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Field Report

MAGNETITE OCCURRENCES IN BENSON LAKE AREA, Vancouver Island, B.C.

by W.G. Jeffery and G.E.P. Eastwood

July 15, 1961

Contents

Diagrams

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Objective:

The study of magnetite occurrences to obtain knowledge of their origin, mode of occurrence, and associations, in particular to obtain guides to the discovery and exploitation of new orebodies.

Scope:

As generally directed in "Study of Magnetite Deposits, Coastal Area", by H. Sargent, May 12, 1961, British Columbia Department of Mines and Petroleum Resources.

Field Work:

A period of approximately six weeks has been spent on a study of the mineralogical associations of magnetite, their character and extent, general megascopic observations, collection of specimens for further microscopic examination, and the systematic sampling of intrusive igneous rocks associated with two magnetite occurrences.

This work and report have been carried out by collaboration and discussion between the two authors. The mapping and sampling have been done by Eastwood, and the manuscript has been written by Jeffery.

Location:

Work has been centred on the operations of Empire Development Ltd., northern Vancouver Island. A resume of the regional and local geology, together with a map of the major showings, is given in the Annual Report for 1960, and the information will not be repeated here. The magnetite occurrences given most attention include the Merry

Widow, Shamrock, Blackjack, and Ajax deposits, with some details noted about the Raven and Kingfisher bodies. A short inspection of the neighbouring Coast Copper deposit (see Ann. Rept. 1960) was made, but detailed examination had not been started at the time of this report.

Acknowledgments:

This work and report would not have been possible without the co-operation and assistance of the staff of Empire Development Ltd. and Mannix Co. Ltd.

RESULTS

a) Mineralogical Studies of the Merry Widow Orebodies

Detailed mineralogical studies were initiated in the Merry Widow open pit because of good exposure and access. The resulting mineralogical map is presented as Figure 1a. It is clear that these studies suffer from the fact that artificial exposures are not more widespread. The fact that open pits are made to extract magnetite limits the extent of study of accessory minerals, and for the detail required natural outcrop in this region is insufficient. Mineralogy has been mapped along the lower parts of lifts between working benches.

The map shows that the ore zone is a complex alteration zone lying between the limestone and the diorite. Primary rocks mapped include limestone, volcanic rocks, and diorite. Fine-grained dark dykes have been included with the volcanic rocks. Alteration minerals, commonly termed skarn, were estimated as major or minor constituents, and the pattern of colouring is an attempt to indicate the relative quantities. Even so, the map is essentially a simplified representation of the actual mineralogical constitution of the ore zone.

In this work skarn has been taken to include all the alteration minerals associated with the magnetite. These include garnet, epidote, calcite, chlorite, ~~epidote~~ amphibole, and quartz. Figure 1a shows that these form an integral part of the ore zone and that there is no definitive ring or halo of these minerals around the magnetite lenses. Figures 1b, 1c, and 1d show separately the distribution of magnetite with respectively garnet, epidote, and calcite. The garnet and epidote distributions are very similar and would appear to be closely connected. A distinct feature of Figures 1b and 1c is that on the basis of this mapping garnet and epidote are largely restricted to the zone of volcanic rocks. The contacts of the volcanic rocks with the diorite and limestone are also boundaries of garnet and epidote mineralization, whereas they are not the boundaries of magnetite formation. Figure 1d shows the distribution of substantial amounts of calcite in relation to magnetite. Calcite as a minor constituent is widespread through the ore zone, but the mapping shows that as a major constituent it is largely restricted to magnetite. Further notes regarding megascopic observations on the skarn and sulphide minerals are added below.

Apart from the distribution of skarn minerals that could be mapped on the surface, a start has been made on mapping the vertical distribution of these minerals. Initially three sections were selected across the Merry Widow ore zone to show information from many diamond drill holes. These sections are shown on Figures 1a-d as AA', BB', and CC'. However it was subsequently found that a great amount of the core was no longer available, and this applied especially to most of the early, vertical diamond drill holes. The available core is principally from inclined holes drilled at various angles to the proposed sections. The plotting of intersections of drill holes with the selected sections and noting of geology at these points clearly would not utilize all the information gained, and in all probability would not provide any useful information. Thus to gain an idea of what could be obtained, nine holes were selected which formed suitable sections, and the surface plan of these holes is shown in Figure 2. Core from ten additional holes within the area of Figure 2 has also been logged, although these holes have been omitted from the figure for simplicity. In all, nineteen holes totalling 5,700 feet of core have been logged using the same mineralogical approach as was used in mapping the Merry Widow pit.

From the holes shown in Figure 2 three sections, shown as Figures 3a, b, and c, have been developed, and the main feature is that a certain degree of correlation of alteration zones and magnetite is possible between diamond drill holes when they are logged on this basis. It so happens that two of the sections (3a and 3b) are vertical planes, whereas 3c is merely an inclined plane formed by the two holes plotted. Most of the core information occurs in holes forming skew sections as seen in Figure 3c. Full use of the information obtained will entail the development of many skew sections and the projection of the geology to the selected sections AA', BB', and CC'. The amount of draughting and office work entailed in this prevented this being done in the field, but sections 3a, b, and c indicate the possibilities of what can be obtained from this approach.

Figure 3a shows the correlation made between the various mineral zones as logged in the diamond drill cores, and also the extension of such information to that developed in section 3c where this is transferred to the plane of section 3a. Another feature is that fault zones can be projected between the holes. Figure 3a suggests a series of shear zones lying roughly parallel with the alteration zones and with the diorite contact. Section 3b is almost parallel to 3a and

and shows similar faulting along the diorite contact. In Figure 3c there is a line which appears to indicate the first noticeable amounts of calcite as one approaches magnetite mineralization down the hole.

