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MINERALOGICAL INVESTIGATION OF MILL SAMPLES FROM MANITOU-BARVUE MINES LIMITED, VAL d'OR, QUEBEC

by

M. R. Hughson

EXTRACTION METALLURGY DIVISION

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SUMMARY

Silver-bearing tetrahedrite-tennantite is present in two of the three mill products studied in this investigation, namely the lead concentrate and the cyanide tails. It was not observed in the mill tails. Microprobe analysis of the silver content of the tetrahedrite-tennantite in the lead concentrate shows that it varies from 0.23 to 17.6 per cent. Although polybasite-pearceite, a silver antimony and arsenic sulphide, was identified in the lead concentrate only, it is likely that very small proportions are also present in the other mill samples. The silver content of polybasite-pearceite normally varies between 55 and 77 per cent. Metallic minerals associated with the silver-bearing minerals are chiefly sphalerite and less commonly galena, chalcopyrite, pyrite and arsenopyrite.

Since most of the observed silver-bearing particles remaining in the cyanide tails are exposed it may be concluded that they are refractory or are protected from the action of the cyanide solution by a refractory coating formed during the treatment process, or that the leaching conditions have been inadequate.

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INTRODUCTION

Six mill samples and six lump specimens were submitted to the Mineralogy Section, Extraction Metallurgy Division, by Mr. R.G. Muscroft, Manager, Manitou-Barvue Mines Limited, Val d'Or, Quebec (through Mr. C.S. Stevens, Extraction Metallurgy Division) on February 19, 1970. The mill samples weighed approximately 1,000 grams each and the lumps were a few inches in diameter. Assays and chemical analyses supplied by the company for the mill samples and the lump specimens are shown in Tables 1 and 2. In a covering letter Mr. Muscroft reported that their silver recovery was in the 75 per cent range and requested that a mineralogical study be made to determine the silver-bearing minerals present in the mill samples. The hand specimens were supplied to assist in this work.

PROCEDURE AND RESULTS

One polished section was prepared from each of the lump specimens for ore microscopic examination.

Of the mill samples, it was decided to study the silver minerals in the mill heads, mill tails, and cyanide tails first and leave the three other mill samples for later study, should such be considered desirable. The plus 14-mesh size fraction was first screened from the mill heads and the remainder washed, dried, and screened as shown in Table 3.

TABLE 1

Assays and Chemical Analyses of Mill Samples*

Sample	oz/ton Gold	oz/ton Silver	% Zinc	% Lead	% Copper	% Iron
Mill Heads	0.01	3.92	2.40	0.35	0.09	8.70
Lead Conc.	0.47	178.81	19.20	33.98	1.10	10.62
Zinc Conc.	0.015	6.08	57.10	0.37	0.18	3.17
Primary Conc.	0.08	20.49	6.20	1.52	0.35	34.56
Cyanide Tails	0.02	12.21	6.00	1.21	0.40	32.64
Mill Tails	0.0013	0.81	0.25	0.0204	0.056	7.36

*Assays and chemical analyses supplied by Manitou-Barvue Mines Ltd.

TABLE 2

Silver Assays of Hand Specimens*

Specimen	oz/ton Silver
#1 2-6-7E-3N-stope	5.81
#2 2-8E-3N-stope	5.41
#3 3-5-6E-3N-stope	13.65
#4 High grade zinc 5-14E-stope	2 approx.
#5 From Silver-Zinc stope - 5 level	
#6 From North Fringe Drift on 360 level-high grade silver	

*Assays supplied by Manitou-Barvue Mines Ltd.

TABLE 3

Screen Analysis, Mill Heads

Mesh Size	Wt Grams	Wt Per Cent
+14	751.6	82.2
-14 +65	98.0	10.7
-65 +100	16.8	1.8
-100 +150	8.7	1.0
-150 +200	11.4	1.3
-200 +325	11.2	1.2
-325	16.2	1.8
Totals	913.9	100.0

The mill tails and the cyanide tails were riffled in two, one half was retained, and the other screen-sized as shown in Tables 4 and 5.

