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THE WHITEHORSE COPPER BELT YUKON

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T H E W H I T E H O R S E C O P P E R B E L T

Y U K O N

S U M M A R Y

In the Whitehorse Copper Belt that is at least 18 miles long an irregular contact between granite and limestone is the locus for over twenty distinct copper deposits. They range from a few hundred tons of possibly 10% copper ore to several million tons of possibly 1% or better. A small but valuable content of precious metals is usually present and in some cases a magnetite concentrate could become a saleable by-product.

The predominance of bornite as the copper-bearing mineral should result in concentrates averaging at least 25% copper.

This type of deposit is unpredictable and should always be adequately explored before going into production.

With an expenditure of $250,000 this year it is expected that enough ore will be indicated to justify a mill.

There is a reasonable chance that the unexpected shallowness of one deposit will be offset by an enlargement at depth of another.

In order to obtain the maximum benefit from the period of three years tax exemption for new mines in Canada each deposit should be mined as a separate entity and in succession so that an unduly large mill is not required.

I N T R O D U C T I O N.

It should be fully understood that I have not visited the area described in this account but that I have had the invaluable cooperation of Mr. B. O. Brynelsen who was the mining engineer directing the exploration work of Noranda Mines in the Yukon in 1947 and 1948. He has made available numerous plans, drill hole logs and reports from which such information has been derived for this report. Some of this material had already been in Mr. Brynelsen's possession for many years when he interested Noranda Mines in the possibilities of the belt and they placed him in charge of an exploration program.

The only official account about this area is 'The Whitehorse Copper Belt' by R. G. McConnell that was published by the Geological Survey of Canada in 1909. In some cases considerable more work was done and much ore shipped since the time of that report. It does describe however the essential features of the geology of the copper deposits and was the basis for planning the detailed exploration that has been done since.

Only a limited proportion of the maps and reports of the large Pueblo mine has survived whilst even less is available from other mines where considerable work has been done. The most unfortunate loss is the report on the numerous drill holes put down between 1926 and 1929 on many of the properties.

In 1947 and 1948 Noranda Mines did extensive geological mapping, geophysical surveying, trenching, sampling and diamond drilling on a number of the properties but as the grade was proving too low for the price of copper at that time the work was stopped. Consequently much of the information remained uncorrelated and no formal report was drawn up.

Without the opportunity of examining these properties on the ground I have attempted to interpret the geophysical, geological and diamond drill results and to suggest possible tonnages of ore that could be developed by further work.

Before going ahead with the program that is proposed in this report it is advisable that I should inspect the various properties and record any observations that could modify this report.

Prints of some of the important maps made by Hernando Mines are enclosed and the various other plans and data will be available from Mr. Brynelsen when required.

H I S T O R Y .

According to McConnell the first claim was located by Jack McIntyre when he staked the Copper King on July 6, 1898. By the following year most of the important claims such as the Pueblo, West Channon, Artic Chief, Grafter, Valerie and War Eagle had been staked.

Development work started in 1899, the most interesting being that on the Pueblo because after 135 feet of sinking and drifting through what has since proved to be a lean section of the ore-body, the mine was closed down until 1906. It has been by far the largest producer of the whole belt and, but for a disastrous collapse in the mine in 1917, would have produced much more.

High grade bornite ore was shipped for the first time in 1900 from the Copper King consisting of nine tons of 46.4% Cu.

By 1909 McConnell could report that not more than 3,500 feet of development had been done to that date on the whole of the belt and that total shipments amounted to 4,000 tons. He attributed the slow progress for such a promising camp to the poor transportation facilities for shipping the bulk of the ore which would average only 4% Cu. He stated that a spur from the main White Pass Railway would shortly make shipping possible for a probable total of half a million tons already developed at the various mines.

There is little factual material with which to continue this history so what follows is rather disjointed.

The comparitively low price for copper of around 13 cents per pound from 1908 to 1911 probably held back the expected large productions but the war-time demand pushed the price to 27 cents in 1916 and 1917 so that numerous mines went into production. It is stated that dangerous mining methods were used to increase the contribution from the large Pueblo mine and a tremendous cave-in resulted with loss of life in 1917. The mine has never operated since.

All production in the Whitehorse area ceased with the end of the war but there are no records available giving the totals for the various companies, except in three cases.

An effort was made to revive the copper mining by an extensive diamond drilling campaign from 1926 to 1929 but little of the records has survived. Presumably the slump of 1930 spoilt any plans that were made to follow up the diamond drilling.

In 1946 Noranda Mines obtained options on some of the principal properties and staked numerous claims along the known favourable belt.

For two years a large amount of geophysical prospecting, geological surveying, trenching and diamond drilling was done. The company then decided to give up the venture because of the low grade of the ore cut by the drilling. Copper was selling for about 20 cents per pound at that time.

S I T U A T I O N A N D C O M M U N I C A T I O N S .

The copper belt is in the southern part of the Yukon Territory, about 45 miles north of the British Columbia boundary and extends for 18 miles along the valley of the Lewes River which is the principal feeder of the Yukon River.

Whitehorse, at the head of navigation on the Yukon River, is the distributing centre for the district. It is about 3 miles from the nearest property on the copper belt and is 110 miles from Skagway at the head of Lynn Canal with which it is connected by a narrow gauge railway.

The Alcan Highway passes through Whitehorse.

Canadian Pacific Airlines has a daily flight between Vancouver and Whitehorse.

T O P O G R A P H Y .

The main physical feature of the district is the large valley of the Lewes River which is 4 miles wide opposite Whitehorse. The central portion of what had been a pre-glacial valley is now filled with silts and boulder clays through which the present Lewes River has cut a narrow, winding secondary valley about 200 feet deep. There are numerous canyon-like tributary valleys entering it from both sides. Away from these secondary valleys the terrain is quite rough with rock ridges and hummocks of glacial material.

