Original Communication

Preliminary discussion on pyrrhotite, gold killer in Wells-Barkerville, British Columbia, Canada

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Abstract

The Wells-Barkerville area of the Cariboo gold mining district is situated within the Quesnel Highlands on the eastern edge of the Interior Plateau in central British Columbia, Canada of the eastern Circum-Pacific volcanic-metallogenic belt. Recorded gold production from the area totals more than 4.0 million ounces, including an estimated 2.7 million ounces from placer mining from 101 creeks and 1.3 million ounces from lode mining. There are five principal types of lode gold deposits in the district; namely, auriferous pyrite replacement, including replacement in limestone and that in calcareous clastic rock; pyrite-quartz vein/veinlet lode gold, including strike vein, diagonal vein, orthogonal vein, and quartz veinlets; basalt-hosted auriferous pyrrhotite-pyrite lode gold; and associated gold in porphyry copper styles. This area is historically a famous gold production area in western Canada, including the initial alluvial gold and later and current lode gold. This original short article uses drilling results to illustrate that pyrrhotite in this area is the killer of gold. Wherever there is pyrrhotite, the gold grade is very poor or even contains no gold. In other words, gold grade is inversely related to pyrrhotite content. Then, the spatial distribution characteristics of the pyrrhotite anomaly zone(s) existing in this area were summarized, including the approximate thickness of zone(s). On this basis, several deep drill holes are recommended to verify whether there is considerable gold mineralization beneath the pyrrhotite anomaly zone(s).

Key words: pyrrhotite; gold killer; calcareous clastic rock; Cariboo gold mining district; Omineca belt; British Columbia; Canadian Cordillera

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1 Introduction

The Cariboo gold mining district is situated within the Quesnel Highlands on the eastern edge of the Interior Plateau in central British Columbia, Canada, in the eastern Circum-Pacific volcanic-metallogenic belt. Recorded gold production from the area totals more than 4.0 million ounces, including an estimated 2.7 million ounces from placer mining from more than 101 creeks and rivers, and 1.3 million ounces from lode mining[1 & 2].

There are five principal types of lode gold deposits in the district; namely, auriferous pyrite replacement, including replacement in limestone and that in calcareous clastic rock; pyrite-quartz vein/veinlet lode gold, including strike vein, diagonal vein, orthogonal vein, and quartz veinlets; basalt-hosted auriferous pyrrhotite-pyrite lode gold; and associated gold in porphyry copper styles[1].

It is a matter of fact that the pyrrhotite is something like a killer of gold in the upper Lowhee Creek area, no matter what the reason is. As pyrrhotite develops in the rock, the grade of gold will be very poor. In other words, there is a negative correlation between gold grade and pyrrhotite content.

In this case, it is necessary to understand how the pyrrhotite develops and distributes in the space so that efficient drilling exploration for gold can be planned and conducted on gold mineralization targets.

Mainly based on the review of all the drill holes completed in 2005 by the related mining company, especially the detailed study on the pyrrhotite mineralization, lithology, alteration, and structure of the four drill holes, LH05-13, LH05-14, LH05-15, and LH05-16 of Section 16 + 050 E in the upper Lowhee Creek, the possible distribution of the pyrrhotite anomaly zone, its thickness, orientation, relationship with lithology, and other alterations as well as structure, are discussed here. In addition, preliminary conclusions and suggestions are proposed for reference of future drilling and exploration of gold deposits in the area.

It is worth saying that more data on drill logs are needed to be reviewed in the future to prove the conclusions in the article.

2 Discussion

2.1 Pyrrhotite zone

On the basis of study on the pyrrhotite mineralization, lithology, alteration, and structure of the four drill holes; that is, LH05-13, LH05-14, LH05-15, and LH05-16 of Section 16 + 050 E, and the review of all other drill holes along the upper Lowhee Creek conducted in 2005, the following geological phenomena about pyrrhotite were discovered:

- There exists one or more pyrrhotite anomaly zone(s) in the upper Lowhee Creek area.
- The pyrrhotite anomaly zone(s) are roughly within the elevations 4100 – 4470 feet above the sea level.
- The total thickness of the pyrrhotite anomaly zone(s) is about 180 feet.
- The pyrrhotite anomaly zone(s) are not horizontal but waving in the three dimensional space, although the thickness of the zone(s) seems stable. In the azimuth of 220° (all on the local mine grid in this article), the pyrrhotite zone dips about 20° down to the bank of the Lowhee Creek for about 200 feet horizontal distance. Then, the pyrrhotite zone(s) go almost horizontally toward the bank. In the opposite direction, namely, in the azimuth of 40°, the pyrrhotite zone(s) dip down into the hill at about 60°.

2.2 Pyrrhotite and lithology

Lithology in the area, appearing to dip north-eastward at about 50° in the sections, can be simply divided into two groups or units as follows:

- The upper dark grey to black graphitic argillite, siltite, and quartzite, usually strongly silicified; and
- The lower grey, greenish grey, greyish green, and/or pale green sericitic and/or chloritic phyllite, argillite, and quartzite; some of these rocks are dolomitic porphyroblastic and/or magnetite porphyroblastic with disseminated magnetite. This unit usually interbeds with some silicified black graphitic argillite, quartzite, and siltite.

