1st class despite failure to find definite answers.

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A REPORT ON THE MICROSCOPIC STUDY OF SELECTED ORE FROM THE CARIBOO GOLD QUARTZ MINE, WELLS, B.C.

A report submitted in partial fulfilment of the requirements of the course in Mineralography, (Geology 409), at the University of British Columbia.

W.D. McCartney
University of British Columbia
April, 1950

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INTRODUCTION

The work described in this report was done in an effort to find and identify a mineral previously reported in minute amounts in this ore with the cosalite and galeno-bismutite. (Haycock, 1933, p. 2; Johnson, 1934, p. 18) The source of the high silver values in galena was also sought. Neither of these objectives were attained although some new observations were made which may aid in a continuation of the investigation. For the most part, the work has duplicated the material reported by Dr. H.V. Warren, R. Maconachie, and E.W. Johnson. Because the laboratory work described here was devoted to the particular problems outlined above, the results will apply only to limited parts of the mineral deposits of the mine. Rather than attempt to present the complex geological background of the mine in an adequate form, I offer a summary of some factors as presented by Dr. Skerl which seem most relevant to this mineralogical study. For a competent understanding of the mine geology as interpreted to date, a study of his report is required and may be profitable augmented by the report on the Island Mountain Mine by P.C. Benedict.

Geological work in the area includes the work of G.M. Dawson, A. Bowman, W.A. Johnson and W.L. Uglow,

G. Hanson, N. F. G. Davis, A. Lang, P. C. Benedict, A. C. Skerl, and S. S. Holland. Amos Bowman's maps have been especially useful in the district and, from personal acquaintance with his work in the Keithley area, the quality and quantity of his work under adverse conditions is outstanding. Regional geology in the Wells area is treated by Dr. Hanson and the best reports of the detailed work at the Island Mountain and Cariboo Gold Quartz Mines given by P. C. Benedict and A. C. Skerl respectively.

The mining claims held by the company include the township of Wells and lie within a four mile by two mile block of ground situated around the north end of the Jack of Clubs Lake.

REGIONAL GEOLOGY AND LITHOLOGY.

The Cariboo Series of metamorphosed sediments is thought to be of Precambrian age by G. Hanson and A. Lang. Though not mentioned by Dr. Skerl, perhaps the most definite age indication other than lithological and structural similarities was the finding of Lower Cambrian trilobites by Dr. Lang in the Little River area to the south in beds which lay with apparent conformity on those of the Cariboo Series. (Lang, pp. 13, 14) On the north-eastern limb of the anticlinorium exposing the older beds, late Paleozoic strata of the Slide Mountain Series uniformably overlie the Cariboo Series and, in the south, the Cariboo Series and the Lower Cambrian beds. (Lang, p. 14) The Jurassic Quesnel River Group occupies a similar position on the south-west limb of the anticlinorium. The Richfield Formation of the Cariboo Series contains all the known lode gold deposits of the district and was divided by Dr. Hanson into five members. The detailed work done by the mining geologists at Wells and by Dr. Holland in the Yanks Peak area to the south indicates that the regional fold structure has been oversimplified and this five-fold subdivision may be modified because of a repetition of members by isoclinal folding and by inversion of the succession on the west limb of an overturned anticline. The rocks encountered in the mine are a well-cleaved series of metamorphosed argillaceous and quartzitic sediments.

<u>FOLD STRUCTURES</u>. (After A. C. Skerl, pp. 578-580)

The lack of readily distinguished marker horizons or fossiliferous beds and the intensity and complexity of the folding makes resolution of the fold structure difficult but Dr. Skerl suggests the following sequence of events immediately preceeding the faulting. (p. 578)

1. Formation of a normal sedimentary series with calcareous and dolomitic rocks associated with volcanic tuffs at the bottom and passing up through dolomitic and muddy sandstones to sandstones and dolomites with muds predominating at the top.
2. Uplift producing a large elongated dome.
3. Compression from the northeast and southwest throwing the simple dome into an anticlinorium.
4. Increased compression producing overfolds.
5. Continued pressure forming cleavage which in the mine area dips 45° NE.
6. Consequent heat metamorphosing the rocks to quartzites, slates, etc., with porphyroblastic dolomite and ankerite in

the horizons containing the necessary ingredients.