C L I M A T E .

The summer weather is dry and not too hot but the winter from November to April is cold.

P O W E R .

The Yukon Hydro Company Limited now has a hydro-electric capacity of 2,190 h.p. in two plants and diesel capacity of 610 h.p. It apparently has available potential power that could be developed to serve a mining industry.

G E N E R A L G E O L O G Y .

McConnell states that carboniferous limestone is the only sedimentary rock in the area. He says that it was first invaded by various kinds of porphyrites partly at least along bedding planes in sills up to 1,000 feet or more in thickness. His detailed descriptions strongly suggest to me that these porphyrites represent a volcanic series of lavas, tuffs and agglomerates with few

with few contemporaneous intrusives.

Wert Butterall describes a second invasion in Mesozoic times of 'plutonic rocks, extraordinarily varied in their mineralogical composition. Normally they are hornblende granites, but transitions to diorites, hornblende and augite syenites and even to gabbros are frequent . This implies to me that granitization and dioritization of the limestone and volcanic series has produced the plutonic types.

These rocks were followed by the formation of the ore deposits.

In Tertiary times a basalt lava flow entered the old Lowes valley. It was largely eroded away by the time that the Pleistocene ice had left its load of silts and boulder clays strewn throughout the valley.

M I N E R A L I Z A T I O N .

The end phase of the granitization of the limestone and volcanics produce along the contact zones widespread masses of metamorphic silicate minerals such as andradite garnet, augite, tremolite, calcite, epidote, clinochore, serpentine and quartz of which the first five are the most abundant. Of more restricted occurance but sometimes in concentrated masses are deposits of magnetite and hematite up to 500 feet long and 60 feet wide. The magnetite is more abundant than the hematite which however is the principal mineral in the large Pueblo ore-body.

The copper sulphides bornite and chalcopyrite and their common oxidation products malachite, azurite, cuprite, melaconite, chrysocolla and native copper are found throughout the contact zones associated with the metamorphic minerals. In limited sections the concentration of the copper minerals is sufficient to form ore-bodies. Although limited amounts of high grade ore averaging 10 to 25%

copper have been shipped in the past large scale mining under present conditions would probably depend on ore-bodies ranging from 1% to 4% copper.

Usually worthwhile precious metal values are present that will probably average from 0.01 to 0.10 oz in gold and 0.3 to 2.0 oz in silver. It is possible that the magnetite and hematite will become valuable by-products after the milling out of the sulphides.

Only small quantities of pyrite and pyrrhotite are found associated with the ores. Molybdenite is reported and may prove to be valuable.

Arsenopyrite is found in only one of the deposits.

The ore deposits known at present are found at or near the contact between granitic rock and a narrow, discontinuous belt of limestone striking for the most part W 30 W but swinging to the north at the north end and to the east at the south end as indicated on the general map of the area (1 in: 2,000 ft.) The known length of the belt is 16 miles but it could well extend for some distance at either end beneath the heavy overburden.

The host rock is usually limestone and often in an embayment of the granite or in a residual island surrounded by granitic rocks.

In a few cases the country rock has been recorded as altered granite but it may be completely metamorphosed limestone.

The deposits can be placed in two classes, although gradations do exist between them, according to whether the copper sulphides are in:

1. Massive magnetite or hematite
2. Silicate bodies.

The significant information available for each of the deposits will be given in order from north to south along the mineralized belt. For ready reference a chart has been prepared summarising the main features in this same order.

W A R E A G L E .

When McConnell described this property it had been in operation for only two years. No information is available about subsequent production except that in 1917 E. E. Wilson reported that the War Eagle was an intermittent shipper of a small tonnage.

The general area is largely drift covered but a section of altered limestone in volcanics is mineralised along a granite contact over an area 250 feet wide and 1,000 feet long. It consists of garnet, tremolite, augite, and epidote associated in places with bornite, chalcopyrite and occasionally magnetite and molybdenite.

The ore-body that McConnell saw consisted of an irregularly shaped area, 45 feet across, in which the sulphides were associated with bands of tremolite. He reports an average of 2.71% Cu. over a width of 45 feet in an open-cut. At 23 feet below the surface a tunnel showed 44 feet of ore consisting of two well mineralised bands 14 and 10 feet wide with lower grade material between. It was from here that shipments were being made in 1917.

Between 1926 and 1929 some drilling was done for which the detailed logs and assays are missing but the following information has been obtained from the notes kept by the diamond driller:

D. D. H. 23 at -46° to N 72 E for 223 feet.

131 - 140' disseminated garnetite ore

140 - 176 garnetite ore

176 - 223 altered limestone

D. D. H. 27 at -53° to N 75° E for 267 feet

Located 200 feet N 29° W from D. D. H. 23

0 - 45' overburden

123 - 129 Ore

129 - 142 spotted ore

142 - 150 ore

262 - 267 granite

These holes were presumably drilled underneath the tunnel described by McConnell since the widths of mineralization are comparable.

A detailed examination should be made of this property.

From the records of the B. Lowe estate the following additional information has been taken:

On the surface there were two lenses of ore each 250 feet long, 6 feet wide and 30 feet apart. They were developed by a shaft 100 feet deep. In the early days production was from open-cuts that were 20 feet deep, and amounted to 1,000 tons averaging 7% Cu. and $2 in gold and silver.

In 1916 and 1917 another 2,248 tons were shipped with a recovered value of 5.7% Cu., 0.03 oz Au and 2.0 oz Ag. This ore came from the shaft and from an open-cut 40 feet long and 200 feet to the south. A sample taken several years later from this open-cut gave over 6 feet Au 0.07 oz, Ag 2.0 oz, and Cu 9.07% whilst the rejects on the dump gave an Au 0.02, Ag 1.96 and Cu. 4.34%.

There is another shaft about 500 feet north of the first which is also 100 feet deep but produced little shipping ore.

