Structural Geology.**

The upper part of the Richfield formation in the vicinity of Barkerville is cut by a multitude of quartz veins, many of which are gold-bearing. The part of the formation characterized by the numerous quartz veins is called the Barkerville Gold Belt.

The gold belt rocks are on the northeastern limb of the northwesterly trending anticline. In general, the strike is northwest, with a northeast dip.

Shearing of the rocks has taken place in varying degrees, so that although the general nature of the original rock is rarely in doubt, the bedding in some places has been obscured.

These rocks are traversed by a great many pre-mineral fractures, many of which are occupied by quartz veins. Most of the fractures cut the strata at roughly right angles, and their strikes range from north 15 degrees to north 60 degrees east. Another set of fractures cross the strike of the beds diagonally, and strike from north 60 degrees east to east. Others are approximately parallel to the strata.

All the fractures diagonally crossing the strata and so far as is known, also those that parallel the strata, contain quartz veins. The transverse and diagonal fractures are not faults. Those roughly paralleling the strata are faults.
A number of post mineral faults occur in the gold belt. Most of them are small, but several large ones exist. These dip approximately 60 degrees to the east. Strike faults are the most common type in the district.

Mineralization.

The ore deposits of the Barkerville district are of two fundamentally different types:

1. Quartz veins.
2. Replacement deposits in limestone.

**Quartz veins.** The quartz vein type is the more numerous of the two. These differ greatly in size, shape and strike. The veins pinch and swell along the strike in short distances, and in places "stringer" out with pyritized schist lying between the stringers.

The mineralization of the veins consists of quartz, ankerite, pyrite, arsenopyrite, sphalerite, galena, galena-bismutite, cosalite and gold. Free gold occurs in grains from minute specks to nuggets. The galenabesmutite and cosalite occurs sporadically in small bunches, and much coarse gold is associated with it. Small quantities of scheelite occurs in places.

**Replacement type.** In these deposits, the gold-bearing pyrite replaces white crystalline limestone. The limestone is in the form of lenses, which vary greatly in thickness, probably due to the result of folding.

The replacement may be found anywhere in the limestone bed, but an essential condition for the formation of an
ore body is the presence of numerous "horsetail" fractures in the adjoining rocks. It seems probable that these were the avenues by which the mineralizing solutions entered the limestone. They are from one-half to two inches in width, and may or may not be mineralized.

The massive pyrite of the replacements is much finer grained than that of the veins, and ore of this type is in general higher grade than the vein ore.

Rarely the ore contains nests of scheelite, and some samples have contained chalcopyrite and galena.

The Cariboo Gold Quartz Mine

Description of the Property.

Location.
The Cariboo Gold Quartz mine, owned by the Cariboo Gold Quartz Mining Company, Limited, is situated southeast of Jack of Clubs lake on the northern slope of Cow mountain, which rises between the lake and Lowhee creek.

Economic Geology.
The property is in the rocks of the Richfield formation of the Cariboo series.

Two or more periods of fracturing have developed many transverse fractures, and several hundred of these contain quartz veins. Later than these fractures are faults that strike in three principal directions. A few with a very small throw lie along some of the quartz veins and strike from north sixty degrees east to north eighty degrees east.
These are offset by others of small throw which parallel the strata.

Two faults, the Rainbow and Lowhee, strike roughly north and dip approximately at sixty degrees to the east. These are of much greater magnitude and are crushed zones twenty or more feet wide, with horizontal displacements of 400 feet and 1000 feet respectively.

The mineral deposits are of two types:

1. Gold-bearing, pyritic, quartz veins.
2. Gold-bearing, pyritic, replacements.

The veins are of three types; transverse veins that strike from north thirty degrees east, to north sixty degrees east, and cross the strata roughly at right angles; diagonal veins that strike north seventy degrees east to east, and cross the strata diagonally; and strike veins that are parallel or nearly parallel to the strata.

The transverse veins are the most numerous and about seven-eighths of these are less than a foot wide; the rest average about three feet in width. The diagonal veins are less numerous, but these are also narrow.

Many of the transverse and diagonal veins are commercially valuable, but no strike vein is yet known to be mineralized.

The replacement deposits are bodies of massive, fine-grained sulphides in limestone, as described in the foregoing discussion of the whole area.
Mineralogy:

Introduction.

The sulphides in the Cariboo Gold Quartz ore occur disseminated through, and in segregations in a white, crystalline quartz. Megascopically, pyrite and small amounts of galena are the only sulphide minerals visible, except where pockets of cosalite and galenabismutite occur. The quartz varies from parts that are massive, to parts where interlocking crystals up to two inches in length form a loose network.

Six polished sections were prepared from ore from the mine. These were studied microscopically, and will be referred to by number.

The following metallic minerals, listed in order of abundance, were determined in the ore.

1. Pyrite.
2. Galena.
3. Sphalerite.
5. Cosalite.
7. Arsenopyrite.
8. Pyrrhotite.
10. Telluride?

Quartz is the principal gangue mineral, but a small amount of calcite is present.

Description of the Minerals.

Pyrite. Pyrite occurs both crystalline and massive, the former type being the more common. The size of the crystals varies from those of microscopic size to cubes measuring half an inch along a side. The pyrite is more or less fractured. The fractures and interstices between the crystals
are filled by quartz. Also, some of the fractures have been healed by galena, sphalerite, chalcopyrite and gold. Minute blebs of pyrrhotite and chalcopyrite occur sparingly as inclusions in the pyrite.

Arseno-pyrite. Arsenopyrite was seen only in Section No. 3. Here a few small, euhedral grains are associated with pyrite.

Quartz. The quartz is milky-white to translucent, and occurs both massive and crystalline. Many fractures are present in the quartz, some of which have been filled with gold, galena, sphalerite and chalcopyrite.

Sphalerite. Sphalerite is very scarce in these sections. The only occurrence noted was as small veinlets in quartz.

Chalcopyrite. Chalcopyrite occurs in relatively small amounts. It was noted as veinlets in fractures of both quartz and pyrite, either alone or associated with galena. Rarely it occurred as minute, rounded or elongated blebs in pyrite. The most interesting occurrence of this mineral was seen in Section No. 1, where it is included in an intergrowth of cosalite and galenabismutite. The smooth, regular boundaries of the chalcopyrite with the other two sulphides indicates a contemporaneous deposition.

Pyrrhotite. Pyrrhotite occurs rarely as minute, rounded inclusions in the pyrite.

Cosalite and Galenabismutite. Cosalite and galenabismutite occur as an intergrowth in Sections No. 1 and No. 2.
These sections were made from ore which showed megascopically only quartz and a needle-like grey mineral containing visible gold particles.

It is possible to distinguish between the two minerals by colour under the microscope after studying the surface for some time. In a fresh, polished section, galena-bismutite is slightly darker than cosalite.

However, if the section is etched for a minute with hydrochloric acid, the two minerals are readily discerned, due to a slight darkening of the galena-bismutite.

Below are the etch reactions for these two minerals:

<table>
<thead>
<tr>
<th>Colour</th>
<th>HCl</th>
<th>HNO₃</th>
<th>FeCl₃</th>
<th>KCN</th>
<th>KOH</th>
<th>HgCl₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cosalite</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Galena-white</td>
<td></td>
<td></td>
<td>blackens slight</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>with eff. irridesc.</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Galena-bis-Light</td>
<td>darkens</td>
<td>blackens</td>
<td>Dark</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>mutite</td>
<td>grey</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>stain</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Neither of these minerals was observed associated with pyrite in the sections, but they have both been reported veining pyrite in small quantities. Coarse, visible gold is associated with these two minerals.

Gold. Gold occurs in the following ways in the sections studied:

1. As veinlets in fractured quartz.
2. As inclusions in pyrite.
3. In cosalite and galena-bismutite.

Gold occurring in fractures in pyrite is often associated with galena. One example (Section No.1) shows gold in chalcopyrite, both of which are included in cosalite and
galenabismutite. In some cases gold in the bismuth sulphides conforms with the crystal structure of those minerals.

**Telluride.** This mineral occurs in what appears to be swarms of minute inclusions in cosalite and galenabismutite. The mineral looks white against the surrounding bismuth-lead minerals and is soft, but is so extremely fine that it is invisible except under very high power. It has a tendency to occur near the edges of the sulphide mass.

Microchemical tests revealed the presence of the element tellurium, and etch reactions placed it in a small group of minerals of which "altaite" and "tetradymite" are the two most likely possibilities.

**Calcite.** A small amount of this mineral was observed in fractures in quartz and sometimes in fractures in the sulphides.

**Paragenesis.**

Pyrite and quartz were undoubtedly the first minerals to be deposited. Arsenopyrite, pyrrhotite, some chalcopyrite and a little gold accompanied the pyrite. It is probable that deposition of the quartz preceded, was contemporaneous with, and continued later than the deposition of the pyrite. Pyrrhotite, chalcopyrite and gold, occurring as tiny inclusions, indicate solidification with the pyrite. Arsenopyrite must also have been deposited at about the same time as the pyrite. Both pyrite and quartz were fractured prior to the deposition of the later sulphides; galena, sphalerite, chalcopyrite, cosalite, galenabismutite, and gold. No
criteria were noted for the definite determination of the age-relationships of cosalite and galenabismutite, except the association (Section No.1), with chalcopyrite. From this, it is assumed that they came in with the later sulphides. The sphalerite, galena, and chalcopyrite were probably deposited more or less together with some overlap. Most of the gold in the ore was deposited near the end of the mineral sequence.