7. Folds become greatly attenuated and the drag-folds sliced off.

8. Increasing metamorphism along certain dolomitic horizons produced highly talcose zones.

FAULT STRUCTURES. (After A. C. Skerl, pp. 580-582)

A series of north-striking and easterly-dipping faults at intervals of 500 to 1000 feet give apparent horizontal displacements of a few feet to a thousand feet or more. A second main set of faults parallels the cleavage striking to the northwest and dip about 45 degrees to the northeast. These two fault directions are thought to be complementary. A third earlier direction of faulting is shown by large shear zones that are thought to parallel or occupy the axial planes of the major drag-folds. Numerous minor faults occur.

MINERAL DEPOSITS. (After A. C. Skerl, pp. 582-590)

The two main sets of openings resulting from the events outlined above are:

a) Tension fractures perpendicular to the pitch of the folds, later filled to form transverse veins.

b) Tension fractures at right angles to the north-south faults, later filled to form diagonal veins.

These resulting veins are of commercial grade adjacent to the two sets of faults which provided channelways for the mineralizing solutions. Further movement along the faults dislocated some of the veins for a few feet and crushed the quartz in the faults producing drag ore. Some mineralization took place in the faults themselves. Since the mineralization occured towards the end of the movements along the north-south faults, no displacement of a particular vein is to be expected although a displacement of the favourable country rock is sought. A third type of vein occupies the shear zones along or parallel to the axial planes of the major drag-folds as in the B.C. Vein.

The replacement deposits of massive pyrite which are of growing importance in the mine since their discovery in 1944 have not been investigated microscopically as far as I know. These deposits have, in large part, accounted for the success of the neighbouring Island Mountain Mine and it is hoped that the present search for further deposits of this type in Cariboo Gold Quartz ground will be successful.

LABORATORY WORK.

Microscopic work on polished sections of selected ore was begun in an attempt to find and identify a mineral previously reported as occuring with the galenobismutite and cosalite. (Haycock, 1933, p. 2; Johnson, 1934, p. 18) The source of the high silver values in the galena was also sought. At the outset of the work, the available ore specimens were studied megascopically and material was selected which might be most productive for the immediate objectives of the study. At this time, these sections were considered as preliminary work which might disclose the minerals sought or suggest further selections of material. It was intended that crushing and separation followed by mounting and polishing of segregated material be a second step in the investigation, aided by the equipment not available to earlier workers. Unfortunately, the determination of the minerals in the first series of polished sections proved a difficult task and time did not permit an extension of the work.

The principal source of difficulty is the close similarities in colour and in many of the etch reactions, and many slight variations in etch reactions were seen. These minor anomalies may be caused in part by orientation, grain size, or by the presence of associated minerals, and suffice to cast doubt on determinations made on the basis of delicate variations in reaction effects. An example is the variable reaction of galena in the selected galena sections to HCl. Many michrochemical tests were used in confirming the etch reactions during the earlier stages of the work.

QUARTZ

Quartz is the most common gangue mineral in the veins. Several specimens of quartz free from visible gold were barren. (H. V. Warren, 1936, p. 209) In these sections, the quartz and pyrite were highly fractured and required cementation by porcelain when the sections were made.

ANKERITE AND RELATED CARBONATES.

No attempt was made to determine the carbonate minerals during this study although ankerite is known. It is a common practice in the district to refer to the iron-magnesium-~~calcium~~ carbonate as ankerite. An analysis of vein "ankerite" from Burns Mountain shows a pistomecite composition of: $FeCO_3$, 65.6%; $CaCO_3$, 1.4%; $MgCO_3$, 29.9%; and $MnCO_3$, 3.2%. (S. S. Holland, p. 26) At the Cariboo Gold Quartz Mine, similar variations may be common and other carbonates may be mixed. An interesting feature in the district of the carbonate is its occurence as narrow selvages along the vein walls in the Stanley area (S. S. Holland, p. 26) and in the Yanks Peak area.

PYRITE.

Pyrite, because of its importance as the mineral with which the run of the mine ore is associated, has already received detailed attention. (H. V. Warren, 1936, p. 207) Because these sections were from the cosalite-rich specimens, the pyrite described here can not be considered typical of that in the normal ore.

The pyrite is highly fractured along with much of the quartz. Most grains show anhedral to subhedral form but many regular crystals are seen. These may appear as triangular areas or as 1 mm. by .5 mm. rectangles. Gold often lies along the edges of pyrite as blebs in cosalite, galena, or galenobismutite and is commonly seen as distinct veinlets occupying fracture up to about .02 mm. wide. In a general way, the pyrite has appeared to favour gold deposition in these sections and a similar attraction by pyrite in the normal ore would agree with the conclusions drawn by Dr. Warren (1936, p. 207) that the gold-pyrite association is probably mechanical or electro-chemical rather than chemical.