In 1939 A. A. McKinnon certified that he had worked on the War Eagle in 1916 when a thirty foot pocket of bornite ore was mined leaving underneath molybdenum ore that was 20 feet long and 10 feet wide.

It is reported that this property produced a net profit of $ 43,379 to its owners.

A N A C O N D A .

This property is in an isolated mass of limestone surrounded by granite about one mile east of ; the War Eagle. A spur of the limestone from 200 to 600 feet wide has been metamorphosed to the usual silicate minerals with associated bornite and chalcopyrite. The limestone dips steeply towards the granite and only certain beds appear to have been replaced. Bands of tremolite form the ore.

A dozen or more showings were known in 1908 but only one was explored. It is 50 feet from the granite contact and consists mainly of tremolite with the copper sulphides for a width of 12 feet. It is 100 feet long ; and has been proved to 70 feet in a shaft.

In 1917 Mr. Wilson reported that this property was an intermittent shipper of ore.

This description suggests that a detailed examination is warranted.

R A B B I T F O O T .

This is adjacent to the Anaconda and the main showings are apparently in the same spur of limestone described at that mine. Two short, overlapping lenses of bornite ore, each 3 to 7 feet in width, have been developed in the limestone. The granite bordering the limestone on the north is also altered in places into solid ridges of garnet. The workings in 1909 consisted of two shallow shafts about 90 feet apart.

C O P P E R K I N G .

This mine is also in an isolated mass of limestone surrounded by granitic rocks. The limestone is largely converted to silicates which are accompanied by copper sulphides especially near the unaltered edges of limestone. The ore

sections are characterized by tremolite. In 1909 McConnell reported that the main deposit dipped at 46° towards the granite contact. It had been followed down dip for 130 feet (91 vertically). Above the 63 foot level an excavation 15 to 30 feet long and up to 10 feet wide showed the size of an original lens of high grade ore.

About 200 feet north of this is a wide garnet-limestone band with copper mineralization which was followed in a steeply inclined shaft for 65 feet. The first 20 feet followed a small high grade lens of bornite ore but the rest of the workings including short drifts from the bottom were in unworkable material.

At 200 feet south of the main shaft another one was sunk for 40 feet on a lens of ore.

Over 300 tons averaging 15% Cu. had been shipped by 1908. In 1917 Mr. Wilcox stated that the property was shipping 300 tons a month. In 1918 good ore was encountered on the 100 foot level.

Between 1915 and 1920 shipments totalled 5,288 tons averaging 18% Cu.

It is stated that net profits amounted to $88,073.

C A R L I S L E .

This property is in the same mass of altered limestone as the Copper King.

There is a two compartment shaft that is vertical for the first 30 feet and then inclined for another 67 feet. At the 30 foot level a 12 foot cross-cut encountered a small lens of rich ore that was drifted on for about 30 feet and then stopped to yield 90 tons averaging 22% Cu. The ore is largely bornite, with some chalcopyrite in a tremolite gangue.

Mr. C. H. White in a report dated 1926 stated that on the 90 foot level drifting found high grade ore but then turned too far into the footwall and lost the ore. In 1926 work was resumed following the ore which then showed

3 to 4 feet of milling ore with high grade in the floor.

Diamond drilling was done soon after this but the only records are notes kept by the diamond driller on two of the holes.

D. D. H. 12

	8 to 11'	garnetite
f	56 - 59	disseminated ore in granite
	61 - 65	ditto
	95 - 109	limestone with altered bands of garnetite
	109 - 110	high grade chalcopyrite
	110 - 131	limestone and garnetite

D. D. H. 15

1 - 18	garnetite
59 - 72	garnetite and limestone
72 - 108	garnetite
108 - 144	garnetite and limestone
144 - 150	disseminated ore in limestone
150 - 161	limestone and garnetite

Mr. Brymelsen was quite impressed with the possibilities of mining large blocks of low grade ore in the altered limestone of the Copper King and Carlisle properties so that geological mapping, geophysical prospecting, trenching and diamond drilling will probably be warranted for the area.

P U R P L E

McConnell describes the ore-body exposed by stripping here in 1908 as an irregularly shaped mass 300 feet in length and up to 170 feet wide with an area of 33,000 square feet. It is entirely surrounded by crystalline limestone but is not more than 300 feet from a granite contact.

The ore is essentially auriferous hematite but for the first 100 feet of depth known in 1909 the copper was in the form of oxide minerals with an average grade of 4 % Cu.

Writing in 1926 C. B. White describes how the ore was mined to the 60 feet level by means of open-cuts and glory holes. Then a main shaft was sunk to 300 feet and stoping was carried out on levels at 200, 300, and 400 feet until March 21st. 1917 when a disastrous cave-in brought the mine to a stand-still that has lasted ever since. The production to that date had been 140,000 tons.

At the time of this closure a diamond drilling campaign was being carried out on the 300 level with considerable success according to the figures of Mr. White. Thus the current flat hole (314) returned 44 feet of 9.6 % Cu starting at 60 feet which would be 240 feet N N W of the shaft. Hole 312 gave 65 feet of 13.8 % copper and 313 gave 11 feet of 3.67 % Cu at 40 feet further north showing that the main ore-body was still present.

The 314 hole was regarded as discovering a new ore-body so that Mr. White recommended drilling from the surface in 1926. As a result three holes cut ore about 200 feet above the 300 level intersection and whilst widths of 23 and 24 feet were reported the true width was probably 5 to 6 feet with an average grade of 4 %. Mr. White interpreted the results as indicating two ore-bodies about 35 feet apart and recommended further drilling.

Mr. R. R. Wilcox in his report on the Arctic Chief dated June 1917 mentions that the Pueblo ' mine has been closed down since last March after a bad cave between the second and fourth levels, but is just now commencing operations again to prepare for further production. Previous to the shut down the mine was producing 200 tons per day.'