Elucidation of the geological pattern from this series of skew and angle holes may be aided in the office by the construction of a model which shows the alteration zones as interpreted from the sections. Combined with the map of the Merry Widow pit some idea of the mineral distribution in the Merry Widow zone might be obtained.

b) Megascopic Observations on Mineralogy

These notes are not intended to be complete. Many observations have been made which have been noted and reported before. The following comments contain the most outstanding features observed.

Magnetite: Jet-black through bluish- to violet-black. Varies from fine-grained anhedral to coarse-grained euhedral. Texture variable: 1) Massive (Merry Widow); 2) Mammillary (Kingfisher); 3) vuggy, containing calcite, chlorite, and quartz (Kingfisher, Blackjack, Shamrock); 4) banded with calcite and/or chlorite (Kingfisher, Blackjack, Coast Copper); 5) acicular, rare (Merry Widow); 6) scaly (Merry Widow); 7) lagoonal, rare - possibly a colloform texture (Merry Widow, Shamrock). Magnetite commonly veins brecciated garnet, and is veined and healed by calcite.

Garnet: Amber to light brown, rarely dark brown to black. Normally fine-grained or massive, but coarse-grained with calcite or limestone. Abundant association with magnetite in all volcanic rocks.

Epidote: Fine-grained, granular; rarely coarse-grained, euhedral. Conflicting evidence of the position of epidote in the paragenesis indicates more than one age.

Calcite: Widespread in small amounts, but larger quantities confined closely to magnetite. As pods and lenses, massive to coarsely crystalline, rarely as continuous veins, in places banded with magnetite, frequently in masses associated with sulphides in the magnetite orebodies. There is a possibility that zones high in calcite in the Merry Widow ore zone may occur above the crests of tight folds in the limestone.

Chlorite: Not common. Distribution and origin difficult to estimate. Infrequently medium-grained in patches and bands in magnetite, also in vugs with calcite.

Microcline: Pink, crystalline. Sparingly but widely distributed through the Merry Widow ore zone in and near diorite. Not consistently associated with any or all of the alteration minerals.

Amphibole: Not common. Crystalline, prismatic; in calcite and probably late stage. Acicular, forming cross-fibre pattern in magnetite and possibly of same age.

Ankerite: Rare - only in diamond drill holes in Shamrock.

Hematite: Rare - in some fractures in Merry Widow.

Sulphides: Pyrrhotite, pyrite, chalcopyrite, widely scattered in small amounts, but are distributed irregularly. Increase in amount from the diorite-ore zone contact to the ore zone-limestone contact at the Merry Widow and Shamrock deposits, also downward in the Merry Widow. Economic amounts of chalcopyrite and bornite occur at the Coast Copper mine. Arsenopyrite rare - as clusters of crystals in Merry Widow. Sphalerite rare - as veinlet cutting pyrrhotite in Raven orebody.

c) Sampling of Diorite

The purpose of this work was to determine the variation in iron and magnetite content in the diorite in relation to a magnetite deposit. A systematic approach to the sampling was adopted by running a planetable traverse approximately at right angles to the surface trace of the diorite-volcanic contact westward from the

Merry Widow pit. Sample locations were limited by available outcrop on the line adopted. Samples consisted of several chips taken from the freshest possible rock. Iron analyses are tabulated in the Appendix and plotted in Figure 4.

In Figure 4 certain analyses have been rejected in the interpretation. Only diorite values were used, and the rejected values were as follows:

Sample No. 2	-	volcanic rock
5	-	sheared diorite
13	-	diorite containing pyrite and chalcopyrite
15	-	monzonite, probably as dykes intruding diorite
17	-	monzonite
21	-	volcanic rock

Figure 4 shows that a smoothly curved line can be interpolated between the remaining points, suggesting that there is a distinct increase in iron content of the diorite over a distance of approximately 1,000 feet away from the Merry Widow ore zone. The range is from approximately 6 per cent total iron near the contact to 11 or 12 per cent at the most westerly point, that is, an increase of the order of 100%. This general result of a test sample run is interesting in that some pattern of total iron distribution has been detected. However this line of samples was taken in order to evaluate the usefulness of sampling more of the diorite. Until this pattern can be shown to be repeated either on different lines from the same ore zone or at different orebodies, little should be inferred from these results. Values for the magnetite content of the samples are still awaited.

Before these analyses were received additional sampling of diorite was done along the Merry Widow headwall and adjacent to the Shamrock zone. Along the Merry Widow headwall six samples were taken within

75 feet of the diorite-ore zone contact. The Shamrock sampling was modified by limited exposure and the samples were taken from an irregular area within 150 feet of the diorite-ore zone contact. In addition sampling was extended across the Shamrock ore zone and 300 feet into the limestone. These analyses are still to be made.

d) Projects Incomplete

1. Sampling of volcanic rocks. Systematic sampling of the volcanic rocks, preferably along strike, adjacent to a magnetite deposit may reveal patterns similar to that already found in the diorite. However, in the present area of study no suitable surface exposures or diamond drill holes were found. The detailed sequence and structure of the volcanic rocks is imperfectly understood, distribution is limited, there are considerable amounts of volcanic type intrusive rocks in the area, and there are numerous small pockets of skarn and magnetite throughout the volcanic belt.

2. Age determination samples. Fresh biotite has not been found in ore or wallrock. Some degraded micaceous mineral that may have been biotite has been found in a few places but was considered unsuitable.

3. Oriented specimens. This project was not given high priority in the operations, and the time for the necessary planetable work was not available.

CONCLUSIONS

At this stage the following conclusions are tentative; further work is necessary on most aspects.

Work done to date suggests that magnetite is an integral part of skarn mineralization. It is true that many small pods of skarn can be found in the region which apparently do not have any associated magnetite, but equally there are also occurrences of garnet without epidote and vice versa. Not all skarn minerals need be present at one showing, and this applies as much to magnetite as to other minerals.