SPHALERITE.

The sphalerite seen in some sections closely associated with galena is generally massive and shows rather smooth boundaries with the galena. A few small 'islands' of galena were seen near the mutual boundaries. Minute flecks of chalcopyrite are seen in the sphalerite. Although the sections as chosen did not favour the inclusion of sphalerite, enough relations were seen to indicate that the ages of galena and sphalerite are essentially similar with galena possibly belonging to a slightly later phase.

GALENA.

In the hand specimens selected for polishing to investigate the silver content of the galena, the crystalline galena appeared homogeneous with sphalerite in quartz. In polished section, however, all these specimens showed cosalite as elongate blebs varying from .05 mm. to 2 mm. in length scattered throughout the galena. (Fig. 1) The general similarity of this cosalite content indicates that the specimens, although selected from various parts of the collection, are probably derived from one or more cosalite-rich sections of the mine rather than that these specimens represent the average run of galena. This opinion is strengthened by the fact that the collection in general is of selected cosalite-rich material.

The galena in these sections is very difficult to distinguish by colour from the cosalite in a freshly polished surface. A light and easily removed differential etch is rapidly produced by HCl fumes when the galena will darken to a light brown, then to a deeper and irridescent blue etch while the cosalite remains unaffected. This method readily differentiates between the two, or the differences are apparent because of the high anisotropism of the cosalite.

Features of the galena important in its identification in these sections include:

a) its anomolous anisotropism which, though weaker than cosalite or galenobismutite, is distinct. Colours obtained with the nicol adjustment used were pale tan to bluish to black although the effects are negligible with close nicol adjustment. Polishing method?

b) The immediate blackening with or without effervescence with HNO_3 with the deposition of a yellow coating. In this respect, it resembles galenobismutite although the effervescence seen on confirmed galenobismutite in quartz was invariably more marked.

c) The pale brown proceeding to blue irridescent tarnish produced by HCl fumes, and the irridescent brown sometimes proceeding to black tarnish given by HCl.

d) The irridescent stain with $FeCl_3$ is especially useful.

e) The triangular pits which are not well developed on the present polished sections.

The anisotropism was especially confusing when the work began and in many cases it was only after michrochemical tests were made that the mineral was accepted as galena. In particular, the cosalite-rich sections such as number 5 showed galena occuring as small blebs in pyrite and with cosalite. Detailed comparative etch tests finally satisfied me that the mineral was galena although an X-ray confirmation would be desirable.

The silver content of the galena or associated minerals or impurities is established by several reports which are compiled in table 1.

Table 1

REFERENCE.	LOCATION.	% Galena	% Pb.	% S.	Ag. oz/T.	Au. oz/T.	TOTAL.
H. V. WARREN, 1936, p. 202.	Cariboo Gold Quartz.	100	84.30	13.75	1.05%	-	99.08
A. C. SKERL, p. 591.	Cariboo Gold Quartz.	ore from mine			0.07 oz.	0.707 oz.	
JOHNSON, p. 24.	Cariboo Gold Quartz.	100			189.0	0.18	
	1200 level.	100			307.3	0.48	
S.S. HOLLAND, p27.	Acme group.	85			32.9 oz/t	0.01	
STANLEY AREA.	Foster Ledge.	SOLID			31.6 oz/t	TRACE	
	Grub Gulch.	80			32.5	8.05	
	Grub Gulch.	90			113.4	0.73	
	Grub Gulch.	80			8.0	TRACE	

The Silver and Gold Content of Galena in the Mine and District.

No trace of the argentite suggested by Johnson (p. 36) was seen in the sections studied.

The gold content of the galena studied is given by small irregular particles of gold in the galena. Section 2 is an example in which the cosalite grains are not apparently related to the gold. Two minute flecks of gold were identified by a positive KCN reaction. Other irregular grains were up to .02 mm. Although these specimens may be high grade material, the presence of these minute flecks in galena seems adequate to explain its gold content. This explanation was favoured by Johnson (p. 22) although his polished sections did not show free gold, nor does he describe any cosalite in galena; thus the material studied by him probably differed from that described here.