TABLE 4

Screen Analysis, Mill Tails

Mesh Size	Wt Grams	Wt Per Cent
+65	64.4	13.1
-65 +100	47.1	9.6
-100 +150	42.4	8.7
-150 +200	60.0	12.2
-200 +325	96.8	19.7
-325	180.3	36.7
Totals	491.0	100.0

TABLE 5

Screen Analysis, Cyanide Tails

Mesh Size	Wt Grams	Wt Per Cent
+65	15.7	5.0
-65 +100	43.6	14.0
-100 +150	49.2	15.8
-150 +200	87.8	28.2
-200 +325	80.9	26.0
-325	34.1	11.0
Totals	311.3	100.0

Polished sections were prepared of highly mineralized chips of the plus 14-mesh fraction of the mill heads for microscopic study. Two polished sections were prepared from each of the minus 65 plus 100-mesh fraction of the mill heads, the cyanide tails, and of the plus 65-mesh fraction of the mill tails. Gravity separations were made on a Haultain Superpanner, of sized fractions of the mill heads, mill tails, and cyanide tails. The results are shown in Table 6. Two polished sections were prepared of each of the Superpanner fractions from the three samples.

In addition to the mill heads, mill tails, and cyanide tails, the lead concentrate was investigated in a further search for silver-bearing minerals because of its high silver

TABLE 6

Superpanner Separations

Fraction	Weight Per Cent			
	Mill Heads -100 +200 Mesh	Mill Tails -150 +200 Mesh	Cyanide Tails -65 +100 Mesh	Cyanide Tails -150 +200 Mesh
Tip	3.1	5.4	4.8	23.4
Midds	28.9	20.8	-	57.7
Tails	68.0	73.8	95.2	18.9

content (178.81 oz/ton). The screen analysis for the lead concentrate is shown in Table 7. Two polished sections each were prepared of the plus 65-mesh fraction and the minus 150 plus 200-mesh fraction.

TABLE 7

Screen Analysis, Lead Concentrate

Mesh Size	Wt Grams	Wt Per Cent
+65	5.9	1.4
-65 +100	31.6	7.2
-100 +150	63.8	14.5
-150 +200	87.4	19.9
-200 +325	106.1	24.1
-325	144.8	32.9
Totals	439.6	100.0

A microprobe analysis to determine the silver content of the silver-bearing minerals was carried out by Mr. D. Owens* on a polished section of the minus 150 plus 200-mesh fraction of the lead concentrate. To determine the proportions of the various constituents in this fraction, a numerical count was made by traversing a polished section with a Swift automatic point counter.

All mineral identifications given in this report were confirmed by X-ray powder diffraction analysis.

The samples will be described in the order in which they were examined, commencing with a preliminary examination of the hand specimens, then going on to a more detailed discussion of the mill samples. To simplify the mineral names in this report, tetrahedrite-tennantite and polybasite-pearceite will hereafter be referred to as tetrahedrite and polybasite.

Hand specimen No. 1 is composed of approximately equal amounts of metallic minerals and gangue. The metallic minerals are mainly pyrite with smaller amounts of sphalerite, galena and arsenopyrite. The gangue minerals are quartz and muscovite. Sphalerite is the major constituent in specimens No. 2, 3, and 4 and forms almost all of specimen No. 4. Small amounts of pyrite, galena, and arsenopyrite are present in all three specimens.

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*Microprobe Analysis Data Sheet No. EP 70-82, Mineral Sciences Division.

Very small amounts of tetrahedrite occur in specimens No. 2 and 3 (Figures 1 and 2). There are trace amounts of chalcopyrite in specimen No. 3. Gangue minerals are more abundant than metallic minerals in specimen No. 5; the latter consists of roughly equal proportions of pyrite, sphalerite, galena, with traces of arsenopyrite. Specimen No. 6 is largely smoky grey quartz plus minor amounts of tetrahedrite and traces of galena and chalcopyrite. The tetrahedrite in the hand specimens is usually intergrown with sphalerite (Figure 1). Also associated with tetrahedrite are galena, chalcopyrite, and arsenopyrite (Figure 2). Occasionally, particles and veinlets of tetrahedrite, intergrown with minor amounts of metallic minerals, occur in the quartz gangue. In one such occurrence observed in specimen No. 6, an unusually large particle of tetrahedrite measured 3 x 10 mm in section.

