GEOLOGY 409
GLACIER GULCH

D. C. MILLER 1959

Failed to distinguish the greenlingite & pyrite, otherwise a careful job.

CONTENTS

ILLUSTRATIONS

THE MINERALOGY OF SPECIMENS FROM GLACIER GULCH

Purpose

The purpose of this report is to describe the mineralogy of ore specimens from Glacier Gulch: to describe the ore textures; to give the paragenetic sequence of mineral deposition and to attempt to classify the specimens according to environment of origin.

Summary and Conclusions

Glacier Gulch is on the east slope of Hudson Bay mountain, about 5 miles northwest of Smithers, B.C. At this location two groups of claims are owned by S. F. Campbell, Grover Loveless, and W. Banta, of Smithers. The claims are: (1) the Glacier Gulch north side group and (2) the Glacier Gulch gold group on the south side of Glacier Gulch.

Gold, silver, zinc, and lead mineralization was discovered in 1926 on the north side group, and later in 1929, gold, bismuth mineralization was discovered on the southern group. The area has been studied by many geologists. Kindle (1) has described the deposits in detail. The deposits are associated with dark fine-grained andesite and have not been related to an igneous intrusion.

A study of hand-specimens, thin-sections and polished sections of specimens from Glacier Gulch, shows the presence of the following minerals which are listed below with the approximate, estimated, amount present:

1. Metallic Minerals

(1)	Gold	1 to 3 ounces/ton	(4)	Bismuthinite	2 to 20%
(2)	Bismuth	0 to 1%	(5)	Molybdenite	trace
(3)	Joseite	2 to 20%	(6)	Pyrite	trace

2. Gangue Minerals

Quartz	10 to 95%	Epidote	1%
Sericite	8 to 30%	Chlorite	1%
Calcite	2 to 10%	Biotite	1%
Microcline	0 to 20%	Apatite	0 to 4%
Kaolinite	2 to 20%	Allanite ?	trace
Zoisite ?	0 to 30%	Clinopyroxene	trace

Ore is either fine-grained altered rock consisting mainly of quartz, sericite, kaolinite, zoisite, and calcite, or coarse-grained quartz. In altered fine-grained ore, metallic minerals are associated with quartz, and together, they heal early fractures and replace altered rock. Fine-grained ore specimens thus have a very weakly banded structure. Joseite and bismuthinite are the principal metallic minerals, with smaller amounts of gold and bismuth.

Metallic minerals comprise up to 20 percent of the volume in some specimens. Gold is in isolated grains, or is associated with bismuthinite or joseite. Gold is generally 30 to 160 microns in grain size. Gold, visable megascopically in most hand-specimens studied, probably has a grade of better than 1 ounce per ton.

Coarse-grained ore consists of coarsly crystalline quartz which carries metallic minerals in fine fractures and intergranular spaces. Quartz forms veins up to 3 inches thick which cut through and replace fine-grained altered rock. Metallic minerals are mainly joseite and bismuth with lesser amounts of bismuthinite and gold, and traces of molybenite. These comprise about 4 percent of the rock. Gold is in isolated grains, or is associated with joseite bismuth or bismuthinite. The largest piece of gold measured 900 microns but the general grain size was 30 to 160 microns.

The order of deposition was observed to be bismuth, bismuthinite, joseite, and molybdenite.

Occasional vugs, extensive hydrothermal alteration, and twinning in bismuth suggest the specimens studied are of epithermal origin.

Location and Accessibility

The Glacier Gulch properties are on the east slope of Hudson Bay mountain, in the Smithers map-area, about 5 miles northwest of Smithers, B.C. The properties are connected by road to Smithers, and to the C.N.R. Station at Lake Kathlyn 2½ miles to the east, (see Figure 1).

