Becker Cochrane

Petrology + Mineralogy
of the Yukon Sb, stibnite
Deposit
Y.T. 005307
(Becker Creek)
J.J. Hylands 1966

PETROLOGY AND MINERALOGY OF THE YUKON ANTIMONY STIBNITE DEPOSIT YUKON TERRITORY

A thesis submitted during the final year in the Faculty of Applied Science, Department of Geological Engineering, at the University of British Columbia.

J. J. Hylands

April 7, 1966

CONTENTS

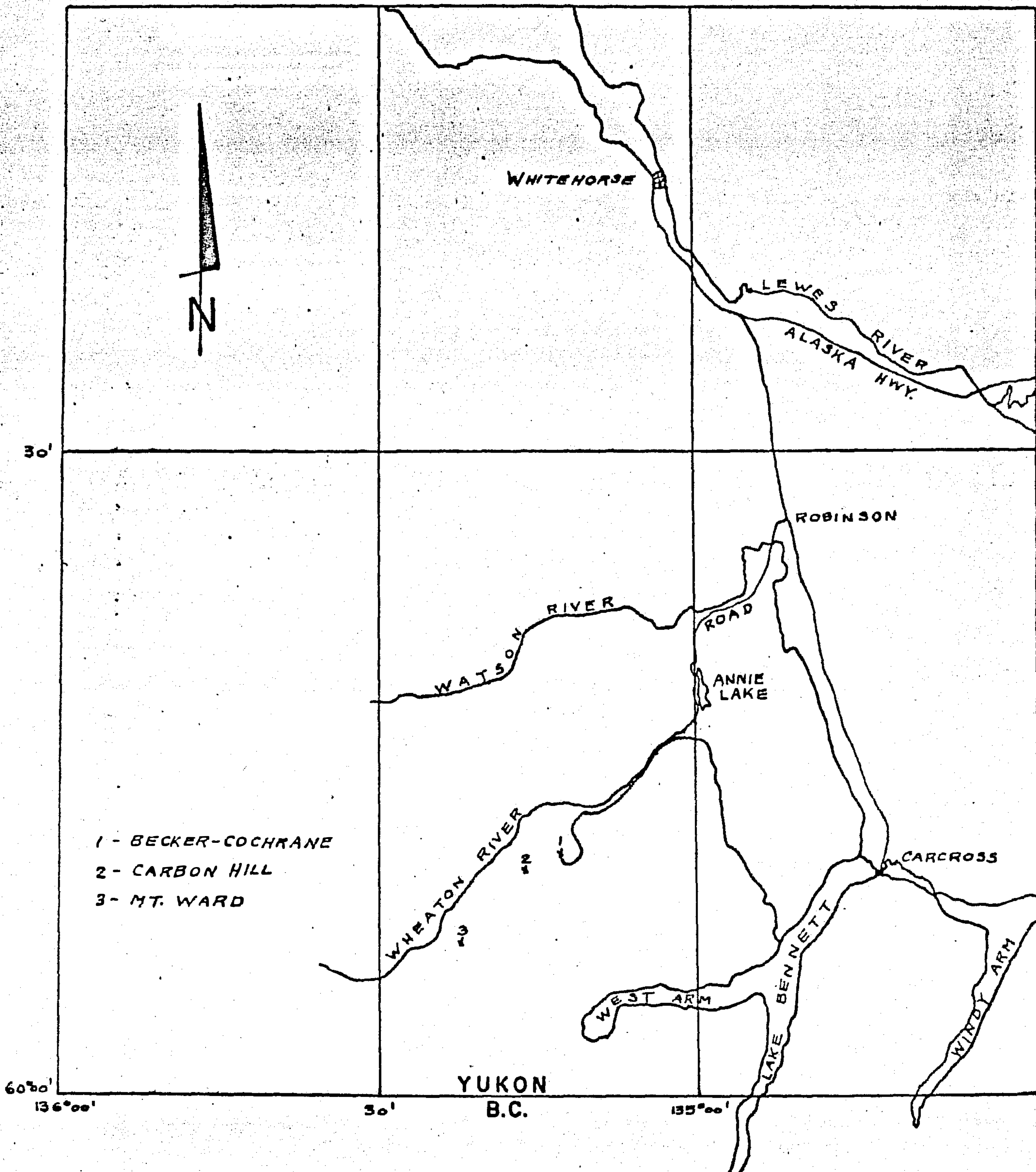
	Page
Illustrations	ii
Acknowledgments	iii
Abstract	iv
Introduction	1
Location and Access	1
Topography	2
Brief Property History	5
Geology	6
General Geology	6
Property Geology	10
(a) Rock types and relationships	10
(b) Mineralogy	20
(c) Structural control and paragenesis	24
Conclusions	26
Bibliography	28
Appendix	29
Diamond Drill Section AA	30
Table II - Comparison of Jarosite Lines	31
Table III - Chemical Analyses of Head Samples	31
Vandeveer Diagram	32
Outcrop Map, 1" = 200'	in pocket

ILLUSTRATIONS

Title	Page
Location map	preceding page 1
Plate 1 - Typical Wheaton River area topography - gently rounded talus-covered hills of about the same elevation with steep, talus-covered sides. Taken from Carbon Hill, looking northeast.	3
Plate II - View eastward along Conglomerate Creek towards the west flank of Mt. Anderson. The strand lines are barely visible left of center. Note V-ed stream valleys, constant slope angles.	3
Plate III - Wheaton rhyolite, extensively silicified. Note "worm-eaten" quartz. Width of field = 125 microns, X-Nicols	11
Plate IV - Typical Wheaton rhyolite, with sericite alteration and pilotaxitic texture. Width of field = 125 microns, X-Nicols	11
Plate V - Twinned hornblende, center of photograph. Light grey patches on phenocrysts are sericite, dark patches are hornblende. Width of field = 125 microns, X-Nicols.	15
Plate VI - Phenocrysts in Hutshi rhyolite replaced by calcite and iron oxide. The euhedral outline of the feldspar can still be seen. Width of field = 125 microns, X-Nicols	15
Plate VII - Blue-grey gouge on the hanging wall of the shear zone. The present adit was collared just to the right of the ladder.	19
Plate VIII - General view of the shear zone and stripping.	21
Plate IX - Stibnite (white), sphalerite (light grey), and quartz (darker grey). Note euhedral quartz grains and stibnite embaying quartz. Width of field = 226 microns.	23
Plate X - Barite in stibnite, width of field = 226 microns.	23

ABSTRACT

Movement caused by intrusion of the Coast Range batholith fractured and sheared a rhyolite dyke, presently exposed east of Carbon Hill, Wheaton River District, Yukon Territory. The fracture acted as a channel way for mineralizing solutions emanating from the magma, which deposited quartz and stibnite within the zone at a high level in the crust. Glaciation of the Late Tertiary terrain has exposed the zone. Subsequently there has been alteration of both the mineralization and the host rocks.



LOCATION MAP

SCALE : 1" = 8 MILES

Distinguish streams from roads

INTRODUCTION

LOCATION AND ACCESS

The Becker-Cochrane stibnite deposit held by Yukon Antimony Corporation Limited is on the east side of Carbon Hill, 61 miles by road from the city of Whitehorse, Yukon Territory (Location Map, previous page). The co-ordinates of the showing are 135°13'39" West Longitude and 60°11'09" North Latitude. It is at an elevation of 5300 feet, at the head of a tributary which flows into Conglomerate Creek, thence into Becker Creek and the Wheaton River.

The main camp of Yukon Antimony during the summer of 1965 was on the east side of Becker Creek one half mile south of its intersection with the Wheaton River. Access to this camp was by 25 miles of good to excellent gravel road from Whitehorse to Robinson, and a further 25 miles of fair to good gravel road from Robinson.

