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A METALLOGRAPHIC REPORT

on ore from

HIGHLAND SURPRISE MINE

Slocan District
British Columbia

by
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APRIL 1940

A C K N O W L E D G M E N T S

The writer wishes to thank the officials of the Highland Surprise Mining Co. for their co-operation in supplying specimens for study. He wishes also to express appreciation for the help given willingly by members of the Departments of Geology and Ore Dressing at the University of British Columbia, particularly that by H. V. Warren and G. Gillis.

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INTRODUCTION

Metallographic investigation of the Highland Surprise ore was undertaken with only one principal objective, namely, determination of the form and association of the gold values. This purpose was accomplished and the results will be of value at such time as it becomes necessary to concentrate the ore.

In addition to this prime information there is undoubtedly much more which could be derived from microscopic study of other polished sections and allied procedure but, unfortunately, such additional investigation was not possible in the time prescribed for this work.

P A R T I

G E N E R A L

Location of the Property and Access.

The Highland Surprise claim lies slightly eastward of north from the town of Retallack, station on the Kaslo-Sandon and Nakusp branch line of the Canadian Pacific Railroad and on the Kaslo-New Denver highway, 18 miles from Kaslo. From Retallack the camp is reached by slightly over 3 miles of road and $\frac{3}{4}$ of a mile of pack-trail.

Topography.

The camp is located on the precipitous northwestward wall of Lyle Creek Basin, at an elevation of 5456 feet. The underground workings extend to the north and northwestward from the camp, into the ridge between Lyle Creek Basin and Whitewater Basin.

The area is one of strong relief. Elevations rise to 9000 feet at the summits of sharply pointed mountains and serrated ridges which are aligned to form ranges of generally north-westward trend. The valleys between the ranges are deeply incised, primarily as a result of glacial action and latterly by rapid erosion of swiftly running water. The annual spring runoff is heavy and reduced flow is maintained throughout the summer from melting ice which still lies in glacial circes at the heads of the higher basins. The precipitous slopes of the higher walls of the valleys are reduced at lower elevations by concentrations of talus and moraine material. Surface erosion is so active that development of upland meadows is rare. The walls of Lyle Creek Basin offer but slight protection from the downward movement of snow during the winter and spring months and 20 feet of snow on the floor of the basin is not unusual in February and March. Lyle Creek enters the basin over a lip of the north-eastward rim; from a lake high up on this rim the creek falls 1300 feet in a horizontal distance of 2500 feet. Maintained by glaciers above, the lake could be dammed to provide water storage.

Climate.

A combination of topographic and climatic conditions render year-round operation difficult. Heavy snowfall during the winter months produces many slides which frequently make it impossible to travel or work on the surface with safety. Snow lies at higher elevations until July and is seldom gone even from the basins, at a mean altitude of from 5000 to 5500 feet, until late in June. Although in the ordinary year at least three months of clear weather may be expected, rain hampered field work until the end of June during the past season and snow storms prevented work entirely during one week in July.

Timber.

Timber-line is close to 6000 feet and below this elevation there is available adequate timber for all domestic and mining needs, constructional and underground. Fir, pine and cedar are abundant below 5500 feet at locations sheltered from snow-slides and not subject to the effects of active erosion.

Water Supply.

Available water is subject to seasonal fluctuation and practically all the small creeks which may be of good flow up until July are completely dry by the end of August. The exceptions are Lyle Creek and Whitewater Creek, but even these are greatly reduced by the time seasonal runoff is complete.

Camp-sites.

Camp-sites are rare at elevations above 5000 feet due to the prevalence of snow-slides off the shear walls of the mountains which surround the basins. Within Lyle Creek Basin proper there is no good camp-site as slides run from the east, west and north and the nearest location which is safe and satisfactory is on Lyle Creek, about 3000 feet below the southern margin of the basin, close to the point where the Eureka Mine road leaves the Lyle Creek road. At this location it would be possible to establish a camp at the level of Lyle Creek, secured from the danger of slides by a good stand of timber and comparatively gentle slopes on the hillsides above.