Four mill samples were studied in this investigation, the mill heads, mill tails, cyanide tails, and lead concentrate. Highly mineralized plus 14-mesh chips of the mill heads were examined first. Pyrite is the major constituent in twelve of the chips and, in the other two, sphalerite is the most abundant. Small amounts of sphalerite occur in six of the chips in which pyrite is the major constituent. Galena occurs in four of the chips commonly with sphalerite. Occasionally it occurs as inclusions in pyrite as does sphalerite. Sparsely disseminated crystals of arsenopyrite occur with pyrite in all 14 chips.

The designation M-M in the photomicrographs refers to mounting-medium.

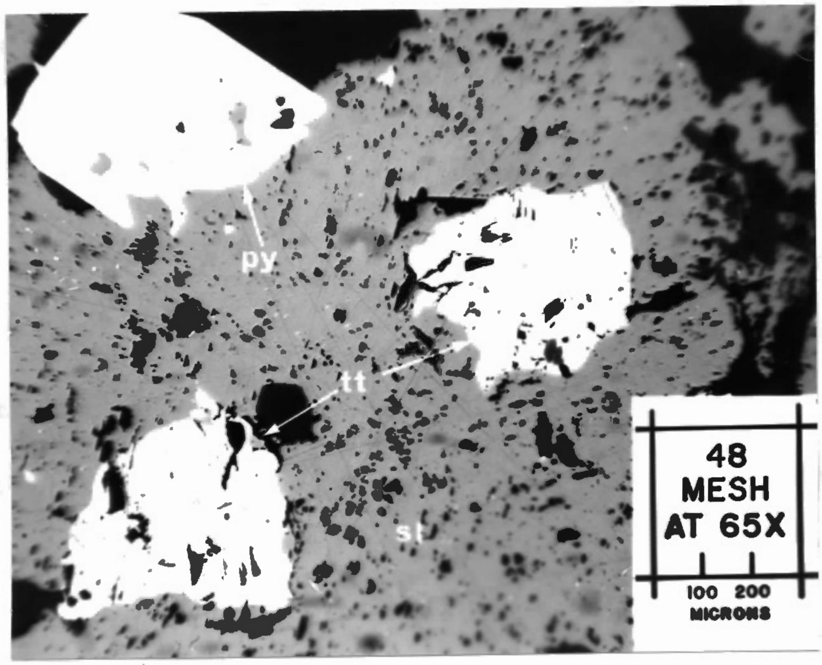

Figure 1. Grains of tetrahedrite (tt) in sphalerite (sl). Pyrite (py) is also present. Hand specimen No. 3. X65.

