MINERALOGY OF THE MOUNT ZEBALLOS MINE

BY

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ACKNOWLEDGEMENTS.

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Arthur B. Irwin.

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A. INTRODUCTION

1. Access.

Zeballos is on the west coast of Vancouver Island about 175 miles west of Vancouver. It is served by direct tri-weekly air connections and by tri-monthly steamship service from Vancouver via Victoria and Port Alberni. Six miles of road connects Mount Zeballos Mine with Zeballos township at tidewater.

2. Topography.

The productive portion of the Zeballos area is extremely rugged, having a relief of about 4,000 feet, but is nevertheless well-wooded. It is drained by the Zeballos River and its tributaries to the south-east, namely, Nomash, Bibb, Goldvalley and Spud Creeks. The latter, on which the three largest producers (1941) are situated, is a typically U-shaped, glaciated valley with precipitous slopes but having the ridge summits well-rounded.

B. GENERAL GEOLOGY OF ZEBALLOS (see Fig. 1)

Gunning (1) describes the rocks as volcanics and sediments of the Vancouver group of Triassic age intruded by the Coast Range batholith of Jurassic age. Three divisions of the Vancouver group are represented in the Zeballos area.

1. Karmutsen volcanic consisting of flows and breccias with minor interbeds of limestone.
2. Quatsino limestone with interbedded volcanics
3. Bonanza formation consisting of flows, tuff, breccia, argillite and limestone.

(1) Gunning, H.C., C.G.S. Summary Report A2, 1932.

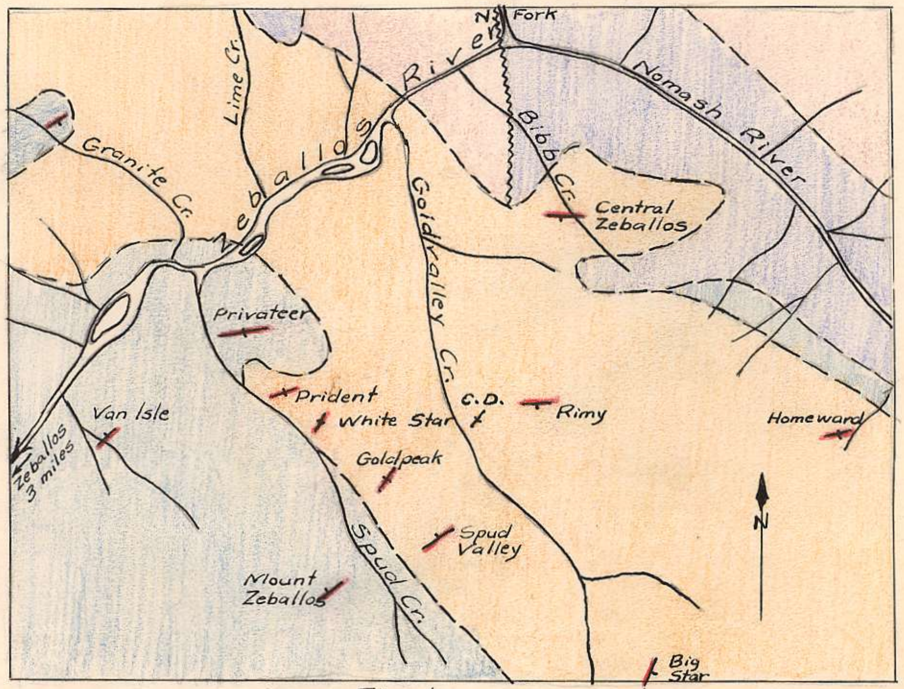


Fig. 1

Granitic Intrusives — Karmutsen Volcanics
Bonanza Group — Strike & dip — Scale 1500 0 1500 3000 Feet
Quatsino Formn — Fault

Sketch-map showing the geology of Zeballos Area.
(Modified from H.C. Gunning & J.S. Stevenson)

These formations, of which the Bonanza is the youngest, are conformable with each other and strike northwest, dipping at moderate angles of not over 50° southwest. They have been intruded by the Zeballos batholith of quartz diorite composition which trends parallel to the strike of the formations and varies from less than one mile, where the Zeballos River crosses it, to over two miles in width in the productive area to the southeast.