General Geology.

The rocks of the area under consideration belong to the Kaslo Series of Triassic Age. The series consists of volcanic rocks, dioritic intrusives, serpentine and sediments; the volcanic rocks may be divided into pyroclastics and flows. Late feldspar porphyry dykes occur in the area.

The region has been subjected to metamorphism, dynamic and hydrothermal, which has obscured many of the original characteristics of the rocks and the contacts between the individual members. While it is not possible to be certain, it is probable that much of the volcanic material was originally andesitic in composition. As most of the volcanic rocks are chloritized it has been found convenient to classify the pyroclastic, flow and sedimentary members as greenstones. Strictly, the sediments should probably not be included in this classification but in the area they are not abundant and scarcely distinguishable from the volcanics. Dioritic intrusives, serpentine and feldspar porphyry dykes are easily identified by the characteristics given below.

Greenstone (includes original flows, pyroclasts and sediments).

Of the three original constituent members the flows are the only ones which may be identified with any degree of ease. Typically pale-green or light-green on the weathered surface, slightly darker-green or grey on fresh fracture, fine to medium-grained in texture, the diagnostic feature is flow structure which is apparent occasionally on a broad scale. Visible when seen in place, in its entirety, but seldom authoritative in fragmentary hand samples, this structure is generally represented by fine lines or elliptical outlines of colour either lighter or darker than the remainder of the rock. Such flow structure is best seen on the south-westward side of the serpentine. Where flow structure is not available as a guide and the ground mass is fine-grained and homogeneous, as in large areas on the north-eastward side of the serpentine, it is sometimes possible to distinguish the flows by means of isolated fragments of unabsorbed early crust. However, these criteria are unreliable as such isolations may often represent coarse fragmental material in finely divided pyroclastics.

Of the pyroclasts a few examples were seen, notably underground at the Highland Surprise, where it was possible to define at least small areas with some assurance. Under a hand lens, or occasionally in the hand specimen, these rocks may be seen to be fragmental in origin.

Sediments are apparently rare in this section; none were seen with characteristics as defined by Cairnes. This however is not surprising, as they are prominent nowhere in the Kaslo Series. There may be some sediments exposed underground at the Highland Surprise but the writer saw no rock which could be classified definitely as such although there are several exposures in which bedding appears obvious at first sight. Closer examination of these exposures shows, however, that the illusion is created by a near parallel arrangement of quartz and albite stringers which follow lines of shearing in highly metamorphosed rock which was probably originally pyroclastic.

Serpentine.

The serpentine is the most extensive and best defined member of the Kaslo Series. Of a north-west strike, with a dip steeply to the south-westward it has exposed widths up to 2500 feet. On weathered surfaces the serpentine is typically black, green of shades from dull to bright, pink or light-brown; the last two colours grade frequently almost to white. The extreme softness and decided greasy feel are easily recognizable characteristics. The greasiness is due to the abundant production of talc as the result of alteration. Fibrous appearance along shear planes is due to the production of serpentine wool.

The whole member probably represents an original ultra-basic injection which has reached its present composition by simple hydration or other more involved metamorphic processes. That it was originally intrusive is emphasized by inclusions of greenstone within it and by the narrow but well defined branches which lead off the main mass.

Dioritic Intrusives.

With the exception of the feldspar porphyry dykes all the minor intrusives seen in the area are approximately dioritic in composition. Typically dark-green in colour, these rocks are composed essentially of oligoclase-andesine plagioclase and shreddy amphibole. There is practically no visible quartz. Fine to medium-grained, they may sometimes be distinguished from the volcanics by slightly coarser texture but frequently the exact margin between the two rocks is indeterminate by a gradational relationship and numerous small inclusions of volcanic rock. However, with the fine-grained, homogeneous and massive facies of the diorite it is usually possible to make distinction from the volcanics only on freshly broken, wetted surfaces where the amphibole and plagioclase are apparent. Structurally this member is probably best described as a series of irregular plugs, of no definite form.