**GRAPHICAL REPRESENTATION OF PARAGENESIS**

<table>
<thead>
<tr>
<th>Quartz</th>
<th>Pyrite</th>
<th>Arsenopyrite</th>
<th>Pyrrhotite</th>
<th>Sphalerite</th>
<th>Galena</th>
<th>Chalcopyrite</th>
<th>Cosalite</th>
<th>Galenabismutite</th>
<th>Gold</th>
<th>Calcite</th>
</tr>
</thead>
</table>

**Distribution and Size of Gold Particles.**

It is apparent from studying these sections that by far the greater percentage of gold present was deposited, and is associated with the later sulphides; galena, cosalite, galenabismutite and sphalerite. Extremely high values are associated with the two bismuth minerals, and, so far as could be ascertained, gold occurs with both cosalite and galenabismutite in equal proportions. The estimated percentage of gold in Sections No.1 and No. 2 is between one percent and six percent of the total mineral content, and varies in size from specks about 1 micron in size to grains visible megascopically. In general, gold associated with these minerals is fairly coarse.

Coarse gold also occurs isolated in quartz, and much of this can be seen without the aid of a microscope.
Particles in pyrite fractures tend to take elongated forms, sometimes being very narrow and long, and varying from 4 microns to 105 microns in size. Gold occurring in pyrite as inclusions is much finer, averaging about 5 microns in size.

Description of Sections:

Section No. 1: Major -- Cosalite and galenabismutite. Minor -- Gold and quartz. Rare -- Chalcopyrite and telluride.

Section No. 2: Major -- Cosalite and galenabismutite. Minor -- Quartz and gold. Rare -- Telluride.

Section No. 3: Major -- Pyrite. Minor -- Quartz. Rare -- Pyrrhotite, gold and arsenopyrite.

Section No. 4: Major -- Pyrite (very fine grained). Minor -- Quartz, galena, and sphalerite. Rare -- Gold.

Gold is abundant in this section.

Section No. 5: Major -- Pyrite and quartz. Minor -- Pyrrhotite and chalcopyrite. Rare -- Gold.

Section No. 6: Major -- Pyrite and quartz. Minor -- Galena and sphalerite. Rare -- Gold and chalcopyrite.

Conclusions.

1. The primary ore of the mine consists of pyrite, arsenopyrite, chalcopyrite, pyrrhotite, sphalerite, galena, cosalite and galenabismutite.

2. The minerals belong to the mesothermal zone of deposition.

3. The greater part of the gold is associated with the later sulphides, and therefore must have come in with them. The gold was probably one of the latest minerals to be deposited.

4. Very high gold values occur with the two bismuth sulphides.
5. Higher values are associated with fine-grained pyrite than with coarsely crystalline pyrite.

6. Although very little gold was seen in contact with either galena or sphalerite, these minerals were usually present in the section.

7. A small amount of gold appears as inclusions in pyrite, and this must have solidified with this early sulphide.

8. The later gold occurs chiefly in fractures in pyrite, or quartz.

9. In general, the gold particles from this property are fairly coarse.

The Island Mountain Mine.

Description of the Property.

Location.

The property of the Island Mountain Mines Company, Limited, consisting of thirty-two claims and fractions, comprises 1027 acres on Island mountain, along the north shore of Jack of Clubs lake, four miles northwest of the town of Barkerville.

Economic Geology.

This mine is also in rocks of the Richfield formation. Both rocks and mineral deposits are cut by faults, the largest of which strikes about north fifteen degrees west, and dips from forty-five degrees to sixty degrees east. It is similar to the large faults in the Cariboo Gold Quartz mine. There are also many faults of small throw, parallel or nearly parallel to the strata.

The mineral deposits are of two types:

1. Gold-bearing, pyritic, quartz veins.
2. Gold-bearing, pyritic replacements in limestone.
Most of the quartz veins strike from north thirty degrees east to north sixty degrees east, and dip steeply southeast. The veins consist of quartz, sulphides and free gold. They occur in swarms or zones which cut across the formation.

The replacement type of deposit consists mainly of gold-bearing pyrite with minor amounts of other sulphides, and so far the grade of this type is roughly twice as high as the grade of the better veins.

Mineralogy.

Introduction.
The four polished sections of ore from Island Mountain were sections which had been already mounted. They were re-polished and studied by the writer.

Megascopically, Island Mountain ore is similar to that of the Cariboo Gold Quartz.

The following metallic minerals, in order of abundance, were determined microscopically in the sections.

1. Pyrite.
2. Arsenopyrite.
3. Galena.
5. Gold.

Quartz is the main gangue mineral with small amounts of calcite.

Description of the Minerals.

Pyrite. Pyrite is the most abundant sulphide in the ore. It is both massive and crystalline, commonly showing euhedral faces against quartz. The pyrite is well-fractured,
and these fractures are filled by quartz, galena, chalcopyrite, and to some extent with gold. No inclusions of pyrrhotite or gold in pyrite were noted in these sections.

Arsenopyrite. Arsenopyrite was observed in only one section, (Section No.2). It is rather plentiful in this section, but not abundant generally. It appears intergown with pyrite and is similarly fractured.

Galena. Galena is not abundant in any of these sections studied. It occurs veining pyrite and arsenopyrite, and to a lesser extent in quartz fractures as veinlets, or small, irregular masses.

Chalcopyrite. Chalcopyrite was not abundant, and where found, occurred as narrow veinlets in fractured pyrite, sometimes intimately associated with galena.

Gold. Gold was seen to occur in the following ways:

1. In fractures in pyrite and arsenopyrite.
2. Intimately associated with galena.

Those grains occurring alone in pyrite fractures appear as veinlets, while those with galena appear as irregular masses intimately associated with the galena.

Paragenesis.

The following paragenesis is suggested.

Quartz, pyrite and arsenopyrite were the first minerals to be deposited. The quartz continued to precipitate during and after a period of fracturing, which shattered the pyrite and arsenopyrite. This conclusion is based on the following criteria.
1. Euhedral pyrite cubes in a groundmass of quartz.
2. Fractured pyrite in which the fractures are filled with quartz.

Later than this period of fracturing, galena, chalcopyrite and gold were deposited. These three sulphides occupy, to some extent, fractures in quartz and pyrite. Calcite appears to be the latest mineral, occurring in fractures in the other minerals.

**GRAPHICAL REPRESENTATION OF PARAGENESIS**

<table>
<thead>
<tr>
<th>Quartz</th>
<th>Pyrite</th>
<th>Arsenopyrite</th>
<th>Galena</th>
<th>Chalcopyrite</th>
<th>Gold</th>
<th>Calcite</th>
</tr>
</thead>
</table>

**Distribution and Size of Gold Particles.**

In the sections studied, gold occurred in only two ways; in fractures in pyrite, and associated with galena. Both of these occurrences indicate deposition later than that of the pyrite. The greater part of the gold seen occurs with or near galena, and suggests a more or less contemporaneous origin. The size of the gold particles varies from 4 microns to 42 microns, with an average of 16 microns. No gold was noted as inclusions in the pyrite in these sections. However, it must not be concluded that the gold does not occur in this way.

**Description of Sections.**

The following is a list of the sections with their constituent minerals. The minerals are separated according to their abundance in each individual section.
Section No. 1: Major -- Pyrite (very fine-grained).  
Minor --  
Rare -- Quartz, galena, gold and chalcopyrite.

Section No. 2: Major -- Pyrite and quartz.  
Minor -- Arsenopyrite.  
Rare -- Gold and galena.

Section No. 3: Major -- Pyrite.  
Minor -- Quartz.  
Rare -- Gold and galena.

Section No. 4: Major -- Pyrite.  
Minor -- Quartz.  
Rare -- Gold and galena.

Conclusions:

1. The primary ore of the mine consists of pyrite, arsenopyrite, galena, and chalcopyrite.

2. The minerals belong to the mesothermal zone of deposition.

3. All the gold seen in these sections was deposited later than the pyrite and quartz. The intimate association of gold and galena suggests that the two minerals were deposited at about the same time.

4. Most of the gold particles occur in fractures in pyrite with galena.

The Cariboo Hudson Mine.

Description of the Property.

Location.
The Cariboo Hudson property is situated in the Cariboo Gold belt in central British Columbia. The group is located at the head of Harvey and Cunningham creeks, approximately twenty miles southeast of Barkerville, which is situated 260 miles north and 60 miles east of Vancouver.

Barkerville is reached by a motor-road from Quesnel, which is the northern terminus of the Pacific Great Eastern
railway. Quesnel is also served by the Cariboo Highway from Vancouver to Hazelton.

**Economic Geology.**

The mineral deposit occurs in rocks of the Richfield formation, which consists of quartzite, schist, argillite and some limestone.

The deposit consists of a zone of veins and lenses of quartz which strikes generally to the southeast.

The mineralization consists of pyrite and galena in a quartz gangue. Small amounts of scheelite and ankerite also occur as gangue minerals.

**Mineralogy.**

**Introduction.**

Cariboo Hudson ore is similar in appearance to that of the Cariboo Gold Quartz mine. Pyrite with small amounts of sphalerite and galena are seen in the ore samples.

Eight sections of ore from this property were prepared and studied. They are numbered from one to eight, and will be referred to by number.

The following metallic minerals, listed in order of abundance, were determined in the ore:

1. Pyrite.
2. Sphalerite.
3. Galena.
5. Pyrrhotite.

Quartz is the usual gangue mineral with minor amounts of carbonates, mainly calcite.
Description of the Minerals.

Pyrite. Pyrite is the most abundant sulphide, occurring in all of the sections studied. It is fractured in all cases to some extent, and the fractures filled with quartz and later sulphides. Larger interstices between pyrite masses and individual crystals are also filled with quartz. About fifty percent of the pyrite observed appeared to be either wholly or partly crystalline. Chalcopyrite and pyrrhotite occur sparingly as minute round, or elongated blebs in the pyrite.

Quartz. Quartz occurs abundantly filling interstices between grains, and in fractures in the pyrite. Most of the quartz was probably deposited at the same time or later than the pyrite. No evidence was seen of more than one type of quartz.

Sphalerite. Sphalerite is rather abundant in some sections, and scarce in others. It occurs as large and small masses between pyrite masses, and also in fractures in both pyrite and quartz. Blebs of chalcopyrite occur sparingly in the sphalerite. Where it is in contact with galena, veinlets and embayments of galena penetrate into the sphalerite, in some cases leaving islands of sphalerite in the galena. Where these features occur, replacement of sphalerite by galena is indicated, but quite often the contact is smooth and regular, giving the appearance of contemporaneous deposition.