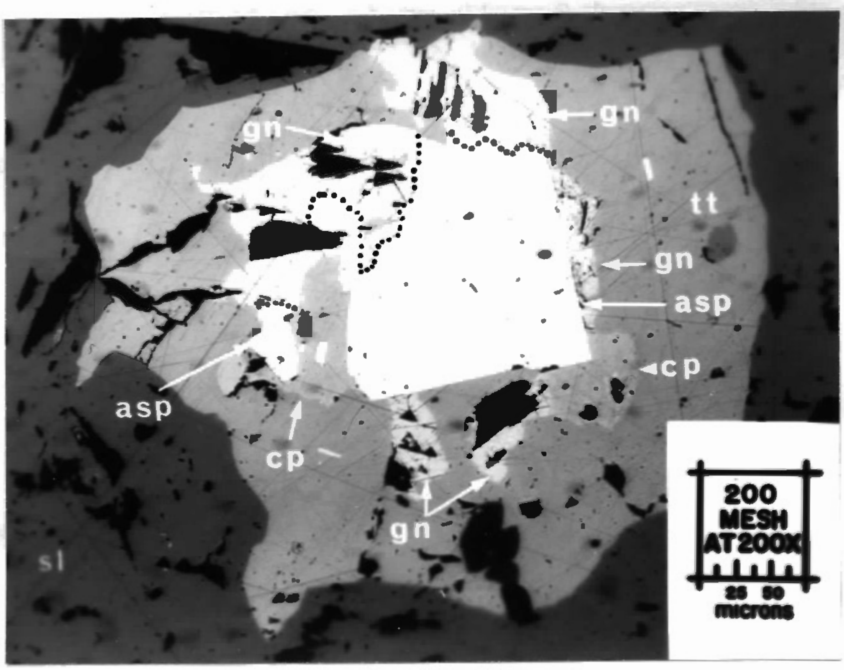

Figure 2. A grain of tetrahedrite (tt) in sphalerite (sl) is intergrown with arsenopyrite (asp), galena (gn) and chalcopyrite (cp). Hand specimen No. 3. X200.

Chalcopyrite is rare. Small amounts of tetrahedrite were found in two of the chips. It usually occurs in sphalerite but is also intergrown with galena, pyrite and gangue (Figure 3).

Study of the minus 65 plus 100-mesh fraction and of gravity fractions of the minus 150 plus 200-mesh size of the mill heads confirms that pyrite is the major metallic mineral. There are minor amounts of sphalerite and smaller amounts of galena, chalcopyrite, and arsenopyrite. Small amounts of tetrahedrite are present as free grains or associated with sphalerite and/or galena. The gangue minerals are quartz, muscovite, and dolomite.

The plus 65-mesh fraction of the mill tails consists largely of gangue minerals. Minor amounts of pyrite, sphalerite, galena, chalcopyrite, and arsenopyrite are present. No silver-bearing minerals were identified even in a gravity concentrate of the minus 150 plus 200-mesh size fraction of the mill tails.

A few grains of tetrahedrite were found in the minus 65 plus 100-mesh fraction of the cyanide tails. Tetrahedrite was also found in the Superpanner tip and midds of the minus 65 plus 100- and minus 150 plus 200-mesh fractions. It occurs either as free grains or associated with sphalerite and galena (Figure 4). Pyrite is the major metallic mineral in the cyanide tails and there are minor amounts of sphalerite, galena, chalcopyrite, and arsenopyrite.

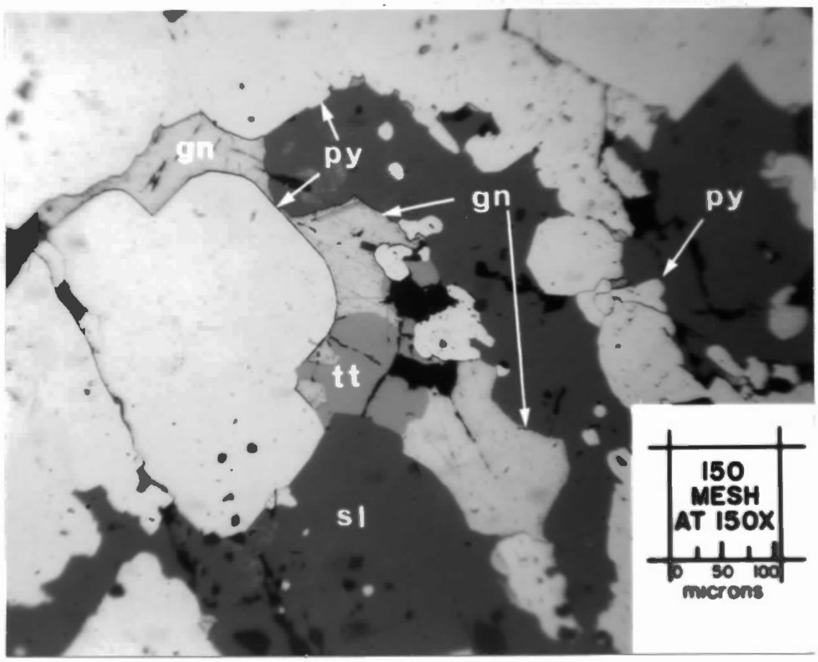

Figure 3. Tetrahedrite (tt) with sphalerite (sl), pyrite (py), and galena (gn). Plus 14-mesh heads. X150.

