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M I N E R A L O G Y O F M A S T O D O N G R O U P

BIG BEND AREA COLUMBIA RIVER B.C.

REPORT FOR GEOLOGY 9

DEPARTMENT OF GEOLOGY

UNIVERSITY OF BRITISH COLUMBIA

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March 1946.

P R E F A C E

This report is submitted as a partial requirement in Geology 9 in the fifth year of Geological Engineering at the University of British Columbia.

The writer wishes to thank Dr. H.V. Warren for providing the problem along with six prepared polished sections and results of previous investigations, and also for making available the Leitz Pan-Phot. microscope for making the photomicrographs included herein. Thanks are also due to J. De Leen and J. Donnan for their advice and willing assistance in matters of technique.

R.C. Macdonald

Vancouver, B.C.
March, 1946.

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Pyrite
Chalcopyrite.

MINERALOGY OF MASTODON GROUP

Big Bend Area, Columbia River, B.C.

INTRODUCTION

PURPOSE

The purpose of the investigations on which this report is based was to determine the minerals present, their grain size, and paragenesis, in samples of mineralized material from the Mastodon group of claims in the Big Bend Area of the Columbia River, B.C.

LOCATION OF CLAIMS

The claims are situated on the divide between La Forme Creek and the south fork of Carnes Creek, about twenty miles by road north of Revelstoke, and seven miles by trail up La Forme Creek east of the Columbia River. The old mine workings are at an elevation of about 4600 feet, and the samples examined were taken from a trench approximately fifty feet south-east of the (main)? shaft.

GENERAL GEOLOGY OF THE MASTODON CLAIMS

(1) "In the vicinity of the workings crystalline limestone, varying from white through grey to black, and intercalations of grey, sericite schist strike on the average north 25 degrees west and dip from 35 degrees to 50 degrees east. Two principal veins have been explored. They occur along fissures that conform with the bedding of the sediments or cut it at a small angle across the dip. In some places the ore minerals have replaced the limestone away from the main fissures. The ore minerals are pyrite, sphalerite, galena, and grey copper (tetrahedrite?). Values are principally in lead, zinc, and silver. The gangue minerals are quartz and calcite".

The mineralization is believed to be due to ascending solutions derived from the magmas which formed numerous granitic intrusions of stocks, irregular bodies, and dykes, cutting the sediments. The age of these granitic bodies is probably similar to the one general period of Jura-Cretaceous intrusions which are widespread in the Kootenay and other large districts of B.C. The mineral deposits in the area represent a distinct gradation from high

(1) Geology and Mineral Deposits of Big Bend Map-Area, B.C. by H.C. Gunning, Summ. Rep. G.S.C. 1928, Pt. A. p.190A

to lower temperature types going away from the exposed granite.

Gunning[2] includes the Mastodon Group in his lower temperature group of lead-zinc deposits of the Big Bend area. In this group pyrrhotite is absent and gold values are generally low, but appreciable silver values are attributed to argentiferous tetrahedrite and other silver-bearing minerals.

Dr. Kidd, who supplied the samples to the University of B.C. stated that the metallic minerals recognized were bournonite, occurring as occasional veinlets in limestone and associated with sphalerite which veins and replaces the limestone.

RESULTS OF MICROSCOPIC INVESTIGATIONS

As only a very limited quantity of the mineralized material was available, no megoscopic examination of hand specimens was possible.

Dr. H.V. Warren had previously determined the presence of bournonite and meneghinite by etching, microchemical, and specific gravity tests, and these determinations were corroborated by X-ray photographs by the University of Toronto.

It remained to the writer to describe the appearance and occurrence of the meneghinite, to

(2) Op. cit.

check the etch tests as given by Short,[3] and to determine the remainder of the minerals and their paragenesis.

The following metallic minerals, in approximate order of decreasing amounts, were determined: meneghinite, tetrahedrite, bournonite, chalcocite, sphalerite, covellite, galena, arsenopyrite(?), and gold. Of these the first three make up possibly 90% of the metallics present. Two gangue minerals, calcite and quartz are also present.

DESCRIPTION OF INDIVIDUAL MINERALS

MENEGHINITE

Color white; hardness C; smooth surface which shows scratches more readily than the associated minerals; black under oblique illumination. Perfect cleavage in one direction is evident as parallel dark lines crossing many of the grains (Plate 1). Strongly anisotropic, with polarization colors passing from pinkish-tan or brown to steel blue twice per revolution. Under crossed Nicols, coarse twin lamellae are frequently observed at about right angles to the cleavage (Plates 2,3,5.), and in such instances the cleavage lines may show bends at their intersections with the twinning planes. When scratched yields a

(3) Short- Microscopic Determination of Ore Minerals. U.S.G.S. Bulletin 914

black metallic powder.

As opposed to Short's[4] description of meneghinite from Italy which "occurs as long, slender needles vertically striated" (samples of which were also examined by the writer), this Meneghinite occurs as anhedral grains. Their mutual contacts are quite irregular and jagged, as though there had been some stress applied to them during formation. This is particularly true in some of the twinned grains (Plates 4,5), and it is considered that some of the jagged contacts may be the result of a stress produced by the force of twinning orientation. Many of the irregularities however are probably due to replacement by chalcocite along the grain boundaries.