Galena. Galena has the same general distribution as sphalerite, and is present in about the same quantities.
In section No. 6, a wide veinlet of galena occurs in a quartz fracture and shows a curved cleavage structure. This deformation may be due to movement along the fracture during solidification of the galena.

**Chalcopyrite.** Chalcopyrite is very scarce in these sections. It occurs only as a few small inclusions in the pyrite and as minute blebs in sphalerite. One tiny veinlet was observed in a pyrite fracture.

**Pyrrhotite.** A few small round, or elongated inclusions in pyrite.

**Gold.** Gold occurs in the following ways:

1. In pyrite as inclusions.
2. In fractures in quartz.
3. In fractures in pyrite, with or without galena or sphalerite.
4. With sphalerite and pyrrhotite.

Gold contacts with galena, sphalerite or chalcopyrite are smooth and regular, suggesting simultaneous deposition; but gold occurring in fractures has an irregular veining appearance.

**Paragenesis.**

The following paragenesis is suggested.

Quartz, and pyrite were the first minerals to be deposited, though precipitation of quartz probably continued longer than that of the pyrite. Small quantities of gold and pyrrhotite appear to have been solidified with the pyrite, as they occur as inclusions in massive pyrite.

Fracturing took place after the pyrite and most of the quartz had been deposited.
These fractures were later filled by quartz, sphalerite, galena, gold and minor quantities of chalcopyrite.

Sphalerite and galena probably came in at the same time with the deposition of galena continuing later than sphalerite. Gold accompanied both of these minerals, but apparently favoured the galena. This is indicated by the frequent intimate association of gold with galena.

Chalcopyrite is associated with both galena and sphalerite.

**GRAPHICAL REPRESENTATION OF PARAGENESIS**

<table>
<thead>
<tr>
<th>Quartz</th>
<th>Pyrite</th>
<th>Pyrrhotite</th>
<th>Chalcopyrite</th>
<th>Gold</th>
<th>Sphalerite</th>
<th>Galena</th>
<th>Calcite</th>
</tr>
</thead>
</table>

**Distribution and Size of Gold Particles.**

The gold association in this ore is similar to that in the Cariboo Gold Quartz ore. By far the greater part of the gold is associated with the later sulphides, galena and sphalerite. Deposition of gold did, however, occur with the pyrite at a much earlier time.

In the sections studied, rich gold-bearing bismuth sulphides like those of the Cariboo Gold Quartz were not identified, but they are believed to be present, in small quantities, at least, in the ore.

The finest gold particles were, in general, those occurring as inclusions in pyrite. These averaged about 8 microns. The rest of the gold varied in size from 3 microns.
to 20 microns. Those grains occurring in fractures had the usual elongated shape in contrast to the irregular patches observed when the grains were associated with sphalerite and galena.

**Description of Sections.**

The following is a list of the sections with their constituent minerals. The minerals are separated according to their abundance in each individual section.

- **Section No. 1:** Major — Quartz.  
  Minor — Pyrite and sphalerite.  
  Rare — Galena and chalcopyrite.

- **Section No. 2:** Major — Pyrite, quartz and galena.  
  Minor — Sphalerite and chalcopyrite.

- **Section No. 3:** Major — Pyrite.  
  Minor — Quartz and sphalerite.  
  Rare — Gold.

- **Section No. 4:** Major — Pyrite and quartz.  
  Rare — Gold.

- **Section No. 5:** Major — Quartz.  
  Minor — Pyrite and chalcopyrite.  
  Rare — Pyrrhotite.

- **Section No. 6:** Major — Quartz.  
  Minor — Galena.  
  Rare — Gold and chalcopyrite.

- **Section No. 7:** Major — Quartz.  
  Minor — Pyrite and galena.

- **Section No. 8:** Major — Quartz and sphalerite.  
  Minor — Pyrite, chalcopyrite and pyrrhotite.

**Conclusions.**

1. The primary ore of the mine consists of pyrite, pyrrhotite, chalcopyrite, sphalerite and galena.

2. The minerals belong to the mesothermal zone of deposition.
3. Most of the gold appears to have been deposited with the later sulphides, and especially with galena, with which mineral it is principally associated.

4. There is a tendency for the gold particles to occur in fractures in pyrite and in quartz.
DISTRIBUTION OF THE GOLD PARTICLES IN THE CARIBOO ORE

<table>
<thead>
<tr>
<th>Mesh</th>
<th>Gold in quartz, with sulphides but not enclosed by them. Percent</th>
<th>Gold in Sulphides</th>
<th>Totals Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>In pyrite</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Along fractures</td>
<td>In dense</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percent</td>
<td>arsenopyrite</td>
</tr>
<tr>
<td>-150</td>
<td></td>
<td>3.7</td>
<td></td>
</tr>
<tr>
<td>-200</td>
<td></td>
<td>3.7</td>
<td></td>
</tr>
<tr>
<td>-250</td>
<td></td>
<td>11.1</td>
<td></td>
</tr>
<tr>
<td>-300</td>
<td></td>
<td>11.1</td>
<td></td>
</tr>
<tr>
<td>-350</td>
<td></td>
<td>7.4</td>
<td></td>
</tr>
<tr>
<td>-400</td>
<td></td>
<td>11.1</td>
<td></td>
</tr>
<tr>
<td>-450</td>
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<td>7.4</td>
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</tr>
<tr>
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<td>3.7</td>
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<td>11.1</td>
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<td>7.4</td>
<td>3.7</td>
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<tr>
<td>-750</td>
<td></td>
<td>11.1</td>
<td></td>
</tr>
<tr>
<td>-800</td>
<td></td>
<td>3.7</td>
<td></td>
</tr>
<tr>
<td>-850</td>
<td></td>
<td>7.4</td>
<td>22.2</td>
</tr>
</tbody>
</table>

(Gold occurring with cosalite and galenabismutite is not shown in this table.)
PART D.

THE BRIDGE RIVER MINING DISTRICT
THE BRIDGE RIVER MINING DISTRICT

Description of the District

Location.

The Bridge River District, in the Lilooet Mining division of British Columbia, is situated between 25 and 40 miles northwest of Shalath on the P. G. E. railway. This district is on the eastern margin of the Coast Range batholithic intrusives.

General Geology.

The following table shows, in general, the geological formations of the district.

### TABLE OF FORMATIONS

<table>
<thead>
<tr>
<th>Cenozoic</th>
<th>Modern</th>
<th>Cenozoic and Mesozoic</th>
<th>Mesozoic</th>
<th>Jurassic (?)</th>
<th>Palaeozoic and Mesozoic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Recent: stream deposits, volcanic ash, slide debris</td>
<td></td>
<td>President Intrusives</td>
<td>Bridge River series</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pleistocene: fluvial-glacial, glacial, and stream deposits.</td>
<td></td>
<td>Peridotite, dunite and pyroxinite</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kersantite and basaltic dyke.</td>
<td></td>
<td>Serpentine (mainly.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bendor Intrusives</td>
<td>Cenozoic and Mesozoic</td>
<td>Summer Gabbro</td>
<td>Diallage-olivine gabbro.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Feldspar and hornblende porphyrite dykes, and related dioritic stocks.</td>
<td></td>
<td></td>
<td>Gabbro, augite diorite, quartz diorite.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quartz albitite and albitite dykes.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


The oldest rocks in the area belong to the Bridge River series, which has been subdivided into four formations: the Hurley, the Pioneer, the Noel and the Fergusson. In this report, however, they will be classed together as the Bridge River series.

The series consists mainly of sediments and intercalated volcanic rocks. Slaty to schistose argillite, crystalline limestone, amygdaloidal basaltic and andesitic lavas, breccias and tuffs with massive chert intimately interbedded with the argillite, are the rock types. The argillites become more abundant toward the top of the series, but interbedded chert bands still occur. These chert bands are cream-coloured and very pure. Extensive thermal metamorphism over large areas by the Edenor intrusives, together with folding and shearing of the series has altered the lavas to greenstones, while the limestone has been re-crystallized and the argillites have become slaty and schistose.

The result of this alteration was to make it very difficult to determine which part of the series is exposed at any point.

The Bralorne intrusives are so named because they are typically developed on the property of Bralorne Mines, Limited. These are of two types; one of which may be referred to as the Bralorne diorite, and the other as the Bralorne soda granite. They constitute the important host rocks to the auriferous, quartz veins of the area, and together represent the intrusives which have generally been referred to as
the Bridge River augite diorite.

The Bralorne diorite is, typically, a greyish-green, medium-grained, crystalline rock intersected by a network of minute, lighter-coloured veinlets frozen to the wall-rock. The rocks vary in composition and degree of alteration, but the common types are diorite, quartz-diorite and augite diorite.

The soda-granite occurs frequently as small masses irregularly distributed through bodies of augite diorite. In some places the contacts are sharp and the bodies are roughly dyke-shaped. Elsewhere, the contacts appear gradational.

This soda granit is of particular interest because the known gold-quartz deposits lie in or near areas of the Bralorne diorite where there are conspicuous amounts of soda granite and related dykes. The gold-bearing deposits in many places are intimately associated with these granitic rocks and the quartz of the veins has certain peculiar features that are characteristic of the quartz in the soda granites.

The Sumner gabbro receives its name from Sumner creek, near the head of which the gabbro is exposed. It resembles the Bralorne augite diorite, but is more veined, more decomposed and more basic in appearance.

The President intrusives vary from dunite to pyroxenite in composition, but peridotite is the most common variety. Serpentinized equivalents of these rocks are
abundant, and in some cases, later thermal alteration of the serpentine has transformed large bodies to a mixture of ankerite carbonate and talc.

The Bendor intrusives are the youngest of the major intrusive rocks, and are representatives of the Coast Range batholithic complex. The rocks are mainly granodiorite and quartz-diorite with small differentiations.