Between the two different units, a quartz veining zone, also a fault structure zone, occurs along the contact dipping NE at an angle of about 50°.

The drilling results indicate that the pyrrhotite anomaly zone develops only in the lower rock unit, and the contact is the upper limit of the pyrrhotite anomaly zone. In other words, the pyrrhotite zone is under the contact between the two different units, though it really does not mean that the pyrrhotite is stratabound in the lower unit.

Most of the alterations, graphite, chlorite, sericite, fuchsite, carbonate including dolomite and calcite, silicification including quartz veinlets, stock works, quartz stringers as well as quartz veins, seem to have similar orientation with the lithology and also dip north-eastward at a similar dip angle.

The pyrrhotite zone(s) cut across all alterations and porphyroblastic (magnetite and dolomite) rocks. To some extent, this might mean that pyrrhotite as well as the associated pyrite mineralization is younger than most, if not all, of the alterations mentioned above.

It does not seem there is any genetic relationship between magnetite porphyroblast rock and the pyrrhotite mineralization, since they cut across each other and have different orientation in the three dimensional space. The magnetite porphyroblastic and dolomitic porphyroblastic rocks have almost the same orientation as that of the other lithology in the region.

Although the term "pyrrhotite anomaly zone" is used here, it does not mean that the pyrrhotite distributes evenly within the "zone area". On the contrary, the pyrrhotite scatters, or distributes discontinuously and unevenly in the zone(s) mainly in the form of very fine veinlets and / or clots/blebs. Some part of the zone area is free of pyrrhotite (Table 1).

Table 1. Representative drill holes that intercepted pyrrhotite

Hole ID	Collar (mine grid)			Azimuth	Dip	End of hole (feet)	Interval with pyrrhotite
	Easting	Northing	Elevation				
LH05-02	17601	2264	4768'	213°	- 57°	696'	495.1' (5%)
							522.3'- 522.6' & 544.1' (15%)
							543'-551' (4%)
LH05-04	17394	2374	477'	357°	- 45°	646'	183.5'-185.1' (5%)
							404.4'-436.0' (5%)
							586'-616' (5%)
LH05-06	16994	2644	4785'	358°	- 46°	616'	396'-405' (1%-2%)
							606''-616' (2%-3%)
LH05-07	16994	2646	4787'	55°	-48°	506'	377.7'-382.5' (5%-7%)
							382.5'-406.0' (2%-3%)
LH05-08	16991	2642	4786'	205°	- 80°	431'	299.2'-321.4' (2%-3%)
							321.4'-376.0' (1%-2%)
							376'-414' (1%)
LH05-09	16802	2804	4788'	216°	- 44°	546'	226.6'-236.6' (2%-3%)
							424.7'- 471.1' (1%-3%)
							509.3'-541.6' (1%-2%)
LH05-10	16598	3000	4809'	194°	- 44°	556'	324.3'- 376.0' (1%-2%)
							376.0'- 395.0' (3%-4%)
							395.0'- 449.5' (1%-2%)
							542.7'- 544.7' (2%-3%)
LH05-12	16396	3102	4809'	179°	- 44°	676'	144'-158' (1%)
							226.0'- 238.7' (1%-2%)
LH05-13	15995	3289	4809'	208°	- 44°	582'	576.2' – 582.0' (3%)
LH05-14	15996	3291	4809'	208°	- 67°	716'	469.2' – 471.0' (0.5%)
							540.4' – 542.5' (0.1%)
							610.0' – 632.5' (1.0%)
LH05-15	15997	3293	4809'	208°	- 90°	557'	343.2' – 388.7' (0.7%)
							399.4' – 522.7' (0.7%)

Most of the known pyrrhotite clots and/or veinlets occur in grey and/or greenish grey phyllite, argillite, and quartzite in drill holes LH05-04, LH05-06, LH05-07, LH05-08, LH05-09, LH05-10, LH05-11, LH05-13, LH05-14, and LH05-16; some pyrite - pyrrhotite veinlets in quartz vein in drill holes LH05-04, LH05-15 and LH05-16, and some other pyrrhotite in the silicified black graphitic argillite / siltite / quartzite interbeds of the lower phyllite/quartzite

unit in drill holes LH05-04, LH05-08, and LH05-15; a few pyrrhotite in the upper black graphitic argillite/siltite/quartzite.

Pyrrhotite content varies greatly in a short distance within the anomaly zone: 01%, 0.5%, 0.7%, 0.8%, 1.0%, 1% - 2%, 1% - 3%, 2% - 3%, 3.0%, 3% - 4%, 4%, 5% , 5% - 7%, 15% and so on (Table 1).