An added observation can be made here. One of the authors (W.G.J.) had a chance to examine magnetite concentrations on Red Island in Rupert Arm. The magnetite is very fine-grained and disseminated through greenstone volcanic rocks adjacent to a granitic intrusive. High dip needle readings were obtained and the magnetite can be detected easily with a hand magnet. A sample gave an analysis of about 16 per cent total iron. No 'skarn' mineralization was observed, and this concentration is far removed from the nearest known limestone. Further, limited concentrations of magnetite have been noted within a brecciated volcanic rock and within diorite, with no evident associated skarn. These are given as occurrences which seem to contradict the above tentative conclusions.

With regard to the extent of the alteration minerals in relation to magnetite it appears from this work that all the usual alteration minerals, at least on a macroscopic scale, are closely associated in space with magnetite. This makes them of little practical use as a guide to ore. There remains the possibility that incipient crystallization of epidote and garnet on a microscopic scale may extend over greater distances, but further research is required on this point.

One mineral noticed in this project, which has not been given much attention previously, is the distinctive pink microcline found in the Merry Widow ore zone in and near diorite. John Lamb of Empire Development reports seeing this mineral in relation to magnetite at Sydney Inlet. Pink microcline should be looked for and its extent noted at other localities.

RECOMMENDATIONS

1. Mineralogical studies.

The tentative conclusions stated above are based on detailed work on one deposit only. Therefore generalization to all magnetite deposits is not possible. At least one more mineralogical study along the lines of this project should be carried out. Care is needed in the selection of the location since it is essential that exposures (either surface or diamond drill) should extend as far as possible beyond the limits of the known magnetite.

2. Microcline.

All field workers should make specific search for and note the presence and if possible the extent of this mineral.

3. Sampling associated intrusives.

As described above, further sampling of the intrusive rocks associated with magnetite deposits is warranted. This work should be done at as many deposits as possible, and should extend over distances of the order of 1,000 feet for economic deposits. Lesser amounts of magnetite may well reveal effects over smaller distances, that is, variations in iron content with respect to amounts of iron present remain unknown. Research can be described in three categories:

a) Sampling into the intrusive from magnetite

b) Sampling along a contact away from magnetite.

c) If available, sampling in diamond drill holes at depth away from magnetite.

In addition, it is necessary to sample a diorite mass where it lies adjacent to volcanic rocks barren of magnetite concentrations, for purposes of comparison.

4. Sampling of volcanic rocks.

Due to the layered nature of volcanic rocks the systematic sampling in search of zones of impoverishment, as found in diorite, is more difficult in the field. Original variations in iron content of the volcanic sequence have to be considered and could confuse the results. Ideally, sampling within one flow or bed is necessary. These conditions should be looked for in the field and sampling should be done if the opportunity arises.

5. A series of thin sections should be studied in order to look for and, if present, gauge the extent of incipient development of all alteration minerals in the country rocks.

G. G. Jeffery

G. E. P. Eastwood

APPENDIX

Total iron analyses of diorite samples taken west from Merry Widow.

Lab. No.	Book No.	Field No.	% Fe	
8237M	1166	1	6.3	
8238	1167	2	(3.4)	Volcanic
8239	1168	3	6.3	
8240	1169	4	5.9	
8241	1170	5	(12.5)	Sheared
8242	1171	6	8.8	
8243	1172	7	8.0	
8245	1174	8	8.4	
8246	1175	9	8.8	
8247	1176	10	8.6	
8248	1177	11	10.5	
8249	1178	12	12.1	
8250	1179	13	(15.1)	Sulphide-bearing
8251	1180	14	10.9	
8252	1181	15	(3.0)	Monzonite
8253	1182	16	13.3	
8254	1183	17	(6.4)	Monzonite
8244	1173	19	(11.4)	
8255	1184	21	(10.1)	Volcanic