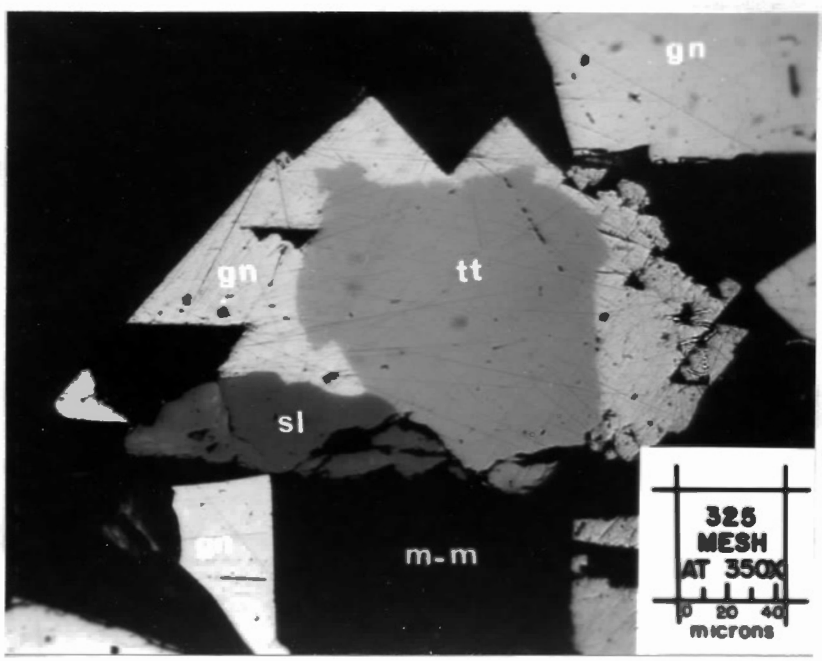

Figure 4. A grain of tetrahedrite (tt), galena (gn), and sphalerite (sl). Minus 65 plus 100-mesh cyanide tails. X350.

A microprobe analysis of the silver content of the tetrahedrite in the lead concentrate showed that it varies between 0.23 and 17.6 per cent with an average value of 4.1 per cent over 28 grains. This analysis also revealed the presence of a few grains of a mineral with a high and variable silver content. The identity of this mineral was subsequently confirmed by X-ray diffraction analysis as a sulphosalt of the polybasite group which includes the isostructural minerals polybasite and pearceite.

The results of a point count analysis of the lead concentrate are shown in Table 8. Both tetrahedrite and polybasite are present as free grains and, less commonly, as particles intergrown with sphalerite, galena (Figure 5), and gangue. Occasionally they were found to be intergrown with chalcopyrite (Figure 6) or each other (Figure 7).

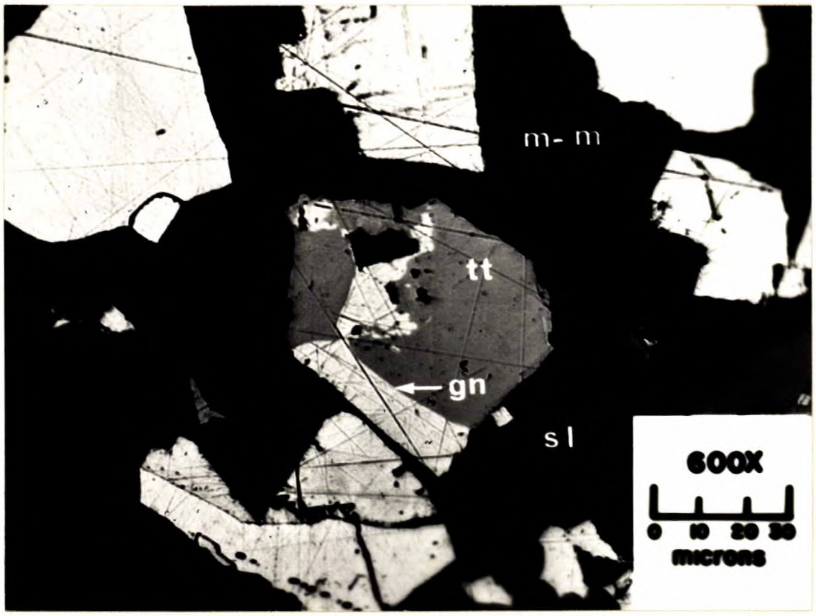

Figure 5. A grain of tetrahedrite (tt) and galena (gn). Py is pyrite and sl is sphalerite. Minus 150 plus 200-mesh lead concentrate. X600.

