

Some Notes on a Gold-Tungsten Occurrence in the Bridge River District 896114

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Introduction

IN October, 1941, the Department of Mining and Metallurgy of the University of British Columbia discovered the presence of scheelite, a valuable tungsten mineral, in a sample of high-grade gold ore from a group of claims known as the Bristol group, in the Bridge River district. This discovery made advisable a mineralogical examination of the ore. The following paper outlines some of the more important results.

History

Some high-grade pockets of ore were found in 1940 on a claim of the Bristol group. Unfortunately no continuity was established between these pockets. However, as development was being carried on a sample was sent to Ottawa to be tested. The ore proved to be unamenable to amalgamation and to cyanidation. Flotation was not entirely satisfactory and pending the development of larger amounts of ore the problem of recovery was shelved.

In September, 1941, the Department of Mining and Metallurgy of the University of British Columbia commenced a series of tests on a high-gold-bearing sample from the Bristol as a practice problem in Ore Dressing for a group of senior students in Metallurgy. In the course of these studies a non-metallic lusted gangue-mineral with a high specific gravity was observed. This mineral proved on testing to be scheelite.

At this juncture the authors decided that a more detailed mineralogical study might prove helpful in determining the amount of scheelite present, its manner of occurrence, the mineralogical relationships of the gold, and possibly some evidence of the nature of the deposit.

This study is outlined in the following pages.

General Geology

The showings occur at elevations between three thousand and four thousand feet on Tommy Creek, a tributary of Bridge River, and about eleven miles air line distance northeast of Pioneer.

The country rock as mapped by W. S. McCann‡ belongs to the Bridge River Series which has, on lithological and structural evidence, tentatively been correlated with the Cache Creek Series of Permo-Carboniferous Age. From descriptions of the property given by others it seems that ore occurs as lenses or pipes within a broad shear zone. These pipes make up high-grade ore which may carry one or more ounces of gold to the ton. The remainder of the shear zone contains much smaller amounts of gold—in places 0.08 oz. per ton—and may or may not constitute ore.

The following study deals with the ore from the high-grade lenses, shoots or pipes—whichever they may prove to be.

Mineralogy

This high-grade ore consists of dark, siliceous material which is dotted with small vugs into which protrude clear

crystals of quartz up to a millimetre in length. Small quartz grains, averaging possibly twenty microns in diameter, and therefore approaching chert in texture, together with sulphides, comprise virtually all the mineralization. Minor amounts of carbonates, usually noticed in the vicinity of the vugs, and scheelite complete the minerals recognized in our samples.

The sulphides known to be present include major amounts of arsenopyrite, pyrite, and marcasite, together with very minor amounts of sphalerite, chalcopyrite, and galena. Gold, although present, is not often seen, even under the microscope. Only five particles were observed while this work was being done.

In polished sections the marcasite is seen to occur as exceedingly irregular grains ranging in size from one hundred microns down to the limit of microscopic resolution, about one-quarter of a micron. In some places it exhibits colloform structure.

The pyrite tends to occur as separate grains independent of the marcasite. These grains vary considerably in size, those observed ranging from 20 to 40 microns. Surprisingly enough no arsenopyrite was recognized in the polished sections which were examined but it is definitely present in considerable amounts because it supposedly was seen in superpanner products and confirmed by chemical analyses in that no other arsenic-bearing mineral has been observed or suspected in this sample.

A minute amount of galena was observed in superpanning but none was seen either in the hand specimens or in the polished sections. The presence of sphalerite was first inferred from small amounts of zinc detected by wet assaying: it was later recognized in a polished section in which it was seen as irregular grains closely associated with the marcasite. Chalcopyrite is rare but a few tiny grains were observed in one section, its mode of occurrence being much the same as that of the sphalerite.

Only one particle of gold, about ten microns in size, was observed in the four polished sections which were examined. This particle was in quartz. However, four particles, all only a few microns in size, were noted in superpanner tips.

Scheelite can not easily be detected in a hand specimen. It can, however, readily be seen in superpanner tips with the naked eye and elsewhere with the help of an ultraviolet lamp.