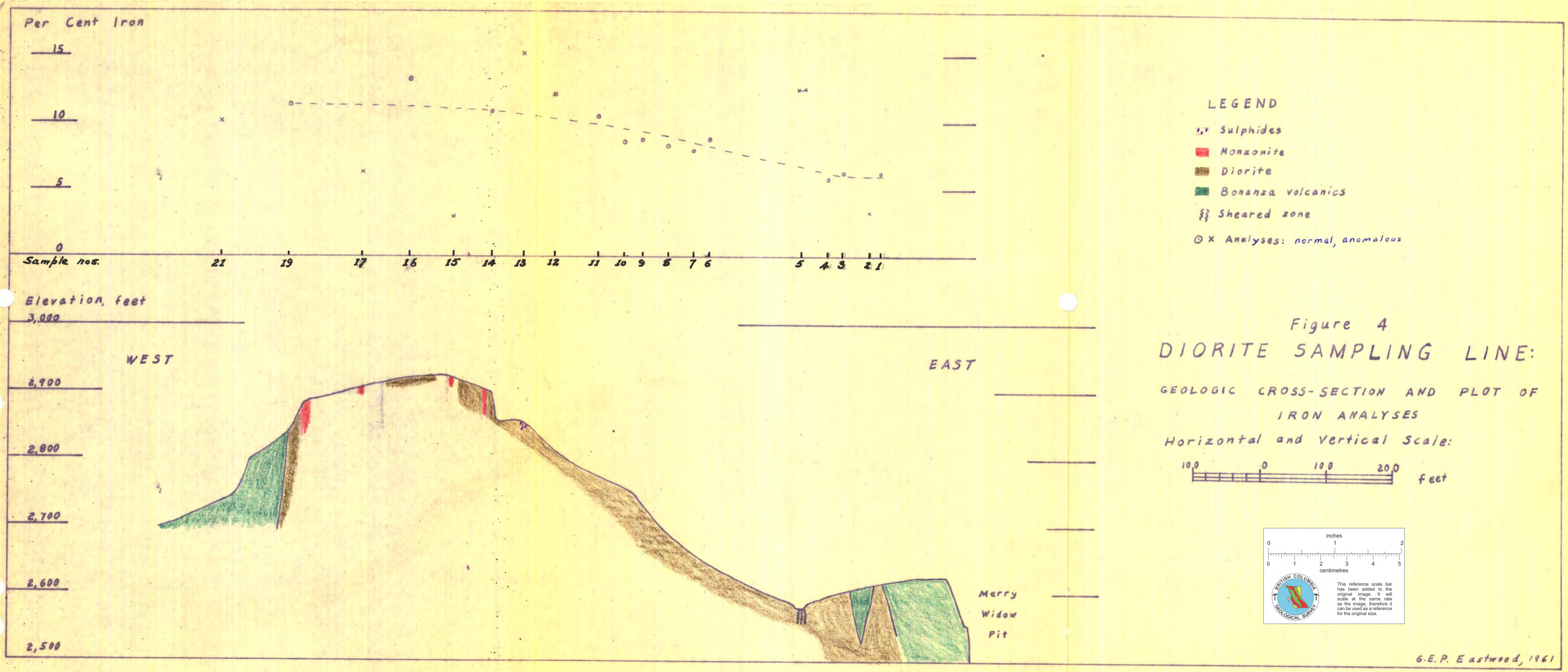


Figure 4
DIORITE SAMPLING LINE:
GEOLOGIC CROSS-SECTION AND PLOT OF IRON ANALYSES

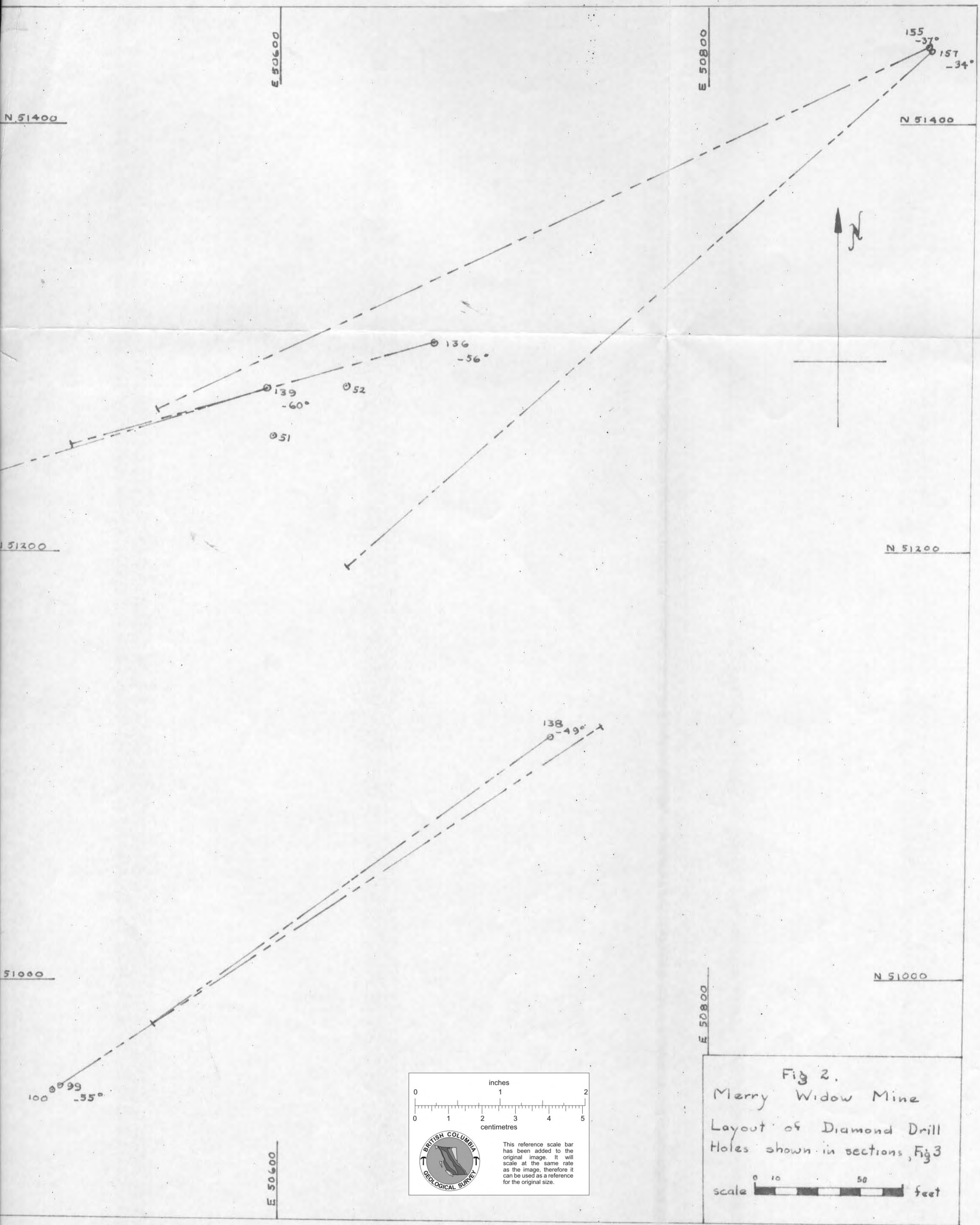
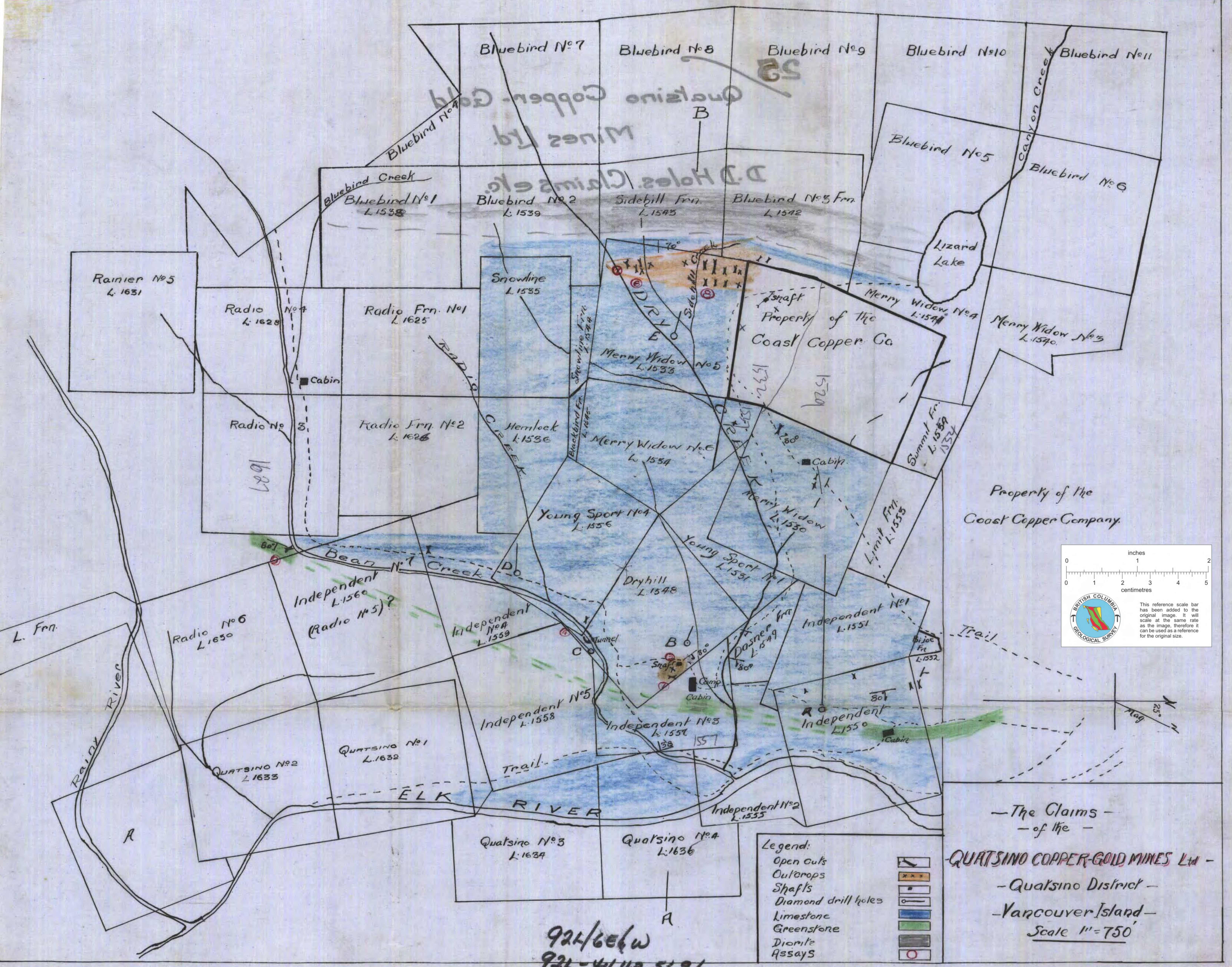