The Bendor batholith invades all of the Bridge River series, and the President intrusives. Metamorphism of the intruded formations is generally strongly pronounced for several hundred yards from the contact, and is noticeable for a distance of a mile or more.

Numerous other lamprophyre and basaltic dykes in the area are probably of Tertiary age.

**Structural Geology.**

The general structural feature of the area is a syncline within a major anticlinal arch trending northwesterly. Zones of weakness along the synclinal axes have been penetrated by intrusions. Minor folding and shearing have caused the structure to be very complex.

The sediments and intercolated volcanic rocks stand mostly at high angles, and, locally, as a result of the Bendor batholithic intrusion, are overturned.

Two main fault systems occur. One system comprises two sets of fractures at angles of about 35 degrees with the formational trend. These fractures crosscut the formations and are best developed in the more massive rock. These are
the fissures which contain the principal gold-quartz veins of the area.

The other system consists of faults or shears conforming with the strike of the formations traversed by them. These are best developed in the least competent formations, and develop marked shear zones.

**Mineralization.**

The mineral deposits are of the fissure vein type, and most appear to be genetically related to the Bralorne intrusives. Other deposits of different character are probably related to the Bendor batholith.

In general, the veins are continuous along straight fissures, though pinching and swelling may occur. Quartz is the chief gangue mineral, but calcite also occurs abundantly. The sulphides in order of abundance are: pyrite, arsenopyrite and galena, while pyrrhotite, chalcopyrite, tetrahedrite and stibnite are comparatively scarce. Native gold is associated with the sulphides.

**The Bralorne Mine**

**Description of the Property.**

**Location.**

The property of Bralorne Mines, Limited, is at Bralorne on Codwallader creek. It lies northwest of, and adjoins, that of Pioneer Gold Mines, and comprises fifty-eight or more claims, mostly Crown-granted, within which lie the
workings of the King, Empire, and Coronation mines. The property is equipped at Bralorne with a 450 ton mill, and is operated by power generated by its own plant and supplemented, as required, by Bridge River Power Company, Limited.

The mine can be reached either by aeroplane, or by motor road from Shalath, a distance of 25 miles. Shalath is served by the Pacific Great Eastern railway from Squamish, B.C.

History.
Most of the original claims were staked in 1897, and for a number of years were owned individually or in small groups, and were prospected and operated on the limited scale necessitated by difficulties in transportation and finance. Between 1900 and 1928 development proceeded slowly, small companies operating groups of claims. In 1928 Lorne Gold Mines, Limited of Vancouver, took over the entire group of mines, and a heavy program of underground development work was started.

Owing to failure of the Company's fiscal agents, all development work was suspended early in 1930, and another company, Bralorne Mines, Limited was formed to acquire a sixty percent interest in Lorne Gold Mines. Since that time to the present, production has been heavy and continuous.

Economic Geology.
The geology of the Bralorne property comprises a faulted syncline of Bridge River formations striking northwesterly and penetrated by Bralorne intrusives, bands of serpentinized peridotite and numerous dykes.

The Bralorne intrusions form three bodies, one of
which is much larger than the others and is exceptionally important in that it contains the principal vein deposits. It consists mainly of augite-diorite, but along its north-eastern flank is composed of soda granite.

Numerous dykes of different types are encountered in underground workings. Those of most interest are light-coloured, quartz-albitite dykes. Their close association with the vein fissures and their probable relation to the Bralorne soda-granite, suggest that they were intruded along fractures that were later re-opened to permit access of vein-bearing solutions.

The principal vein deposits occur in fault fissures striking mainly about east. Other veins follow fissures striking more to the north. Only some of the later are fault fissures. In most cases the vein-bearing fissures striking east, dip to the north, and the north-south veins dip to the west.

Mineralization consists of white quartz with irregularly distributed amounts of pyrite, arsenopyrite, galena, sphalerite, tetrahedrite and gold.

Mineralogy.

Introduction.

Three polished sections of ore from the Bralorne mine were prepared and studied microscopically.

Section 1. — Mainly quartz with a small amount of visible gold, galena and millerite.

Section 2. — Consists of Jig concentrate material.

Section 3. — Mainly quartz with a little visible gold, sphalerite, galena and tetrahedrite.
The following metallic minerals were identified in the sections.

1. Pyrite.
2. Arsenopyrite.
3. Sphalerite.
4. Tetrahedrite.
5. Galena.
7. Chalcopyrite.
8. Millerite?

Quartz is the only gangue mineral present.

**Description of the Minerals.**

**Pyrite.** Pyrite occurs as euhedral grains and small masses in the quartz. Usually the pyrite is surrounded and veined by the quartz; a few cases were seen, however, where galena and sphalerite veined and enclosed the pyrite particles.

**Arsenopyrite.** Arsenopyrite occurs in the same way and in about the same quantity as pyrite. In Section No. 3, arsenopyrite was seen to be veined by sphalerite, indicating deposition prior to that of the sphalerite.

**Sphalerite.** Sphalerite occurs relatively abundantly in all sections, although it comprises a very small percentage of the vein material. As noted above, it veins into arsenopyrite, and pyrite is, therefore, of later origin than both of these minerals. Chalcopyrite occurs as small blebs in most of the sphalerite.

**Chalcopyrite.** The only occurrence of chalcopyrite noted was a few small blebs with rounded boundaries in sphalerite. It appears to be due to exsolution.

**Galena.** Galena is relatively abundant. It occurs as irregular masses in the quartz, usually along fractures. Where pyrite and galena are in contact, the galena appears
to be the later mineral of the two. Galena forms rounded, smooth boundaries with sphalerite where the two minerals occur together. No definite criteria were noted to reveal the age relations between the two.

**Tetrahedrite.** Tetrahedrite was seen in small quantities in Section No. 3. It is intimately associated with galena, with which mineral it forms smooth, intimate boundaries. Tetrahedrite and galena were probably deposited at the same time.

**Gold.** Gold was observed in all three sections. It occurs in the following ways:

1. As isolated blebs or masses in quartz.
2. Intimately associated with galena.

By far the greater proportion of the gold occurred as large and small masses either included in or beside patches of galena, with which mineral it forms smooth, rounded boundaries, suggesting simultaneous deposition. A few scattered grains were seen in quartz fractures with no other mineral near them.

The gold is mainly very coarse, and much of it is visible megascopically, but the average size of the grains is about 30 microns.

**Quartz.** Quartz makes up approximately 95 percent of the sections. It ranges from milky white to translucent, and is in general finely crystalline.

Two different generations of quartz occur in Section No. 1. The early quartz is by far the more abundant, and this generation has been fractured, and these fractures filled with
sphalerite, galena and gold. The later generation was observed rimming cavities in the older quartz. In nearly all cases where the younger generation was seen, it contained numerous rod-like inclusions of a yellow mineral.

Millerite? The rod-like, brass-yellow mineral included in the second generation quartz, was tested both by etching and by microchemistry. Due, however, to the extremely fine size and the rareness of the mineral, conclusive results were not obtained. However, both the etch reactions and the microchemical results indicated that it was the nickel sulphide, millerite. Its strong anisotropy and fibrous form also suggest this mineral.

Paragenesis.

The following paragenesis is suggested.

Pyrite appears to be the first sulphide mineral deposited. Arsenopyrite may be of the same time, but no pyrite-arsenopyrite boundaries were observed. Probably some quartz accompanied these minerals. Fracturing of the pyrite and arsenopyrite followed their deposition and preceded the precipitation of more quartz, which was then itself fractured. Later, sphalerite, galena and tetrahedrite were deposited, with galena and tetrahedrite probably overlapping and later than the sphalerite. Gold is intimately associated with galena, and must have been deposited with that mineral.

No definite age relationships were observed between the second generation of quartz, and the above-mentioned sulphide minerals, and it is therefore not advisable to place its precipitation at a definite time in the mineralogical sequence.
All that can be said about it is that it is later than the other quartz in the sections.

With this later quartz, is associated the mineral tentatively identified as millerite. It appears to be present as inclusions in the quartz, and must, therefore, be of the same age.

**GRAPHICAL REPRESENTATION OF PARAGENESIS**

<table>
<thead>
<tr>
<th>Pyrite</th>
<th>Arsenopyrite</th>
<th>Quartz</th>
<th>Sphalerite</th>
<th>Galena</th>
<th>Gold</th>
</tr>
</thead>
</table>

**Conclusions.**

1. The primary ore of the mine consists of pyrite, arsenopyrite, sphalerite and galena.

2. The minerals present suggest the deposit belongs to the mezothermal zone of deposition.

3. The gold is associated mainly with galena and was one of the last minerals to be deposited.

4. A brass-yellow mineral of fibrous or rod-like structure occurs in quartz, which is thought to be the nickel sulphide, millerite. The writer suggests that more research be done on this mineral before a definite conclusion as to its identity is reached.
PART E

THE YMIR MINING DISTRICT

AND THE

SECOND RELIEF MINE
PART E: THE YMIIR MINING DISTRICT

Description of the District

Location.

The Ymir district is located about twenty miles south of the town of Nelson in the Kootenay district of British Columbia. The area is readily accessible. Nelson, on the Canadian Pacific railway and the southern transprovincial highway, acts as a distributing centre. A branch line of the Great Northern railway, which follows for some way the valley of Salmo river, passes near the main productive mines. A highway from Nelson to Spokane also traverses the area, and connecting branch roads lead to many of the properties.

General Geology.

The mineral deposits of the area occur mainly in three formations; the Pend d'Oreille series, the Rossland volcanic group, and the Nelson batholith.

The Pend d'Oreille series strikes roughly north, conforming in a general way with the north-south border of the granitic masses. This group consists of metamorphosed sedimentary rocks; argillites, quartzites, quartz-mica schists, and crystalline limestone with some tuffs and greenstones.

The Rossland volcanic group occurs to the west of the Pend d'Oreille series, and extends north in a wide belt
to near Nelson. In the Salmo map-area, to the south, the
name Beaver Mountain-Rossland group has been applied due to
the difficulty in differentiating the Rossland from the Beaver
Mountain flows. The rocks of this belt consist of a complex
assemblage of basic volcanic rocks with pyroclastics. In
places where these rocks are highly sheared, they are con­
verted into chlorite schists.