The textural relations indicate that the galena was probably later but possibly contemporaneous with the sphalerite, was definitely later than the pyrite and quartz (section 4), and was earlier than the cosalite and galeno-

Fig 1.

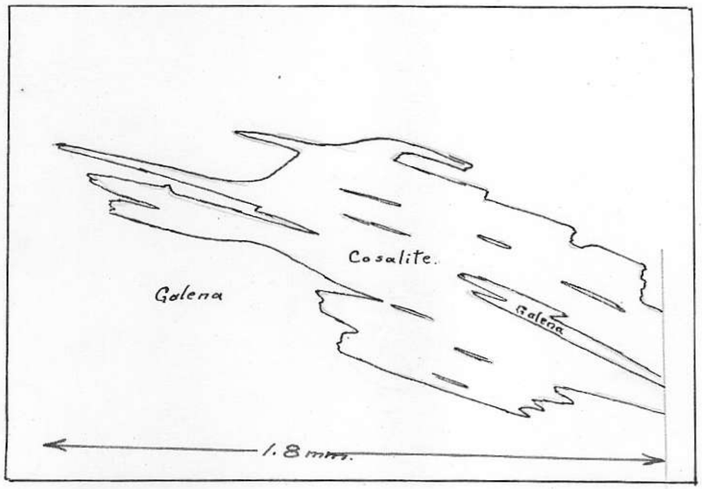
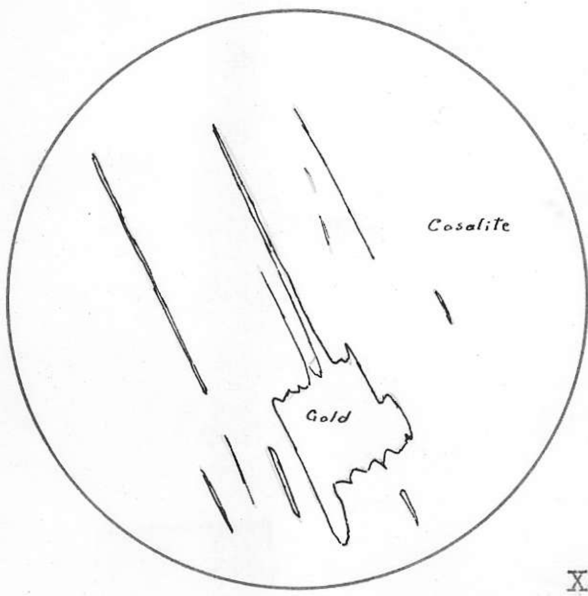


Fig. 1, Section 1: Typical Shape of Cosalite in Galena Which Appears Homogeneous in the Hand Specimen.



X40

Fig. 2: Gold in Cosalite. (From E.W. Johnson, Plate 4, p. 21)

bismutite. (Fig. 4) The galena is commonly mildly fractured and, though the veinlet structure shown in figure 3 is not common, these fractures may have provided access for bismuth and gold rich solutions or these solutions may have formed part of the late phase of galena deposition.

<u>COSALITE</u>. ($Pb_2Bi_2S_5$)

The sections selected were rich in cosalite because it was hoped that the third mineral described as a telluride by Johnson (p. 18) might be found in them. The elongate and fibrous nature of the mineral is well marked in hand specimens and is apparent in the polished sections. (Fig. 1) The surface is smooth although the fibrous appearance may be seen in some differentially polished sections.

Further microscopic characters include:

Colour - galena white, but very slightly lighter than galena.

Hardness - B.

Strong anisotropism is shown which is often distinctive.

When the crystal is in a bright position, the nicol may be adjusted to give a dark tan to brown colour. From this position, a slight rotation will give black and a 90^0 rotation will produce a steel grey, steel blue, or sometimes mauve colour with extinction beyond the 90^0 position until the deep tan is repeated at 180 degrees. Some variation is probable depending on the light source,