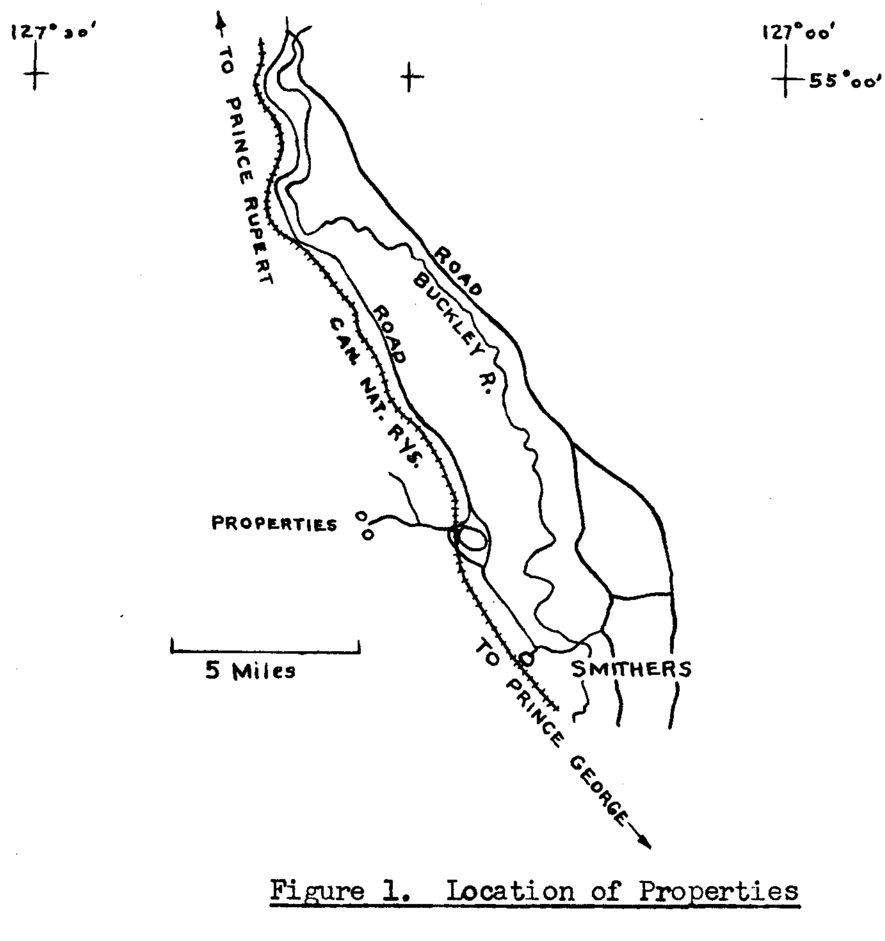

Figure 1. Location of Properties

It is about 221 miles by rail from Lake Kathlyn to Prince

Rupert. Smithers is linked by motor road to the Caribou-Vancouver highway through Prince George, about 270 miles to the east.

Glacier Gulch is a narrow, U-shaped, steepwalled gulch, about a mile long, and trending northeasterly. The head of the gulch rises steeply 1000 feet to an ice-filled hanging valley. Melt water from the ice supplies abundant water most of the year. The sides of the ravine are steep, commonly in excess of 40 degrees, and difficulty ie experienced in prospecting them.

There are two properties at Glacier Gulch: one on the north side at an elevation of about 2900 feet, and one on the south side between elevations 3150 and 3400 feet approximately. Both properties are owned by S. F. Campbell, Grover Loveless, and W. Banta of Smithers, B.C.

History of Mining In Area

The northern property, or Glacier Gulch north side group (1) possesses zinc, silver, gold and copper mineralization. Surface work in 1926 and 1927 by the owners disclosed 4 small veine carrying much sphalerite, and small amounts of silver and gold. F. H. Taylor sank a 23 foot shaft in 1928 on the largest vein and found that silver and zinc values decreased severely at that depth. The vein ranges from 4 inches to 2 feet in width with an average width of one foot. It strikes north 10 degrees east and dips between 50 and 60 degrees west. The vein consists largely of dark sphalerie with lesser amounts of arsenopyrite, pyrite, pyrrhotite, galena, and chalcopyrite. The sulphides are accompanied by a little quartz gangue. At the bottom of the shaft, the vein is reported as 9 inches in width and composed of nearly solid pyrrhotite.

The Glacier Gulch gold group is on the south side of Glacier Gulch. Gold and bismuth mineralization was discovered on this property, by the owners, in 1929. Development work which followed disclosed some small shoots of high-grade gold ore. In 1933 the owners shipped 26 tons of ore carrying 82 ounces of gold, 15 ounces of silver, and a quantity of bismuth, which was not paid for. R. W. Wilson held an option on the property during 1934 and made another shipment of ore. Thirty tons of high-grade gold ore was shipped by the owners in 1935. In 1937 ore was shipped from a silver-lead-zinc vein, which was discovered 700 feet east of the gold-bearing veins. Up to 1938, most of gold ore was quarryed from a small area about 150 long and rising through 75 feet of height. The ore occurs in the most altered parts of shear-zones. The shear-zones may exceed 100 feet in length and are about 1 to 2 feet wide. Ore shoots range from a few feet to several feet in width and from a few feet to 50 feet in length. Several small adits, drifts and raises have been driven to mine and explore the ore.