The following etch tests were obtained:

HNO_3 - effervesces slightly; surface stains black; this reaction starts in about 3-5 seconds, and the black etching proceeds rapidly as a wave from one side of the drop to the other. This test is considered distinctive, and the specimen usually requires repolishing to remove the stain, unless the drop of acid is removed very quickly.

HCl- Around the periphery of the drop the fumes tarnish some areas light brown.

KCN, $FeCl_3$, KOK, $HgCl_2$- Negative.

(4) Op. cit.

The writer was unable to detect the presence of copper michrochemically, as determined by Short,[5] although a spectroscopic analysis indicated it's presence. Lead and antimony were readily proven.

BOURNONITE

Color bluish-white; hardness C+; surface slightly pitted (Plate 1); black under oblique light. Strongly anisotropic, with polarization colors passing from robins egg blue to brownish mauve or pinkish purple. Under crossed Nicols, fime multiple twinning, with the twinning lamellae sometimes crossing each other at acute angles and forming a grid, is quite common (Plate 2). When scratched, yields a black metallic powder.

The following etch tests were obtained:

HNO_3- stains very slightly brown near the inside edges of the drop; fumes tarnish very slightly light brown.

HCl, KCN, $FeCl_3$, KOH, $HgCl_2$- negative.

Aqua Regia- stains purplish gray; distinctive.

Copper, lead and antimony were determined michrochemically.

TETRAHEDRITE

Color light- yellowish gray; hardness D-; surface is slightly pitted, and most areas of this mineral have large fractures filled with gangue (Plate 1).

(5) Op. cit.

Isotropic. Appears black under oblique illumination. When scratched, yields a black metallic powder.

The following etch reactions were obtained:

HNO_3- stains light brown to iridescent after sometime; fumes tarnish similarily.

HCl, KCN, $FeCl_3$, KOH, $HgCl_2$- negative.

Aqua Regia- Fumes tarnish dark brown.

The presence of copper, iron and antimony were proven michrochemically.

SPHALERITE

Color bluish gray; hardness C; surface smooth. Isotropic. Under oblique illumination some areas show dull red internal reflection. When scratched, this mineral yields a black powder.

HNO_3 darkens slightly or stains iridescent.

HCl, KCN, $FeCl_3$, KOH, $HgCl_2$- negative.

Aqua Regia- slight effervescence, and stains purplish.

This mineral is present in such small amounts that no michrochemical tests were carried out.

GALENA

Color, white; hardness B; surface shows a few small triangular pits. Under oblique illuminations this mineral appears dark mauve. Isotropic.

The following etch reactions were obtained;

HNO_3- stains brown to black; no effervescence noted.

HCl- stains gray, brown, black, or iridescent.

HCN- negative.

$FeCl_3$ stains definitely iridescent; stain hard to remove.

KOH, $HgCl_2$- Negative.

Since this mineral occurs in such small amounts, no michrochemical tests were possible.

CHALCOCITE

Color, dark gray; hardness B+; appears dark blue-green under oblique illumination. Yields a black metallic powder.

The following etch tests were obtained;

HNO_3- effervesces, and blackens.

HCl- negative, to faint black or iridescent tarnish.

KCN- stains black very definitely.

$FeCl_3$- stains dark.

KOH- negative.

$HgCl_2$- darkens slightly, almost negative.

A positive Michrochemical test for copper was obtained.

COVELLITE

Color, indigo blue; hardness B+; appears dark blue black under oblique illumination. This mineral is anisotropic with polarization colors from shiny red to gray.

The following etch tests were obtained:

HNO_3- negative

HCl- negative

KCN- stains black, very definitely

$FeCl_3$- KOH, $HgCl_2$, Negative.

Since this mineral occurs in such small amounts, no michrochemical tests were possible.

GOLD

Gold was determined by color, hardness, isotropism, and the KCN etch test.

OCCURRENCE AND MUTUAL ASSOCIATIONS

As previously stated, the three principal minerals present are meneghinite, bournonite, and tetrahedrite. In the largest polished section, No. 6, fairly large areas of tetrahedrite (up to about 1/8 in. diameter) are more or less uniformly distributed. These give the appearance of phenocrysts since they are almost invariably zoned or surrounded firstly by Bournonite, and then by meneghinite filling the "groundmass" area. In other words, in traversing from one area of tetrahedrite to an adjacent area, the order in which the minerals are met with is as follows: tetrahedrite, bournonite, meneghinite, bournonite, and tetrahedrite. It is of interest to note that this general arrangement from "phenocrysts" to "groundmass" passes: from a copper-iron-antimony-sulphide,

through a copper-lead-antimony-sulphide,

to a lead-antimony-sulphide.

This zonal arrangement is noted in all of the polished sections which contain these minerals, and connot be considered as accidental (Plate 1).

Contrary to Short's[6] description of bournonite in which he states that it is " distinquished from tetrahedrite by means of polarized light," the tetrahedrite and bournonite in these specimens are readily distinquished from one another. The former has a yellow-greenish tinge, and is broken up by large fractures filled with a black colored gangue which is much more abundant in the tetrahedrite than in the other minerals.

The contact between the bournonite and meneghinite is in many cases difficult to determine without using crossed Nicols. (Plate 1). However, the meneghinite cleavage is quite distinctive in many grains. (Plates 3 and 4). Further, it's apparent greater susceptibility to replacement by chalcocite and covellite (Plate 1) assists in differentiating it from the bournonite. Etching with

(6) Op. cit.