Also he wrote ' I have been informed that ore with less than 3.5 % copper content was not considered a shipping grade from this mine.'

In 1943 Normeda Mines drilled two inconclusive holes from the surface in an attempt to test the original ore-body at depth on either side of the shaft. No. 1 was stopped at 591 feet owing to badly caving ground before reaching the projected position of the main ore at 50 feet south of the shaft. From 516 to 527 a low grade band assayed 0.34 % Cu over a probable true width of 7 feet. No. 3 was aimed at -58° to cut the supposed projection of the ore in D B M. 514 at the 400 level. The results were disappointing and amounted to three narrow sections in 72 feet of limestone that assayed respectively 1.05 % for 2.2 feet, 1.3 feet of 0.59 % and 3.0 feet of 0.36 % Cu at130 to 70 feet above B. B. M. 514. At 30 feet beyond the last value the hole entered granite and stayed in that rock to the bottom at 160 feet further. Without a geological plan of the various levels it is not possible to analyse these results.

White describes how, on the east side of the creek about 800 feet below the mine, the granite is intensely mineralised for a length of 300 feet. The west bank is limestone and the actual contact must be covered by the flats. He recommended drilling under these flats which was subsequently done but the results are lost except for a map showing the locations of five holes over a strike length of 250 feet and a note that three of these holes gave the following values:

No.	Mer. Width	Ag.	Cu.
16	30 ft.	1.66 oz	4.96%
18	6	6.35	3.70
19	35	1.50	5.20

Bermuda Mines checked No. 18 hole with their No. 4 for which sludges only are given because core recovery was poor:

80 - 90'	0.3% Cu
100 - 110	0.3
120 - 130	0.2
150 - 170	0.2
260 - 300	0.28

The country rock was nearly all granite.

Bermuda No. 5 was drilled 200 feet south of No. 4. It encountered granitic rocks with patches of limestone and some mineralization. The following values were reported for the sections of core assayed:

85 - 87'	0.55%
87 - 93	Tr.
93 - 97	0.15
180 - 189	0.25
200 - 206	0.21

The limited amount of drilling done by Bermuda Mines unfortunately failed to confirm the values reported by White so that pending further investigation on the ground no definite conclusion can be given for the Pueblo area.

It is interesting to note that in 1916 Mr. T. Kerruish found from the old records that the Pueblo mine had made a net profit during its operation of $576,532.

Between the Pueblo and the next group of properties there is a gap of 19,000 feet along McIntyre Creek that is entirely covered with overburden. It should be prospected by geophysical means preferably by air-borne magnetometer first in the hopes that the cover is shallow in some areas.

The Spring Creek, Empress of India, Retribution and Best Chance properties lie along a 2,000 feet length of contact between granite and limestone. The only information available is that given by McConnell in 1909. Some of this group was optioned by Noranda.

S P R I N G C R E E K .

Here the zone of unaltered rocks is unusually wide on each side of the contact with mainly garnet replacing limestone and garnet with epidote replacing granite. Bornite, chalcopyrite and magnetite accompany the secondary silicate minerals. A 43 foot shaft opened up a small lens of rich bornite and chalcopyrite ore.

E M P R E S S O F I N D I A .

A limited amount of development work was done on the contact zone which is similar to that in Spring Creek. The sulphides, including molybdenite, are widely disseminated along the altered zone but no large lens of pay ore was found. Wilson reported in 1917 that a few tons daily was being shipped.

R E T R I B U T I O N .

Here the main showing consisted of large blocks of copper-stained magnetite in glacial drift over a length of 30 feet and appear to be approximately in place. They are on strike with a band of garnetized granite.

B E S T C H A N C E .

McConnell stated that this property contained the largest surface showing of cupriferous magnetite so far discovered in the district. It

measured 360 feet in length, maximum width of 65 feet and average width 30 feet. It is at the contact of the intensely altered granite and limestone. The altered granite with some chalcopyrite is only 50 feet wide along the edge of the ore-body.

There is 35 feet shaft with a 19 feet drift and two other shallow shafts.

The copper minerals occur in quantity both in the magnetite and in portions of the altered garnetized zone adjoining it on the east.

No shipments had been made although a large proportion of the ore-body was expected to exceed 4% Cu so this was probably an optimistic estimate.

The deposit should certainly be mapped in detail and then diamond drilled.

L I T T L E J O H N N I E .

I have no information about this claim except that it is immediately west of the Best Chance and could include part of the contact zone.

G R A F T E R .

This property is 1,200 feet south-west across a nose of granite from the Best Chance. The ore-body is near the end of a small limestone tongue where the contact zone consists of alternating dioritic bands in limestone more or less replaced by secondary silicates.

There is a 100 feet shaft sunk on the ore-body. At the 50 feet level a semi-circular drift has followed ore for 130 feet with widths from 6 to 17 feet. A cross-cut for 137 feet to the south-west failed to find a second showing known on the surface. The ore-body has a core of pure limestone 20 feet across. The ore consists of bornite and chalcopyrite disseminated through a silicate gangue.

A drift was to be started on the 90 foot level in 1909. Up to then a total of 2,000 tons was shipped averaging 7% Cu that was practically unsorted. More was shipped later because Wilcox reported in 1917 that production was about 600 tons per month whilst later that year he stated that the ore was practically worked out to the shaft depth of 150 feet.

The records of the R. Lowe estate show that 11,450 tons averaging 6% Cu and $3 in Au and Ag were shipped to Anyox from 1915 to 1917. There was a barren zone between the 125 and 150 levels but diamond drilling showed ore at 300 feet. When the mine closed down in 1919 there were between 2,000 and 5,000 tons of milling ore on the dump.

The total net profit from this mine was $200,532.

A R C T I C C H I E F .