Both of these groups are cut by granodiorite of
the Nelson batholith. One large tongue of the batholith
occurs to the east of the principal belt of the Pend d'Oreille
rocks, and many smaller apophyses or dykes cut the intruded
Pend d'Oreille schists. Grey granodiorite of medium texture
is the most common granitic type in the area, but variations
range from a true granite to quartz diorite.

A number of granite porphyry tongues, slightly
older than the Nelson batholith, but younger than the Rossland
volcanics, are believed to be related to some of the ore
deposits. In most cases these are altered and schistose.

A small stock of monzonite and pulaskite, occurring
near Ymir, is thought to be of Tertiary age.

Numerous dykes of syenite-porphyry, granite-porphyry,
quartz-porphyry, and lamprophyre have invaded all but the
youngest of the rocks described. Some of these cut the vein
deposits, and some occupy post-mineral faults.

Mineralization.

The mineralizing solutions are thought to have been
late differentiates of the Nelson batholithic magmas.
A large number of the veins are mainly sulphide-bearing silicified schist veins. Fragments of both schist and granite are included in the matrix.

**The Ymir Yankee Girl Mine**

**Description of the Property.**

**Location.**


The mine is situated on the northern slope of Bear creek valley, about two miles from Ymir. A branch road from the road up Bear creek connects with the lower or working tunnel of the mine.

**Economic Geology.**

The Yankee Girl vein deposits occur in the contact zone of a mass of the Nelson granodiorite, which trends northeasterly across the camp. At the mine, a large number of tongues of this rock intrude the Pend d'Oreille schists. The deposits of the Yankee Girl are of the fissure vein type, having been localized in faults. Three of these veins are present; the Yankee Girl, the Spur, and the Lakeview.

The Yankee Girl vein strikes north 60 to 70 degrees east, with an average dip of 65 degrees to the southeast. It averages about four feet wide, and has a maximum width of 30 feet. In productive sections, it does not exceed 12 feet.
The Spur vein parallels the Yankee Girl vein for a considerable distance. This is a branch of the Yankee Girl vein because its intersections with the latter are known.

The Lakeview, a non-commercial vein, occurs within the Lakeview fault fissure, which parallels the formation in a long, narrow remnant of Pend d'Oreille rocks enclosed between thick granite tongues. The Yankee Girl vein lies to the southwest of the Lakeview for a considerable distance, and then merges with or is offset by the Lakeview vein.

The principal structural control of ore deposition appears to be the intersection of the Lakeview and Yankee Girl veins, but locally ore shoots occur where tongues of granodiorite are cut by the Yankee Girl vein.

Oxidation occurs, but in general does not extend below the 400 foot level.

Mineralogy.

Introduction.

Four sections of ore from the Ymir Yankee Girl mine, previously prepared by D. M. McKinnon, were remounted and super-polished by the writer. The sections were re-numbered to correspond with the numbers on the original sections.

The following metallic minerals, listed in order of abundance, were determined to be present in the sections.

1. Pyrite.
2. Sphalerite.
3. Galena.
5. Pyrrhotite.
Description of the Minerals.

**Pyrite.** Pyrite is found generally as irregular masses in quartz, and to a lesser extent in sphalerite, and galena. As a rule, pyrite develops crystal form, but in Section No. 2, massive pyrite was seen filling a fracture in sphalerite. These criteria suggest the presence of two generations of pyrite. The early pyrite is considerably fractured, and these fractures are filled with quartz, sphalerite and galena. It contains a few blebs of chalcopyrite.

**Sphalerite.** Sphalerite is relatively abundant in the sections. It occurs in fractures in quartz and pyrite, and in areas of much shattered pyrite. Intimate intergrowths of galena and sphalerite are numerous, but galena was noted in a fracture in zinc sulphide.

**Quartz.** This mineral is the chief gangue constituent. It occurs between pyrite masses and grains, and in fractures in the pyrite. Shattering of the quartz allowed sphalerite, galena and pyrite to fill the fractures. The occurrence of a second generation of quartz is suggested by its association with pyrite and galena in fractures in sphalerite.

**Galena.** Galena has about the same general distribution as sphalerite. It occurs for the most part intimately associated with sphalerite. This suggests deposition more or less at the same time, but some galena must have been deposited later than the sphalerite, as it fills a fissure in that mineral. Galena was also noted in fractured quartz.

**Pyrrhotite.** Pyrrhotite occurs as a few small blebs in pyrite.
Chalcopyrite. Chalcopyrite is exceedingly scarce. A few blebs were observed in pyrite.

Arsenopyrite. A few grains of this mineral were noted in Section No. 3. It occurs intergrown with pyrite.

Gold. Gold occurs only in Section No. 2. It is associated with both galena and sphalerite in fractures in pyrite. The greater number of gold blebs were with or near galena.

Paragenesis. The following paragenesis is suggested.

Pyrite was the first sulphide to be deposited. Some fracturing then occurred and was followed by the deposition of quartz, which filled spaces between pyrite grains and masses, and also in smaller fractures in pyrite. After solidification of the quartz, a second period of fracturing caused cracks in both pyrite and quartz in which some of the sphalerite and galena were deposited. Shattering of the sphalerite is not extensive in the sections, but some deformation is indicated. Fractures caused by this deformation are filled by galena, quartz and pyrite. Galena was the last sulphide to be deposited although it probably overlapped the deposition of the sphalerite. Gold appears to be associated with both sphalerite and galena and probably accompanied these two minerals.

GRAPHICAL REPRESENTATION OF PARAGENESIS

<table>
<thead>
<tr>
<th>Pyrite</th>
<th>Pyrrhotite</th>
<th>Chalcopyrite</th>
<th>Quartz</th>
<th>Sphalerite</th>
<th>Galena</th>
<th>Gold</th>
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</table>
Assays.

In order to determine the mode of occurrence of the gold, the following samples were picked out under the microscope and assayed by Mr. D. M. McKinnon.

1. Pure pyrite of the first generation in contact with quartz. (Section No. 3) ................. 0.08oz.
2. Pure sphalerite. (Section No. 1) .............. Trace.
3. Pure galena (Section No. 4) ................. 0.64oz.
4. Pure pyrite in contact with galena and sphalerite. (Section No. 2) ...................... 1.80oz.

It is interesting to note that Section No. 2, which gave by far the highest assay, was the only section in which the gold was seen microscopically by the writer.

Description of Sections.

The following is a list of the sections with their constituent minerals. The minerals are separated according to their abundance in each individual section.

Section 1: Major — Sphalerite.
Minor — Pyrite and galena.
Rare — Quartz and chalcopyrite.

Section 2: Major — Pyrite.
Minor — Sphalerite, galena and quartz.
Rare — Chalcopyrite, pyrrhotite and gold.

Section 3: Major — Pyrite.
Minor — Quartz, sphalerite and galena.
Rare — Chalcopyrite and pyrrhotite.

Section 4: Major — Galena.
Minor — Quartz.
Rare — Pyrite and sphalerite.

Conclusions.

1. The primary ore in the mine consists of pyrite, sphalerite, galena, with minor amounts of chalcopyrite.

2. The minerals belong to the mesothermal zone of deposition.
3. The gold is associated with sphalerite and galena.

4. The majority of the gold particles occurred in fractured pyrite, with galena and sphalerite.

5. No secondary minerals were observed in these sections.

The Second Relief Mine

Description of the Property.

Location.

The Second Relief Mine is owned by Relief-Arlington Mines, Limited, which in turn is controlled by Premier Gold Mining Company, Limited. The property is on Erie creek, about 13 miles from the village of Erie on the Great Northern railway. It is connected by a road with Erie.

History.

This is an old property which has been operated intermittently for many years, generally by Lessees. In 1929, the Second Relief Mining Company, Limited was amalgamated with the Arlington Mining Company to form the Relief-Arlington Mines, Limited, and in 1934 the Premier Gold Mining Company, Limited secured control.

Economic Geology.

The property is underlain by rocks of the Rossland-Beaver-Mountain group, which here consists of greenstone, slate, tuff and argillite. At the surface these sediments dip eastward at moderate angles, but underground they have been found dipping to the west.

About half a mile north of the mine, the Rossland-
Beaver-Mountain rocks are invaded by the Nelson batholith. The intrusive rocks of the batholith are light-grey, medium-grained granodiorite, in general.

Two groups of dykes occur on the property. One group consists of diorite and diorite-porphyry, and is pre-mineral. A prominent dyke of this type is followed by the main vein. So far as is known, most of the other dykes are younger than the vein deposits and strike from north to northwest. These consist of granite-porphyry, quartz-porphyry, and a few lamprophyre dykes. It is thought that the lamprophyres are the youngest of the dyke rocks, but little evidence as to their age has been obtained except that one of them cuts the Second Relief vein.

The ore-deposits are fissure veins, occurring mainly in the greenstone of the Rossland volcanics. The veins strike northeast and dip, generally, to the northwest at steep angles. One vein, known as the Second Relief vein, is the most important and has supplied most of the production of the mine. It follows the hanging-wall of a diorite-porphyry dyke, as mentioned above. Small later dykes cut both the vein and granite-porphyry, some of these following the vein for a distance before passing out on the other wall. Small faults are present which offset the vein a few feet.

The ore minerals consist of pyrite, pyrrhotite and chalcopyrite. Molybdenite has also been reported. The gangue consists of country rock and quartz carrying some magnetite, garnet and epidote. The time of formation of the vein is
between that of the injection of the diorite-porphyry dyke, and the injection of the quartz or granite-porphyry dykes. Both the ore deposits and the dykes are undoubtedly related to the differentiation of the Nelson granodiorite.

Mineralogy.

Introduction.

Three polished sections, previously prepared by Mr. H. Kipp, and two new sections prepared by the writer, were studied microscopically.