A silver-lead-zinc vein lies between elevations 2850, and 3300 feet about 700 feet north of the gold-bismuth deposits. It strikes south 20 to 40 degrees west and dips 40 to 60 degrees northwest. It is 4 to 18 inches thick and it consists of banded alterations of calcite, siderite, galena, sphalerite, arsenopyrite, pyrite with a little quartz and occasional tetrahedrite. At elevation 2950 feet an 80 foot adit was driven southwest along the vein. The vein assayed about 22 ounces per ton, silver; .07 ounces per ton, gold; 4 percent lead, and 4 percent zinc across a width of 5 inches.

Geology of Properties

In the Glacier Gulch north side group, the veins occur in dark fine-grained andesite close to a fault contact with younger sedimentary rocks that lie to the east. An albite porphyry dyke, 12 feet wide, intrudes the andesite, but is not thought to be related to the mineralization (1). The sediments consist of a sequence of quartzite, greywacke, slate, and conglomerate, with a few coal seams, near the base of the formation.

In the Glacier Gulch gold group, the gold ore occurs along shear-zones in "massive, finely crystalline tuffs, with which some beds of argillite are interstratified" (1). Most of the shear-zones accord with the bedding planes of the tuffs and have a south to southeast strike. They dip 20 to 40 degree southwest in low westerly zones, and 20 degrees east in upper easterly zones. The productive zones are largely confined to the crest of an anticlinal fold. The axial plane of the fold is nearly vertical and trends southwest. The fold pitches about 25 degrees southwest. Above the deposits, the rocks grade into argillites interbedded with graywacke and conglomerate. Below the deposits, the rocks grade into a thick sequence of dark fine-grained andesite flows. No intrusive rocks are seen in the claim area except some lamprophyre dykes. The dykes carry ½ inch seams of calcite and molybdenite in their joint-planes.

MINERALOGY

General Mineralogy

The ore specimens studied may be divided into the following types:

1. Coarse-grained ore

(a) Light grey coarsly crystalline quartz rock, carrying gold, joseite, bismuthinite, bismuth and molybdenite.

2. Fine-grained ore

(a) Light grey-white, fine-grained, moderately altered ore composed mainly of quartz, sericite, calcite, albite and kaolinite, and carrying gold, joseite, bismuthinite, and bismuth.

(b) Dull white, fine-grained, strongly altered ore, composed mainly of kaolinite, altered feldspar, albite and quartz, and carrying gold, joseite, bismuthinite, and bismuth.

Further, a specimen which was nearly barren of metallic mineralization was studied. It was pink and grey fine-to-medium-grained rock composed mainly of quartz, sericite, and microcline and carried fine-grained pyrite.

Texture and Composition of Ore, Gangue Minerals

Three hand-specimens and 3 thin-sections were studied to determine the texture and composition of the ore from Glacier Gulch.

1. Coarse-grained ore

The coarse-grained ore is composed of medium to coarse-grained quartz-rock carrying bismuth, gold, joseite, bismuthinite and molybdenite. The metallic minerals fill interstitial spaces, and find fractures in the quartz-rock. The quartz forms replacement veins, up to 2 inches wide, which cut through altered fine-grained ore.

2. Fine-grained ore

(a) Light grey-white, fine-grained, moderately altered ore. The hand-specimen is a fine-grained xenomorphic granular, crystalline, aggregate of quartz and altered feldspar carrying about 5% of joseite and bismuthinite. The rock has a weakly banded appearance arising from very thin bands of metallic minerals and fine-grained quartz, which together heal early fractures in the rock. Gold, less than 1 mm. in size, is visable megoscopically, associated with quartz and the metallic minerals. In thin-section, the following mode was determined:

Quartz	55%	Kaolinite	5%
Sericite	15%	Biotite	1%
Calcite	10%	Bismuthinite & Joseite	4%
Albite	10%		

Quartz is the dominant mineral and is of two kinds: (1) moderate-sized grains associated with metallic minerals, and (2) very fine-grained quartz intimately mixed with sericite. Calcite fills a set of late fractures in the rock.