Here the main deposit consists of a lens of massive magnetite containing bornite and chalcopyrite with little of the oxide copper minerals even at the surface. It was developed by an adit which outlined an ore-body 190 feet long and 35 feet wide in limestone at its contact with a dioritic intrusive. According to an assay plan by F. M. Bates dated August 1916 the average grade of three cross-cuts is 2.6% Cu, 0.05 oz gold and 1.0 oz silver.

A second tunnel about 30 feet below the first cross-cut the formation but failed to find ore which however could be raking to the north or to the south. A raise connects the two levels and shows that the ore ends in diorite at 15 feet below the upper level. A tonnage of 25,000 can be estimated above this elevation.

In 1917 Wilcox sampled the mine and estimated the same tonnage with a grade of 2.57% Cu and $0.99 in precious metals with gold at $20 and silver at $0.70 per ounce. He recommended diamond drilling to increase the ore

reserves but this was not done.

On the top level the main drift was continued north beyond a fault that appears to limit the ore but in 210 feet only sporadic values are recorded.

Mr. Brynelsen reports that the ore-body has not been stoped and even the dumps appear to be intact.

According to Mr. McConnell ' The granites near the Arctic Chief ore-body are exceptionally mineralized. The affected area has a length of 1,000 feet following the limestone contact and a width of 400 feet. The mineralization is not uniform and gradually diminishes away from the ore-body.' This possibility should be thoroughly investigated since only a quarter of such an area would yield a million tons per 100 feet of depth for an open pit operation.

Noranda Mines carried out detailed geophysical work in the area with interesting results:

1. The original deposit gives a strong anomaly 220 feet long and averaging 50 feet wide.

2. Another anomaly that is 250 feet long and immediately to the north suggests that the limiting fault at the north end of the main ore-body has moved the ore 50 feet to the west.

3. To the south the main ore-body is cut off by a dyke 30 feet wide beyond which the magnetic and self potential anomalies suggest another 140 feet of ore.

4. About 400 feet east of the old mine Noranda drilled two holes under magnetic and self potential anomalies. I interpret the results as indicating an ore-body 180 feet long, striking N E and 15 to 20 feet wide. The two holes gave average grades of 1.5 and 1.0% Cu respectively. There is 25 feet

of overburden and the dip would be 65° S E. The country rock is limestone with diorite dykes. The gangue is partly silicates and partly magnetite. There could be 27,000 tons of ore in the first 125 feet from the surface.

5. There is still another anomaly area at 300 feet S E of the old mine at the granite-limestone contact. D.D.H. 1 appears to have intersected the ore at an oblique angle giving an average of 0.83% Cu for 41 feet. Here again the strike appears to be N E with a steep dip; the true width is probably 15 feet. It is in two segments that are separated by an E-W dyke that probably has a flat dip to the north. The S W segment is 160 feet long and the N E one is 100 feet long.

6. At 160 feet S E of this mineralized zone is a further anomaly that is parallel and has an old shaft at its S W end.

A considerable amount of diamond drilling should be done to test thoroughly the main ore-body at depth, its extensions north and south as indicated by the geophysical work and the other anomalies as described above.

B I G C H I E F A N D L I T T L E C H I E F .

The mineralization in this section lies at the contact of an elongated bay of limestone in the granite parallel to the main contact for a distance of half a mile. There has been no production from this area in which copper minerals are wide-spread but do not form high grade ore. It was investigated in considerable detail by Noranda Mines with the results given below.

A dip needle survey gave three pronounced anomalies totalling 2,400 feet out of the 2,700 feet of contact. They are referred to the Big Chief, Middle Chief and Little Chief respectively.

The original Big Chief showing is at the north end and consists of a contact zone up to 30 feet wide around a mass of porphyritic granite that forms

V-shape with limbs 450 feet long. The pronounced anomaly reflects this shape. The principal mineral is magnetite that is accompanied by copper sulphides that are partially oxidized.

Directly opposite the nose there are three trenches over a strike length of 70 feet that average:

1.46% Cu over 30 feet, 0.65% Cu over 25 feet and 0.86% over 35 feet. These give an average of 1.0% Cu over 30 feet for say 100 feet.

At 200 feet south of this another section given in two trenches that are 80 feet apart:

0.67% Cu over 55 feet and 1.1% Cu over 70 feet which average

0.90% Cu over 62 feet for say 100 feet.

The ground between these two sections appears to average only 0.40% Cu. Neither of the two were drilled but the extension south that was indicated by the anomaly was tested by D.H.C. 5 at 150 feet south of the second area. In a length of 60 feet of core three sections gave 6 feet of 1.0% Cu, 2.5 feet of 2.1% Cu and 12 feet of 0.7% Cu.

At 200 feet south of this hole is the beginning of the second or Middle Chief anomaly that is 700 feet long. At 200 feet south of its north end D. H. C. 6 was drilled towards bulldoze trench No 5 where there is an outcrop of magnetite. The hole was in granite all the way (365 feet) and so did not reach the contact.

From 200 to 300 feet further south there is an area with magnetite outcrops that has been opened up by bulldoze trench No 4 which gave an average assay of 1.47% Cu over 36 feet. D. H. C. 4 was drilled about 30 feet north of the trench and found only limited mineralization; 7 feet recovered from first 16 feet gave 0.97% Cu, 39 to 53 feet 0.70% Cu, 59 to 63 feet 1.40% Cu, 103-117 ft 0.37% Cu. D. H. C. 3 was drilled 150 feet south of the trench and

returned 0.60% Cu over 63 feet.

There is a gap between the second and third (or Little Chief) anomalies suggesting that the latter is offset 200 feet to the east.

The Little Chief has an indicated length of 700 feet and widths up to 200 feet. There is a group of three irregularly spaced bulldoze trenches that have not fully exposed the ore because of the thick overburden. No. 1 trench gave 2.3% Cu over 77 feet, No. 2 gave 0.65% Cu over 105 feet and No. 3 gave 1.2% Cu over 25 feet.