HNO_3 immediately shows the contacts.

Sphalerite, while minor in amount, is fairly abundant as small curved areas in the bournonite. In some cases it takes the place of the bournonite in separating the tetrahedrite from the meneghinite. Occasionally it protrudes into the tetrahedrite, but is never enclosed in the meneghinite. (Plate 1).

Chalcocite and covellite are commonly intimately associated with each other, and in many areas they seem to grade into one another gradually. An extremely good polish is required to bring out sharp contacts, and even then such a contact is apparently lacking in some areas. The chalcocite is much more abundant than the covellite. The former is very difficult to distinquish from the calcite gangue, even though they are closely associated in many places. Stringers of calcite merge with almost identical appearing stringers or areas of chalcocite, and vice versa, and the use of oblique illumination to distinquish between them was found to be necessary.

Small areas of covellite not associated with chalcocite are common, and occasionally the covellite appears in tiny veinlets or filling cracks in sphalerite. Likewise, larger areas of chalcocite without covellite are very common. Other than in the sphalerite, covellite without chalcocite is found mainly in the bournonite. On the other hand, chalcocite without covellite is most widely distributed in meneghinite (Plate 1).

Most of the galena is found in the meneghinite, although occasionally in bournonite, and is also associated with chalcocite and covellite (Plate 6 and 7). It is also commonly seen in small areas contacting bournonite and extending into meneghinite.

Very rarely, tiny white rhombs which were seen only under high magnification in the tetrahedrite, were assumed to be arsenopyrite. (Plate 7).

Gold was found fairly readily in very small grains in tetrahedrite. (Plate 7).

PARAGENESIS

The occurrence of tetrahedrite as "phenocrysts" surrounded by bournonite or sphalerite in a "groundmass" of meneghinite, leads the writer to the conclusion that tetrahedrite was the first mineral to be precipitated. Whether the tetrahedrite was deposited during an early stage of mineralization, and then partially replaced at a later stage by bournonite and meneghinite, or whether the principal mineralization all took place at one period is not certain. However, if the former were the case, gold might be expected to be found in bournonite and meneghinite as well as in tetrahedrite; also irregular veinlets of bournonite or meneghinite might be expected to be found penetrating the tetrahedrite.

Since neither of these phenomena are evident, and considering the Zonal arrangement mentioned earlier, it is concluded that there was only one main period of mineralization during which the hypogene mineralizing solutions carried copper, lead, iron, antimony, sulphur, zinc, gold, and silica, and possibly a small amount of arsenic.

As the temperature and pressure decreased, it is considered by the writer that tetrahedrite was first precipitated (carrying the gold) in scattered areas throughout the solutions. This apparently used up all the iron, and was followed by precipitation of sphalerite, in minor amounts, which used up all the zinc present. The bournonite was probably precipitated contemporaneously with the sphalerite, using up the remainder of the copper, and these two minerals precipitated on and around the already solid tetrahedrite globules. The remaining liquid then probably contained mainly lead, antimony, and sulphur, and the meneghinite used up the remaining antimony and precipitated probably contemporaneously with galena, more or less filling the "groundmass" area.

Chalcocite and covellite appear to be later than all of the above minerals, and irregular veinlets and areas show preferential replacement of earlier minerals in approximately the following order: meneghinite, galena, sphalerite and bournonite. (Plates 1,6,7).

The writer does not feel competent to form a conclusion as to the origin of the chalcocite and covellite. The chalcocite is isotropic, and therefore apparently the isometric rather than the orthorhombic form. This isotropism may be due to the presence of more than 8% dissolved covellite[7] and could then be either hypogene or supergene in origin.

The calcite gangue has probably been partially replaced by all of the above minerals. The time of deposition of the quartz gangue was not easy to determine, due to the small amount of material available. However, most areas of quartz seen in the polished sections occur as "phenocrysts" largely rimmed by chalcocite and calcite. These areas of quartz appear to be fractured in about the same manner as the tetrahedrite. The writer suggests the possibility of the quartz and tetrahedrite having precipitated more or less simultaneously, and later subjected to some stress or movement which caused fracturing of these early minerals before the remainder of the solutions had precipitated.

(7) Economic Mineral Deposits- A.M. Bateman- P.38

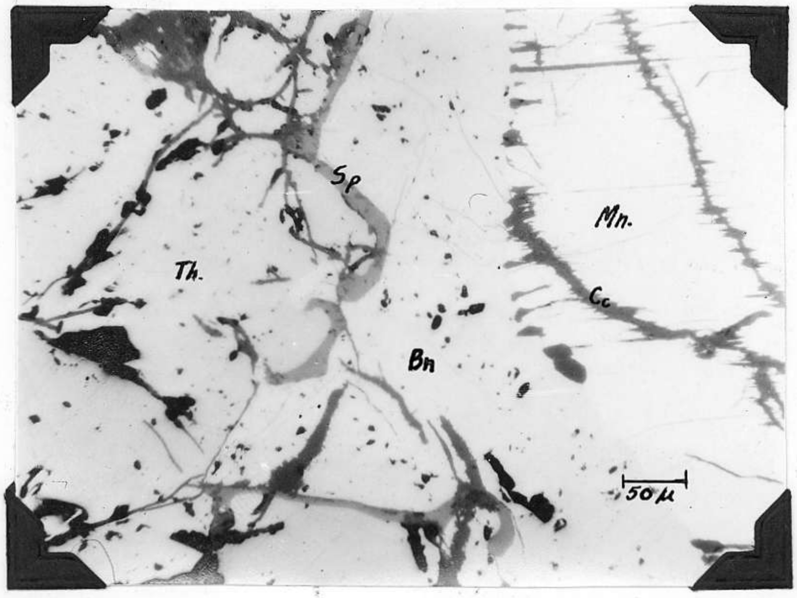


PLATE 1

Photomicrograph of polished section (X170) showing tetrahedrite partially rimmed by sphalerite, and separated from meneghinite by bournonite. Note large gangue-filled fractures in tetrahedrite, and preferential replacement of meneghinite by chalcocite.