Feldspar Porphyry Dykes.

These dykes are apparently the youngest rocks in the area. They are intrusive into fractures in the greenstone marginal and approximately parallel to the serpentine contact. In width they vary from 1 to 10 feet, often with marked variation in width along the strike which tends to produce characteristically lenticular outline. Like that of the serpentine, their strike is generally north-west; the dip is usually north-eastward but it varies radically, even between the two walls. As an example, underground at the Highland Surprise one wall of a dyke dips at 10 degrees to the north-eastward and the other stands vertically.

In colour these rocks are grey on fresh surfaces and shades of pale-pink, light-brown or white on weathered surfaces. Their composition is markedly uniform throughout the area; in a fine-grained feldspathic ground-mass plagioclase phenocrysts are abundant, quartz grains are usually absent or nearly so, carbonates are freely developed. In addition to the plagioclase, which is principally albite-oligoclase, minor, variable amounts of orthoclase are present. These feldspars are ordinarily somewhat sericitized. Subordinate minerals are biotite, actinolite and epidote. Noticeable amounts of pyrite and some chalcopyrite are often present.

Veins.

Two types of vein occurrence have been exposed at the Highland Surprise. Both are in the fractures of north-west strike in the greenstone marginal to the serpentine. For purposes of identification one type will here be referred to as "vein", the other as "vein-zone". The veins are composed of quartz and calcite gangue which contains gold-bearing sulphides. The sulphides are principally pyrite and chalcopyrite. No free gold was seen in hand specimens.

The veins on the north-eastward margin of the serpentine have proved upon development to be sufficiently mineralized by gold-bearing sulphides to warrant serious consideration; those on the south-westward margin, by evidence of surface exposures alone, are almost barren of sulphides. Those on the south-westward contact appear to have been deposited at comparatively low temperatures; drusy structure is common, wall-rock alteration is almost absent in many places and several angular and unaffected inclusions of wall-rock were noted within the vein-quartz.

To date development indicates considerable weakness and irregularity both along the strike and on the dip of the veins. The veins have naturally assumed the habit of the fractures and, like the feldspar porphyry dykes, are variable in width along the strike. However, the veins are even more irregular than the dykes, particularly when the wall-rock is highly sheared, for, while the general occurrence of vein-quartz may continue on strike, individual strands are often highly contorted and irregular in dip as a result of having followed minor local folds and fractures in the greenstone. In other places the width of vein-quartz may pinch abruptly to a single narrow stringer. Vein widths vary up to $5\frac{1}{2}$ feet; this may be of solid quartz or may be comprised of several strands or lenticular bunches of quartz and included low-grade rock. Where vein and feldspar porphyry dyke occur together in the same fracture the vein gains strength from the competency of the dyke.

The vein-zones may be representative of the veins at locations where vein solutions were not abundant and where fracture of the greenstone was represented by tight shearing rather than by well maintained openings. In at least one case there is apparently a transition on strike from vein-zone to vein. The width of the vein-zones is comprised of very narrow stringers of albite and quartz which strikes north-west. Pyrite is disseminated sparsely in the quartz, in the albite and in the included and marginal greenstone. Highly altered, the marginal greenstone is often dark in colour, homogeneous and compact. To date the gold content in the vein-zones has been found to be small but if there is proved to be transition from them to the veins the zones may be followed as a guide in development.

The veins may prove to be simple shoots within the vein-zones but there is some suggestion that there may be cross-fracturing of the vein-zone shearing and that the intersections of the two sets of fractures permit concentrations of mineralization along the cross-fractures. Nowhere was it possible to see two fracture-systems which actually crossed but at two locations veins which contain commercial values strike north to north-east as against the general vein-zone strike to the north-west. In the course of further exploration particular attention should be given to the possibility that there is such a secondary and less conspicuous fracture-system.