D. H. C. 1 was drilled under trench No 1 to give 35 feet of 1.0% Cu and after a gap of 21 feet another 31 feet of 0.7% Cu. A dip of 60° N toward the granite contact is indicated.

D. H. C. 2 was drilled 200 feet north of D. H. C. 1 giving three lengths of mineralization:
0.7% Cu for 21 feet, 1.5% Cu for 14 feet, 0.3% Cu for 63 feet.

The evidence presented above is not sufficient to block out ore of a definite grade but it seems probable that the Little Chief is an important ore-body that could yield one million tons per 100 feet of vertical depth by open-pit mining with a grade of at least 1% Cu.

A series of vertical drill holes on a pattern of 50 feet apart with rows 100 feet apart is suggested in order to block out ore to a depth of say 250 feet. This would involve 7,000 feet of diamond drilling at an overall cost of approximately $50,000.

A smaller program should be tried on the Big and Middle Chief anomalies but the tonnage will be smaller because of the narrower widths and an apparent dip into the granite at a shallow depth.

V A L E R I E .

The original Valerie mine is at an embayment in the contact of the granite and limestone but the magnetic survey demonstrated that it was the southernmost of a line of six anomalies along the contact over a distance of 4,000 feet, the most northerly being the Big Chief which caps the end of a large promontary of granite that has the Middle and Little Chief properties on the east side and the Valerie group on the west. The four anomalies between the Big Chief and the Valerie mine are all hidden by overburden and the one hole that was tried was lost at 92 feet without entering bedrock.

The Valerie itself was described by McConnell as being situated on a ragged contact between limestone and hornblende granite with the usual alteration to secondary minerals. There was a steeply inclined shaft to a vertical depth of 84 feet with a total of 270 feet of various drifts from the bottom. Copper mineralization is seldom absent from the contact zone where exposed. The shaft started in chalcopyrite ore 10 to 15 feet wide which ceased (or passed into the wall) at 25 feet. Short drifts to the north and northeast from the shaft bottom seem entered an ore-body 30 feet long and up to 17 feet wide.

Three lenses of shipping ore occurred on the surface while only one had been found underground by 1909. No bornite was seen by McConnell and he said that the only shipment had been 40 tons of selected ore claimed to average 12% Cu and 0.25 oz Au. However Wilson stated that the Valerie was an intermittent shipper in 1917 and Keruish gave the total net profits as $56,185 which would represent a considerable tonnage.

The magnetic survey showed an anomaly 430 feet long and striking due north over the old mine with another 280 feet long with a much larger area of lower intensity around it starting 200 feet to the N.W. A third anomaly

at another 470 feet is 500 feet long. After a gap of 400 feet there is a N W striking anomaly that is 250 feet long and at another 700 feet there is a 50 feet long anomaly.

Since the Valerie ore itself contains only a small percentage of magnetite it is interesting that definite anomalies can be obtained.

All these anomalies should be drilled using the heavy mud technique to penetrate the overburden.

N O R T H S T A R .

This prospect is 7,000 feet S E of the Valerie in a small embayment of limestone in granite. The magnetic work did not disclose any pronounced anomaly.

McConnell describes two pits 200 feet apart and each 10 feet deep. One pit is in 6 feet of magnetite and calcite flecked through with chalcopyrite and bornite; occasional masses of chalcopyrite up to 12 inches in diameter are present. The second pit shows a copper stained magnetite lens 3 to 4 feet in width dipping towards the granite. Both the granite and the limestone are mineralized over a considerable area on either side of the contact.

There are other undeveloped prospects between the North Star and the Valerie and also for the 12,000 feet south to the Copper Cliff. McConnell briefly mentions ' the Buckingham, Meeden, Jo Jo, Yukon Belle, Josephine and others as containing ore out-croppings of more or less promise'.

The next 12,000 feet to the S E is devoid of prospects.

C O P P E R C L I F F .

The following is taken verbatim from McConnell:

' The principal showing on the claim occurs at the northern contact

of a small area of limestone with granite, and has been opened up by a short tunnel. The ore body is cut across, and partially destroyed by a large porphyrite dike. The section along the tunnel shows three bands of ore, each from 3 to 5 feet in width, separated by dike rock. The ores consist of bornite, and chalcopyrite, with garnet as the principal gangue mineral. Magnetite, tremolite, and various other secondary minerals are present.'

There appears to be no further record since the above was written.

K E E W E N A W .

This is an important though isolated prospect at the south end of the belt on the east side of Wolfe Creek. It was trenched, mapped, sampled and diamond drilled by Noranda with the following notable results:

There is a mineralised contact zone which is exposed in an irregular manner by trenches and pits over a N W aligned area 1,000 by 400 feet. There are many late dykes striking E S E that could amount to 30% of the volume explored so far.

At the north end two E-W trenches and a crossing N W trench give an average of 1.00% copper for an area of about 125 by 100 feet. A series of three open-cuts about 50 feet further south give an average of 1.21% Cu over 110 feet assuming nil for two gaps totalling 25 feet.

With 50 feet added each way north and south an area 200 long and by 125 feet wide averages 1.15% Cu. 75 feet east of this a N-S trench averages 0.46% Cu for 82 feet.

A N-S trench immediately S W of this area averages 1.30% Cu for 126 feet. There is insufficient evidence as to whether these values strike as far to the east. If they do then the area becomes 350 feet long and 125 feet wide.

Some good values have been uncovered further south however so that there is the probability of an area 300 by 150 feet wide without limits so far on three sides. This area could give three quarters of a million tons per 100 feet vertically.

Isolated pits and cuts show that mineralization is present for another 300 feet to the south.

Four diamond drill holes put down by Newmaks in the trenched area suggest that the zone is 175 feet wide and dips 65° E.

No 1 hole was drilled at -45° to the E so that it cut the presumed dip of the ore very obliquely. In 220 feet, after excluding one section of 40 feet of dyke, an average grade of 0.37% Cu was obtained. At 170 feet vertically below the surface the hole passed into the footwall.