Thin sections were examined to attempt to learn more about the relationships between the sulphides and the gangue. Although the bulk of the sulphides occurs between quartz grains, a few sulphide particles may be seen partially or completely enclosed in quartz grains. The authors were surprised to find no scheelite in the two thin sections they examined. Possibly the sections are not representative, or possibly the presence of scheelite is the result of a chance mixture of material from two sources, one gold- and one tungsten-bearing.

Pyrite and marcasite in places show crystal outline and therefore appear to be contemporaneous with or older than the quartz. Nevertheless in other places these sulphides are definitely being replaced by the gangue. Contemporaneous de-

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‡McCann, W. S.—G.S.C. Mem. 130, Geology and Mineral Deposits of the Bridge River Map-area.

position is also indicated and it may be inferred that there was sudden chilling and coincident deposition of sulphides and gangue.

Evidence as to the Type of Deposit

Few samples, and these not necessarily representative, do not permit us to say much about the nature of the deposit, but the presence of vugs and the fine-grained character of the ore suggest deposition at comparatively shallow depths. Deposits of the shallow type are usually not as persistent as those deposited at greater depths.

Infrasizing and Superpanning Results

The sample of ore was all crushed until it went through a 65-mesh screen. A representative sample was then screened and infrasized. These results are given in Table 1.

TABLE 1

Sample screened—meshes 100, 150, 200, minus 200 mesh into Infrasizer products 1, 2, 3, 4, 5, 6, and 7. Gold assays on each screen product and Infrasizer product.

Size and Distribution of Gold

Product	Wt.* Grams	Assay Oz./Ton	Au. Content Mg.	% Wt. in Total	% Au. in Total	% Au. Cumulative
+100 Mesh	3.0	2.16	.2	.3	.3	.3
+150 Mesh	52.5	1.74	3.1	4.3	4.6	4.9
+200 Mesh	171.0	1.76	10.3	13.8	15.3	20.2
No. 1 I.S.	35.0	2.60	3.1	2.8	4.6	24.8
No. 2 I.S.	277.0	1.64	15.6	22.4	23.2	48.0
No. 3 I.S.	206.5	1.20	8.5	16.7	12.6	60.6
No. 4 I.S.	139.0	1.12	5.4	11.2	8.0	68.6
No. 5 I.S.	100.0	1.20	4.1	8.1	6.1	74.7
No. 6 I.S.	75.0	1.22	3.1	6.1	4.6	79.3
No. 7 I.S.	177.0	2.28	13.9	14.3	20.7	100.0
Total	1236.0	(1.59)	67.3	100.0	100.0	
(Head Assay)		1.63	69.1)			

*To nearest gram. Corrected for small loss, between 2% and 3%.

It may be readily seen if No. 1 Infrasizer product is omitted—faulty operation necessitates the grouping of this product with No. 2 Infrasizer product—that the gold content of the variously sized products is at its lowest at No. 4 Infrasizer size, approximately 28 microns, and rises in value both above and below this product.

These sized products were then superpanned into three or four products as circumstances permitted. These products were as follows:

- (1) Tip. Ninety-nine percent scheelite. A trace of galena and arsenopyrite and rare specks of gold.
- (2) Middling No. 1. Scheelite both locked and free, free arsenopyrite, arsenopyrite locked with pyrite and marcasite, free pyrite and marcasite, and small amounts of gangue.
- (3) Middling No. 2. Locked arsenopyrite, locked and free pyrite and marcasite, quartz locked with these sulphides and possibly some sphalerite.
- (4) Tails. Quartz largely but with appreciable amounts of sulphides locked with it, small amounts of carbonates.

All these products were assayed for gold and the results appear in Table 2.