C. GENERAL MINE GEOLOGY (see large-scale map)

Mount Zeballos mine lies wholly in the Bonanza formation within a quarter mile of the batholithic contact. Here the Bonanza formation consists of white to green to greyish-brown, altered and unaltered flows varying in texture from aphanitic to porphyritic. Specifically the wall-rock in the Mount Zeballos mine consists of three main lithologic types in order of abundance as follows:

1. Dense, unaltered greenstone flows of andesitic composition striking about N 40° W and dipping 45° S.W.
2. Porphyritic flows conformable with the above but of gradational texture. These vary in colour from mottled green to greyish-brown. Stevenson(2) described this phase as consisting of albite phenocrysts set in an albite-quartz groundmass and infers that it is the product of replacement of an original andesitic greenstone.
3. White silicious rock. This sometimes occurs in sill-like bodies with indefinite contacts between the flows. However the largest mass occurring in the mine is irregularly elliptical in the plane of the vein, being 500 feet long and 200 feet deep.in the vicinity of the 1800 level. The contacts of this mass are gradational into the porphyry or greenstone and it exhibits ghost bedding in places. Microscopic study led Stevenson to suggest that this rock is truly metamorphic and that recrystallization under the influence of sodic solutions introduced at the time of the Zeballos batholithic intrusion produced the present quartz-albite composition.

D. STRUCTURE

The Mount Zeballos vein is a narrow but persistent fissure -- filling typical of the mesothermal gold-quartz type of deposit, striking S50° W and dipping nearly vertical. The fissure has a proved vertical range of over 1000 feet, a horizontal range of over 1200 feet and a width averaging two or three inches in the commercial portions of the vein.

(2) J.S. Stevenson, Geology and Ore Deposits of the Zeballos Area, B.C. Trans. C.I.M.M. 1939.

Spur fissures in places break away from the main fissure but do not continue for any appreciable distance. Minor post-mineral faults occur having a maximum offset of three feet, although six inches is typical.

Although the average vein material is only two or three inches wide, a pale grey alteration material extends three or four inches into each wall. A.R. Allen (3) determined this to consist leargely of calcite, chlorite and sericite with minor amounts of plagioclase, quartz and titanite.

E. NATURE OF THE ORE SHOOTS.

The outline of the known ore shoots is shown on the accompanying ore shoot profile. It will be seen from this that the ore shoots are very erratic in nature. There has been no single depositional control but rather indications that the following have contributed towards ore deposition.

1. The increase in competency of the wall-rock resulting in:

    (a) Greater relative movement between walls along the fissure.

    (b) Greater width of the fissure

    (c) Greater tendency for the occurrence of split fissures.

    This is a purely physical or structural control which is born out in the vicinity of the white, silicic wall rock (type (c) above which is locally called aplite) where the richest shoots are found.

2. Mineralogical change -- increase in the amount of sulphides favours increase in values. This latter factor applies locally but is also conditioned by depth for it is noted that on the 1250 or bottom level, although the vein is strong there are no commercial shoots of ore. This poverty in values is associated with a lack of sulphide minerals in the quartz-fissure-filling on this level.

This paper is concerned with the detailed mineralogical study of the Mount Zeballos ores in an effort to explain the apparent bottoming of the commercial ore shoots. Both megascopic and microscopic studies are described on the following pages.

(3) Allen, A.R. Thesis submitted for M.A.Sc. on "Wallrock Alteration of the Zeballos Ores" 1941.

E. MACROSCOPIC EXAMINATION

1. Field Study.

From April to September 1941 the writer had an opportunity during his duties as engineer to observe the mineralogy of the ore in the mine and to discuss with other employees their experience in mineral associations within the commercial ore shoots. The following general observations were made:

(a) In the upper levels of the mine the vein material had a large content of coarse sulphides with only moderate ore values. In the middle part of the mine, as characterized by the 1603 stope, the phenomenally rich ore had a smaller content of very fine-grained sulphides. In the lower levels the sulphides were much scarcer with a resultant decrease in gold values to a non-commercial grade.