No 2 hole at -45° E was in values for 95 feet before entering what is thought to be the footwall. Of this distance 67 feet was either dyke or non-mineralised granite. The 28 feet of mineralised rock averaged 0.5% Cu.

No 3 hole was drilled at -45° W leaving a gap of 45 feet from No 2 hole. Here the hole passed through the hangingwall at 60 feet and of this distance the first 29 feet was dyke and another 15 feet was non-mineralised. The remaining 16 feet averaged 1.13% Cu.

No 4 hole was at -45° S but only the assayer's sheet is available at present. Assuming each of the values represents 5 feet the average would be 1.49% Cu for 125 feet diluted by an unknown amount of dyke.

Mr. Brynelsen reports that core recoveries were poor, especially where the friable bornite was encountered so that values are probably below the actual.

No geophysical work has been done here and it is doubtful if that a magnetic survey would respond but a self potential survey should at least define the higher grade sections and could be useful now that the habit of

the dykes is known.

With the distinct possibility of developing two and a half million tons of 1% or better copper ore in a block 300 by 175 by 300 feet deep that would be available for an open-pit operation it is suggested that vertical holes spaced at 50 feet intervals in six E-W lines at 100 feet apart are drilled. This would total 7200 feet.

To obtain a good core recovery A size should be drilled.

The drilling together with engineering and assaying would probably cost $50,000.

If successful this drilling would be extended both to the north and to the south.

B L A C K A N D B R O W N C U B S .

McConnell states that from the Keweenaw east to the Black and Brown Cubs the country is heavily drift covered but at the latter prospect the granite and limestone are again seen with an altered garnetized zone fully 300 feet wide along the contact and heavily copper-stained at a number of points. There are two shafts, one 62 feet deep that was sunk through a garnet-augite-tremolite rock carrying some rich bornite ore.

This is the last property known at the south end of the copper belt. It is probably the one drilled recently by Hudson Bay Mining & Smelting.

G E O P H Y S I C A L P R O S P E C T I N G .

1. An air-borne magnetometer survey would provide a quick answer to the possibilities in the large sections of potential ground that are concealed by overburden. Some understanding should be arrived at with the company doing this work that the same ground would not be flown for another mining company this season. Any anomalies found would have to be staked immediately.

It is likely that once a start is made on the large scale exploration recommended in this report some other mining company will 'fly' the area so that it is important to do this work soon.

2. Dip needle or preferably magnetometer surveys should be done on those properties that were not held by Noranda and also to follow up any aerial magnetometer results.

3. In areas that are thought to be essentially devoid of magnetite but still contain valuable sulphides it is advisable to conduct self potential surveys.

D I A M O N D D R I L L I N G .

The experience gained by Noranda Mines shows that the procedure outlined below should be followed:

1. Drill A size instead of the usual E size so as to get a better core recovery in friable ground.

2. Use the heavy mud technique to penetrate thick overburden.

3. Take proper sludge samples at all times.

M I N I N G .

An attractive feature about the Whitehorse Copper Belt is the possibility of open-pit mining of large ore-bodies that will give low unit costs. Any small deposits that have to be mined more expensively from underground would at least have the advantage of cheap milling in the large mill required for treating the open-pit ore.

One important draw back to open-pit mining will be the handling of broken rock in freezing weather if the ore is at all wet. However similarly

situated properties are operating successfully so presumably it is not an overwhelming problem. It may be possible to switch to underground ore-bodies during the severe weather.

Another problem will be maintaining a sufficient labour force especially in the winter.

It may even be best to plan on closing down for say 3 months every winter similar to the dredging operations in the Yukon so that the staff and crew can go south.

T R E A T M E N T .

In the past these ores were smelted direct. Today it is normal practice to mill such sulphide ores and to ship the concentrate to a smelter. At present the nearest smelter is at Tacoma but within two or three years it is expected that Granduc Mines will be erecting a smelter for producing blister copper at Stewart, B. C. which is much closer.

An unknown proportion of the copper in the ore that was shipped was in the form of oxide minerals. It will be important to observe if an appreciable amount is present in the ore-bodies as they are being drilled and if so to determine the proportions by assay. Special test work will then be necessary to determine a suitable flow sheet that will recover both the sulphide and oxide minerals.

A S S A Y I N G .

A large number of samples will be taken from the diamond drill cores so that it will be advisable to consider setting up an assay office to handle the samples. The two public assay offices in Vancouver will undoubtedly be swamped with work this year owing to the record activity on many copper properties.

V A L U A T I O N A N D C O S T S .

The true value of the ore will depend on the mill recovery, the grade of the concentrate, transportation and the price paid by the smelter.

Assuming an average mine grade of 1.0% copper, a 95% recovery and a 35% copper concentrate it is expected that with copper at 45¢ the smelter would pay 39¢ which is equivalent to $7.40 per ton mined. The gold and silver should bring this up to $8.00 per ton mined. Also molybdenite and magnetite are possible by-products.

With a milling rate of say 3,000 tons per day it should be possible to operate an open-pit mine and mill for a total of $4.00 per ton. The write-off for plant and equipment could be high depending on the tonnage available. It should be possible however to prove up sufficient ore to depreciate it at $1.00 per ton leaving a net profit of $3.00 per ton.

If the mine grade was only 0.6% Cu or if the price of copper was only 27¢ then with the above figures the profit would be reduced to zero.

R E C O M M E N D A T I O N S .

1. An aerial magnetometer survey would be invaluable to obtain a quick view of the possibilities in the areas of heavy overburden in the known 18 miles of strike and in any extensions at each end.

2. A detailed diamond drilling campaign using A size core should be be started as soon as possible on the Little Chief and the Keewenawan deposits where the results obtained by Murgoda Mines suggest the possibility of developing several million tons of 1.0% Cu or better that could be mined by an open-pit.