The following minerals, in order of abundance, were determined to be present in the sections examined.

1. Pyrrhotite.
2. Pyrite.
3. Sphalerite.
4. Galena.
5. Chalcopyrite.
6. Arsenopyrite.
7. Gold.

Quartz and calcite are the gangue minerals present. Quartz is by far the more abundant.

Description of the Minerals.

Pyrite. Pyrite is fairly abundant. It occurs as anhedral masses and also crystalline. Two generations of pyrite appear to be present in the ore. The first generation occurs as isolated crystals and small anhedral fractured masses. Pyrrhotite and quartz fill the fractures in pyrite, and also the interstices between the pyrite grains, suggesting deposition later than the pyrite. The second generation occurs veining pyrrhotite, and is evidently later than the pyrrhotite.

Arsenopyrite. Arsenopyrite occurs as euhedral grains in pyrrhotite, and is intimately associated with pyrite,
with which mineral it forms mutual, smooth boundaries. It is not as plentiful in the sections as pyrite.

**Pyrrhotite.** Pyrrhotite is the most abundant mineral in the ore. It occurs massive, and fills spaces between pyrite and arsenopyrite grains, and also fills fractures in these minerals. Hexagonal sections of quartz crystals were observed in the pyrrhotite, indicating deposition later than some of the quartz. One small mass of pyrrhotite was seen in a quartz fracture.

**Sphalerite.** Sphalerite is rather scarce in the sections studied. It occurs as small masses in quartz, and in one section was seen to fill a fracture in pyrrhotite. Some sphalerite was evidently deposited later than the pyrrhotite.

**Chalcopyrite.** Chalcopyrite is not abundant. It occurs as small masses in quartz, as small, included blebs in pyrrhotite, and along contacts between pyrrhotite and quartz.

**Quartz.** Quartz occurs both crystalline and massive. Sections of hexagonal crystals were observed in pyrrhotite, and massive quartz occurs filling fractures in pyrite.

**Gold.** Most of the gold particles occurred either in quartz fractures or along quartz-pyrrhotite boundaries. A small amount was seen included in pyrrhotite and sphalerite, with which minerals it forms smooth, mutual contacts.

**Paragenesis.**

The following paragenesis is suggested.

Pyrite and arsenopyrite were the first sulphides to be deposited. Some quartz may have accompanied or even
preceded their precipitation, but most of it appears to be later than the pyrite and arsenopyrite. Some fracturing took place either previously to or during the deposition of the quartz. The deposition of pyrrhotite appears to have occurred later than the quartz. Some of it evidently fills cavities in the quartz, as sections of quartz crystals were seen projecting into the pyrrhotite masses. Some sphalerite was deposited later than the pyrrhotite, as it was observed filling a fissure in the pyrrhotite. Gold appears associated with both pyrrhotite and sphalerite, but most of it was probably deposited near the end and later than the deposition of the sphalerite.

**GRAPHICAL REPRESENTATION OF PARAGENESIS**

| Quartz   | Pyrite         | Arsenopyrite | Pyrrhotite | Chalcopyrite | Sphalerite | Gold |

**Distribution and Size of Gold Particles.**

In these sections, a large part of the gold occurred at the contact of pyrrhotite and quartz, a little occurred in quartz and some was seen in sphalerite and pyrrhotite. This distribution suggests that most of the gold was late and probably was the last metallic mineral to be deposited.

The size of the gold particles varies from 4 microns to 15 microns, with an average of about 12 microns. No very large pieces were seen, but in general it is fairly coarse.

**Description of Sections.**

Section No.K1: Major -- Pyrrhotite.
Minor -- Quartz and pyrite.
Rare -- Chalcopyrite and gold.
Section No. K2: Major — Pyrrhotite and quartz.
Minor — Chalcopyrite and arsenopyrite.
Rare — Pyrite and gold.

Section No. K3: Major — Pyrrhotite.
Minor — Sphalerite and quartz.
Rare — Pyrite, arsenopyrite, chalcopyrite and gold.

Conclusions:
1. The primary ore seen in the sections consists of pyrrhotite, pyrite, arsenopyrite, chalcopyrite, sphalerite.

2. The minerals suggest deposition under conditions between medium and high temperatures.

3. Deposition of the gold appears late in the mineralogical sequence, probably accompanying the last sulphides.

4. No gold was observed as inclusions in pyrite or arsenopyrite.

5. Most of the gold particles occur along the boundaries between pyrrhotite and quartz, or in quartz fractures.

The sections marked (K) are those prepared by Mr. H. Kipp.
PART F:

THE SURF INLET AND HUNTER PROPERTIES
PART F: THE SURF INLET MINING DISTRICT

Description of the District

Location.

The Surf Inlet area, as used here, refers only to those parts of the British Columbia coast in the vicinity of and including Princess Royal Island. The district is located approximately east of Moresby Island of the Queen Charlotte group, and about 450 miles northwest of Vancouver, B. C. It is accessible only by boat, as it is an exceedingly rugged and mountainous area consisting of a part of the Coast Range batholith.

General Geology.

The following table shows the geological formations of the district.

<table>
<thead>
<tr>
<th>TABLE OF FORMATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tertiary</strong></td>
</tr>
<tr>
<td><strong>Pleistocene or Pliocene</strong></td>
</tr>
<tr>
<td><strong>Mesozoic</strong></td>
</tr>
<tr>
<td><strong>Mesozoic</strong></td>
</tr>
</tbody>
</table>
This section of the Pacific coast consists largely of one great formation, the Coast Range batholith. More than nine-tenths of the area is occupied by quartz-diorite and related rock types. The only older rocks are a few relatively small patches of metamorphosed sedimentary and volcanic rocks, which occur as inclusions in the batholith. The only rocks younger than the batholith are dykes of late Pliocene or early Pleistocene age, and some tuffs and flows of post-Pleistocene age.

The oldest rocks in the district consist of a few small inclusions in the batholithic rocks about one mile in width scattered throughout the district, and one or two much larger ones, which occur in the northern part of it. These rocks consist of chloritic and sericitic schists, grading into gneiss. Some of them are interbedded limestones and andesite, and resemble the Vancouver volcanics of upper Triassic age.

The rocks of the batholith vary considerably in type. The most typical rock of this section is a light-grey, medium-grained, quartz-diorite, consisting of white plagioclase, quartz, hornblende, and varying amounts of biotite, with little or no alkali feldspar. A light-coloured, medium-grained, granodiorite is the chief variation.

Pegmatitic and aplitic variations are common in the vicinity of Princess Royal island. These occur as dykes and pipe-like masses, but differ only in their coarser texture from the normal country rock. They contain no minerals of the rarer elements.
Basic variations are very uncommon, but do occur near some of the more basic inclusions. These are darker in colour due to a higher percentage of hornblende and little or no quartz.

The post-batholithic dykes are dark-coloured, and of basic composition. One of these cuts the veins in the Surf Inlet mine.

**Structural Geology.**

The batholithic rocks are gneissic in many places near inclusions. The foliation is parallel to that of the inclusions.

Faulting is general in the district, but is more pronounced near the Surf Inlet mine where there is a strong shear zone.

**Mineralization.**

Mineralization in the vicinity of Surf Inlet consists of pyritized quartz veins in a zone of intense shearing, which strikes a few degrees east of north. The mineral deposits are probably associated with the later stages in the cooling of the Coast Range batholith.

**The Surf Inlet Mine**

**Description of the Property.**

**Location.**

The Surf Inlet gold mine is owned and operated by the Princess Royal Gold Mines, Limited. It is situated about
seven miles inland from the head of Surf Inlet, on Princess Royal island. The mine is one mile from Bear lake, which is one mile above Cougar lake, and Cougar lake extends to within two hundred yards of the head of Surf Inlet.

**Economic Geology.**

The ore of the Surf Inlet mine occurs in large pyritized quartz veins. These lie in a zone of intense shearing, which cuts the rocks of the Coast Range batholith in a direction about north three degrees east, and for a distance passes through an inclusion of chloritic schist.

The foliation and contacts of the schist with the batholithic rocks strike approximately parallel to the shear zone.

Inclusions of the older rocks occur at several places, but the most important is a large band of schist which occurs on the surface above the upper levels of the mine and extends down to the lower levels.

This schist is a dark-green, medium-fine rock, grading into gneiss, composed chiefly of chlorite, sericite and talc. Batholithic rocks in the mine consist entirely of quartz-diorite.

Two pegmatite dykes occur on the 550 foot level and vary from one to two feet in width. The pegmatites and veins are similar in composition and therefore, probably closely related in origin.

The ore occurs mainly in two large quartz veins, one on the west or hanging-wall side, and the other on the foot-wall side of the shear zone. In the upper levels the
veins are from 100 to 160 feet apart, but converge until they meet at the 550 foot level to form one large vein.

The veins have a maximum length of 1000 feet, a maximum width of 40 feet, and dip from 40 to 60 degrees to the west.

Above the 550 foot level, the two veins are connected by a large cross-vein striking at right-angles to the other two. Besides this, there are numerous small veins in the fractures and shear planes of the diorite. These strike in all directions.

The pyrite usually lies in streaks and bands parallel to and sometimes adjacent to, the bands of included country rock. The veins consist chiefly of quartz and pyrite, the latter carrying the gold. Minor amounts of chalcopyrite, native silver, chalcocite, bornite, covellite, hematite and molybdenite also occur.

Mineralogy.

Introduction.

Three sections of Surf Inlet ore were cut, mounted and polished. The ore consisted of massive pyrite in white, to translucent, quartz, which was in all samples seen, finely crystalline. Pyrite was the only sulphide visible in the ore samples.

The following metallic minerals were determined by microscopic examination to be present in the ore. They are listed in order of abundance.

1. Pyrite.
2. Chalcopyrite.
Quartz was the only gangue mineral in the sections.

**Description of the Minerals.**

**Pyrite.** Pyrite is the only abundant sulphide in all these three sections. It occurs massive, and is somewhat fractured. Quartz fills all the fissures in the pyrite. A few small, scattered inclusions of chalcopyrite were observed in this mineral. These were in all cases very small and more or less rounded.