Th	Tetrahedrite
Bn	Bournonite
Mn	Meneghinite
Sp	Sphalerite
Cc	Chalcocite

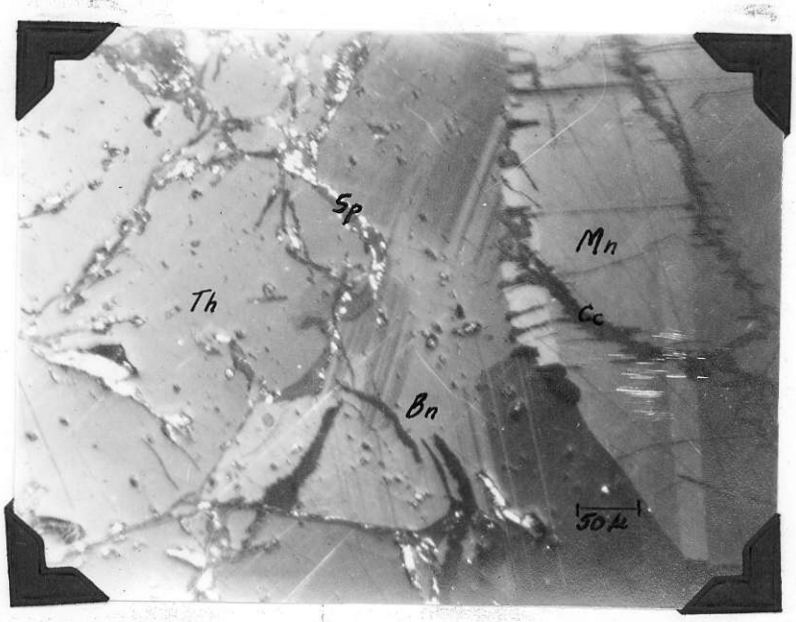


PLATE 2

Photomicrograph of polished section (X 170) using partially crossed Nicols and showing the same field as Plate 1. Note coarse twinning in meneghinite, and fine multiple twinning in bournonite.

Th	Tetrahedrite
Bn	Bournonite
Mn	Meneghinite
Sp	Sphalerite
Cc	Chalcocite

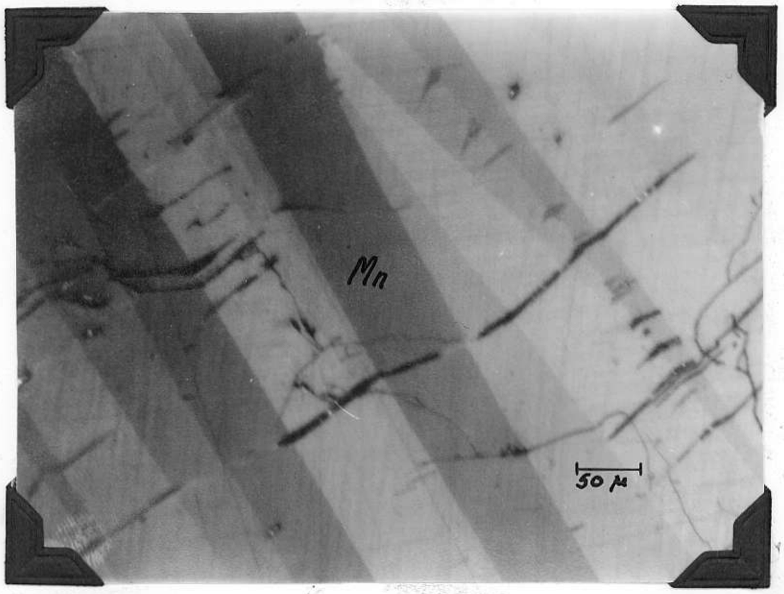


PLATE 3

Photomicrograph of polished section (X170), using partially crossed Nicols to show meneghinite twinning at approximately right angles to the cleavage.