(b) Dull white fine-grained strongly altered ore.

The hand-specimen studied is a dull white, fine-grained aggregate of quartz and altered feldspar with irregular shaped grains of bismuthinite and joseite up to 5 mm. in size, associated mainly with the quratz. Gold, less than 1/10 mm. is visible, and is associated with quartz and metallic minerals. The feldspar appears extensively kaolinized. The following mode was determined in thin-section:

Quartz	10%	Calcite	10%	Chlorite	1%
Albite	15%	Sericite	8%	Epidote	1%
Kaolinite	20%	Apatite	4%	Metallic Minerals	4%
Zoisite ?	30%				

The quartz is present in locally concentrated masses of fine anhedral grains. Much of the original rock was composed of plagioclase, some of which was later altered to sericite, calcite, zoisite and kaolinite. Remnant zoning appears in zoisite. The calcite is present in large anhedral masses.

A specimen nearly barren of metallic mineralization was studied. The hand-specimen is a grey and pink fine to coarse-grained aggregate of quartz, 2 mm. in size, pink K-feldspar 5 mm. in size, and a porous mass of fine grained sericite. In thin-section, the following mode was determined:

Quartz	35%	Biotite	2%	Calcite	2%
Microcline	20%	Pyrite	1%	Rutile	1%
Sericite	30%	Chlorite	1%	Allanite	1%
Albite	6%	Epidote	1%	Clino Pyroxeme	1%

Clinopyroxene

Metallic Minerals

A study of hand-specimens and polished sections of ore from Glacier Gulch shows the presence of gold, bismuth, joseite, bismuthinite, molybdenite and pyrite. What are the differences?

1. Joseite $Bi_{4+x}(Te, S)_{3-x}$ (2). Gruenlingite

Joseite is probably present as two forms: (1) joseite A, $Bi_{4+x}Te_{1-x}S_2$ and (2) joseite B, $Bi_{4+x}Te_{2-x}$. Joseite is about equally common in both fine-grained ore and coarse-grained ore. In fine-grained ore it is associated with bismuthinite and gold, while in coarse-grained ore, it is associated with bismuth, bismuthinite, molybdenite, and gold. Joseite was observed in grains over 1 cm. in size in coarse grained quartz, where it comprised up to 5 percent of the rock. In fine-grained ore joseite comprises 2 to 20 percent of the ore.

Joseite was determined by its (1) high reflectivity; (2) yellowish-white color; (3) hardness, B; (4) weak to moderate anisotropism, brown to grey; (5) pale grey stain developed by testing with $FeCl_3$; (6) dark stain developed from testing with HCl; and (7) dark stain and effervescence developed from testing with HNO_3.

2. Bismuth Bi

Bismuth is observed in hand-specimen only in coarse-grained ore, where grains up to 5 mm. are seen. In the fine-grained ore, small grains, less than 300 microns in size, were observed surrounded by bismuthinite. In coarse-grained ore bismuth was in contact with joseite, gold, bismuthinite and molybdenite. In coarse-grained ore, bismuth comprised about 1 percent of the rock, while in fine-grained ore, it was present in trace amounts. Twinning was observed in bismuth, which indicates it was transformed from the α to the β state.

Bismuth was determined by the following properties:

(1) pink color;
(2) hardness, A;
(3) anisotropism, moderate, yellowish-brown to greyish-brown;
(4) perfect basal cleavage;
(5) dark stain quickly produced by testing with $FeCl_3$;
(6) a dark stain and etching resulting from testing with HCl;
(7) a dark stain etching, and effervescence resulting from testing with HNO_3;

an anomalous light-brown stain developed on some areas from testing with KOH.

3. Gold Au

Gold was observed in many hand-specimens, and was observed in all polished-sections. In coarse-grained ore, the largest grain of gold observed was 900 microns in size. In both fine-grained and coarse-grained ore gold generally was between 30 and 160 microns in grain size. Frequently, gold was present in isolated grains associated with quartz around grain boundaries, or in small fractures, or was in contact on one edge with bismuth, joseite, and bismuthinite. Occasionally, gold was seen in contacts between bismuth, bismuthinite and joseite. Rarely, gold was observed enclosed in the cleavage planes of bismuthinite and joseite.

Gold was determined by its butter-yellow color, the black stain developed when it was tested with KCN, and its high sectility.