Fig 3.
sect 7
x170

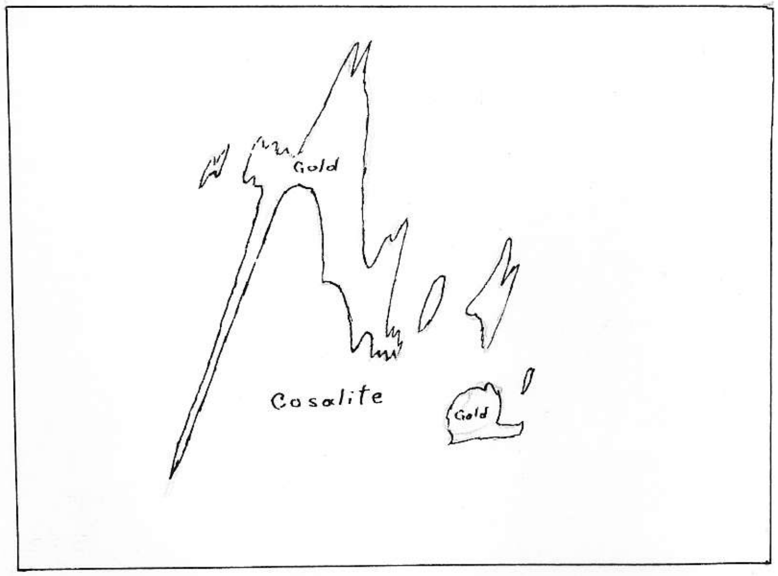


Fig. 3, Section 7: Gold in Cosalite
X 170

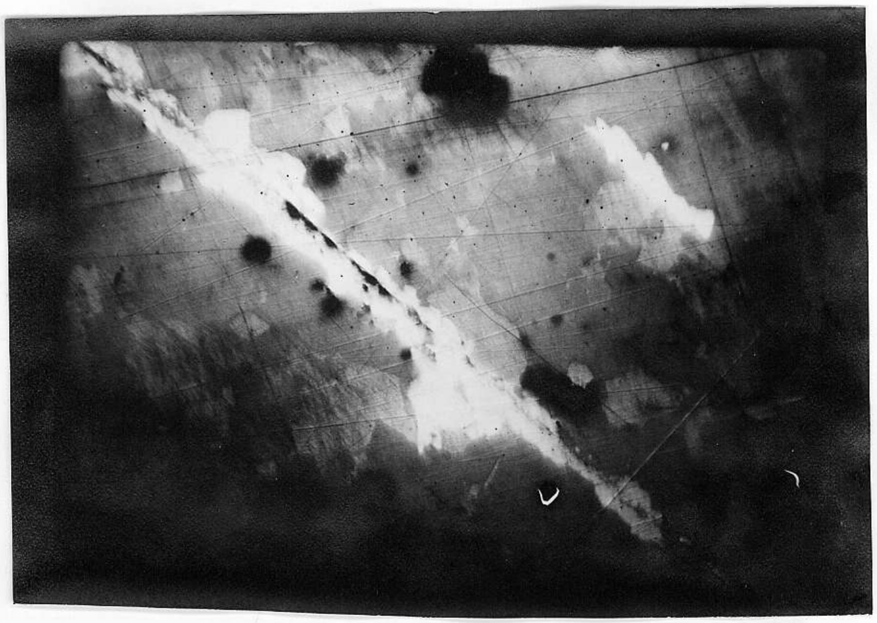


Fig. 4, Section 1: Cosalite Veining Galena.
HCl fume tarnish on the Galena.
X 170

polish, orientation, etc., but if comparative methods are used on known cosalite, a distinctive sequence of polarization colours can usually be recognized.

Etch reactions include:

HNO_3 - Deep black etch with slight effervescence. The reaction lacks the vigorous effervescence of galenobismutite. In galena, the cosalite darkens slightly faster than the galena.

$FeCl_3$- Minor irregular light brown stain in part, essentially negative.

HCl, KCN, KOH, $HgCl_2$ - negative

An analysis of this material (Warren, 1940; 1936, p. 208) shows; Lead ~~Pb~~, 41.20%; Bismuth, 39.35%; Sulphur, 16.4%; Copper, 3.60%.

The close association of native gold with cosalite and galenobismutite has been described in detail by previous workers. The elongate, uniformly oriented cosalite grains commonly contain irregular blebs of all sizes up to 1.8 mm. of gold and interstitial leaves and wires of gold. (Figs. 2, 3,) (H.V. Warren, 1939; E. W. Johnson, 1934, p. 20,21,30) The veining relationship of cosalite in galena shown in figure 4 is quite conclusive proof for post-galena replacement along a fracture plane, and it is thought that the cosalite grains in galena are due to replacement of galena rather than by replacement of cosalite by galena.