Mn Meneghinite

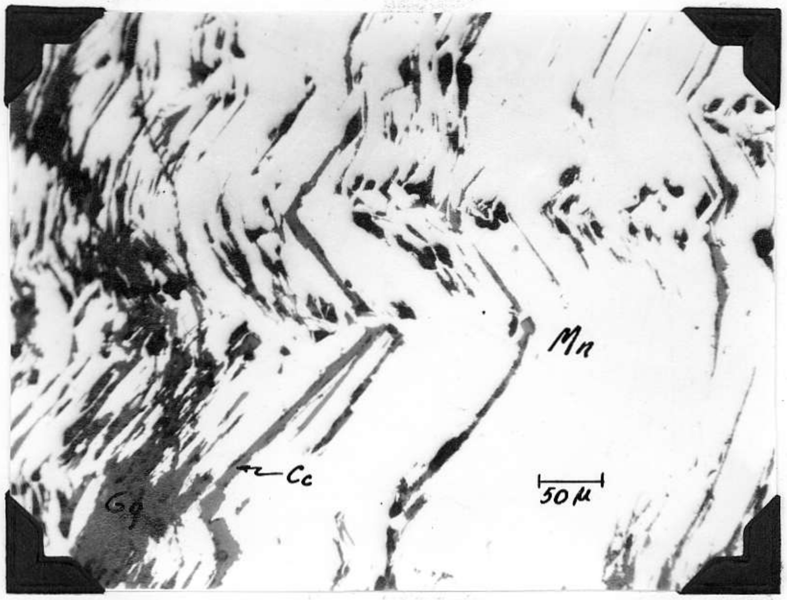


PLATE 4

Photomicrograph of polished section (X170), showing meneghinite cleavage. Chalcocite fills some, but not all, of the cleavage traces.

Mn	Meneghinite
Cc	Chalcocite
Gg	Gangue

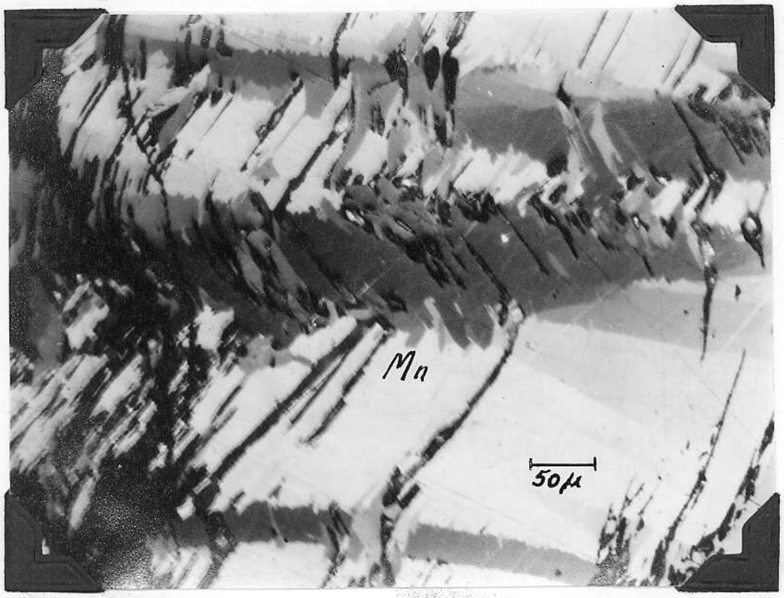


PLATE 5

Photomicrograph of polished section (X170), using partially crossed Nicols and showing the same field as Plate 4.

Mn Meneghinite

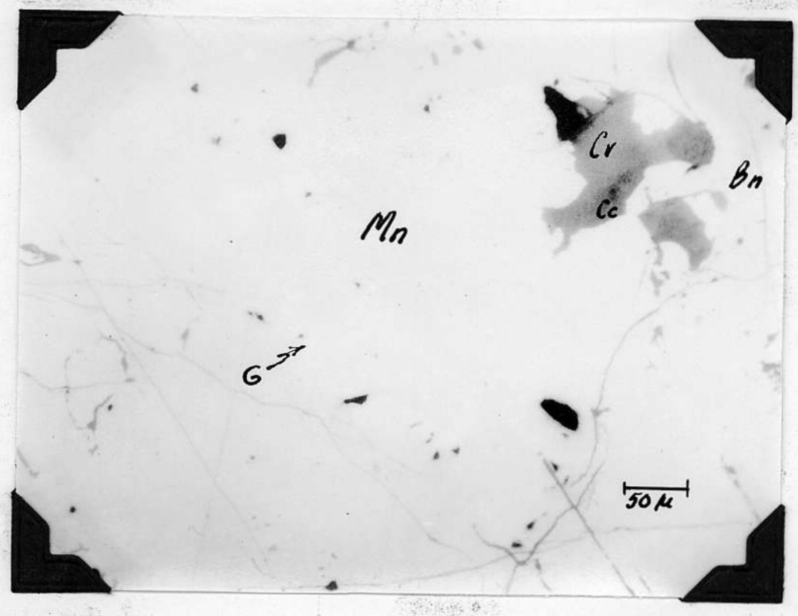


PLATE 6

Photomicrograph of polished section (X170), showing typical small areas of galena in meneghinite.