**Chalcopyrite.** Chalcopyrite is present in small, scattered blebs in the pyrite, and rarely as small veinlets filling fractures in the pyrite. The boundaries between pyrite and the inclusions of chalcopyrite are very smooth and mutual, indicating contemporaneous deposition, while the veinlets occurring in fractures were undoubtedly solidified later than the pyrite.

**Gold.** Gold was seen only in Section No. 1, and occurred in only one way. In this section two grains of fair size were observed only after etching with nitric acid. Before etching, each section was studied for a long time without detecting any gold. 1:1 Nitric acid was then placed on the polished surface for about 30 seconds and then washed off. The surface of the pyrite, after etching, revealed multitudes of pits of various shapes and sizes. Many of the fractures appeared wider and new ones were observed. In two of these pits gold was observed. The grains were of fair size, but had not been visible on the original polished surface.

The following explanation of the phenomenon of gold appearing after etching, in a previously barren field,
is suggested by the writer.

To obtain a high polish on the pyrite, as much weight as possible was used on the sections in the polishing process. Also, in the final stages of polishing, the sections were kept very dry. This would be likely to cause "smearing" of the soft minerals. A coating ground into the surface of the gold particles during the polishing process would make the detection very difficult.

This explanation appears probable, especially as no other mineral, which might mask the gold, occurred with it.

**Paragenesis.**

The following paragenesis is suggested.

Pyrite and possibly some quartz were the first minerals to be deposited. Some fracturing of the pyrite took place and was followed by deposition of more quartz, some of which filled fractures in the pyrite.

All the gold that was seen appeared to be included in the pyrite and evidently solidified with that mineral.

Some chalcopyrite is present as inclusions in pyrite, and some is present in fractures. It would seem, therefore, that part of the chalcopyrite was deposited later than the pyrite.

**GRAPHICAL REPRESENTATION OF PARAGENESIS**

<table>
<thead>
<tr>
<th>Quartz</th>
<th>Pyrite</th>
<th>Chalcopyrite</th>
<th>Gold</th>
</tr>
</thead>
</table>

**Distribution and Size of Gold Particles.**

The gold was observed to occur only as inclusions in the pyrite. The sizes of the two particles seen were
8 microns and 20 microns respectively.

**Description of Sections.**

Sections No. 1, No. 2 and No. 3, all consisted of pyrite with small amounts of chalcopyrite. Gold occurred in Section No. 1.

**Conclusions.**

1. The primary ore of the mine in the sections studied consists of pyrite and chalcopyrite.
2. The gold occurs with the pyrite, and is included in the pyrite.
3. No conclusion was arrived at as to the probable temperature of the deposit.

**PART F: THE HUNTER PROPERTY**

**Description of the Property.**

**Location.**

The Hunter group, composed of 12 claims, is owned by C. W. Meldrum and associates of Vancouver. The property is situated eight and one half miles up the north fork of the Khutze river, and 13 miles from seaboard at the head of Khutze inlet, about 100 miles south of Prince Rupert, B. C.

**General Geology.**

Although the Hunter property lies considerably north of Surf Inlet, the general geology of the district is very similar, both properties occurring in the rocks of the Coast Range batholith and associated with remnants of older sedimentary and volcanic roof-rocks.

**Economic Geology.**

The Khutze river section is situated in the heart
of the Coast Range batholith. Biotite and biotite-hornblende quartz-diorite are the characteristic rock types of the area. Besides the batholithic rocks, there occur small, isolated areas of older roof-rocks of limestone and altered sediments.

The district is characterized by a wide distribution of pegmatite and aplite dykes, and zones of differentiation near the remnants of older roof-rocks.

The ore deposit consists of narrow and erratic quartz veins, mineralized with high-grade gold-bearing pyrite. Two systems of veins occur varying from one-half to 18 inches wide, one striking north-easterly and dipping between 30 and 80 degrees east, the other striking approximately north and dipping from 50 to 80 degrees east.

There is a tendency for ore to occur in greater quantity near the more basic portions of the wall-rock. Mineralization consists of crystalline, gold-bearing pyrite in isolated patches, scattered blebs and streaks. At least nine veins and stringers are exposed, and these have been traced for distances up to 400 feet.

Mineralogy.

Introduction.
The ore from this property consists of pyrite, with minor amounts of other sulphides in a quartz gangue. Macroscopically, pyrite was the only sulphide mineral observed.

Four sections of this ore were prepared and studied microscopically.

The following metallic minerals were determined by
microscopic examination to be present in the sections. They are listed in order of abundance.

1. Pyrite.
2. Sphalerite.
3. Galena.
5. Pyrrhotite.

Quartz was the only gangue mineral observed in the sections.

Description of the Minerals.

**Pyrite.** The pyrite occurs as large anhedral masses. It is considerably fractured and these fissures are filled with quartz, and sphalerite, and with galena and chalcopyrite to a lesser extent. Small, rounded inclusions of chalcopyrite, and rarely pyrrhotite, occur in the pyrite. The boundaries between these inclusions and pyrite are smooth, regular and mutual. Usually, the pyrrhotite blebs are associated with chalcopyrite.

**Pyrrhotite.** Pyrrhotite is extremely rare and occurs only as inclusions in pyrite.

**Chalcopyrite.** Chalcopyrite occurs, as noted above, in pyrite as inclusions, and also sometimes in fractures in pyrite. Some masses occurring in fractures are up to 40 microns in size, but in general, chalcopyrite is a minor constituent of the ore.

**Sphalerite.** Sphalerite is not abundant. It occurs in masses surrounding pyrite and sometimes filling fractures in pyrite. In most cases small, rounded and elongated blebs of chalcopyrite occur in the sphalerite as inclusions.
The chalcopyrite is probably due to exsolution. Galena was also seen as irregular patches and veinlets in the sphalerite.

**Galena.** Galena is less abundant than the sphalerite. It occurs mainly in fractures in pyrite. Galena-sphalerite boundaries are usually smooth and regular, but occasionally galena veins into the zinc sulphide. The two minerals appear to have been deposited at the same time with the deposition of the galena lasting longer than that of sphalerite.

**Quartz.** Quartz is abundant. It occurs surrounding pyrite masses and filling fractures in that mineral. Some fractures are present in the quartz, and to some extent these are filled by galena, sphalerite and chalcopyrite.

**Gold.** Gold was observed only in Section No. 4. It occurred in the following ways:

1. As inclusions in pyrite.
2. At the contact of pyrite and sphalerite.
3. With galena in pyrite fractures.
4. With sphalerite in pyrite fractures.

**Paragenesis.**

The following paragenesis is suggested.

Pyrite and quartz with minor amounts of chalcopyrite, pyrrhotite and gold, were the first minerals to be deposited. Fracturing of the pyrite was followed by the deposition of more quartz, which filled most of the fissures in the pyrite. Some shattering of the quartz also occurred, causing fractures into which some of the chalcopyrite, gold, galena and sphalerite were deposited. Sphalerite, chalcopyrite, and galena were deposited at about the same time, with the deposition of galena extending beyond that of sphalerite. Gold is intimately
associated with both galena and sphalerite, and was evidently deposited with these two minerals.

**GRAPHICAL REPRESENTATION OF PARAGENESIS**

<table>
<thead>
<tr>
<th>Quartz</th>
<th>Pyrite</th>
<th>Pyrrhotite</th>
<th>Chalcopyrite</th>
<th>Sphalerite</th>
<th>Galena</th>
<th>Gold</th>
</tr>
</thead>
</table>

The majority of the gold particles occurred associated with either galena or sphalerite in fractures in pyrite. A few were observed in pyrite as inclusions, and none at all seen in quartz.

The size of the grains varies from 4.2 microns to 25 microns. The average size is about 12 microns.

**Description of Sections.**

- **Section No. 1:** Major -- Pyrite and quartz. Minor -- Chalcopyrite and sphalerite. Rare -- Pyrrhotite.
- **Section No. 2:** Major -- Pyrite and quartz. Minor -- Chalcopyrite. Rare -- Pyrrhotite.
- **Section No. 3:** Major -- Pyrite and quartz. Rare -- Chalcopyrite and pyrrhotite.
- **Section No. 4:** Major -- Pyrite and quartz. Minor -- Galena, chalcopyrite and sphalerite. Rare -- Pyrrhotite and gold.

**Conclusions.**

1. The primary ore in the sections consist of pyrite, pyrrhotite, sphalerite, galena and chalcopyrite.
2. The minerals belong to the mesothermal zone of deposition.
3. The greater part of the gold is associated with the later sulphides, galena and sphalerite.
4. A small amount of gold appears to have been deposited with the pyrite.

5. There is a tendency for the gold to occur in pyrite fractures.

6. The gold particles are irregularly distributed and occur in groups or swarms.
PART G

THE DIVIDEND-LAKEVIEW MINE
PART G: THE DIVIDEND-LAKEVIEW MINE

Description of the Property.

Location.
The Dividend-Lakeview property, partly owned by Osoyoos Mines, Limited, and partly leased by that company from the Dividend-Lakeview Consolidated Gold Mining Company of Elmira, New York, consists of eight claims and three fractions.

The property is located on the eastern slope of Kruger mountain, to the west of Osoyoos lake, and about a mile north of the international boundary. A branch line of the Kettle Valley railway extends south from Penticton to Oliver, which is about 16 miles north of Osoyoos, and the main trans-provincial highway passes down the southern Okanagan valley to Osoyoos. A branch road connects the property with the highway.

General Geology.
The oldest and most important rocks in the district are the Anarchist series. These consist of micaceous quartzites, mica and chlorite schist, crystalline limestone, and greenstone. The rocks are all highly metamorphosed and sheared, and as a result, almost complete alteration to secondary minerals has taken place. The general strike of the rock is to the north with a prevailing dip to the west.