(b) In the upper levels the quartz is well-crystallized and often displays well-developed comb structure. Small vugs are common while in many places late calcite has filled the vugs. This is well illustrated by specimen 3 from 2150/9 stope. In the lower levels the quartz becomes massive and calcite much less plentiful.

2. Laboratory Study.

The above field observations are confirmed by a subsequent careful study with hand lens and binoculars, of ores from various parts of the mine.(see large-scale map). Unfortunately specimens of vein material from the barren 1250 level are not available. The following additional observations have been made.

(a) There is no appreciable change in the metallic minerals from the 1600 (lower) level to the 2250 (top) level, the order of abundance of the metallic minerals being:

(1) Arsenopyrite
(2) Pyrite
(3) Sphalerite
(4) Galena
(5) Chalcopyrite
(6) Gold

In the 2150 and 2250 levels (most recently developed) the order of abundance of the pyrite and the arsenopyrite is reversed. In addition, specimen No. 34 from within 100 feet of the surface in 2005 stope shows covellite in comb quartz in close association with sphalerite. It is most likely secondary as it is in a zone where there has been much oxidation of vein material.

(b) Specimen No. 32 from 2150/9 stope shows heavy sulphide mineralization in which sphalerite veins the pyrite.

(c) Specimen No. 12 from 1705 stope shows three generations of quartz.

(1) Dense watery quartz containing arsenopyrite and pyrite mineralization.

(2) Type (1) is cut by coarsely-crystalline quartz, which in this specimen is of a rusty colour.

(3) Types (1) and (2) are both cut by tiny veinlets of a later quartz.

Types (1) and (2) are common in all specimens. In addition, specimens 8, 9 and 10 from 2005 stope and 32 from 2150/9 stope display gold occurring in type (2) and at the margin between types (1) and (2). Several specks of gold with a copper-coloured stain were found in specimen No.8.

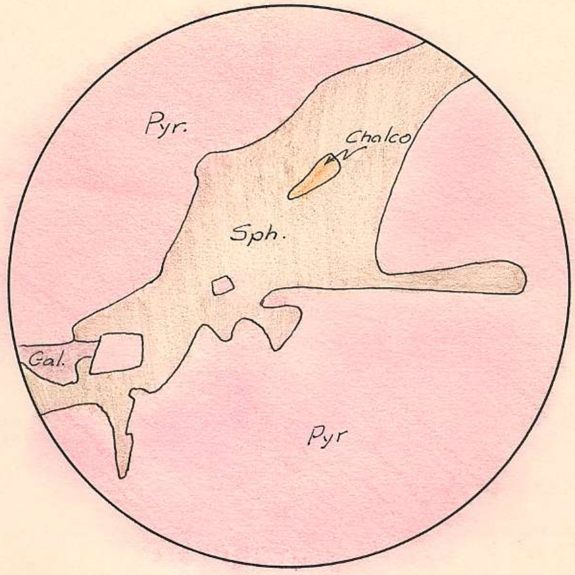
G. MICROSCOPIC EXAMINATION.

Hand polished sections were prepared from the following specimens (see large-scale map for locations):

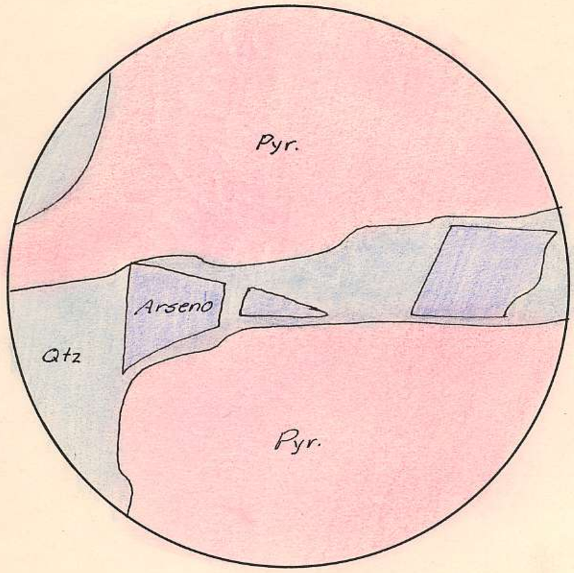
No.	Location	No.	Location
5	2150/9 Stope	29	1906 Stope
7	2005 "	32	2150/9 "
12	1705 W "	38	1604 W "
17	1908 "	40	1603 "