Mn	Meneghinite
G	Galena
Bn	Bournonite
Cc	Chalcocite
Cv	Covellite

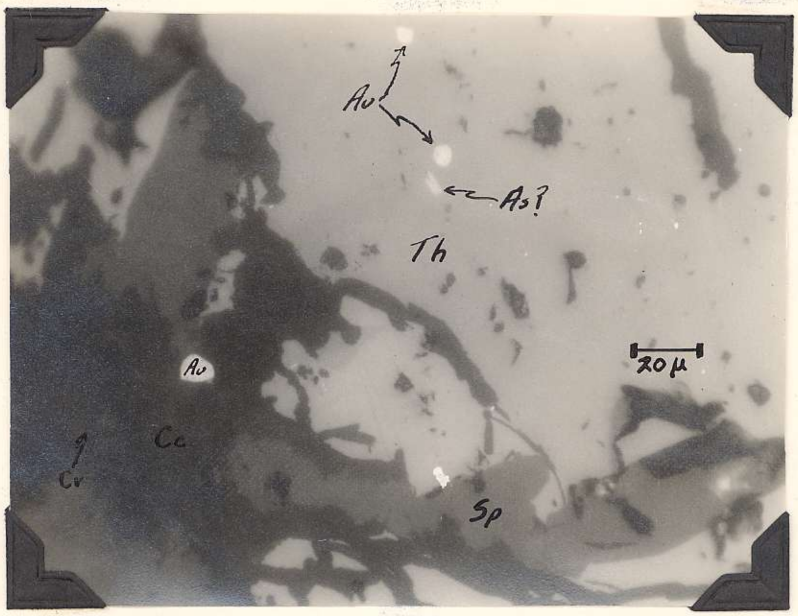


PLATE 7

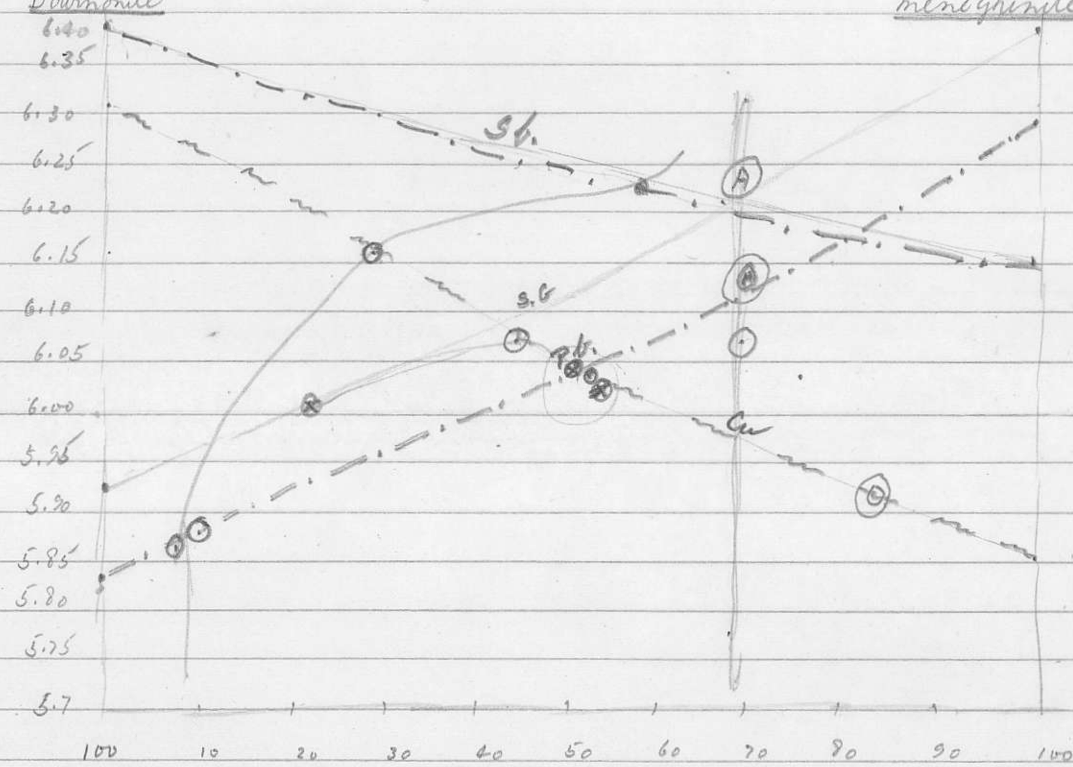
Photomicrograph of polished section (X460), showing gold in tetrahedrite, with one large grain in chalcocite. Also possibly arsenopyrite.

Au	Gold
Th	Tetrahedrite
Sp	Sphalerite
Cc	Chalcocite
Cv	Covellite
As	Arsenopyrite

Bournonite.

Mastodon Prospect ~~F~~ on the ridge between La Forme and Carnes creek, seven miles by trail up La Forme creek. Cabin at elev. 5000 (an) Shaft directly uphill to east of cabin at elev 5500 an. ~~Bournon~~ The bournonite occurs in a trench approx 50' S.E of the shaft. It ~~occurs~~ is present as occasional veinlets 1/4" in limestone. It is associated with honey yellow sphalerite which veins and replaces the limestone. No other metallic minerals were recognized.

in the Big Bend district 20 miles north of Revelstoke



Pb.	Cu.	Sb.
65	14	24
63	13	23
61	12	22
59	11	21
57	10	20
55	9	19
53	8	18
51	7	17
49	6	16
47	5	15
45	4	14
43	3	13
41	2	12
	1	

85/15   50/50   30/70

Analyses removing Fe. Insol. & Zinc.

	A	B.	C.
Lead.	45.95	52.61	55.70
Copper	9.97	7.95	4.97
Arsenic	1.58	3.95	0.62
Antimony	18.60	14.34	17.68
Sulphur	18.61 -1.11	16.83 - .99	16.80 - .74
	94.71	95.68	95.77

Analyses corrected to 100%

	A	B	C
Lead	48.6	55.0	58.2
Copper	10.3	8.3	5.2
Arsenic	1.7	4.1	.7(3)
Antimony	19.7	15.0	18.55
Sulphur	19.7	17.6	17.4
	100.0	100.0	100.0

	A.	B.	C.

Analyses removing Fe, Insol, Zinc and Sulphur needed for sphalerite.