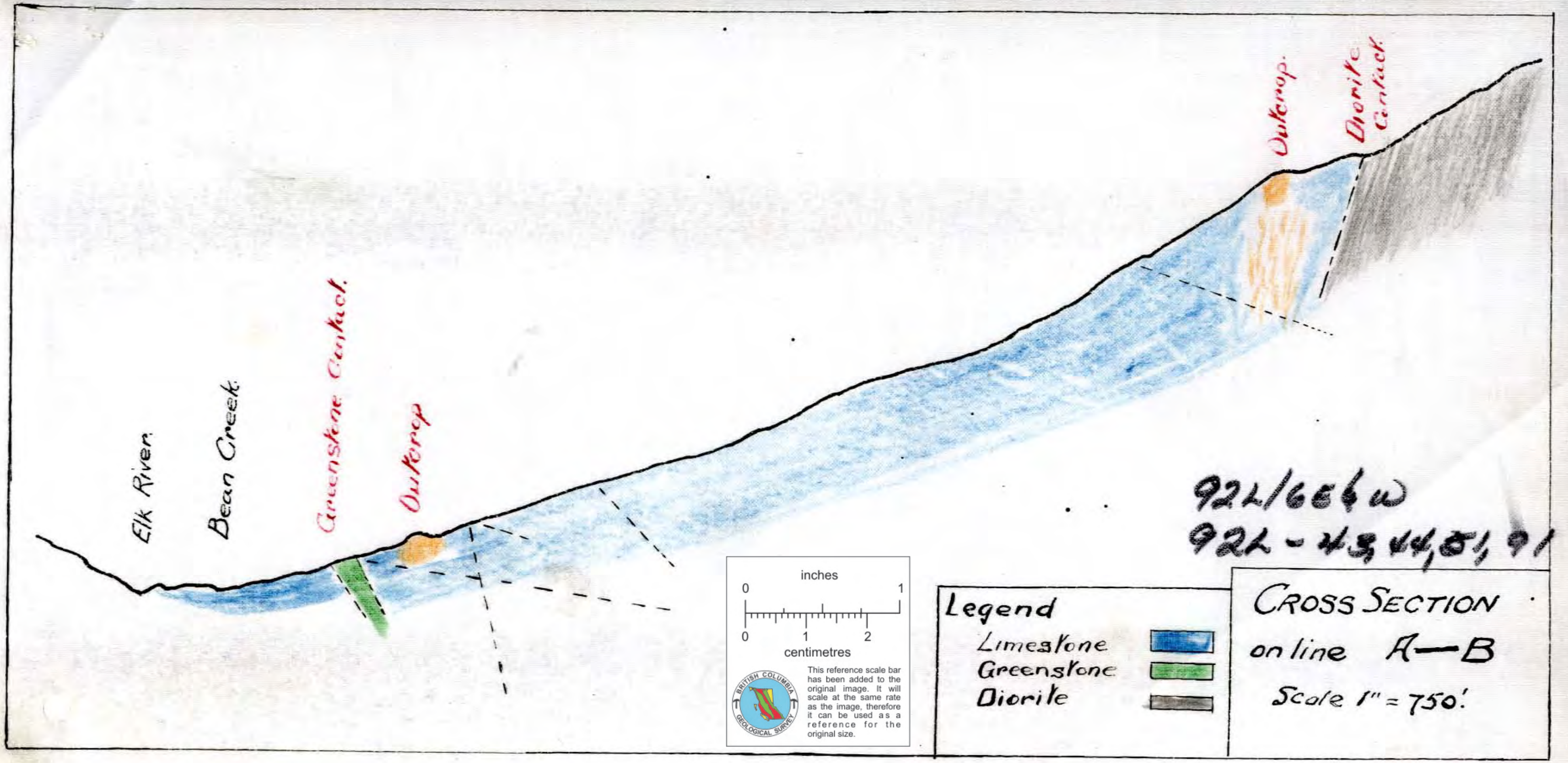
Fig 2.
Merry Widow Mine
Layout of Diamond Drill Holes shown in sections, Fig 3