Access to the property from the main camp was by six miles of fair to poor gravel road. During June this road was almost impassable. The last mile had a grade of approximately 25%, which limited its use to four-wheel-drive vehicles and crawler tractors.

TOPOGRAPHY

The highest point in the vicinity of the property is Mt. Bell (6415 feet), south of Conglomerate Creek. The surrounding hils are well rounded, with maximum heights of about 6100 feet. The angle of repose of the talus on the hillsides is 35°, remarkably constant throughout the area. To the west of Carbon Hill, overlooking the Wheaton River and Antimony Creek, the slopes are mostly bare rock, with slope angles of 40° to 50°.

The general impression is that at one time this area was a mature lowland which was rapidly uplifted and has since been deeply dissected by streams. Cairnes dated this uplift as Late Tertiary (D. D. Cairnes, 1915, page 413). This region has undergone two still-distinct periods of erosion, the first shown by the gently rolling uplands and the second by the steep-walled valleys and rapidly flowing streams which drain the uplands. (Plates 1 and 11, page 3).

Ice and water have created and are modifying this topography. Permafrost breaks the rock, water (and gravity) moves the fragments. At least 75% of the ground cover is talus. Depth to the frost line in the talus varies between three feet and twelve feet, depending on whether the slopes face northeast or southwest. Up to 30% of the solid material at the frost line is ice. The rock fragments within this ice "matrix" seldom exceed 18 inches in any dimension, and average four to six inches. The size of the talus is surprisingly constant from ridge crest to valley bottom. Fine material (mud to sand sizes) is concentrated above the frost line.

Plate I
Typical Wheaton River area topography - gently rounded talus-covered hills of about the same elevation with steep, talus-covered sides. Taken from Carbon Hill, looking northeast.

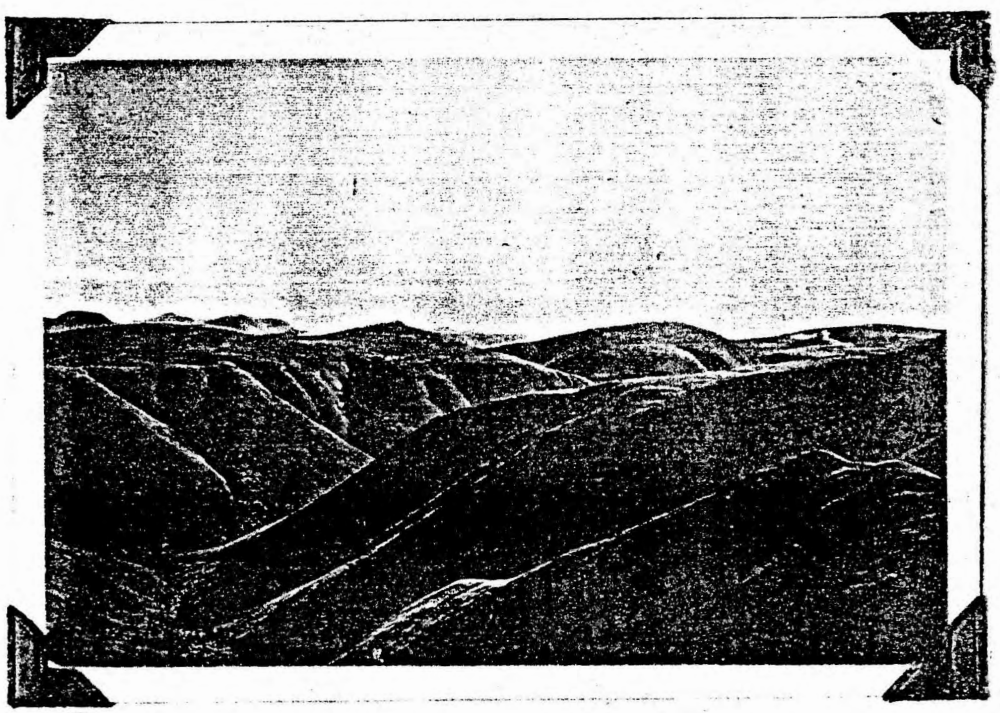


Plate II
View eastward along Conglomerate Creek towards the west flank of Mt. Anderson. The strand lines are barely visible left of center. Noted V-ed stream valleys, constant slope angles.

As the snow cover melts during the Spring, material is steadily moving down-slope. This is particularly noticeable because material accumulates in side-hill road cuts. Movement occurs in two ways. The greatest volume is moved by mudslides in small gullies on the hillsides. As the meltwater moves beneath the talus into runoff gullies it carries fines. The density of the resulting fluid increases until it is capable of picking up and carrying six inch pieces of rock down to the creeks. These mudslides are most noticeable during late June and early July.

The second mechanism involves the melting of the winter ice, allowing the talus fragments to move to fill the voids. This slight movement is often enough to dislodge pieces of rock. Once momentum develops, rock slides form. This mechanism is responsible for most of the larger talus at the bottom of the slopes. During the latter part of July and early August large pieces of talus came to rest on the hillside roads almost as fast as they could be removed. On any quiet day the movement was clearly audible and often visible, as rock fragments rolled and bounced down the slopes.

The U-shape of the major river valleys is evidence of glacial action. The bottoms of these valleys are mantled with till and gravel. There are well marked terraces of glacial debris both north and south of the Wheaton River. On the southwest flank of Mt. Anderson, extending south above Becker Creek, are two parallel strand lines formed by an ice-dammed lake, probably Glacial Lake Bennett. South of the juncture of Conglomerate Creek with Becker Creek, and at the same elevation as the strand lines, is a delta. It has been deeply incised by a post-glacial stream. Most of the streams on Carbon Hill, if not all, are post-glacial, with V-shaped valleys and steep gradients.

BRIEF PROPERTY HISTORY

The stibnite showings on Carbon Hill were first found in 1893 by two prospectors, Frank Corwin and Thomas Kirkman, heading overland from Bennett Lake to the goldfields to the north. The location of these veins was lost with the death of Corwin and Kirkman, and they were not relocated until 1906. The old workings were discovered by H. E. Porter, on the south-west and west sides of Carbon Hill, and 18 claims were staked by him.

The first mention of the Carbon Hill Becker-Cochrane property is in Cairnes Report of 1915 (Cairnes, 1915, page 423), where it is noted that Theodore Becker and Howard Cochran owned a claim probably situated over the present lower pit. Between 1926 and 1940 an adit had been driven approximately 100 feet (Cockfield, 1926, page 46 and Bostock, 1941, page 35). There is no mention of further work until 1940 when Walter McAlister acquired the property. When J. O. Wheeler visited the property in 1951 (Wheeler, 1961, page 132) McAlister and Jim Cox were doing further exploratory work, which consisted of cleaning old trenches and the adit. Cox held the property after McAlister's death, but let the claims lapse when he could not option them.

In 1960 Cox restaked the area but never recorded the claims (personal communication). During the winter of 1963-

1964 most of Carbon Hill was staked for Yukon Antimony Corporation. Some stripping was done during the Fall of 1964, and a full program begun in May of 1965. The stripping and drifting revealed a mineralized shear zone approximately 1,000 feet long and seven feet wide, with a minimum vertical extent of 400 feet.

GEOLOGY

GENERAL GEOLOGY

The Wheaton District is underlain by Coast Range intrusives, mainly granite and granodiorite with some quartz monzonite and quartz diorite. These rocks were probably emplaced at different times (Wheeler, personal communication) although they have been placed in the Middle Cretaceous Epoch. This complex of granitic rocks contains inclusions of older rocks and is intruded by younger ones.