	A.	B.	C.
Lead	45.95	52.61	55.70
Copper	9.97	7.95	4.97
Arsenic	1.58	3.95	0.62
Antimony	18.60	14.34	17.68
Sulphur.	17.50	15.84	16.06
	93.60	94.69	95.03

Analyses corrected to 100%

	A.		B.		C.	
Lead	49.3		55.6		58.6	
Copper	10.4		8.4		5.2	
Arsenic	1.7	21.6	4.2	19.3	·7	19.3
Antimony	19.9		15.1 (5)		18.6	
Sulphur.	18.7		16.7		16.9	
	100.0		100.0		100.0	

Meneghinite ($4 PbS \cdot Sb_2S_3$)

Short p 124. Orthorhombic; color galena white; hardness C.
Strong anisotropism; polarization colors light gray, pinkish brown, steel blue. HNO_3 effervesces; surface stains black; usually reaction is slow in starting, but once started it rapidly advances from one side of the drop to the other. HCl fumes tarnish; some areas negative. KCN, $FeCl_3$, KOH, and $HgCl_2$ negative.
Occurs as long slender needles vertically striated. Contains about 3 percent of copper, readily detected microchemically.

Dana P. 402. cleavage 010 perfect but interrupted SG. 6.36 ± .01
6.39 calc. corrected.

		Theory	Bodenmais	H.W.
analyses.	Pb	62.88	59.21	55.70
	Cu	—	3.54	4.97
	Fe	—	.35	nil.
	Sb.	19.91	19.28	17.68
	S	17.21	16.97	16.80
				Zn 1.48
				Insol 2.55
				As 0.62.

Bournonite. Mastadon. Revelstoke. D.F. Kidd Jan '45

1	91.20	76.28	14.92	5.27
2)	76.11	64.89	11.22	5.85 ✓
3)	69.29	58.61	10.68	5.60
4)	70.24	59.78	10.46	5.79 ✓
5)	61.45	52.42	9.02	5.86 ✓
6)	54.06	46.14	7.92	5.88 ✓
7)	61.78	52.43	9.35	5.70
8)	89.18	76.26	12.92	5.95
9)	64.30	54.17	10.13	5.46
10)	90.39	76.88	13.51	5.76
11)	84.30	71.41	12.89	5.64
12)	55.92	47.32	8.60	5.60
13)	44.02	37.32	6.70	5.66
14)	69.73	58.63	11.10	5.42
15)	50.23	43.19	7.04	6.15
16)	64.30	54.12	10.18	5.45
17)	42.45	36.43	6.02	6.02
18)	22.00	18.76	3.24	5.85.

5.93

5.85
5.83

(6.09 ~~5.95~~ 6.21)
5.96 6.08
(5.83. — 5.95)
(5.70 — 5.82)