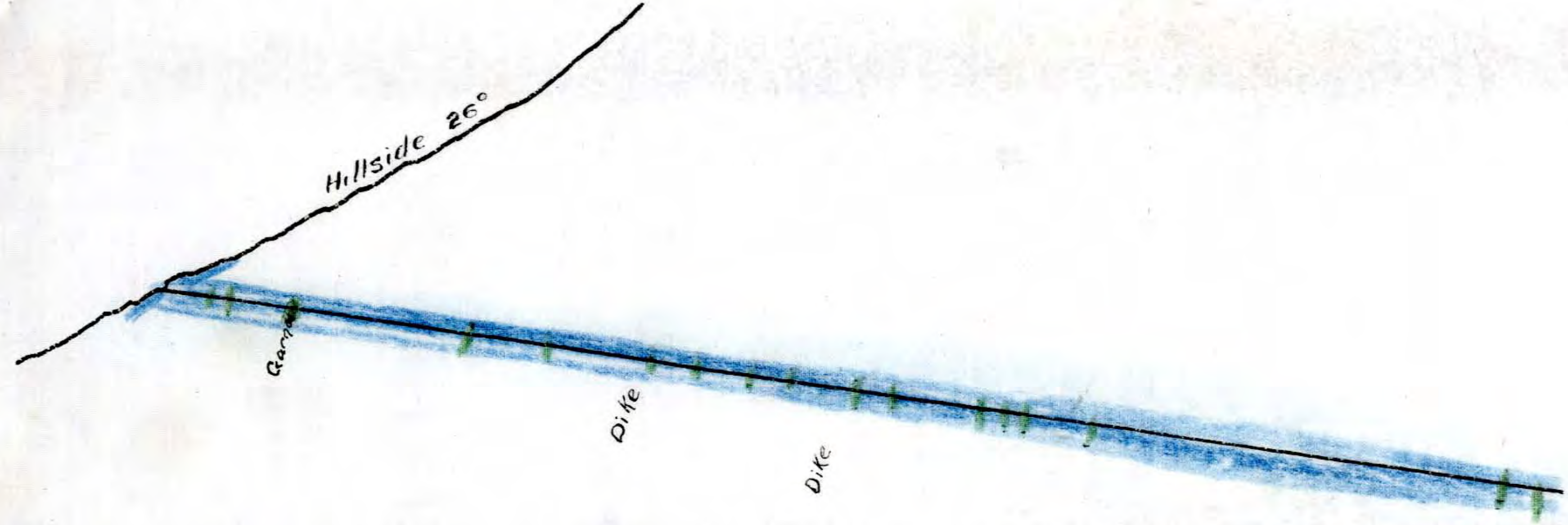
scale 0 10 50 feet



92L/6E&W

92L-44, 43, 51, 91


Elk River
Bean Creek
Greenstone Contact
Outcrop
Outcrop
Diorite Contact
92L/6E&W
92L-43,44,51,91
inches
0 1
0 1 2
centimetres
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.
BRITISH COLUMBIA GEOLOGICAL SURVEY
Legend
Limestone
Greenstone
Diorite
CROSS SECTION
on line A—B
Scale 1" = 750'.



inches
0 1
0 1 2
centimetres

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.