The oldest rocks in the vicinity of Carbon Hill are the Yukon Group, possibly Precambrian, probably Paleozoic in age. These are metamorphic rocks, mainly sericite and chlorite schists with quartz gneisses, hornblende gneisses and altered basic volcanics. The Yukon Group rocks occur as pendants in the Coast Range intrusives south of Mt. Bell and Conglomerate Creek, northwest of Carbon Hill, between Carbon Hill and the Wheaton River, east of Mt. Anderson and elsewhere. One small body of hornblende gneiss occurs about 1,000 feet north of the mineralized zone, and another about 2,000 feet east. Both are exposed in stream beds.

Overlying the Yukon Group, in order, are the Late

Paleozoic Taku Group, Late Triassic Lewes River Group, and Early Jurassic Laberge Group, none of which have been identified on Carbon Hill.

Next in the sequence is the Late Jurassic (?), Early Cretaceous, Tantalus Formation. This formation is composed of arkoses, siltstones, argillites, and conglomerates, with a few coal seams. Scattered occurrences of Tantalus chert pebble conglomerate crop out on Carbon Hill and Mt. Bell.

Intruding the conglomerates are basic and acid intrusions of the Early Cretaceous Hutshi Group. They were not found in contact with granite on Carbon Hill. This group is represented on Carbon Hill by flat lying andesite flows which, to the east, are believed to be related to steeply dipping, westerly trending andesite dykes. Paralleling the andesite dykes are relatively narrow rhyolite dykes.

Some of the Coast Range intrusives were emplaced about this time, as they have been intruded by the Early Tertiary Skukum Group of volcanic rocks - flows of andesite, basalt, and rhyolite, with associated breccias - north and west of the Wheaton River. None of the Skukum Group have been positively identified on Carbon Hill.

The Youngest rocks in the area have not been assigned to a group or formation. These are the Tertiary, probably Miocene, rhyolites. They form extensive outcrops in the vicinity of the Becker-Cochrane property, and occur as large outcrops and swarms of dykes elsewhere. Cairnes originally called these the "Wheaton River Volcanics" (Cairnes, 1915, page 417), but Wheeler has apparently placed them in the Skukum

Group (Wheeler, 1961, page 78). Cairnes on his map of 1915 shows the acid volcanics intrusive in the Skukum Group, although he did not call them this. Comparison of Cairnes' description of these acid volcanics (Cairnes, 1909, page 332) and of Wheeler's minor intrusive rocks (Wheeler, 1961, page 101) leads the author to believe that they are the same and hence of Late Tertiary age. For the purposes of this paper these acid intrusions will be called the Wheaton Intrusives.

There are scattered occurrences of sulphide mineralization, principaplly stibnite, on Carbon Hill. The stibnite occurs in (1) quartz-barite-stibnite veins, with minor jamesonite, zinkenite, tetrahedrite and chalcostibite, which intrude the Coast Range granites, and (2) a quartz-stibnite vein in a gouge-filled shear zone, cut by Wheaton Volcanics. Thus the mineralization is post Late Cretaceous, pre Early Tertiary.

PROPERTY GEOLOGY

(a) Rock types and relationships

The Becker-Cochrane property was mapped by the author during the summer of 1965, with the assistance of Ron Von Vogt, a high school student from Whitehorse. Because of the relief and lack of trees a plane table was used on a control grid surveyed by triangulation and stadia. The mapping was done to a scale of 1" = 50' and then reduced to 1" = 200'. The final map (Appendix, in envelope) is an outcrop map only. Because of the fractured nature of all outcrops contacts are, at best, approximate.

Fifty percent of the "mine" area outcrop is Wheaton Intrusives. These rhyolites are buff to light rusty brown fine-grained intrusions. They are characteristically slightly porphyritic, rarely becoming rhyolite porphyries. Iron oxide staining is visible on all weathered surfaces, but very little pyrite was found. On cross-sections weathered rock is marked by concentric rings of iron oxide which become surfaces in three dimensions. This layering often resembles flow banding or bedding. There are no visible mafic minerals in hand specimens to account for the iron oxide.

Two large dykes of Wheaton rhyolite intrude a shear mineralized by quartz and stibnite a wide dyke in the upper pit area and a narrower one in the lower pit. The upper rhyolite looks fresh, even at the contact with the mineralization. The lower one is extensively fractured and altered at the rhyolite-mineralization contact. The two dykes are approximately parallel to each other and to the regional northeast-southwest trend of other rhyolite dykes. The upper dyke has a lobe which extends southeast into the mineralized zone.

A thin-section made from a specimen from the tip of this lobe shows that the rhyolite has been extensively silicified (Plate III, page 11). There is no visible orthoclase left in the groundmass. Secondary quartz has a wormy appearance because of inclusions of albite. Plagioclase in phenocrysts and as inclusions in the quartz has been moderately sercitized. Albite has a dull appearance, with no evidence of zoning. Primary quartz is clear, with an anhedral granular texture.

The mode is:

Introduced quartz,

with feldspar inclusions	- 79.5%
Albite in phenocrysts	- 8.0%
Sericite	- 7.0%
Primary quartz	- 4.5%

Many grains of primary quartz have "worm-eaten" rims. There has been some replacement of primary quartz by secondary quartz. The primary quartz average percent is low, and the secondary quartz average percent high, by about five percent. The secondary quartz is approximately 35% albite inclusions. Assuming that five percent of the secondary quartz is altered primary quartz, that the remaining secondary quartz represents original orthoclase, and that sericite replaced albite, the original mode was probably:

Orthoclase	- 50.0%
Plagioclase	- 40.0
Quartz	- 10.0

No mafic minerals were found. From the reconstructed mode the rock would appear to have been a porphyritic quartz latite.

Specimens from locations away from the dyke contacts gave a much more rhyolitic mode. The colouring and weathering characteristics of this rhyolite resemble those of the rock just described. It is fine-grained and composed essentially of quartz and feldspar, with scattered small (1/8") euhedral phenocrysts of albite. The albite and groundmass are slightly to moderately sericitized, the greatest concentration of sericite occurring along fractures (Plate IV, page 11) . The presence of sericite alteration indicates that the solutions

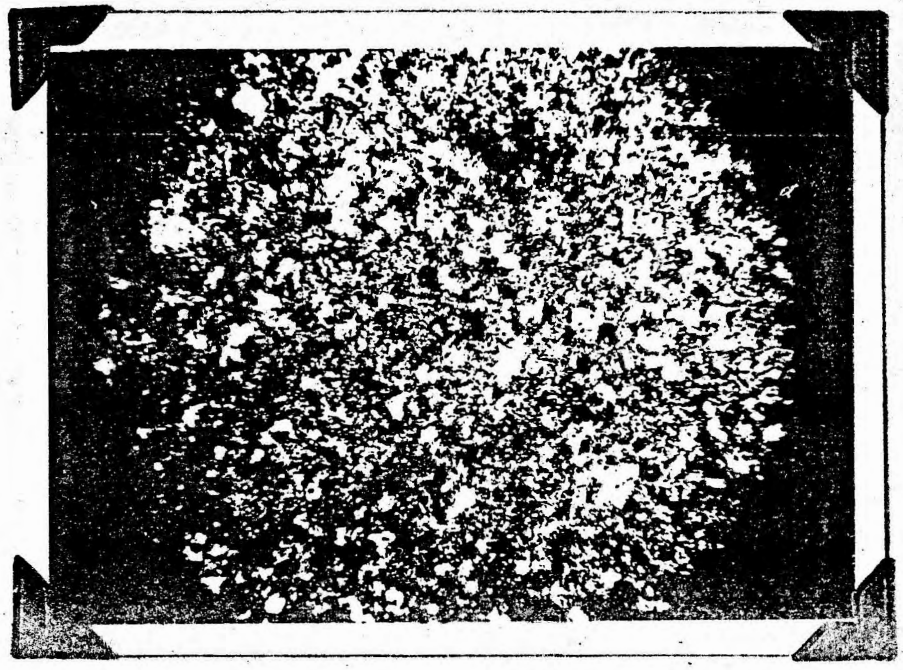


Plate III - Wheaton rhyolite, extensively silicified. Note "worm-eaten" quartz, euhedral feldspar phenocrysts. X-Nicols, width of field - 125 microns.