In addition, 10 super-polished sections were prepared from specimen 17 which contained a large amount of free gold. The following relevant information was obtained:

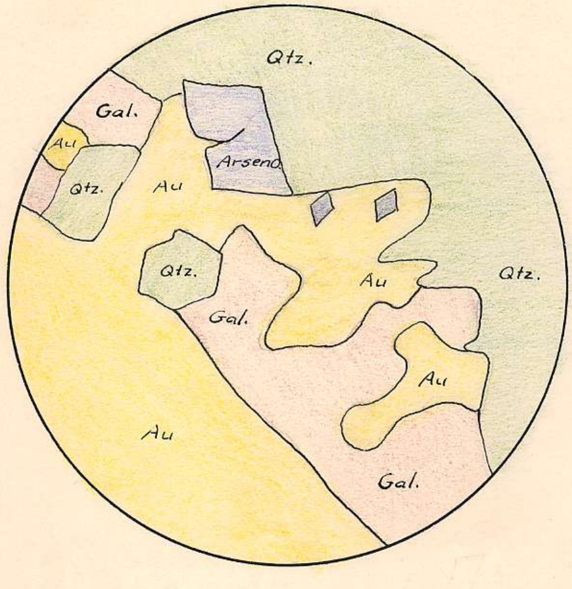
1. Sections 40A and 40B show fragments of silicic wallrock rimmed by arsenopyrite. In section 12, however, the brecciated calcic wallrock is not rimmed by arsenopyrite. This illustrates the chemical effect of wallrock composition on mineral deposition.
2. Section illustrates also the lateness of the crystalline quartz which in this section has a rusty colour.
3. Sections 5 and 29 show more altered wallrock being cut by veinlets of quartz containing pyrite and arsenopyrite with some sphalerite and chalcopyrite. Close examination of section 5 disclosed two generations of quartz, the minor generation being earlier, of a milky white colour, and apparently barren of sulphides originally.
4. In section 32 sphalerite with exsolved chalcopyrite cuts pyrite. The whole seems to have undergone fracturing.
5. Sections 12, 38, 40A and 40B are typical of the average high grade mine ore, the main sulphide being fine-grained arsenopyrite upon which the gold deposits. Where pyrite occurs it is relatively coarsely crystalline and is rimmed by fine crystals of arsenopyrite. Sphalerite, chalcopyrite and pyrrhotite are minor constituents.
6. Section 7 shows coarse pyrite, sphalerite, galena and chalcopyrite crystallized in a cluster exhibiting no crosscutting or replacement features. This would indicate that there was little time-spread during the deposition of these minerals.