The Osoyoos batholith is the only intrusive rock
in the immediate vicinity of the property. These rocks are thought to have been originally of granodiorite or quartz diorite composition, but subsequent alteration has resulted in a decided gneissic texture in places.

An assemblage of plutonic rocks, consisting of syenites and granodiorites occur several miles to the west. These form a large mass on the slope of the Similkameen river.

Economic Geology.

The ore-bodies are typical high temperature replacement deposits, developed at some distance from the intrusion, which gave rise to them, and occurring mainly in the lime beds of the Anarchist series. Some occur in the altered volcanics, which also contain considerable lime.

The sulphide mineralization followed in general the development of the lime-silicate gangue. The gangue consists of altered limestone or altered volcanics in which occur typical silicate minerals such as garnet, epidote and wollastonite.

The most probable source of the mineral solutions appears to be the rocks of the Osoyoos batholith.

Mineralogy.

Introduction.

No polished sections of ore from this property were made by the writer. The sections studied were those prepared by Miss N. L. King.

The following metallic minerals were found to be present in the ore:
1. Pyrite.
2. Arsenopyrite.
3. Pyrrhotite.
4. Magnetite.
5. Chalcopyrite.
7. Unknown.

The gangue consisted of quartz and altered volcanic rock.

**Description of the Minerals.**

**Pyrite.** Pyrite is abundant in the sections examined. It occurs as small fractured masses and as euhedral grains. Quartz, pyrrhotite and magnetite, with small amounts of chalcopyrite, fill fractures in the pyrite.

**Arsenopyrite.** Arsenopyrite is not plentiful. It occurs sometimes with pyrite and forms straight, smooth, mutual contacts with this mineral, but generally it was seen as shattered euhedral grains in early quartz. Like pyrite, it is badly fractured, and these fractures are filled with quartz and pyrrhotite.

**Quartz.** Two generations of quartz are present in the sections studied. The early quartz occurs surrounding pyrite, and arsenopyrite masses and grains, and also fills fractures in these minerals. The quartz itself is extremely shattered and the fractures are filled mainly with a later quartz of darker colour, and to a lesser extent by pyrrhotite, magnetite and chalcopyrite.

Few fractures were noted in pyrrhotite, but where these occur, they are filled mainly by the later quartz, and sometimes with magnetite.

**Pyrrhotite.** Pyrrhotite is abundant in some
sections, but rare in others. It was seen surrounding pyrite masses and grains, filling fractures in pyrite and arsenopyrite, and sometimes filling fissures in early quartz. The pyrrhotite masses are anhedral and irregular.

**Magnetite.** Magnetite occurs in fractures in quartz, pyrite and pyrrhotite. In all cases, it appears granular and usually definite, euhedral outlines are visible. Where pyrite and magnetite are in contact there appears to be no alteration of the former mineral. This suggests that the iron oxide was deposited in fractures in pyrite. The same relationship holds for pyrrhotite and magnetite.

**Chalcopyrite.** This mineral is abundant in some sections, but is not a major constituent of the ore. It is seen in fractures in the early quartz, in fractures in pyrite and arsenopyrite, and in some cases surrounding magnetite grains. In one case, it was seen filling a small fracture in magnetite. Usually it occurs as small blebs and stringers, but occasional larger masses are present.

**Gold.** The gold occurs in the following ways:

1. As blebs in chalcopyrite.
2. In fractures in pyrite associated with late quartz and chalcopyrite.
3. As inclusions in pyrite.

**Unknown.** This mineral was seen in small quantities intimately associated with chalcopyrite. It is very soft, greyish-white in colour, and strongly anisotropic.

**Paragenesis.**

The following paragenesis is suggested.
Pyrite and arsenopyrite were the first sulphides to be deposited. These two minerals are extremely shattered and the fractures filled with quartz. The quartz is also shattered. Pyrrhotite appears to have been deposited later than the earlier quartz and before the magnetite. The criteria which indicate this order are:

1. Pyrrhotite filling fractures in early quartz.
2. Magnetite filling fractures in pyrrhotite.

Chalcopyrite occurs veining magnetite, and also enclosing grains of that mineral. Rarely, the relationships between two minerals are reversed, but enough evidence was seen to indicate that most chalcopyrite was deposited later than the magnetite. The later deposition of quartz took place about the same time as the deposition of chalcopyrite, or perhaps later. No definite criteria between the two were observed.

The deposition of most of the gold occurred later, probably with the chalcopyrite and quartz, as it is mainly associated with these minerals. A small quantity may be of the same time as the pyrite, as some blebs appeared to be inclusions in the iron sulphide.

The unidentified, soft, white mineral occurs intimately associated with chalcopyrite only, and the deposition of the two must have been at about the same time.
Distribution and Size of Gold Particles.

The majority of the gold particles occurred either in chalcopyrite or with this sulphide in pyrite fractures. A small amount was seen with late quartz in fractured pyrite, and a very minute quantity appeared as inclusions in pyrite.

The size of the grains varied from 3 microns to 40 microns, with an average of 10 microns.

Conclusions.

1. Primary ore of the mine consists of pyrite, arsenopyrite, pyrrhotite, magnetite, and chalcopyrite.

2. The minerals present suggest that the deposit belongs to the hypothermal zone of deposition.

3. Most of the gold was one of the last minerals to be deposited, and is associated with chalcopyrite and late quartz. Values are likely to be higher where these late minerals occur with shattered pyrite.

4. A small quantity of gold probably occurs as inclusions in pyrite and arsenopyrite.

5. The unidentified, greyish-white mineral may contain silver and thereby account for the silver values in the ore.

6. The relationships between magnetite and the iron sulphides in this ore are unusual. The oxide is generally formed before the sulphide minerals. It is possible that a deficiency amount of sulphur is a part of the explanation in this case.
SUMMARY AND CONCLUSION

The study of the ore from the foregoing properties shows two, and possibly three, types of mineralization.

The first type includes all those quartz vein deposits except possibly the Hunter and Surf Inlet properties. Deposits of this type contain minerals which suggest precipitation under conditions generally of medium temperature, but grading from the mesothermal into the upper part of the hypothermal zone. The Reno mine, in the Sheep Creek district, contains a greater abundance of pyrrhotite than the other properties similar to it. This may indicate a temperature higher than usual, or may be the result of other conditions at the time of deposition.

Typical minerals of this type of deposit are pyrite, arsenopyrite, sphalerite, galena, chalcopyrite and gold. Frequently small amounts of pyrrhotite are present.

The second type of deposit is illustrated by one mine only; the Dividend-Lakeview property near Osoyoos. This is a high-temperature replacement deposit containing an abundance of pyrrhotite, magnetite and chalcopyrite, but no sphalerite and galena.

The Hunter and Surf Inlet properties may represent a quartz-vein type deposited under conditions of fairly high
temperature. The veins on these properties occur in granitic rocks of the Coast Range batholith. This occurrence of the ore filling fractures in the igneous rock from which the mineral solutions are thought to have been derived, and the scarcity of minerals typical of the mesothermal zone, indicates different conditions of deposition to the other vein deposits studied. Pyrite is the principal sulphide mineral, with small amounts of sphalerite, chalcopyrite and galena.

In general, gold occurs in only two ways in all the ore examined:

1. With massive pyrite as inclusions.
2. With galena, sphalerite, chalcopyrite and pyrrhotite.

Gold occurring as inclusions in pyrite or arsenopyrite is very finely disseminated, and in most cases extremely rare. Only in a few cases could it be positively said that a particle was included in these sulphides. However, it is possible that nearly all pyrite contains minute amounts of gold, in this way; but very rarely are the values high enough to constitute ore.

In the Surf Inlet ore, the few grains of gold seen, occurred as inclusions in massive pyrite. While in the Hunter ore, some occurred as inclusions and some in fractures in the iron sulphide.

The great abundance of gold observed in the various ores studied was associated with galena, and to a small extent with pyrrhotite, chalcopyrite and sphalerite. In nearly all
cases where much gold was seen it was intimately associated with, or occurred near, galena. The converse to this statement is not true. Gold is not necessarily present where galena is found. In some cases, gold was seen to be associated with pyrrhotite, sphalerite and chalcopyrite. The amount occurring in this way is small, and was found in ore that contained little or no galena.

There is a strong tendency for gold particles to be deposited in fractures in pyrite and arsenopyrite, and many more occur with the later sulphides in such fractures than in the later sulphides alone.

In general, it appears that the condition most favorable for high gold values in the ores studied, is the presence of galena, sphalerite or chalcopyrite in shattered pyrite and arsenopyrite. This is true also of the Dividend property, except that galena and sphalerite are absent.

High values occur with the intergrowth of cosalite and galenabismutite in the Cariboo Gold Quartz mine. In the sections studied, no pyrite was present, but evidence was seen that the bismuth minerals were deposited at about the same time as the galena.

It is therefore evident that while some gold is undoubtedly deposited early in the sequence of mineralization, most of it is precipitated with the last minerals to solidify. From this, it is concluded that, with a few exceptions, higher gold values may be expected in pyritic deposits containing amounts of sphalerite, galena and chalcopyrite, than in deposits where these minerals are absent.
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PLATE Ia.
Gold in an intergrowth of cosalite and galenabismutite. The gold conforms to the structure of the bismuth minerals.

X600

PLATE Ib.
Showing a large grain of gold in quartz.

X600
PLATE IIa.
Gold occurring in a fracture in pyrite.

PLATE IIb.
Gold inclusions in pyrite. Galena occurs nearby.
PLATE IIIa.
Gold occurring in a fracture in arsenopyrite.

PLATE IIIb.
Showing inclusions of gold in arsenopyrite.
PLATE IVa.
Showing millerite in quartz.

PLATE IVb.
Unknown mineral containing tellurium in cosalite and galenabismutite.
PLATE Va.
Showing an inclusion of gold in galena.

PLATE Vb.
Showing gold with quartz in fractured pyrite.
PLATE VIa.
Showing gold in sphalerite near pyrite.

PLATE VIb.
Showing gold in pyrrhotite near quartz.