When occurring in the quartz veins, pyrrhotite content is the highest (10% - 15%) and usually associated with pyrite in the form of pyrrhotite-pyrite vein or veinlet (drill holes BC2K-18, LH05-04, LH05-15, and LH05-16). From this point of view, there is no any major difference between the pyrrhotite in drill hole BC2K-18 and that of the Lowhee drill targets.

At least one fault or fault zone, cutting across the lithology and alteration, develops above the pyrrhotite zone(s). Several other faults or fault zones occur within or below the pyrrhotite zone(s). The genetic relationship between these faults or fault zones and the pyrrhotite zone(s) is not clear at this time.

Depending on the dips and collars of the drill holes in the upper Lowhee Creek area, the possible depth ranges within which drill holes might hit the pyrrhotite zone(s) are summarized in Table 2. The depth ranges listed here might be affected and thus changed by fault and/or fold as well some other geological events.

Table 2. Possible depth ranges that drill holes might intercept pyrrhotite

Azimuth (mine grid)	220°			40°
Elevation (feet)	4809.33’			
Dip	- 45°	- 67°	- 90°	- 80°
Depth interval with pyrrhotite (feet)	576’ – 750’	470’ – 630’	340’ – 520’	480’ – 680’
Example	LH05-13	LH05-14	LH05-15	LH05-16
End of hole (feet)	346’	716’	557’	626’

Table 3 lists those drill holes that do not hit pyrrhotite zone(s), possibly due to the shallower end of holes than the depths of the supposed upper limit of the pyrrhotite zone(s). For example, drillhole LH05-17 ends at a depth of 575 feet. No pyrrhotite is found in the core. Considering the drill pad of LH05-17 is at a little higher elevation and its end of hole a little less than the proposed upper limit depth of the pyrrhotite zone(s), LH05-17 should not hit any of the pyrrhotite.

Table 3. Drill holes without pyrrhotite possibly due to their smaller EOH

Hole ID	**Collar (mine grid)**					**End of hole (feet)**
	Easting	**Northing**	**Elevation (feet)**	**Azimuth**	**Dip**	
LH05-01	17601	2263	4769’	206°	- 45°	346’
LH05-03	17634	2282	4771'	4°	- 45°	376’
LH05-05	17183	2502	4782’	206°	- 58°	306’
LH05-11	16598	3002	4809’	194°	- 55°	557’
BB05-03	18119	2156	4773’	238°	- 44°	493’
BB05-02	18126	2155	4773’	238°	- 132°	526’
BB05-01	18133	2032	4747’	238°	- 44°	536’

3 Conclusions and suggestions

On the basis of the discussion above, the conclusions and suggestions are reached as follows:
There exist pyrrhotite anomaly zone(s) under the contact of the upper black graphitic argillite/siltite/quartzite and the lower grey/green phyllite (argillite)/quartzite. The pyrrhotite zone(s) are waving in the space.
Pyrrhotite distributes unevenly and discontinuously and its content varies greatly (0.1% - 15%) in a short distance within the zone(s).
Pyrrhotite occurs mainly in the form of clot/bleb and/or veinlet.
Several deep holes are suggested in Table 4 below in order to confirm how the gold mineralization below the pyrrhotite anomaly zone(s) is.

Table 4. Recommended drill holes to test gold mineralization below the pyrrhotite zone(s)

Azimuth (mine grid)	220°			40°
Dip	- 45°	- 65°	- 90°	- 80°
Depth interval with pyrrhotite (feet)	1100' – 1200'	800' – 900'	750'- 850'	1200' – 1300'

Based on the result of the drill holes recommended above, the proposed depths of future drill holes would be determined whether or not to cut through the pyrrhotite zone(s). If there is not any promising gold mineralization below the pyrrhotite zone(s), it is unnecessary to drill deeper exploration drill holes in the area. And the possible end of holes would be determined by referring to Tables 1 and 2 in this article, depending on the dips and collars of the proposed drill holes.
Drill holes with dip angles of -45° and -60° and an azimuth of 40° are recommended in order to avoid the pyrrhotite zone(s) and to hit the quartz veining zone along the contact between the upper black graphitic argillite/siltite/quartzite and the lower greenish grey phyllite (argillite)/quartzite.
More drill holes are recommended and listed in Table 5. These drill holes are mainly based on the orientation of most of the quartz veins and dominant structures including big faults and/or fault zones in the region.

Table 5. More recommended exploration drill holes for quartz vein style of gold mineralization

Azimuth (mine grid)	300°			90°		
Dip	- 45°	- 65°	- 80°	- 80°	- 65°	- 45°
End of hole (feet)	900' – 1000'	800' – 900'	700'- 800'	1200' – 1300'	800' – 900'	900' – 1000'

It should be pointed out that the conclusions on the pyrrhotite zone(s) in this report are certainly preliminary and thus may not be applied to the entire exploration region, since they are mainly based on several limited drill holes.

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Data availability statement The data that support the findings of this study is available from the author upon reasonable request.

Declarations The author declare that he has no conflict of interest.

4 References

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