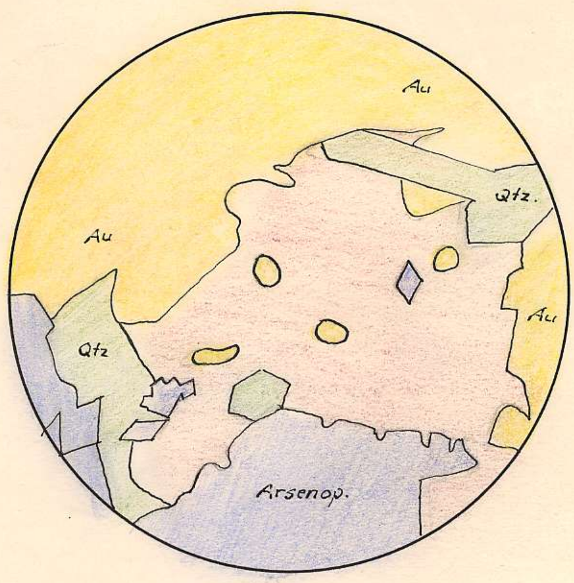
Mag. 6X Fig. 2 Sect #32



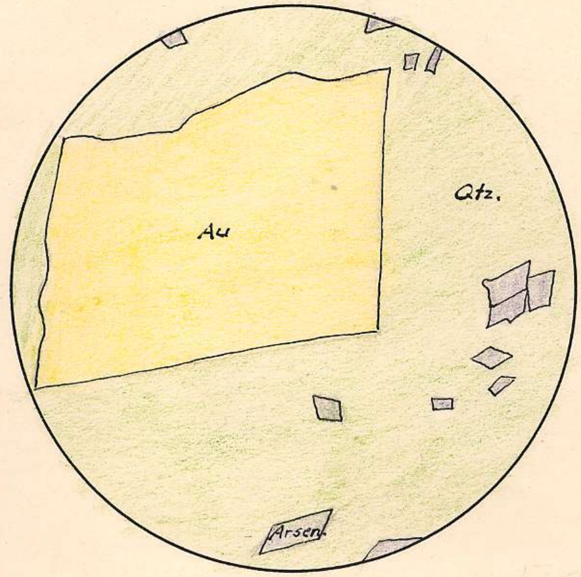
Mag. 54 x Fig. 3 Sect #5



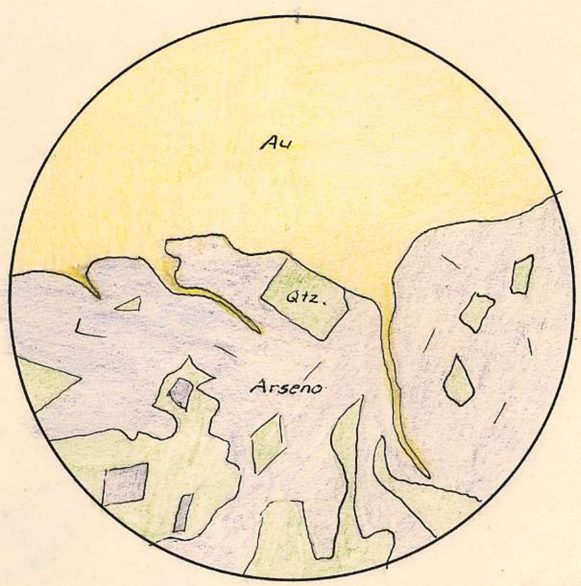
Mag. 140X Fig. 4 Sect. #17E



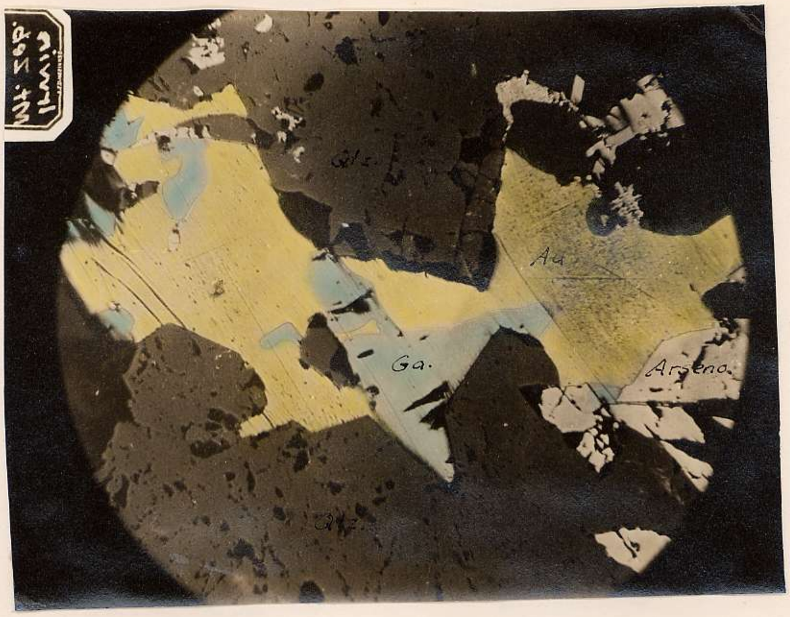
Mag. 140X Fig. 5 Sect. #17



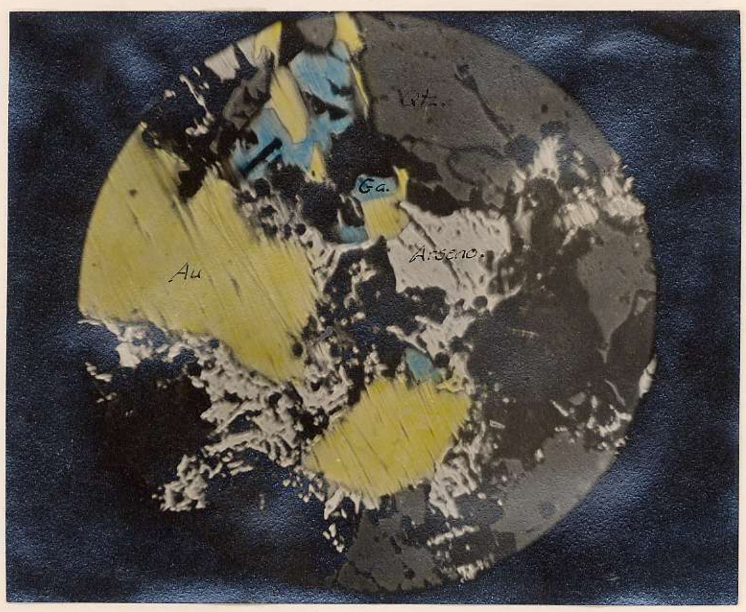
Magn. 140X Fig. 6 Sect. #17D



Mag. 140X Fig. 7 Sect. #17c



72x Plate 1. Section 17A



60x Plate 2. Section 17B

7. Sections 17, 17A, 17B, 17C, 17D and 17E all cut from specimen 17, illustrate the associations of gold with arsenopyrite and galena.

   (a) The occurrence of blebs of gold in galena is represented in Fig. 5 from section 17.

   (b) In Fig. 4 from section 17E gold is seen surrounding arsenopyrite and partially replacing it. In both Figs. 4 and 5 gold and galena are shown depositing around the crystalline quartz.

   (c) Gold actually veins arsenopyrite in Fig. 7 from section 17C

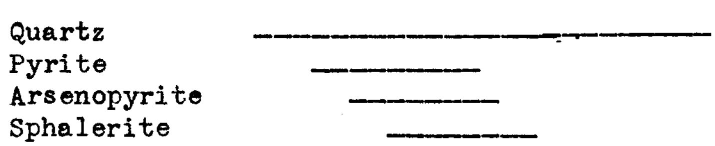
   (d) In Fig. C from section 17D, gold is seen pseudomorphic after arsenopyrite. Other pseudomorphs are seen in sections 17B, 17C, 17E, and 17F, that from 17B being illustrated in plate 2.