GALENOBISMUTITE. ($PbBi_2S_4$)

Galenobismutite was not common in the sections studied as compared to those prepared by Johnson and Maconachie. It is thought that the material selected for the planned preliminary sections was not sufficiently variable in this respect. One specimen of quartz showed galenobismutite as a thin massive coating and this specimen was mounted and polished. (Section 7) A suspicion was held that an unknown mineral was present at the edge of the section because of an apparent difference in colour and anisotropism. A delicate removal and X-ray of this small "mineral" by Dr. Thompson produced a definite galenobismutite pattern. The variation in colour was ascribed to its position and possible bevelling on the edge of the slide. The galenobismutite displayed a generally irregularly pitted surface as contrasted to cosalite. These pits are not so well developed as those indicated by Johnson (Plate 6, p. 26) but are distinct in the present sections.

The microscopic characteristics include:

Colour - approaching galena white, though slightly darker than cosalite.

Anisotropism - Polarization colours are lively as compared with the anomolous anisotropism of galena in these sections. More common polarization colours include a bright grey-white to tan, with some shades of deep red-brown seen on closer adjustment of the nicols.

Etch tests:

HNO_3 - In the homogeneous galenobismutite tested in quartz, effervescence was invariably strong, distinct, and immediate with the formation of a black deep etch and a yellow coating.

HCl - In some tests on the confirmed homogeneous mineral in quartz, the surface was darkened to a medium grey after 60 seconds, but in other tests the reaction appeared to be negative. HCl fumes gave a rather pitted brown to irridescent soluble tarnish which was distinctly less marked than the galena reaction.

$FeCl_3$ - Stains differentially light brown, much less marked than galena.

KCN, $HgCl_2$, KOH - negative.

An analysis of this material (Warren, 1940, p. 208) shows; Sulphur 16.40%; Bismuth, 51.00%; lead, 30.50%; Fe, 1.50%; silver not assayed.

From the descriptions given by Johnson and Maconachie, and from my observations it seems clear that the galenobismutite was formed at essentially the same stage as the cosalite and gold.

<u>GOLD</u>.

The association of gold with the cosalite-rich material has been discussed in part under the treatment of the various minerals. Its occurrence as thin leaves or wires interstitial to the cosalite cleavage and its irregular vein-like form through some cosalite indicates that it was deposited in the latter stages of the galenobismutite and cosalite introduction.

Dr. Skerl (1948, p. 590) refers to the high tailing loss incurred when the bismuth-sulphide-rich ore is milled. The subject of coarse gold losses was discussed by Johnson (appendix pp. 1, 2) in 1934. Much of this coarse gold is probably mechanically retained in the various parts of the mill circuit, but since Dr. Skerl refers to tailing loss, further investigation of this loss might be profitable and a simple blanket recovery previously suggested would seem feasible if the gold being lost is shown to be coarse.

CONCLUSION.

Because the primary objectives of this work were not attained, the principal problems of the possible telluride mineral and the silver carrier in the galena remain. The difficulty experienced in identification by etch reactions or colour may cause a third mineral associated with the cosalite and galenobismutite to be misidentified and, in my opinion, an X-ray confirmation of questionable determinations is often necessary in these sections.

The highly fractured condition of the quartz and pyrite in some sections, the slight fracturing of the galena, and the fresh galenobismutite, cosalite, and gold may be a direct relation to the field interpretations of Dr. Skerl in which he ascribes the mineralization as occuring towards the end of the movements along the north-south faults. From the sections studied, I suggest that a considerable gap in mineralization could have occured following the quartz-pyrite or quartz-auriferous pyrite deposition which forms the ore most typical in the mine. With further movement along the north-south faults, fresh openings in the ore may have allowed local access of the later solutions from which the sphalerite and galena and, in the latter phases, galenobismutite, cosalite, and gold were deposited. The dependence of this second series of minerals on further openings might account for the highly irregular distribution of the bismuth-lead-sulphides. The gold associated with pyrite in the normal ere could be deposited in the later stages of the first quartz-pyrite mineralization or could represent deposition from wide-spread late stages of the second mineralization. Such a proposal would not contradict observations made on these sections and it might explain the high values often associated with slightly later faulting which I have noticed in both the Barkerville and Keithley Creek areas. A study of the assay and geological plans of the mine and the distribution of the bismuth-lead-sulphides might corroborate or disprove this suggestion.

ACKNOWLEDGMENTS

I wish to thank Dr. H.V. Warren and Dr. R.M. Thompson for their advice, assistance, and encouragement during the laboratory work reported here.

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