Alteration.

The most marked alteration is that of the serpentine to talc and carbonate in the vicinity of the veins on the Highland Surprise property. This effect is so far advanced that where intersected by underground workings walls and back of adits may be held only by considerable effort.

Wall-rock alteration adjacent to the veins is generally confined to widths which may be as much as 6 feet but which are often considerably less. In the vein-zones alteration has taken place in the greenstone which remains within the limits of the zone as well as in the marginal rock. Analysis of typical greenstone wall-rock adjacent to a narrow vein showed abundant plagioclase feldspar, abundant carbonate, and chlorite as the only remaining ferro-magnesian mineral. The rock here was seamed by quartz and albite veinlets. Typical of this alteration is the darkened colour of the rock and the presence of scattered pyrite. At the Highland Surprise it has been found that where marginal to veins such wall-rock, unsilicified, dark in colour and mineralized sparingly by pyrite, will often contain sufficient value in gold to be of milling-grade; marginal to the low-grade vein-zones it has not found to be of value.

There has apparently been little or no active emanation from the feldspar porphyry dykes. The only effect they have had has been to bake the greenstone for a very narrow width at the contact.

Development.

Development has been by three adits at elevations of 5742, 5600 and 5456 feet. These are known as the 100, 110 and 120 levels respectively. All have been driven to explore the vein-system on the north-east margin of the serpentine.

The 100 level drift was 69 feet long at the time of examination and provided a good exposure of vein-structure which here strikes north 10 degrees west, dips 65 degrees westward. Although probably not over 30 feet north-eastward from the serpentine contact the greenstone vein walls here are strong and well maintained. On the walls of the vein, often frozen to them, is a narrow band of albite; outside this the greenstone walls have been highly metamorphosed for several feet and are frequently well mineralized by disseminated pyrite. The vein-quartz itself is compact and solid in the central width of 2 to 3 feet but is inclined to stringer out into the walls. The best defined quartz width has been carried on the west wall of the drift; in places it is within the wall and is exposed by small side-swipes. Near the face an added width of poorly mineralized quartz makes on the eastward side of the vein and at 69 feet from the portal, at the face, a sample was taken across 54 inches of vein-quartz. To the eastward of this width there is an additional 2 feet of albitization and quartz stringers. Pyrite and chalcopyrite occur together in the vein but beyond its limits only pyrite is present.

The 110 level was driven first as a crosscut for 80 feet in a direction slightly northward of west. At 63 feet from the portal very narrow quartz stringers were exposed. These struck north 30 degrees west and were followed for 70 feet in that direction until they pinched and disappeared on the right wall. At 45 feet from the crosscut these stringers were well mineralized by pyrite and chalcopyrite and subsequent stoping and lateral development in 1020 stope and 1060 drift proved that here the principal mineralization is in a quartz vein which strikes east, north-east and finally northwest, dips irregularly. Additional development to the northward from 1020 stope proved no further commercial values.

The lowest level, the 120 level, was driven first as a crosscut and was carried into the serpentine for a distance reported to be 80 feet. This work in the serpentine is now inaccessible. Encouraged by narrow and erratic quartz stringers close and parallel to the serpentine the adit was then extended to the north-westward. At 155 feet from the crosscut there was exposed irregular vein-quartz which contained considerable pyrite and chalcopyrite. Drifting, raising and stoping on this exposure proved a small, irregular but attractive concentration of ore. Further work to the north-westward from beyond this exposure disclosed no additional ore.

P A R T II

M E T A L L O G R A P H Y

Locations Represented by Sections

Sections No. 1 and No. 2 represent typical vein zone material. The sections were made with little expectancy of finding visible gold as the average gold content is very low--probably less than 0.10 oz. per ton.