The amount of gold is probably in excess of 1 oz. per ton in the specimens studied.

4. Molybdenite MoS_2

Molybdenite was observed in trace amounts, in coarse-grained ore, where it was associated with bismuth and joseite.

Molybdenite was determined by its:

(1) strong pleochroism, white to violet;
(2) strong anisotropism, white to black, showing 4 extinctions per revolution;
(3) hardness, B;
(4) negativity to all reagents;
(5) association.

5. Bismuthinite Bi_2S_3

Bismuthinite was seen in all polished sections. In coarse-grained ore, bismuthinite was present as sparse grains less than 600 microns in size, associated with bismuth, gold, and joseite. In fine-grained ore bismuthinite is abundant, comprising 2 to 20 percent of the ore, and it is intimately associated with joseite.

Bismuthinite was determined by the following properties.

(1) distinct pleochroism, light-grey to yellow-white,
(2) strong anisotropism, yellow-brown, blue-grey,
(3) hardness B
(4) Negativity to all reagents except HNO_3, which slowly stained it inidescent and then black, with slow effervescence, and etching.

6. Pyrite FeS_2

Pyrite was observed only in one specimen studied. This specimen possessed no bismuth-gold mineralization. Pyrite was observed in thin-section and in hand-specimen as fine-grained, euhedral cubes.

In 4 other specimens studied, however, rust stains were present, which indicate iron mineralization is nearby.

The relative quantities metallic minerals present in the the specimens studied have been estimated as follows:

Joseite	10%
Bismuthinite	8%
Bismuth	0 - 1/2%
Gold	1 - 3 ounces per ton
Molybdenite	trace
Pyrite	trace

Texture and Paragenesis

In coarse-grained ore the metallic minerals clearly have been deposited along fine fractures in quartz, and in interstitial spaces among quartz grains. Little replacement of quartz gangue is seen. In fine-grained ore, however, the gangue, mainly quartz, sericite, kaolinite and altered feldspar, has been extensively replaced by fine-to-medium-grained bismuthinite and joseite. In some specimens, very thin shear fractures have been healed by fine-grained quartz, bismuthinite, and joseite, and the rock shows a weakly irregular banded structure.

Bismuth appears to be the first metallic mineral that was deposited. It was observed in several specimens occupying interstitial spaces, nearly enclosed by bismuthinite, which was replacing it around the rim (Fig. 3).

Twinning was observed in bismuth suggesting possible low temperature deposition. Joseite was observed in two specimens replacing bismuthinite around the rim. Toungues of joseite penetrating into bismuith along an otherwise smooth contact were observed in several places (Fig. 4). Molybdenite was seen as laths in the cleavage of bismuth and joseite, and between grains of bismuth and joseite (Fig. 5). Gold was seen in contacts between other metallic minerals, in contact with the outer edges of grains of joseite, bismuth and bismuthinite, as isolated grains occupying interstital spaces among quartz grains, and as isolated grains in fine fractures (Fig. 6 & 7).