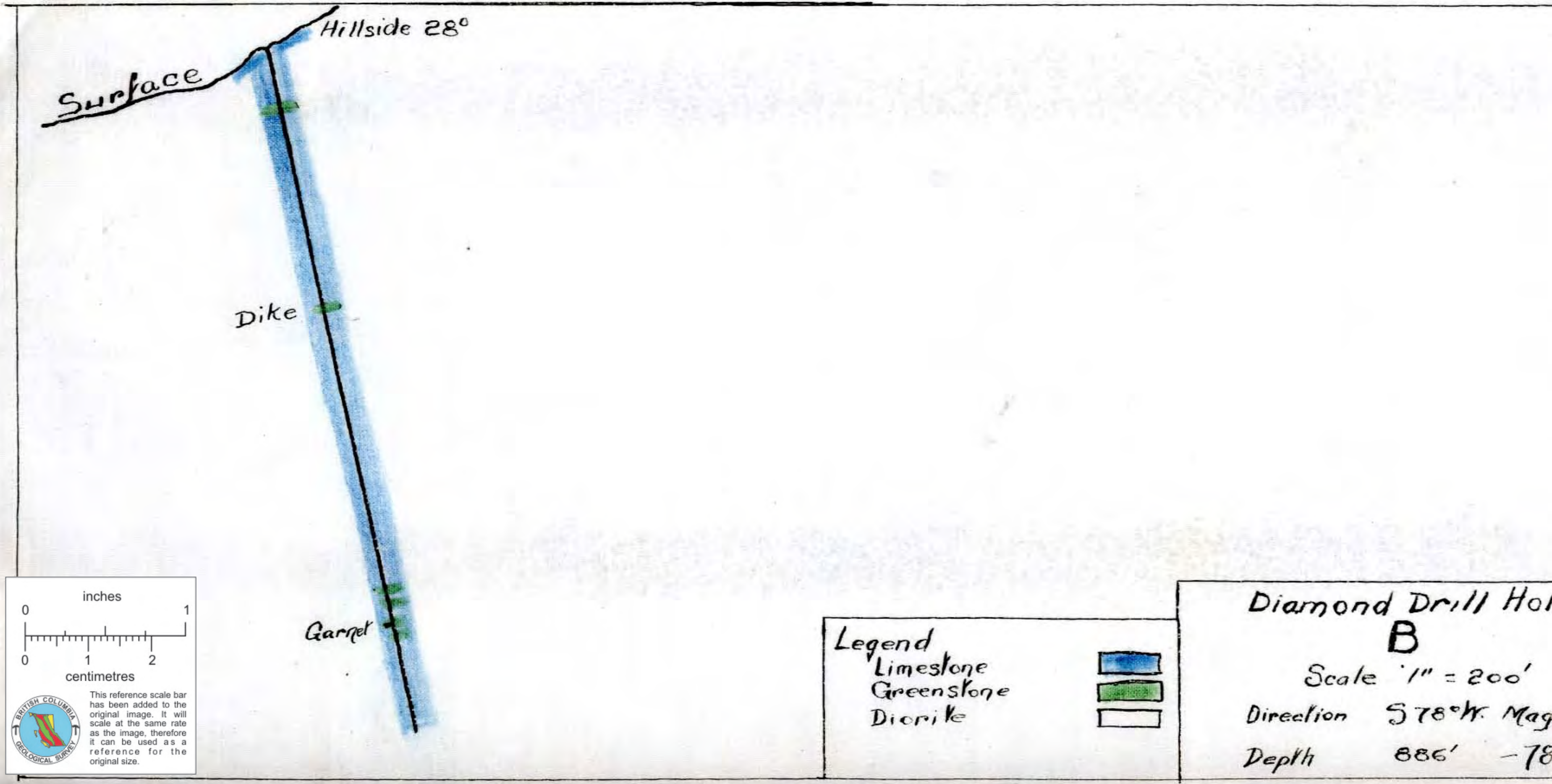
Legend
- Limestone
- Greenstone
- Diorite

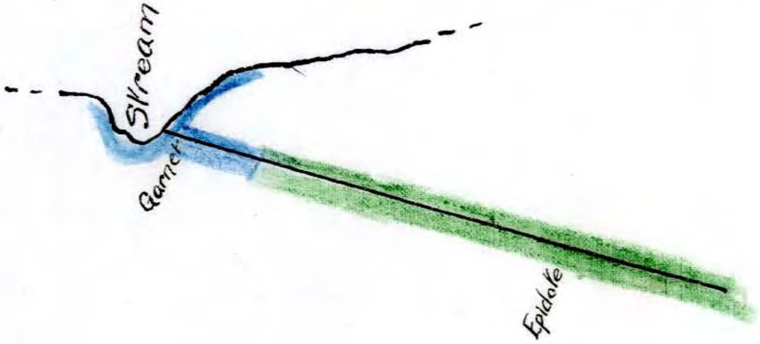
Diamond Drill Hole A

Scale 1" = 200'

Direction S 63° W. Mag

Depth 1622' $-6\frac{1}{2}°$


Hillside 28°
Surface
Dike
Garnet
Legend
Limestone
Greenstone
Diorite
Diamond Drill Hol
B
Scale 1" = 200'
Direction S78°W. Mag
Depth 886' -78
inches
0
1
0
1
2
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.



Legend

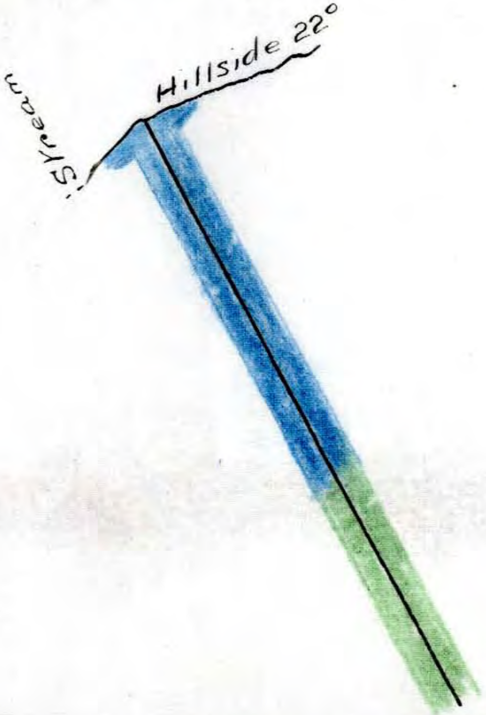
- Limestone
- Greenstone
- Diorite

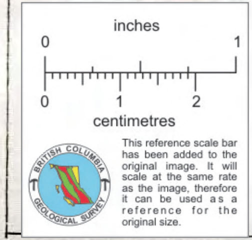
Diamond Drill Hole C

Scale 1" = 200'