Plate IV - Typical Wheaton Rhyolite, with sericite alteration and pilotaxitic texture. X-Nicols, width of field = 125 microns.

which caused the alteration were alkaline. Iron oxide occurs as euhedral pseudomorphs after pyrite (?), and as irregular dendritic deposits, with the greatest concentration also along fractures. The presence of iron oxide without chlorite suggests a very low original mafic mineral content. Rusty looking flakes of biotite were seen here and there, but the overall mafic mineral content is much less than one percent. It is probable that any mafic minerals that were present have been altered to pyrite and/or iron oxide (plus clay and quartz).

Under crossed nicols the groundmass texture is "felted" rather than granular. Grain boundaries are very indistinct, with the exception of some of the quartz grains. With plane light the rock is spotted because of round grains of altered brownish feldspar. The mode of such a fine grained rock is difficult to determine. Twenty percent of the feldspar appears to be albite, the rest orthoclase. Quartz varies between 10% and 15%. Thus the rock would be close, in composition, to potash rhyolite. The flat appearance and lack of zoning of the albite phenocrysts suggests albitization, as phenocrysts in potash rhyolite are usually zoned andesine or oligoclase. Albitization has thus released calcium.

The next most abundant rock is andesite of the Hutshi Group. Much of it is dark greyish-green, medium grained and porphyritic. Phenocrysts are unzoned andesine containing small irregular grains of pyroxene, probably augite, and hornblende, much of it twinned euhedral laths (Plate V, page 15). All the plagioclase has been moderately sercitized, but not appreciably albitized. Where andesine and hornblende crystallized together there is a sericite halo in the andesine around the hornblende. Augite grains, in feldspar and in the groundmass, are commonly surrounded by hornblende. Hornblende also occurs as very irregular grains in the groundmass.

Very fine-grained magnetite is disseminated in the groundmass, and larger sub-angular to rounded grains of pyrite are scattered throughout. A few phenocrysts replaced by hornblende contain pyrite. The groundmass is very fine-grained, with a pilotaxitic to felted texture. Individual microlites of feldspar can occasionally be distinguished.

The mode of this rock is:

Groundmass	- 45%
Andesine	- 37
Hornblende	- 11
Pyrite	- 5
Augite	- 1
Magnetite	- 1

Within about 20 feet of the Wheaton rhyolite the andesite becomes slightly silicious and rusty maroon to mauve. The rock is hard and breaks into angular fragments. It is porphyritic, with small white to pink phenocrysts in an aphanitic groundmass.

The composition of the feldspar in the phenocrysts varies from An_{20} to An_{35}. The plagioclase has been moderately to strongly sericitized and partly albitized. No zoning is visible, and most of the plagioclase is untwinned. Narrow silicified layers cut the rock. These contain more iron oxide and fewer phenocrysts, and are a slightly paler colour, in polarized light, than the unsilicified layers. The phenocrysts in the silicious layers are the most sodic, with compositions between An_{20} and An_{30}. The groundmass is pilotaxitic throughout. The only indication of mafic minerals is light rusty patches in the groundmass.

Within five feet of the Wheaton rhyolites the andesite has been extensively silicified and sericitized. Superficially it has a granitic texture. The andesite is light rusty orange, coarse grained and extensively fractured. There is little of the original groundmass left, most of it having been replaced by sericite. The feldspar phenocrysts are untwinned, strongly sericitized, and appear to have been albitized.

All the quartz is secondary, fine to medium-grained and clear. Some grains have sutured boundaries. Many of the feldspar phenocrysts have irregular boundaries due to replacement by quartz. The fractures are filled with iron oxide, and some of the feldspars have been replaced by iron oxide. Apparently all the mafic minerals, typically hornblende in the fresher andesites, have been altered to iron oxide.

Associated with the Hutshi andesite is a rhyolite dyke, average width approximately 14 feet. This dyke occurs on the hanging-wall and foot-wall of a major shear zone. The rhyolite is typically extensively fractured and rusty near mineralization. Away from the mineralization it is very light yellowish to greenish white. It, like the Wheaton rhyolite, is porphyritic. All the phenocrystic feldspar is albite. Sixty percent of the feldspar in the phenocrysts has been completely replaced by calcite and iron oxide (Plate VI, page 15). The remainder has

Plate V - Twinned hornblende, center of photograph light grey patches on phenocrysts are sericite, dark patches are hornblende. X-Nicols, width of field = 125 microns.

Plate VI - Phenocrysts in Hutshi rhyolite replaced by calcite and iron oxide. The euhedral outline of the feldspar can still be seen. X-Nicols, width of field = 125 microns.

been moderately sericitized and partly replaced by carbonate. Most of the calcified phenocrysts retain their euhedral outlines. Small patches, possibly once phenocrysts, have been completely altered to sericite, calcite and iron oxide, and then silicified. The groundmass is finely granular, with fine disseminated sericite and crystalline quartz.

Both the Wheaton and Hutshi Volcanics intrude the older Tantalus conglomerate. One small "pendant" of conglomerate was found in the Wheaton Rhyolite. Five feet from this rhyolite-conglomerate contact there is an inordinate amount of dusty looking grey chert in the rhyolite. The silica was probably assimilated by solution and redeposited. There are very few fragments of chert in the talus below 5,000 feet. The conglomerate appears to be a flat lying horizon with a bottom somewhere around an elevation of 5,500 feet, although isolated outcrops have been found as much as 400 feet below this base in the vicinity of the shear zone (see Diamond Drill Section AA, Appendix).

The chert conglomerate consists of sub-angular to rounded chert pebbles, usually 3/4 inch to one inch in diameter, seldom greater than two inches. Some quartz is also present, but it is subordinate to the chert. This rock is well cemented, principally with silica, but some muscovite and plagioclase are also present (Wheeler, 1961, page 72). The conglomerate typically weathers to a bright yellow colour. Occasionally crimson streaks appear in the yellow. L. H. Green reported that these weathering products gave good chemical tests for alumina and iron plus alumina, respectively (Personal communication).

Scattered at various elevations in the mine area are plugs of granitic rocks. The majortiy are less than 30 feet in diameter, although one is at least 100 feet in diameter. West of the mineralized zone these are diorites, with pink plagioclase, green biotite and minor quartz. The plagioclase is albite, moderately sericitized and carbonatized. East of the shear zone there are granitic rocks, composed of microcline, quartz, sericite and carbonate. The carbonate occurs as a secondary mineral in fractures, in microcline and around quartz grains.

Because the Hutshi rhyolite is a factor in the localization of mineralization, it is necessary to be able to distinguish between it and the Wheaton rhyolite. The Hutshi rhyolite in the immediate vicinity of the mineralization is very rusty and badly fractured. Forty feet away it closely resembles the Wheaton rhyolite in colour and texture. The Wheaton rhyolite is predominantly yellow, usually with rusty bands. The Hutshi rhyolite is greyish-green on fresh exposures, yellowish on weathered surfaces. The most accurate way of distinguishing these two rhyolites was found to be with a microscope and thin-sections. The Hutshi rhyolites have been moderately to strongly carbonatized, whereas the Wheaton rhyolites contain very little to no carbonate (Plate VI, page 15).