TABLE 2

Mineralogical Distribution of Gold

Product	Wt. gms.	Assay Oz./ton	Au. Cont. Mg.	Distribu- tion in products		Distribu- tion in total	
				Wt. %	Au. %	Wt. %	Au. %
+100 Mesh	3.0	2.16	.2	....	....	.3	.3
+150 Mesh	52.5	1.74	3.1	....	....	4.3	4.6
Midd. No. 1	1.7	4.3	.2	3.2	6.2	.1	.3
Midd. No. 2	9.0	1.8	.6	17.2	18.8	.8	.9
Tail	41.8	1.62	2.4	79.6	75.0	3.4	3.6
			3.2			4.8	

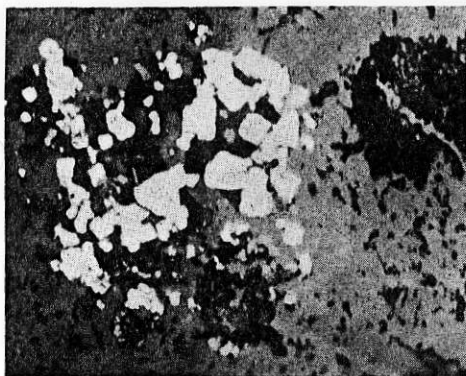
+200 Mesh	171.0	1.76	10.3	....	....	13.8	15.3
Tip	.16	1.2*	.0	.1	....	.0	.0
Midd. No. 1	3.6	4.7	.6	2.1	5.8	.3	.9
Midd. No. 2	10.7	3.95	1.4	6.3	13.5	1.0	2.1
Tail	156.6	1.56	8.4	91.5	80.7	12.5	12.4
			10.4				15.4
No. 1 I.S.	35.0	2.60	3.1	....	....	2.8	4.6
Tip	1.56	1.2*	.1	4.5	3.2	.1	.1
Midd. No. 1	7.9	3.8	1.0	22.6	32.3	.6	1.5
Midd. No. 2	10.5	4.25	1.5	30.0	48.4	.9	2.3
Tail	15.0	1.02	.5	42.9	16.1	1.2	.7
			3.1				4.6
No. 2 I.S.	277.0	1.64	15.6	....	....	22.4	23.2
Tip	1.19	1.2*	.1	.4	.6	.1	.1
Midd. No. 1	25.3	4.7	4.1	9.1	25.8	2.0	6.1
Midd. No. 2	16.3	5.2	2.9	5.9	18.2	1.3	4.3
Tail	234.2	1.10	8.8	84.6	55.4	19.0	13.1
			15.9				23.6
No. 3 I.S.	206.5	1.20	8.5	....	....	16.7	12.6
Tip	.67	1.2*	.0	.3	.0	(.05)	.0
Midd. No. 1	4.6	4.0	.6	2.2	7.1	.4	.9
Midd. No. 2	13.3	4.5	2.1	6.5	24.78	1.1	3.1
Tail	188.0	.89	5.8	91.0	68.2	15.2	8.6
			8.5				12.6
No. 4 I.S.	139.0	1.12	5.4	....	....	11.2	8.0
Tip	.17	1.2*	.0	.1	.0	.0	.0
Midd. No. 1	2.1	(4.3)	.3	1.5	5.7	.2	.4
Midd. No. 2	6.4	3.9	.9	4.6	17.0	.5	1.3
Tail	130.3	.92	4.1	93.8	77.3	10.5	6.1
			5.3				7.8
No. 5 I.S.	100.0	1.20	4.1	....	....	8.1	6.1
Midd. No. 1	2.5	4.6	.4	2.5	10.0	.2	.6
Midd. No. 2	8.4	3.6	1.0	8.4	25.0	.7	1.5
Tail	89.1	.86	2.6	89.1	65.0	7.2	3.9
			4.0				6.0
No. 6 I.S.	75.0	1.22	3.1	....	....	6.1	4.6
Midd. No. 1	.7	4.8	.1	.9	3.2	.1	.1
Midd. No. 2	4.2	5.2	.7	5.6	22.6	.3	1.1
Tail	70.1	.96	2.3	93.5	74.2	5.7	3.4
			3.1				4.6
No. 7 I.S.	177.0	2.28	13.9	....	....	14.3	20.7
Total:	1236.0	1.60	67.6	(Sum of Super-panner Parts)		100.4	
		1.59	67.3	(Sum of Sized Parts)			
		1.63	69.1	(Head Assay)			

*Average value from combined tips.