Direction S 14° W. Mag

Depth 598' −14°





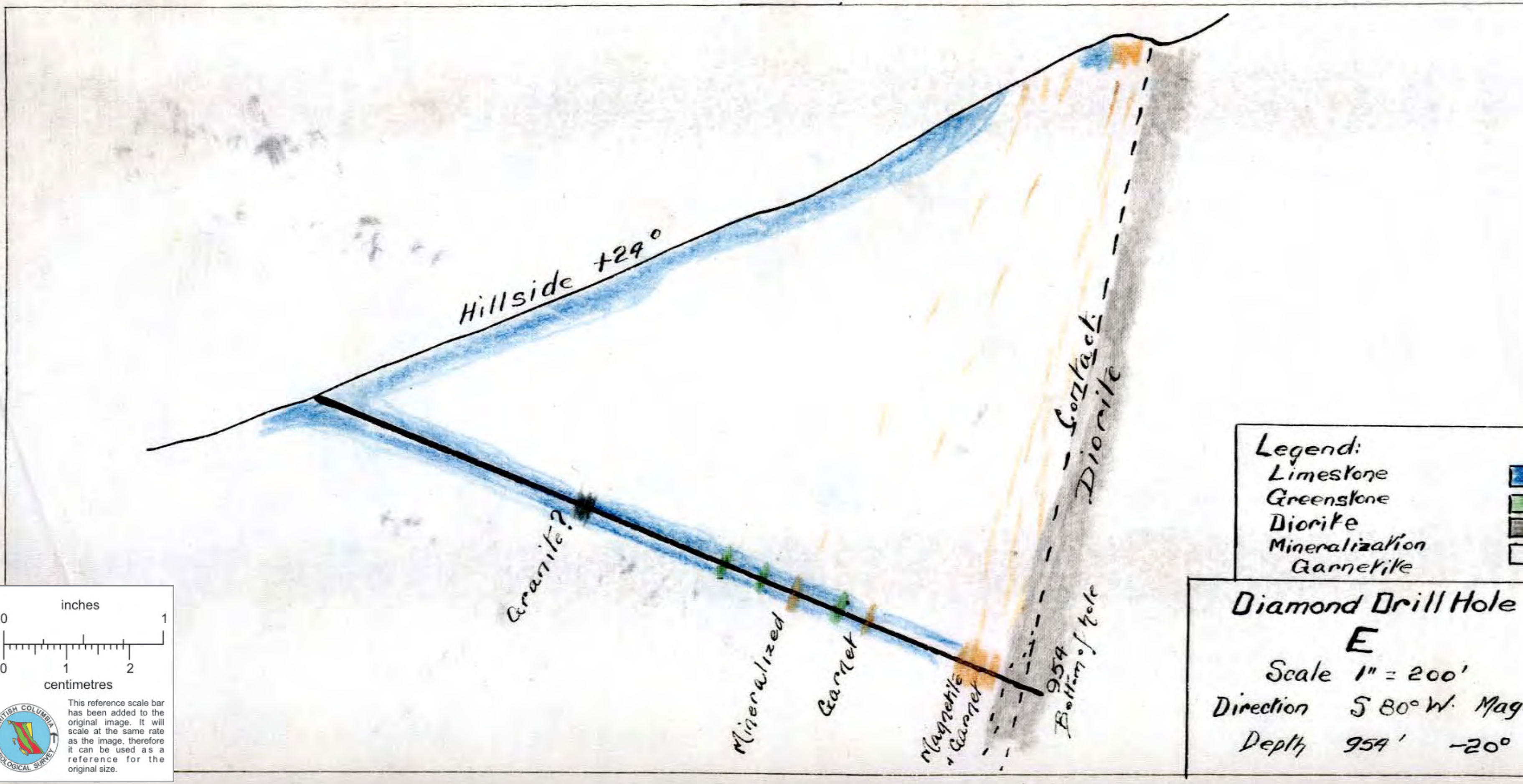
Legend
- Limestone
- Greenstone
- Diorite

Diamond Drill Hole
D

Scale 1" = 200'

Direction S 66° W. Mag

Depth 680' -60°


Hillside +24°
Granite?
Mineralized
Garnet
Magnetite + Garnet
954 Bottom of hole
Contact
Diorite
Legend:
Limestone
Greenstone
Diorite
Mineralization
Garnetite
Diamond Drill Hole
E
Scale 1" = 200'
Direction S 80° W. Mag
Depth 954' -20°


B
A
Jeep Road
No. 2 Bench
2460'
No. 3 Bench
2425'
No. 6 Bench
2338'
South
Pit
2490'
C
A'
B'
C'
2660
2640
2680
Figure 1c
MAGNETITE + EPIDOTE
Legend on Fig 1a
Geological Plan
MERRY WIDOW PIT
Benson River Area, V.I.
G.E.P. Eastwood. 1961.
0 10 50 feet 100 150
inches
centimetres

A
A'
B
B'
C
C'
Road
No. 2 Bench
2460'
No. 3 Bench
2425'
No. 6 Bench
2330'
South
Pit
2490'
Figure 1b
MAGNETITE + GARNET
Legend on Fig. 1a
Geological Plan
MERRY WIDOW PIT
Benson River Area, V.I.
G.E.P. Eastwood. 1961.
feet

Figure 1d
MAGNETITE + CALCITE
Legend on Fig. 1a

Figure 3

SECTIONS THROUGH DRILL HOLES SHOWN ON FIG. 2

Scale: 40 0 40 80 120 feet

Legend on Fig. 1

G.E.P. Eastwood, July 1961