TABLE 8

Mineral Composition of Lead Concentrate
-150 +200 Mesh

Mineral	Counts	Specific Gravity	Wt. Per Cent
Pyrite	466	5.0	34.9
Galena	271	7.6	30.8
Sphalerite	469	4.1	28.8
Tetrahedrite	59	4.9	4.3
Polybasite	5	6.1	0.5
Chalcopyrite	6	4.3	0.4
Arsenopyrite	3	6.2	0.3
Covellite	observed	4.7	trace
Totals	1279	-	100.0

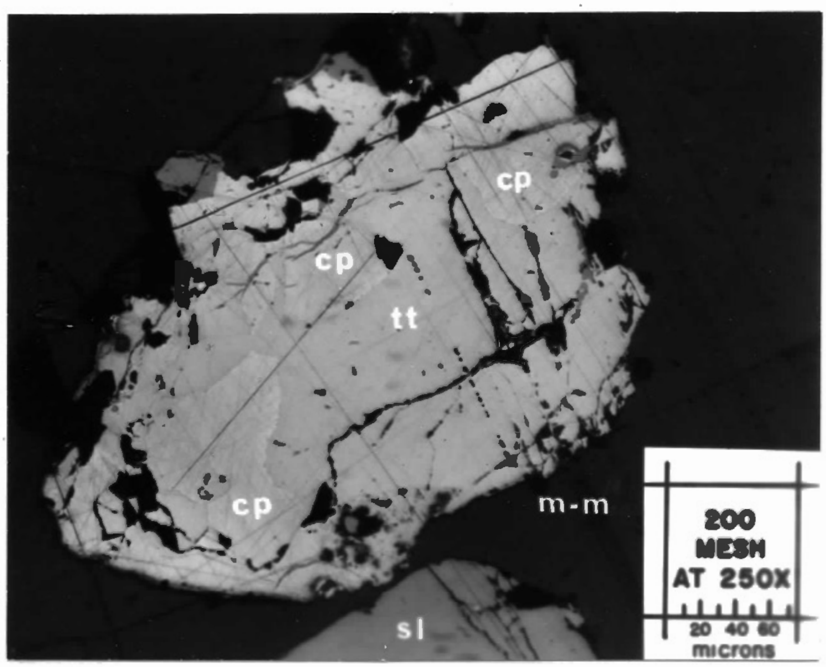

Figure 6. A grain of tetrahedrite (tt) intergrown with chalcopyrite (cp). Sphalerite is sl. Plus 65-mesh lead concentrate. X250.

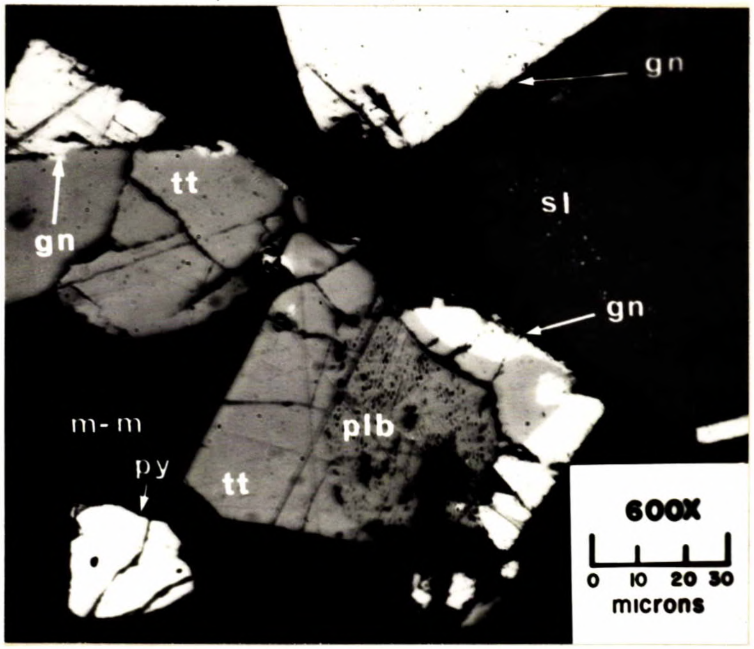

Figure 7. A grain containing tetrahedrite (tt), polybasite (plb) and galena (gn). Sphalerite is sl and pyrite py. Minus 150 plus 200-mesh lead concentrate. X600.