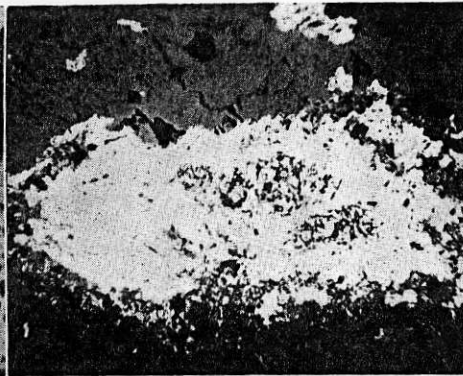
A study of Table 2 reveals that grinding No. 3 Infrasizer size—about 325 mesh—does not enable one to obtain a mechanically separated tail much below 0.90 oz. Au. per ton.

The low value of the combined tips 1.2 oz. Au. per ton, and this in spite of an occasional gold particle, shows clearly that no precious-metal tellurides are present in the ore.

The relationship between the No. 1 and No. 2 middlings suggests that it is not possible mechanically to separate the arsenopyrite and pyrite into two clean products because of mechanical locking of these two minerals with each other and with gangue minerals. This conclusion is endorsed by examination of the middling-products under an ultrapak microscope. As will be shown later, the high value of the tails is largely the result of minute sulphide-particles being locked with the gangue. In bulk flotation a large amount of these minute sulphide-particles could be floated with their interlocked gangue-particle but this would necessarily involve a lowering of the grade of the concentrate with an increasing of the recovery, and furthermore would indicate that a high ratio of concentration, such as might be indicated by the relatively low percentage of sulphides, less than 15 per cent by weight, is not possible. The only concentration which may be achieved is that of bulk flotation with a low ratio of concentration.



No. 1



No. 2



No. 3

No. 1—Cubes and well-formed crystals of pyrite in siliceous gangue; pyrite—white; gangue—grey; $\times 120$.

No. 2—Band of marcasite showing exceedingly irregular grain boundaries and fine dissemination in adjacent gangue: marcasite—white; gangue—grey; $\times 40$.

No. 3—Marcasite showing a cleavage or orientation of impurities; marcasite—grey; gangue—white; $\times 22$.

Summarizing Table 2 we find that gold values expressed in percentages are distributed in the various products:

TABLE 2a

Product	Tip	Midd. No. 1	Midd. No. 2	Undiff.	Tail
+100	....	....	....	.3	....
+150	....	.3	.9	....	3.6
+200	....	.9	2.1	....	12.4
I.S. No. 1	.1	1.5	2.3	....	.7
I.S. No. 2	.1	6.1	4.3	....	13.1
I.S. No. 3	....	.9	3.1	....	8.6
I.S. No. 4	....	.4	1.3	....	6.1
I.S. No. 5	....	.6	1.5	....	3.9
I.S. No. 6	....	.1	1.1	....	3.4
I.S. No. 7	....	....	....	20.7	....
	.2	10.8	16.6	21.0	51.8

Summarizing still further and distributing the undifferentiated reasonably we find that the freed sulphides carry about 35 per cent of the gold, the remaining 65 per cent being carried in a tail which contains a large number of locked sulphide-particles.

Considering only weights we find from table 2 that the scheelite tips contained 0.303 per cent, the middlings 11.5 per cent, the tails 87.4 per cent, after distributing the undifferentiated in a reasonable manner.

If then the scheelite be ignored for the moment it may be said that the sulphides which have been freed comprise about 11.5 per cent of the sample by weight and contain 35 per cent of the gold. The remainder of the gold is in the tail which comprises a considerable amount of locked sulphides.