An attempt to distinguish the two rock types with fused glass beads gave inconclusive results (Table 1, page 18). Three specimens of each rock type were pulverized to minus 200 mesh and treated with 1:1 HCl until there was no further reaction, to remove any carbonate. These six samples were then fused to give six glass beads, and the index of refraction of each determined. The following results were obtained:

Table 1 - Comparison of Indices of Refraction

Specimen number	Wheaton	Specimen number	Hutshi
17-1	1.480	12-1	1.486
27-2	1.480	10-1	1.480
49-2	1.486	167	1.486

If the carbonate had not been removed, the Hutshi rhyolite beads would have had even higher indices of refraction. The visual percent carbonate in the phenocrysts of the three specimens of Hutshi rhyolite used was:

Specimen number	% $CaCO_3$
12-1	80
10-1	80
167	50

(b) Mineralogy

The sulphide mineralization occurs in a major shear zone, which strikes N 50° W and dips between 60° SW and vertical. This shear zone has no noticeable surface expression. Once the talus is removed a grey, gouge-filled zone with red and yellow streaks is apparent. Scattered in the gouge near the surface are fist-sized to three foot boulders of massive stibnite, usually coated with red and yellow secondary minerals. Where the shear zone and a stream valley intersected a pit was excavated (the "lower pit"). The secondary minerals were still visible at a depth of

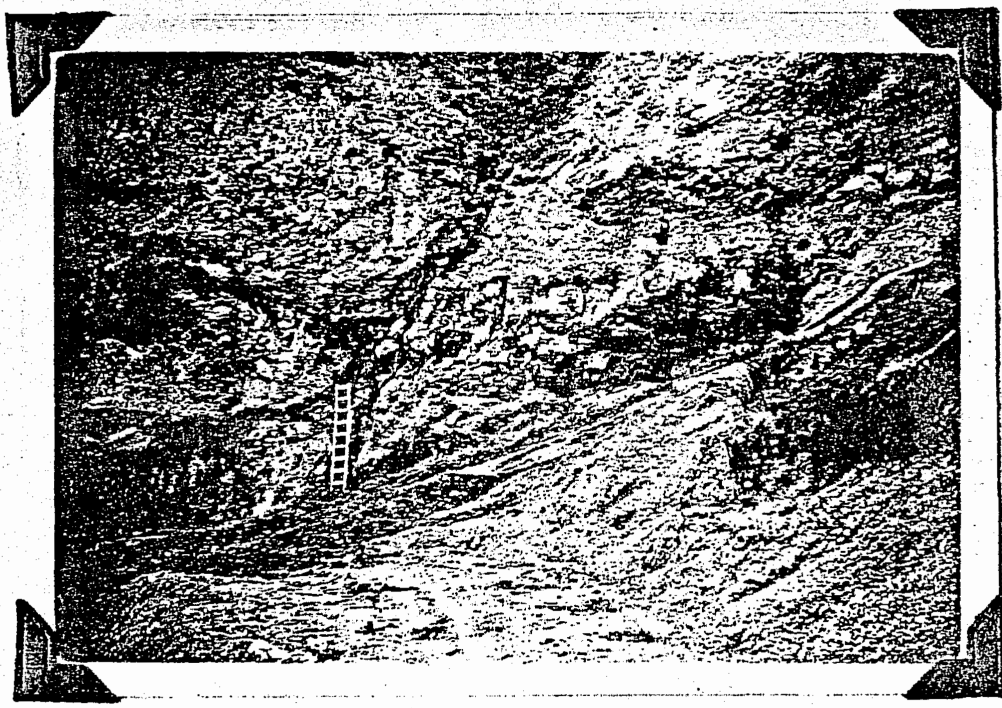


Plate VII - Blue-grey gouge on the hanging wall of the shear zone. The present adit was collared just to the right of the ladder.

30 feet, and the amount of massive stibnite increased with depth.

Stibnite, Sb_2S_3, and sphalerite, ZnS, were the only primary sulphides found by the author in mineralized specimens from the Becker-Cochrane property. Polished sections were prepared, but the stibnite was found to be very difficult to polish, due to its fine grained nature and the high percentage of quartz. The result is a stippled surface which makes observation of small features difficult. However, with crossed nicols typical fine lamellar twinning is visible in the stibnite. The stibnite has replaced quartz along fractures and has formed embayments in the quartz.

Sphalerite is not always visible in hand specimens, but the presence of zinc was indicated by a chemical analysis run by Wright Engineers, Limited, Vancouver, on material supplied by Yukon Antimony. Sphalerite is visible in polished sections (Plate IX, page 23). It occurs as distinct subhedral grains in stibnite, usually in contact with quartz. Under crossed nicols it has poor internal relection; in plane light a golden amber colour. With this colour it would be expected to contain some iron, but microchemical tests by the author on the sphalerite for iron gave negative results.

Gangue minerals visible in polished sections are quartz and barite. The quartz occurs as distinct anhedral grains and aggregates of grains with fractures and embayments filled with stibnite. Barite is found in stibnite as euhedral "rhombohedral" and rectangular grains and stringers of euhedral to subhedral grains (Plate X, page 23). These stringers do not appear to be related to grain boundaries or twinning in the stibnite.

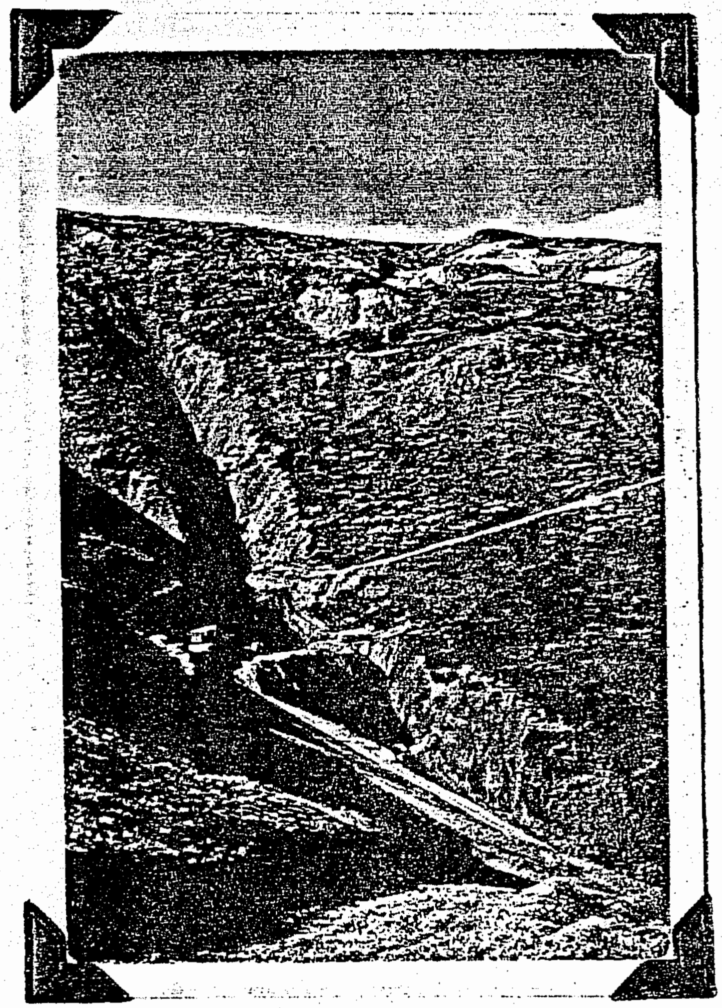


Plate VIII - General view of the shear zone and stripping.

The mode, as determined from six polished sections, is approximately:

Stibnite	- 60%
Quartz	- 39
Barite and Sphalerite	- 1

Specimens of the red and yellow secondary minerals were sent for analysis to R. N. Delabio, X-ray Laboratory, Geological Survey of Canada, Ottawa. He reported that the yellow powder was jarosite ($KFe_3(SO_4)_2(OH)_6$) from GSC film #28022. The author confirmed this, but with a certain amount of doubt (UBC film #5279). Comparisons of intensities and d-spacings of jarosite and the yellow powder are given in the Appendix, Table 2, page .