Sections No. 7, C, D, E, F, G and H are from the best showing of ore so far exposed in the mine, from 1150 drift and from the stope above it at rail plus 30 feet. Section 7 is from the drift; the remainder, from the stope.

Megascopic Examination

In the hand specimen the first impression of the ore is the scarcity of sulphide mineralization. Pyrite occurs sparsely as irregular concentrations in anhedral form. Chalcopyrite is scarce but is generally in close association with the pyrite. Marginal to the concentrations of pyrite and chalcopyrite a very small amount of euhedral pyrite may be disseminated in the quartz gangue. Pyrite in crystalline form is also common in the wall rock and constitutes the principal sulphide mineralization of the vein zones.

Microscopic Examination

Pyrite

The principal additional information of interest concerning the pyrite which is developed by microscopic examination is that irregular fracturing of that mineral is general and that the pyrite is the host for the gold. The fractures are healed by chalcopyrite and quartz.

Chalcopyrite

This mineral occurs generally either as fracture filling in the pyrite, as rims around the pyrite or in small concentrations closely associated with the pyrite. The occurrence is generally anhedral. No gold was seen in direct association with chalcopyrite.

Quartz

Quartz comprises the greater part of the sections. Although usually massive in form there is a vague hexagonal outline in section E (W: 6. 1, N: 54.2).

The possibility of recrystallization of quartz is suggested by growth lines which are apparently later than original deposition. The above mentioned hexagonal outline may be evidence of this action or may indicate original crystallization.

Gold

Gold occurs as wheat-like and triangular grains within the pyrite. Three of these blebs are visible in section D in the region of co-ordinates W: 17.2, N: 47.6. The close proximity of these three grains and the absence of gold in the rest of the section suggests that probably erratic local conditions governed precipitation of the mineral.

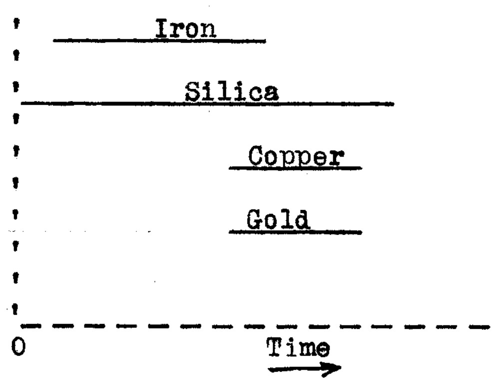
The gold is typically dark in colour, rough-surfaced and of smooth outline.

Carbonates

Carbonates are abundant, particularly in the vein zones, as demonstrated in sections 1 and 2. This mineralization is secondary, either of supergene origin or as a result of hydrothermal decomposition of the feldspars in the closely adjacent feldspar porphyry dykes or in the volcanic wall rock. Little may be said of the distribution of the carbonates within these sections except that they are disseminated and widely spread.

Paragenesis

The limited variety of minerals present in this ore renders consideration of paragenesis comparatively simple. Graphically it may be represented thus:



Evidence for this representation is as follows:

Pyrite veining quartz indicates that quartz is older than pyrite.

Crystal and incipient crystal outlines of both quartz and pyrite indicate approximately contemporaneous deposition (i. e. under relatively similar conditions).

Quartz veining pyrite indicates some quartz later than some pyrite.

Some chalcopyrite was later than some pyrite and some quartz, as it heals fractures in both pyrite and quartz.

Probably some overlapping of chalcopyrite and pyrite, if isolations (unsupported nuclei) of chalcopyrite within pyrite are acceptable as evidence of earlier deposition of chalcopyrite. Admittedly such evidence is open to the opposite interpretation but such a possibility here appears unlikely.

Gold appears of contemporaneous deposition with copper by reason of the fact that gold was not observed in the sections except where the enclosing pyrite was in close relation with chalcopyrite. Further, no commercial gold values have been found at the property at locations where chalcopyrite is not present. Whether or not gold deposition should be shown as extending through the entire period of copper deposition is admittedly open to question.