In order to determine more accurately the amount of the different minerals present in the various products and also to ascertain whether or not all the values in the tails should be allocated to locked sulphides, assays for arsenic, iron, sulphur, and insoluble material were run in several representative products, namely the heads, No. 2 Infrasizer Middlings No. 1 and No. 2, and a composite tail selected from Infrasizer No. 2 to No. 6 inclusive. Unfortunately there was not sufficient time or material available to make similar analyses of all the sized products. It is believed, however, on the basis of examination under the ultrapak, that No. 2 Infrasizer products are fairly representative of the distribution of minerals in the other products, and furthermore the finer sizes fail to show any appreciable lowering of the grade of the tails.

Table 3 shows the assays of these four products.

The ten to fifteen per cent not accounted for in the above analyses may be assumed to be composed of moisture, carbonates, and minor amounts of various elements including copper, zinc, and lead.

TABLE 3

Heads	No. 2 Infrasizer		Tails I.S. Nos. 2-6 inclusive
	Midd. No. 1	Midd. No. 2	
Arsenic	2.5	9.6	1.7
Iron	6.0	28.2	3.2
Sulphur	5.9	29.9	3.1
SiO ₂	72.2	8.0	81.6
Scheelite		13.6		39.7
Total	86.6	89.3	86.9

From the above table the percentage of arsenopyrite present may be calculated assuming that all the arsenic present is accounted for by this mineral. It was considered that either lollingite or leucopyrite might be present in the ore but a consideration of the several analyses ruled out these possibilities and demonstrated that arsenopyrite was the only arsenic mineral present.

Table No. 4 shows the amount of arsenopyrite present in the various products, and the quantities of the various elements needed for this percentage of arsenopyrite.

TABLE 4

Heads	No. 2 Infrasizer		Tails I.S. Nos. 2-6 inclusive
	Midd. No. 1	Midd. No. 2	
Arsenopyrite	5.5	20.8	3.7
46.0% As	2.5	9.6	1.7
34.3% Fe	1.9	7.1	1.2
19.7% S	1.1	4.1	.8

The balance of iron and sulphur remaining after the arsenopyrite is satisfied as given in Table 5.

TABLE 5

Heads	No. 2 Infrasizer		Tails I.S. Nos. 2-6 inclusive
	Midd. No. 1	Midd. No. 2	
Fe	4.1	21.1	2.0
S	4.8	25.8	2.3

From this table the percentage of pyrite and marcasite present may be calculated assuming that all the iron present is accounted for by these minerals. This assumption is slightly in error because some of the iron present might be derived from tramp iron or from chalcopyrite. However the former, on account of its high specific gravity would normally be found in superpanner tips, not the middlings or tails, and the amount of chalcopyrite present is unimportant. Therefore the error likely to be introduced by the assumption that all the iron is present as pyrite and marcasite is negligible.

Table No. 6 shows the amount of pyrite and marcasite present in the various products, the amount of iron and sulphur needed for this, together with the balance of unallocated sulphur.

TABLE 6

Heads	No. 2 Infrasizer		Tails I.S. Nos. 2-6 inclusive	
	Midd. No. 1	Midd. No. 2		
Pyrite + (or) marcasite	8.8	45.2	26.2	4.3
S	4.7	24.1	14.0	2.3
F	4.1	21.1	12.2	2.0
mallocated) .....	.1	1.7	1.0	....

These small amounts of sulphur may well belong to the small amounts of galena and sphalerite known to be present. Actually a head-analysis run independently of our work ran 0.16 per cent Zn or just short of the amount of sphalerite necessary to account for the surplus sulphur indicated above.

The Scheelite Content of the Sample

Because of the possible importance of the scheelite in making any estimate of the ore's value and the difficulty of assaying low-grade tungsten products an attempt was made to ascertain the amount of scheelite present in the ore.

The tips which contain 99 per cent of scheelite amounted to 0.303 per cent of the total weight of the sample. The tips, therefore, contributed 0.30 per cent scheelite.

The No. 1 middling products which contain 12½ per cent + or — of scheelite, amount to 3.9 per cent of the total weight of the sample. This product, therefore, contributes 0.50 per cent scheelite.