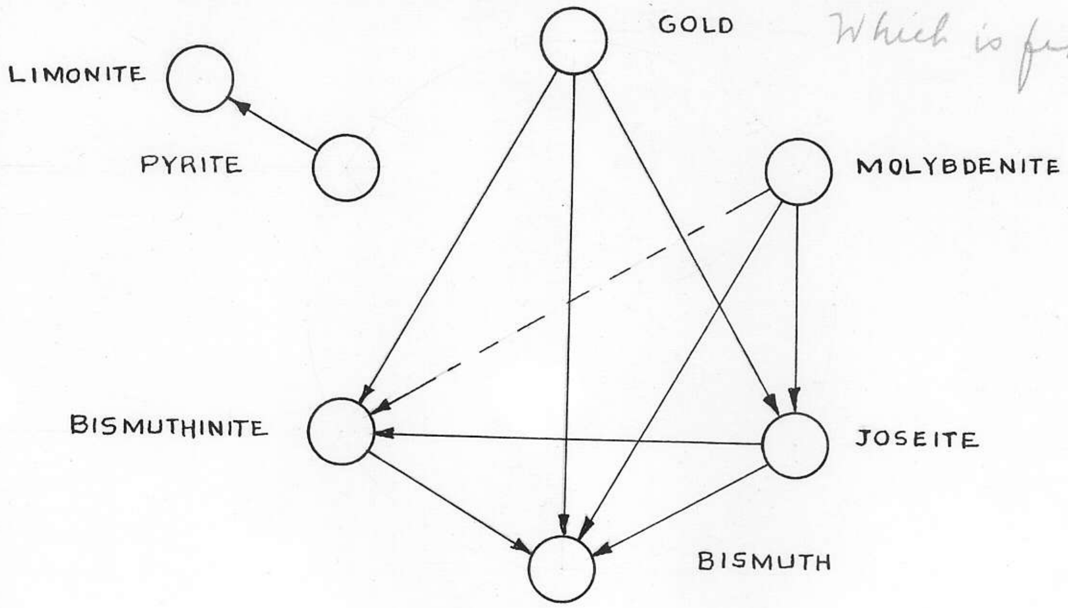

Figure 2.

Paragenisis

In some hand-specimens, vugs were observed with small (2 mm.) euhedral quartz crystals growing in them showing comb texture. This texture, extensive hydrothermal alteration, and twinning in bismuth suggest the specimens may be of epithermal origin.

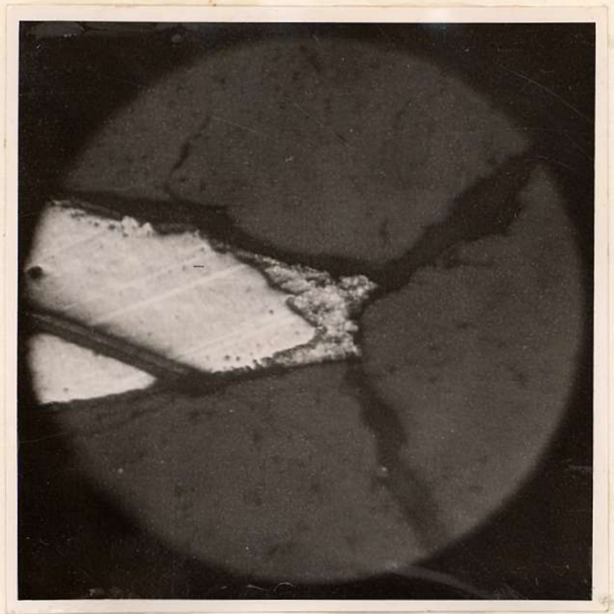

Figure 3.

Bismuthinite, (dark), replacing bismuth (light). X40.

Figure 4.

Tongue of joseite (J) in bismuth (B); bismuthinite (Bn).X40.

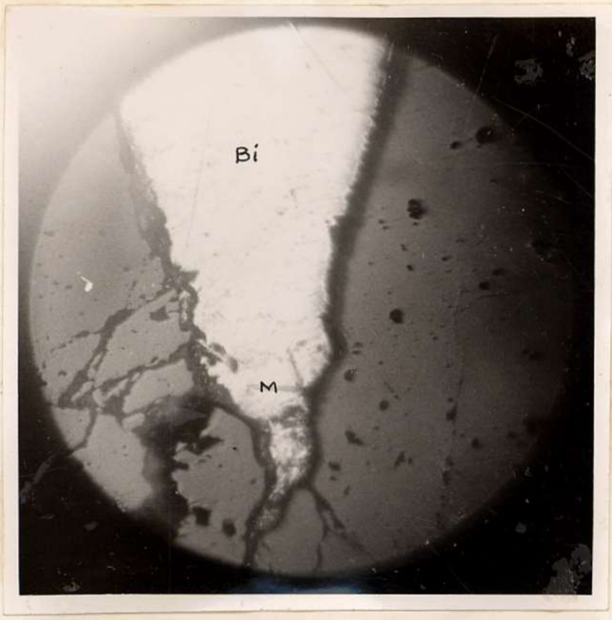

Figure 5.

Molybdenite (M), in Bismuth (Bi). X100.

Figure 6.

Gold (Au) between joesite (J) and bismuth (Bi). X40.

Figure 7.

Gold as isolated grains in quartz. X40.

Figure 8.

Joseite (dark) and bismuthinite (light). X40.

REFERENCES

1. Kindle, E.D. (1940): Mineral Resources, Hazelton and Smithers Areas, Cassiar and Coast Districts, British Columbia - Geol. Surv. Canada, Mem.223,pp.72 to 77.

2. Thompson, R.M. (1949): The Telluride Minerals and their Occurrence in Canada - The American Mineralogist No. 1. 34 pp.342-382.