Delabio reported a great deal of difficulty with the red powder, but one x-ray powder pattern indicated senarmontite, Sb_2O_3 (GSC film #28021). X-ray analysis by the author indicated that the red "mineral"was amorphous (UBC film #5280). The powder occurs on small grains of stibnite, and a pure sample could not be obtained. Examined under a microscope it was found to be very fine-grained - no crystals were observed. This red powder was originally thought to be kermesite, Sb_2S_2O, a common cherry-red oxidation product of antimony minerals. However, the x-ray powder pattern obtained on the red material contained no kermesite lines. An amorphous red precipitate of Sb_2S_3 has been reported (Dana, 7th edition, Vol. 1, pages 274, 275). This powder might be metastibnite.

Euhedral barite crystals were found on oxidized surfaces.

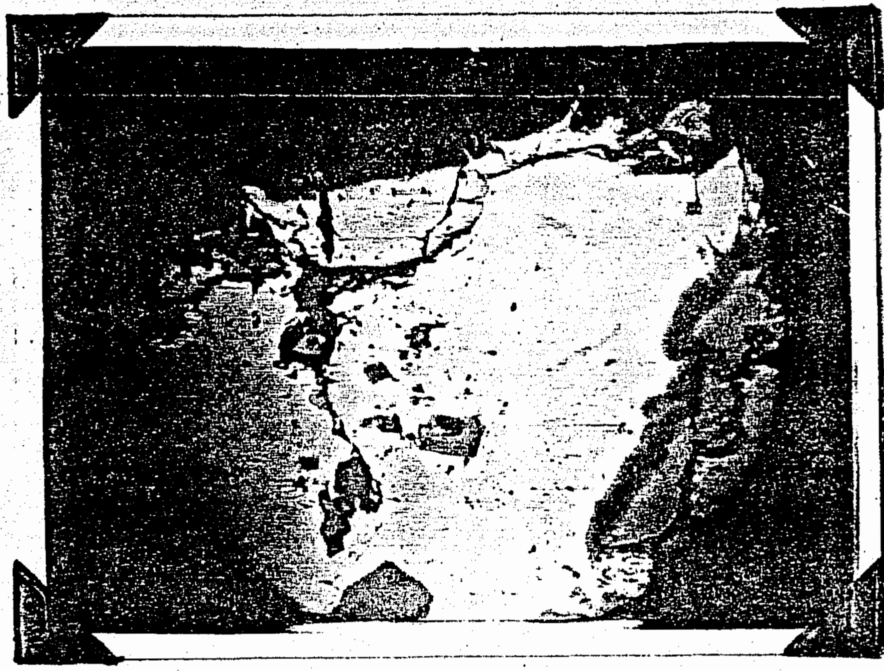


Plate IX - Stibnite (white), sphalerite (light grey), and quartz (darker grey). Note euhedral quartz grains and stibnite embaying quartz. Width of field = 226 microns.

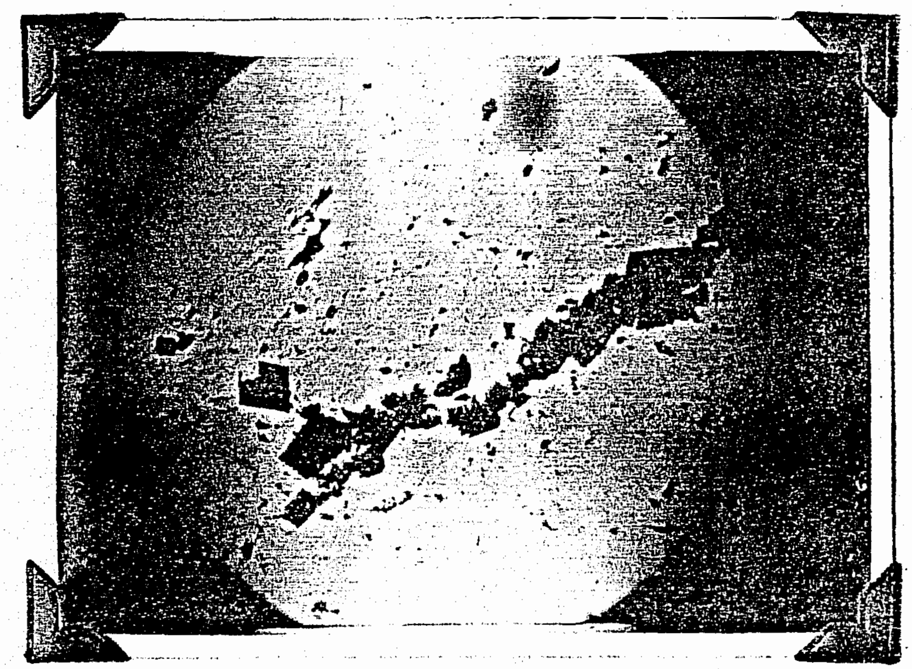


Plate X - Barite in stibnite, width of field = 226 microns.

Some crystals were coated with the red powder, but most were clear. Tiny amorphous black crystals (isometric?) were also found, but not identified. A greenish-grey "mineral", which occurred as smears in the gouge parallel to the walls of the shear zone, was identified as a mixture of illite, a hydrous mica, and quartz.

In Table 2, Appendix, are the results of two different chemical analyses of head samples. These are included to indicate that the mineralogy is not as simple as it would appear from polished section study. Minerals containing Pb, Cu, Fe or Ni were not found in the polished sections, although ZnS could contain Fe and Cu. Pb and Fe could indicate the presence of jamesonite, $Pb_4FeSb_6S_{14}$; Cu, the presence of tetrahedrite, $Cu_{12}Sb_4S_{13}$. Both these minerals have been found associated with stibnite elsewhere on Carbon Hill.

In the most western exposure of gouge in the upper pit area red realgar, AsS, and yellow orpiment, As_2S_3, were found. Both are common associates of stibnite deposits (Dana, 7th edition, Vol. 1, pages 257, 268). These are the only arsenic minerals identified on the Becker-Cochrane property. The depth extent could not be checked because of permafrost.

(c) Structural control and paragenesis

The primary structural control on the localization of the mineralization is a shear zone. Stripping and drifting revealed that it is persistent along a horizontal strike distance of at least 1,000 feet. The average true width on surface is approximately seven feet; underground over 370 feet it is approximately five feet. The vein appears to occupy the full width of the zone.

The role of the Hutshi rhyolite is not as apparent. This dyke is the footwall of the mineralization wherever observed on surface; the hanging-wall is chert in the upper pit, andesite in the lower pit. To the best of the writer's knowledge, mineralization has not been found outside the Hutshi rhyolite or the shear zone on this property.

The rhyolite is believed to have acted as a plane of weakness when shearing occurred. This opinion is based on the surface geology and one diamond drill hole. Core recovered showed relatively wide brecciated and sheared zones within the rhyolite dyke (Diamond Drill Section AA, Appendix). The shearing probably occurred as a result of, and towards the end of, the intrusion of the Coast Range granitic rocks. The mineralizing solutions were derived from the granitic magma as a last stage, after almost complete crystallization of the granitic magma. This conclusion is based on the occurrences elsewhere on Carbon Hill of quartz-barite-stibnite veins in andesite and the batholith itself, and the assumption that the mineralization is all of the same age. The granite had crystallized enough to fracture and maintain the fractures until mineralized.

Quartz was deposited from hydrothermal solutions, followed by stibnite and sphalerite in the shear zone. Elsewhere on Carbon Hill galena and several sulphosalts were also deposited. The carbonate in the Hutshi rhyolite and Coast Range granite is associated with these same solutions. Barite crystallized after the quartz and contemporaneously with the stibnite, and was thus trapped in the stibnite. (Vandeveer Diagram, Appendix). The euhedral barite crystals on oxidazation surfaces are supergene.