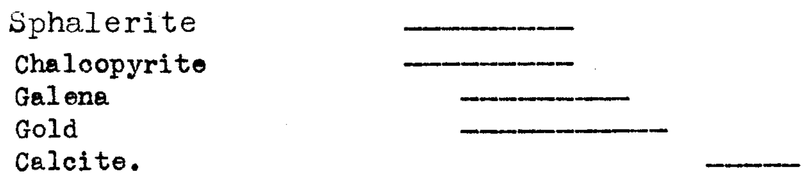
   (e) Plate 1 from section 17A substantiates the argument for contemporaneous deposition of gold and galena for the illustration shows smooth-margined apophyses of gold in galena and galena in gold. However, gold appears to have continued to deposit after the galena, for gold is seen occasionally filling narrow spaces between galena and arsenopyrite crystals.

8. In sections 7, 12 and 32 stringers of calcite vein all the other minerals including quartz.

H. MINERALOGICAL CONCLUSIONS

1. From the above examinations the paragenesis of the vein minerals may be deduced as below:





2. There are probably four generations of quartz:

   (a) Milky-white, barren variety
   (b) Darker, watery-coloured quartz carrying the pyrite and arsenopyrite and possibly the sphalerite and chalcopyrite.
   (c) Crystalline quartz which introduced gold and galena.
   (d) The fourth generation occurs only as tiny veinlets, barren of mineralization.