Mastenden

19) 27.77 5.40 (from 1)
23.34
4.43

20) 29.94 6.12
25.73
4.21

21) 19.07 6.16
16.41
2.66

22) 22.85 6.14
19.64
3.21

23) 69.28 5.60
58.62
10.66

24) 44.40 5.76
37.82
6.58

25) 53.23 5.93
45.51
7.72

26) 29.82 6.06
25.57
4.25

27) 61.45 5.86
52.42
9.03

28) 70.23 5.80
59.80
10.43

29) 53.80 5.61
45.55
8.25

30) 64.20 5.50
54.13
10.07

31) 42.40 6.14
36.45
5.95

32) 43.99 5.68
37.32
6.67

33) 61.64 5.78
52.45
9.19

34) 54.05 5.84
46.07
7.98

35) 84.40 5.62
71.45
12.95

36) 90.35 5.80
76.92
13.43

37) 69.69 5.95
58.67
11.02

38) 50.04 − 43.08 = 6.96 6.18

39) 76.05 − 64.82 = 11.23 5.83

40) 59.73 − 49.84 = 9.89 5.80

41) 53.67 − 45.07 = 8.60 5.38

42) 23.68 − 19.48 = 4.20 X

43) 82.01 − 69.39 = 12.62 5.60

44) 49.42 − 42.39 = 7.03 6.05

45) 46.89 − 40.07 = 6.82 5.92

46) 45.57 − 39.23 = 6.34 6.20

47) 34.98 − 29.93 = 5.05 5.96

48) 71.55 − 61.17 = 10.38 5.95

49) 50.44 − 42.62 = 7.82 5.55

50) 36.40 − 31.02 = 5.38 5.83

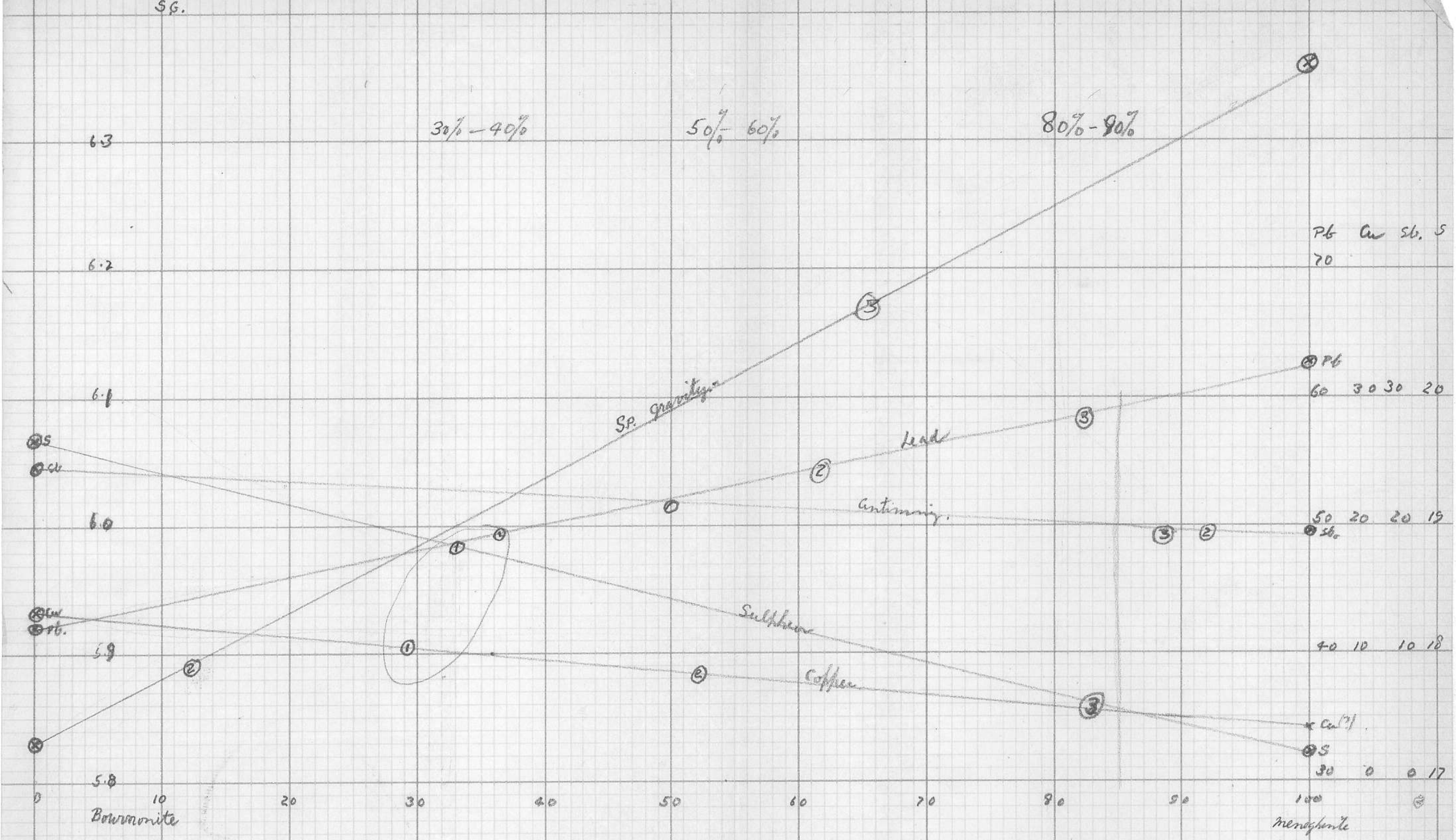
51) 61.24 − 52.04 = 9.20 5.74.

52) 58.93 − 50.20 = 8.73 5.82

53 90.42 − 76.79 = 13.63 5.72

54 47.92 − 40.05 = 7.87 5.23

55 91.17 − 77.55 = 13.62 5.77



S.G.
30% – 40%
50% – 60%
80% – 90%
6.3
6.2
6.1
6.0
5.9
5.8
Sp. gravity
Lead
Antimony
Sulphur
Copper
Pb Cu Sb. S
70
60 30 30 20
50 20 20 19
40 10 10 18
30 0 0 17
Pb
Sb
Cu
S
Cu (?)
0
10
20
30
40
50
60
70
80
90
100
Bournonite
Meneghinite

FLOTATION
CYANIDATION
AMALGAMATION
TABLE CONCENTRATION

TELEPHONE: MARINE 5821
RES.: FRASER 1628

J. R. WILLIAMS & SON

PROV. ASSAYERS & METALLURGICAL CHEMISTS

OFFICE AND LABORATORY:
BASEMENT, ARTS AND CRAFTS BUILDING
576 SEYMOUR ST.

File Nos.68105/106.
68125.

VANCOUVER, B.C. Feb. 5th./45.

Messrs.Strategic Metals Reserve.
University of B.C.
Vancouver. B.C.

Samples of Bournonite.

	No.1. 70% Bournonite	No.2. 50%	Special. 86% min
	Sp.g.5.7-5.82	Sp.g.5.83-5.95	Sp.g. 6.12-6.2. 6.02
Insoluble..........	1.20%	0.80%	2.55%
Lead...............	45.95%	52.61%	55.70%
Silver.............	trace	trace	trace
Iron...............	1.67%	1.46%	Nil
Copper.............	9.97%	7.95%	4.97%
Zinc...............	2.22%	1.98%	1.48%
Arsenic............	1.58%	3.95%	0.62%
Antimony...........	18.60%	14.34%	17.68%
Sulphur............	18.61%	16.83%	16.80%

JRWilliams

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