Further movement on the shear plane occurred during the last period of volcanism, when the Wheaton rhyolites were emplaced. The movement was probably all vibration with little or no translation. This would be sufficient to granulate and shear some of the mineralization to form gouge. The gouge was relatively permeable to groundwater, which formed secondary minerals at the expense of the mineralization and the fractured wall rock.

Hydrothermal alteration of the potash feldspar in the rhyolite released potassium which combined with alumina and silica to form sericite, and with iron and sulphate to form jarosite. The source of the calcium to form carbonate is uncertain, but the calcium could have been a constituent of the hydrothermal solutions and derived in part by alteration of the calcic plagioclase in the andesite on the hanging-wall of the vein.

CONCLUSIONS

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Yukon Antimony's Becker-Cochrane stibnite occurrence on Carbon Hill is a high level epithermal deposit. The quartz-stibnite mineralization was derived from hydrothermal solutions emanating as a late phase from the magma responsible for the Coast Range batholith, emplaced in the Wheaton District during the Late Cretaceous. A major shear zone, formed in a rhyolite dyke by intrusion of the batholith, acted as a channel way for the solutions. After deposition of the quartz and sulphides, the solutions developed moderate to intense sericite and carbonate alteration in the wall rocks. Tertiary volcanism caused repeated movement, and the resulting gouge was altered to secondary minerals by ground water in Recent time. Glaciation and erosion have exposed the mineralized zone.

Judging from the persistence in width and length of the mineralized shear zone, the favourable horizon should extend downwards at least 500 feet below the present surface.

BIBLIOGRAPHY

Cairnes, D. D., Wheaton District, Southern Yukon, Summary Report for 1915, GSC Memoir 284, 1957

Cockfield, W. E., and A. H. Bell, Whitehorse District, Yukon, GSC Memoir 150, 1926

Bostock, H. S. Mining Industry of Yukon, 1939 and 1940, GSC Memoir 234,1941

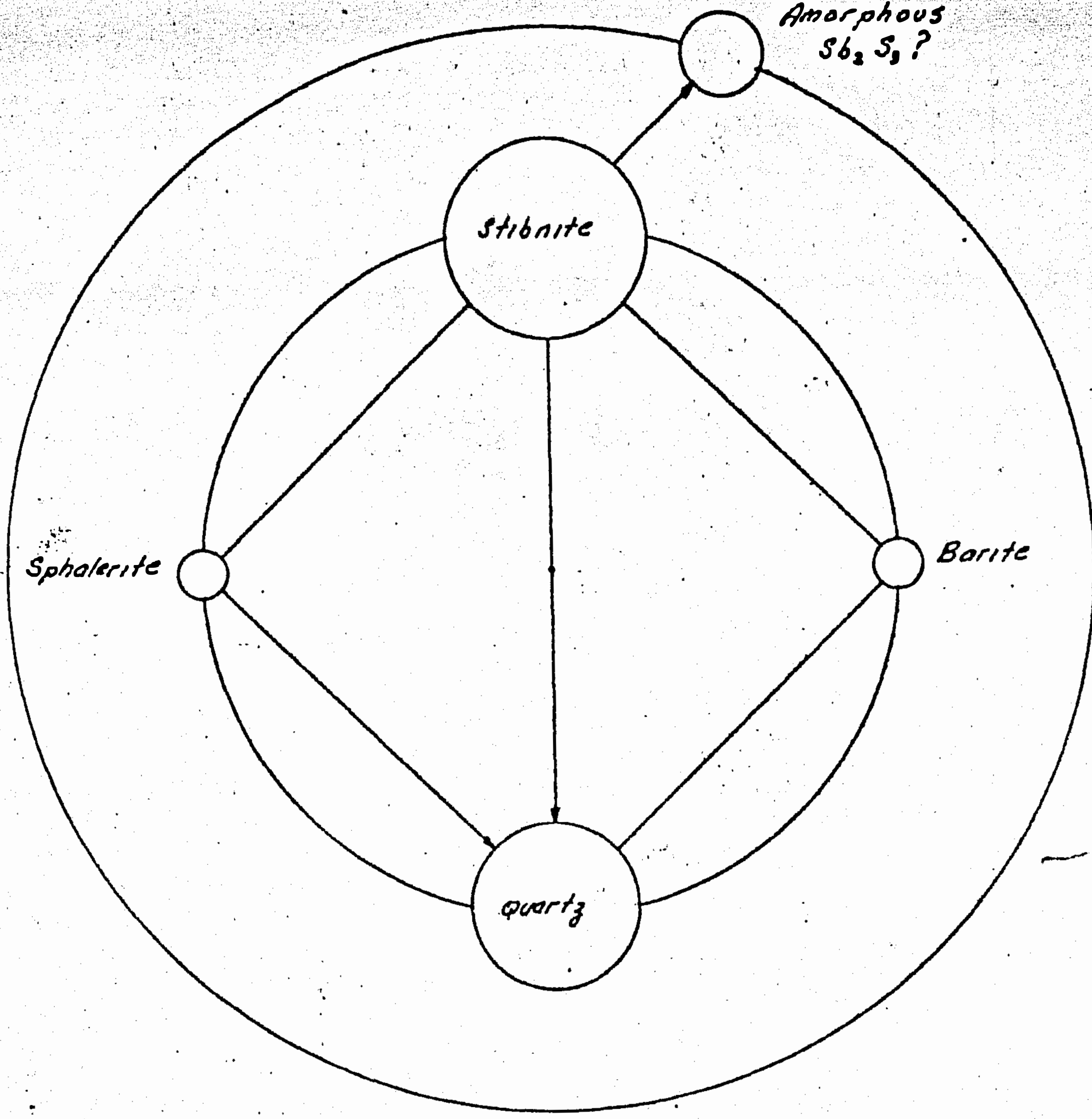
Wheeler, J. O., Whitehorse Map-Area, Yukon Territory, GSC Memoir 312, 1961

Cairnes, D. D., The Wheaton River District, Yukon Territory, Summary Report for 1909, GSC Memoir 284 , 1957

Palache, C., H. Berman and C. Frondel, Dana's System of Mineralogy, Seventh Edition, Volume 1, 1944.