3. Exploratory drilling should be done on the Valerie group of anomalies

and on the Arctic Chief.

4. Geological and geophysical work should be started as soon as possible on the promising Best Chance, War Eagle and Copper King deposits so that they can be diamond drilled this year.

5. The remaining sections of the ore-bearing belt can then be investigated in turn.

6. At least $250,000 should be made available to carry out the above program this year.

7. A good staff is essential to the success of this exploration work and owing to their scarcity an early start should be made to engage suitable men. I suggest that a senior exploration engineer or geologist is placed in charge with three assistant geologists, two geophysical operators, one surveyor and one assayer.

8. Five diamond drills should be allocated as follows:

A. Two machines on double shift on the Rossmany with a geologist to log, sample and draw up results of the drilling. He would also be mapping the Brown and Black Bear area at the same time.

B. Two machines on double shift at the Little Chief and one machine on double shift on the Valerie anomalies with a geologist logging and sampling ore.

C. One machine on double shift at the Arctic Chief with a geologist who will also be mapping the area that includes the Best Chance, Grafter, Empress of India etc.

NOTE:

If this report is published it is respectfully requested that no deletions or additions are made without the writer's consent.

TABULATION OF PROPERTIES ALONG THE WHITEHORSE COPPER BELT

Name	Distance from Pueblo - feet	Known Ore-Bodies							Shipped Tons
		Long ft.	Wide ft.	Deep ft.	Strike	Dip	Tons	Grade % Cu.	
War Eagle	6,500 W	2-250 40	6 6	100 10					4,245
Anaconda	11,000 NE	100	12	30					
Rabbit Foot	10,000 NE		367						
Copper King	8,000 NE	1,000	30	100	NASW	25W			5,788
Carlisle	8,500 NE			90					93
Pueblo	-	500	60	500	W	75E			140,000
Pueblo N. Extn.	150 W	50	5?	250				5?	
Pueblo Prospect	700 NE	300	30?	130	NEOE			5?	
Spring Creek	19,000 S			43					
Empress of India	19,800 S								
Retribution	20,000 S	50							
Best Chance	20,500 S	360	30	35					
Little Johnnie	20,500 S								
Grafter	21,900 S	150	10	90		V.			13,450
Arctic Chief	25,500 S	190	25	30	NAOW	?	25,000	2.6	?
" " N.	25,300 S	250							
" " S	25,700 S	140							
" " E	25,600 S	100	17	125	NE	85NW	27,000	1.25	
" " SE	25,800 S	260	15		NE	85NW		0.83	

CORRELATION OF PROPERTIES ALONG THE WHITEHORSE COPPER BELT (CONT.)

Name	Distance from Pueblo - feet	Known Ore-Bodies							Shipped
		Long ft.	Wide ft.	Deep ft.	Strike	Dip	Tons	Grade % Cu.	
Big Chief	38,000 S	900	50	?				0.5% ?	
Middle Chief	38,600 S	700	70					0.8 ?	
Little Chief	39,600 S	700	150		N30W	60W		1.0 ?	
Valerie	43,000 S	450	12	84	N	80?			400
NW	42,800 S	380							
S #1	42,800 S	300							
N #2	41,000 S	250							
N #3	40,000 S	50							
Morgan Star	47,000 S		6	10					
Copper Cliff	39,000 S		10						
Keewatin	72,000 S	300	175	100	NW	65E	?	1.0 ?	
Black & Brown Claim	10,000 E of Keewatin			62					

Grade Oz/T	Net Profits $	Anomaly Mag.	Anomaly E-M	Rock	Minerals Ore	Minerals Gangue	Source	Remarks
7	63,370			Lat	Br Cp Mo	Sil	GSC LE	In zone 1000 by 250'
	3,968			Lat	Br Cp	Sil Tra	GSC LE	Amt. Shipped unknown
				Lat	Br		GSC	
10.8	88,079			Lat	Br Cp Mo	Tra	GSC LE	
23	12,896			Lat	Br	Tra	GSC LE	
51	576,552			Lat	Br Cp Mo	Mag	GSC LE Nor Wh	
							Nor Wh	D.D. only
				Gr			Nor wh	D.D. only
				Gr Lat	Br Cp	Mag Sil	GSC	
				Gr Lat	Br Cp Mo	Mag Sil	GSC Wi	Small shipments
				Gr	Br	Mag	GSC	
				Lat	Br Cp OX	Mag	GSC	
6	308,932			Lat	Br Cp	Sil	GSC LE	
	4,146	X	X	Lat	Br Cp	Mag	GSC Wi	
		X	X					Anomaly only
		X	X					Anomaly only
		X	X					Anom & D.D.
		X	X					Anom & D.D.

Hole No.	Tot Profile ft.	Anomaly Mag.	Anomaly E-M	Rock	Minerals Ore	Minerals Gangue	Source	Remarks
		X		Lst	Br Cp	Mag	GSC Mor	
		X		Lst	Br Cp	Mag	Mor	
		X		Lst	Br Cp	Mag	GSC Mor	Possibly large
8	36,185	X		Lst	Cp	Sil	GSC Mor Wi LE	
		X						Anomaly only
		X						" "
		X						" "
		X						" "
				Lst	Cp Br	Mag Cal	GSC	
				Lst	Br Cp	Gar	GSC	
				Gr	Br Cp	Sil	Mor	Possibly large
				Lst	Cu	Sil	GSC	

Abbreviations used above:

Lst	Limestone	Sil	Silicate
Gr	Granite	Trm	Tremolite
Cp	Chalcopyrite	GSC	Geological Survey of Canada
Br	Bornite	Mor	Noranda Mines
Cu	Oxide of Cu	Le	Love Estate
Mag	Magnetite	Wi	Wilson
Mo	Molybdenum	Wh	White
Hem	Hematite		