The No. 2 middling products which contained 1 per cent + or — of scheelite amounted to 6.6 per cent of the total weight of the sample. This product, therefore, contributes somewhat less than 0.10 per cent.

The tails contain only a trace and are not, therefore, considered as contributing any significant amount of scheelite.

The undifferentiated, mostly less than 10 microns in size, proved difficult to estimate, but it is assumed to contain 1 per cent scheelite. As the weight of the undifferentiated amounted to 8.8 per cent of the whole sample this would add another 0.14 per cent + or — to the scheelite content of the ore.

Summing up we get:

Tips 0.30 per cent. No. 1 Middling 0.50 per cent + or —. No. 2 Middling 0.10 per cent + or —. Undifferentiated 0.14 per cent + or —, giving a total of 1.04 per cent + or — or 1 per cent for all practical purposes and a WO₃ content of 0.8 per cent.

All the above values were estimated carefully by means of comparisons with known standards using an ultraviolet lamp. The No. 1 middling content was also checked by chemical means.

Because great care was taken to obtain tips of pure scheelite it was inevitable that some freed scheelite particles found their way into the No. 1 middling product. It may be safely assumed that at least 50 per cent of the scheelite was freed in the 81.6 per cent minus 200 mesh grind to which this sample was subjected.

Mineralogical Composition of Some of the Products

Summarizing all the information acquired above we find as follows:

	Heads	Tips	Midd. No. 1	Midd. No. 2	Tails
Arsenopyrite	% 5.5	1	20.8	20	3.7
Pyrite + Marcasite	% 9.0		45.2	26.2	4.3
Scheelite	% 1.0	99	12.6	tr.	tr.
	+ or —				
Gold	Oz. 1.62	1.2	4.7	5.2	.97
Quartz	% 71.2		8.0	39.7	81.6
	+ or —				
Malcopyrite, sphalerite, etc.	% 0-1		5	3	tr.
			+or—	+or—	
Carbonates, water, etc.	% 10-15		7.5	10.0	10.0
			+or—	+or—	+or—

Both middlings were represented by Infrasizer No. 2 products, because they are not only representative but also available in sufficient quantities for chemical analyses. Similar reasons determined that the tails representative would be taken from a composite sample taken from Infrasizer No. 2-6 (inclusive) tails.

Summing up the information in the above table with that already obtained we may conclude that although the gold is undoubtedly most closely associated with the arsenopyrite and to a lesser degree with the pyrite and/or marcasite, some does occur in the quartz. The gold in the sulphides is fine-grained, as is evidenced by the fact that fine-grinding frees no significant amount of gold from the sulphides.

Grinding this sample to approximately 80 per cent minus 200 mesh frees all the relatively coarse gold present in the ore and about 50 per cent of the scheelite in the ore. Finer grinding will free negligible amounts of further "free" gold and no important amounts of sulphides which contain the bulk of the gold.

A conclusion arising from the above is that if any effective recovery is to be achieved it can only be by roasting in conjunction with cyanidation. Whether or not preliminary bulk-flotation would be worth while can only be determined by consideration of many factors not available to the authors. Much of the scheelite should be recoverable by combination of gravity separation and flotation. However, extensive work would have to be carried out before the commercial possibilities of this scheelite recovery could be intelligently weighed.

Summary of Conclusions

The deposit was probably laid down at shallow depths. This type of deposit may extend only to limited depths and in development this must be taken into account.

It is not practical to determine the amount of gold carried by arsenopyrite and the iron sulphides respectively. Combined they carry between 5 and 15 oz. of gold per ton when uncontaminated, and between them account for the bulk of the gold in the ore. A small amount of gold is carried by the quartz.

No system of flotation will be able to effect a high ratio of concentration with any satisfactory recovery. Any effective recovery must include roasting or possibly smelting of a flotation concentrate. This conclusion is amply borne out by laboratory tests.

The scheelite content of the ore, about 1 per cent, is high enough in view of the present crisis to suggest that if sufficient ore can be found and if roasting facilities were available a satisfactory overall-recovery of the gold might be obtained and the scheelite saved as a by-product of the gold-recovery operations.

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