Turner, Williams and Gilbert, Petrography

APPENDIX



VANDEVEER DIAGRAM

TABLE II

Comparison of Jarosite Lines

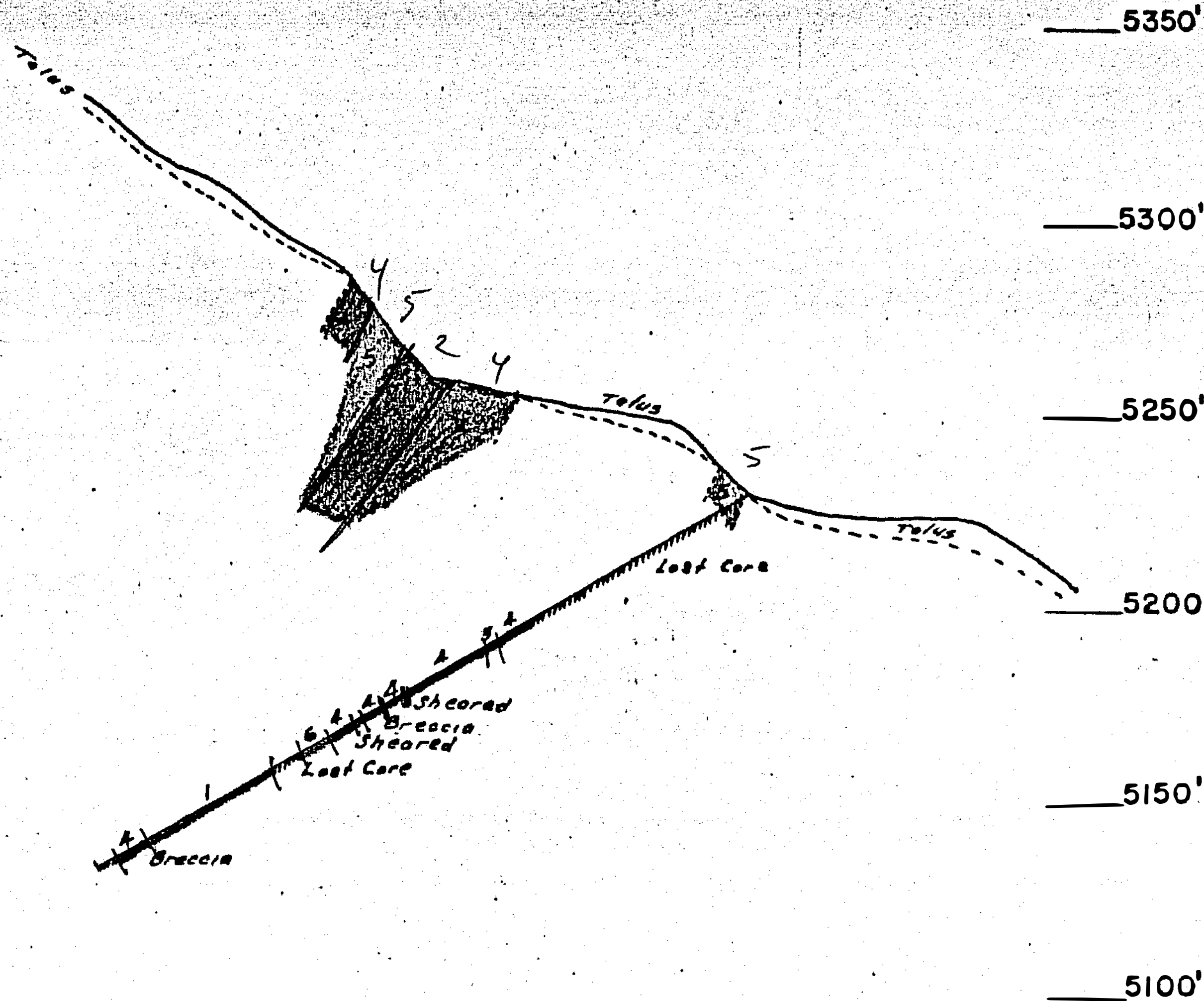
Jarosite, ASTM Card #10-443		Measurements from UBC film # 5279		Illite, ASTM Card #9-334 (3 strongest lines)	
I	d,Å	I	d,Å	I	d,Å
3	5.94	?	6.01		
2	5.74				
4	5.09	8	5.11		
		½	4.54	10	4.46
1	3.65	½	3.64		
		2	3.35	10	3.36
6	3.11				
10	3.08	10	3.10		
1	2.97				
2	2.87	½	2.84		
		1	2.61	10	2.57
3	2.55				
5	2.29	1	2.29		
5	1.978	1	1.980		
2	1.941				
1	1.913				
5	1.823	1	1.827		
Several	weak lines				
3	1.539	½	1.543		
3	1.512	½	1.514		
1	1.484				

TABLE III

Chemical Analyses of Head Samples

Element	Department of Mines and Technical Surveys	Wright Engineers Ltd., Vancouver
Au	0.01 oz/ton	0.008 oz/ton
Ag	0.03 oz/ton	0.15 Oz/ton
Sb	9.52%	11.78%
As	0.12	0.06
Pb	0.024	0.02
Cu	0.004	0.017
Ni	0.12	
Fe	0.28	2.45
Zn		0.43
S	5.64	5.27

G. I. Mathieu, Non-Ferrous Minerals Section, Department of Mines and Technical Surveys, reported a zinc content of 1.2% in the concentrate he made from the head sample.

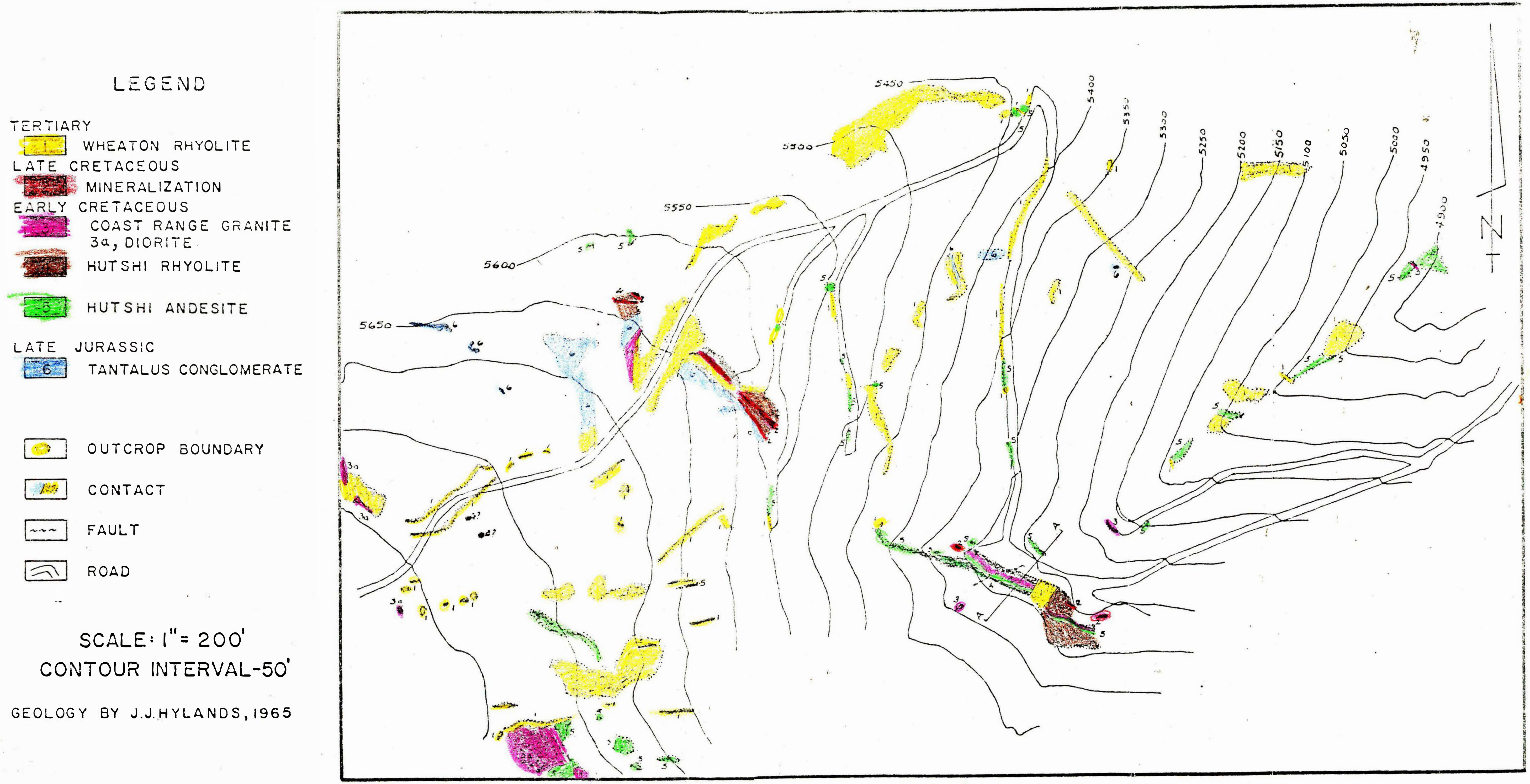


DIAMOND DRILL SECTION A-A

(LOOKING NORTHWEST)

SCALE: 1" = 50'

LEGEND SAME AS ON MAP



OUTCROP MAP OF BECKER-COCHRANE PROPERTY YUKON TERRITORY