3. The gold has an affinity for the finely-crystallized arsenopyrite, tending to deposit on its margins and to replace it.

4. Gold and galena are contemporaneous, although not always found in close association.

5. The more silicic wallrock favours deposition of the arsenopyrite which is associated with the richer gold values.

I. GENERAL OBSERVATIONS

Since writing the foregoing, the author had occasion to refer to the results of Stevenson's microscopic examination of the Zeballos ores (2), and was surprised to find that in general the mineralogical conclusions on the Mount Zeballos ores coincided with Stevenson's findings on Zeballos district ores with the following minor exceptions:

1. Stevenson places arsenopyrite earlier than pyrite.

2. Stevenson states "the amount of gold is directly proportional to the amount of sulphide present."

Stevenson's conclusions concerning "Relationship Between Mineralization and Faulting" are also substantiated by the foregoing mineralogical conclusions and nothing further can be added to his excellent treatment.

Below is a table showing generalized relationship of gold values to mineralogy and wallrock composition in the Mount Zeballos Mine:

LOCATION	VEIN QUARTZ	SULPHIDES	WALLROCK	GOLD VALUES
Lower levels (below 1600)	Compact	Scarce	Soft andesite	Sub-commercial
Intermediate levels (1600 - 2000)	Crystalline	Arsenopyrite only is abundant	Very hard "felsite"	Very rich
Upper levels (2000 - 2850)	Crystalline and open.	Mixed sulphides abundant	Moderately hard porphyry	Moderately rich

J. ECONOMIC APPLICATION

The generalized relationship of gold values to mineralogy and wallrock composition in the Mount Zeballos mine is inconclusive. The ore occurrence as a whole is so erratic that such a generalization does not present a true picture. Further study of structural and petrological features of the deposit and further correlation with other deposits of the Zeballos area would aid towards predicting definitely the depositional controls and the possibility of finding ore deposits with depth. However, the foregoing mineralogical study indicates that the Mount Zeballos ore shoots are bottomed:

1. The wallrock composition apparently has a control on ore deposition. It has been shown in the polished sections that there is a chemical control -- arsenopyrite deposits more readily on siliceo us wallrock than on the softer calcareous alteration from the dark andesite. There may also be a physical control due to the competency of the siliceous wallrock ("aplite" and porphyry). There seems to be a decrease with depth of siliceous "Aplite" and porphyry so the chance of finding ore shoots with depth grows less.
2. The mineralogical occurrence of the vein filling alone tends to substantiate a suggestion by Gunning (4) that the vein fissures of the Zeballos area were filled at a period when the topography was little different to what it is at present, so that ore deposition took place under near-surface conditions.

In the light of the above indications, vertical exploration at depth would not be warranted.

(4) Gunning, H.C., Unpublished notes on "Privateer Mine and the Zeballos Mining District." 1940.


2250 SUB-LEVEL
2150 LEVEL ELEV: 2153
2000 LEVEL ELEV: 2032
1900 LEVEL ELEV: 1916
1800 LEVEL ELEV: 1826
1700 SUB-LEVEL
1600 LEVEL ELEV: 1600
1500 LEVEL ELEV: 1488
1250 LEVEL: ELEV 1278
Property Boundary
2006
2005
2008
1908
1906 B
1906 A
1906 W
1906
1903
1809
1808
1806
1805
1803
1708
1705
1608
1604
1603
1601
1506
1504
1503
1501
1500
LEGEND
Defines excavated areas in non-commercial rock.
Defines excavated ore shoots i.e. portion of vein valued at 200 inch-dollars or over.
Defines geological boundary.
Volcanic or greenstone.
Aplite or felsite.
Porphyry.
Aplite in volcanic.
Aplite in porphyry
MOUNT ZEBALLOS GOLD MINES LTD.
ORE SHOOT PROFILE
SHOWING RELATION TO
GEOLOGICAL FORMATIONS
SECTION: VERTICAL, STRIKING N51°E
Scale: 1in. = 40 ft.
September 1st, 1941
Prepared by: A.B. Irwin.
inches
0
1
2
0
1
2
3
4
5
centimetres
BRITISH COLUMBIA GEOLOGICAL SURVEY
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.