DISCUSSION

Two silver-bearing minerals were identified in mill samples from Manitou-Barvue Mines Limited, tetrahedrite-tennantite $(Cu,Fe)_{12} Sb_{14} S_{13}$ - $(Cu,Fe)_{12} As_{14} S_{13}$ and polybasite-pearceite $(Ag,Cu)_{16} Sb_2 S_{11}$ - $(Ag,Cu)_{16} As_2 S_{11}$(1). Silver may substitute for copper in the tetrahedrite-tennantite series, the silver content varying from 0 to 18 per cent. In the present sample the silver content in the lead concentrate was found to vary from 0.23 to 17.6 per cent. The antimony-arsenic elements form a complete series from tetrahedrite to tennantite. In the polybasite-pearceite group, in which silver is an essential constituent, the silver content normally ranges from 55 to 77 per cent and copper may substitute for silver up 30 atomic per cent. Polybasite and pearceite do not form a complete series from antimony to arsenic. Tetrahedrite was found in the lead concentrate, mill heads, and cyanide tails; polybasite was found in the lead concentrate.

Although polybasite was observed only in the lead concentrate, the observed distribution of silver in this sample and the silver contents of the other mill samples indicated that polybasite is present in these other samples as well. Assuming that the average silver content of tetrahedrite and polybasite in the lead concentrate is 4 per cent and 65 per cent respectively, then the ratio of silver contents is 1:16. Since the weight proportions of the minerals are 4.3 and 0.5 per cent respectively (approximately 8:1) the distribution of the silver in tetrahedrite and polybasite is in the ratio of 1:2. Thus, although about twelve times as many grains of tetrahedrite as of polybasite were observed in the lead concentrate, the former contributes about one third and the latter contributes about two thirds of the total silver content.

If tetrahedrite and polybasite are present in the other mill samples in the same proportions relative to each other as in the lead concentrate, it may be further deduced that in those samples with a very low silver content, for example in the mill tails (0.81 oz/ton silver), there will be few if any visible grains of silver-bearing minerals (particularly polybasite) in a given polished section.

Sphalerite is the most common mineral associated with tetrahedrite. Other metallic minerals intergrown with tetrahedrite are galena and occasionally chalcopyrite, pyrite, and arsenopyrite. In one occurrence in a hand specimen, tetrahedrite occurs in quartz intergrown with minor sphalerite, galena, and chalcopyrite. In the few occurrences of polybasite that were observed, it was found to be intergrown with galena, tetrahedrite, and occasionally chalcopyrite.

Almost all particles of the silver-bearing minerals remaining in the cyanide tails are at least partly exposed as observed in polished section. This would indicate: that some of the tetrahedrite and polybasite particles are more refractory than others, the presence of a refractory coating around the silver-bearing mineral particles, or inadequate leaching. The last might be due to grain size, length of leaching time, or strength of the leaching solutions. If a refractory coating is protecting the tetrahedrite and polybasite grains, it is either extemely thin or has been subsequently removed; no coating was observed around such grains in polished sections of the cyanide tails.

ACKNOWLEDGEMENTS

The author wishes to thank Mr. D.R. Owens of the Mineralogy Section of the Mineral Sciences Division who carried out the microprobe analysis and Mr. P. O'Donovanwho prepared the many polished sections studied in this investigation.

REFERENCE

1. Palache, C., Berman, H. and Frondel, C. (1944). Dana's System of Mineralogy, John Wiley and Sons Inc., New York, Vol. I, pp. 351-357 and 374-384.