Description of Individual Sections.

Section 1

Vein zone. This is interesting in that there is practically no pyrite in the quartz stringers. There is a considerable amount of well crystallized pyrite in the metamorphosed wall rock adjacent to the stringers. The pyritic mineralization thus apparently preceded quartz mineralization at this location. Probably all this mineralization was complete before copper deposition commenced.

The yellowish mineral in the section is albite; albitization is a common occurrence in the vein zones. There is considerable carbonate gangue in the section.

Section 2

Similar to Section 1.

Section 7

Dissemination of fine grains of pyrite and chalcopyrite in quartz gangue. Also visible are isolations of chalcopyrite in pyrite and pyrite in chalcopyrite.

Section C

Sulphide mineralization by pyrite and chalcopyrite. The pyrite is well crystallized in the albite and wall rock gangue which is irregularly marginal to the quartz.

Section D

This is the most interesting section in the suite. In addition to the presence of easily visible gold, microscopic examination reveals most of the diagnostic relations for the determination of paragenesis.

Chalcopyrite clearly veins pyrite and occurs marginal to it. Chalcopyrite occurs isolated in quartz. Pyrite occurs isolated in quartz. Chalcopyrite veins quartz. Gold occurs as three blebs in the region of W: 17.2, N: 47.6. These blebs are isolations in pyrite, one triangular in shape, one oval and the third an elongated ellipse. The gold is typically grainy on the surface, smooth in outline.

Section E

This section should show gold, according to the assay. (See section "Assays") However none was observed.

Pyrite shows definite crystal habit. Quartz occurs with vague crystal outline. Fractures in pyrite are filled by chalcopyrite and quartz.

Section F

Shows dissemination of pyrite and chalcopyrite in quartz; defined inclusions of quartz within pyrite, establishing precedence of some silica over some iron.

Section G

Crystalline pyrite in quartz, establishing precedence of some iron over some silica.

Section H

Definite occurrence of pyrite and chalcopyrite in fractures in quartz. Fractures in the pyrite are filled with chalcopyrite. The local sequence is: silica, iron, copper.

Assays

Fire assays were run on samples cut from around the sections examined microscopically.

The results were as follows:

Section No.	Oz. Au. per ton
1	trace
2	0.08
7	1.24
C	0.40
D	1.08
E	2.04
F	0.80
G	0.50

Visual Assay

An attempt was made to estimate an assay by relative area of gold in section D to the total area of the section. For this an integrating spindel was used as an accessory to the microscope. The results were not highly successful, which is not surprising when it is realized that near-accuracy can be expected only by extraordinarily good luck or from measurements on a number of sections cut in a variety of directions through the area to be sampled.

Proportions of Constituent Minerals

By use of the integrating spindel, determination was made of the relative amounts of pyrite, chalcopyrite and quartz present in the highest grade sections.

	Pyrite	Chalcopyrite	Quartz
Section D	19.52%	10.57%	69.91%
Section E	23.83%	6.04%	70.13%

Value of Findings

Of importance as a guide to milling practice is the locating of the gold with the pyrite--rather than with the chalcopyrite as previously believed. Further, it is of importance that the gold occurs locked within the pyrite and not marginal to it or in fractures from which it could be freed easily by grinding.

These data, in conjunction with findings of the Department of Metallurgy, permit preliminary consideration of a mill flow sheet (flotation).

Milling

In the investigation by the Department of Metallurgy it was found that the factor of principal importance was the degree of grinding. It was not until the ball mill product was at least 90% minus 200 that commercial recovery of the gold values became possible. This fact, discovered independently and without knowledge of the metallographic findings as detailed in this report, provides an excellent check on these findings and indicates that the close physical relation between the gold and the pyrite is a general condition in the ore.

Metallurgical detail is as follows:

Grind to 90+% minus 200. Pulp density 4 to 1.

1 pound soda ash per ton in ball mill.

Flotation reagents:

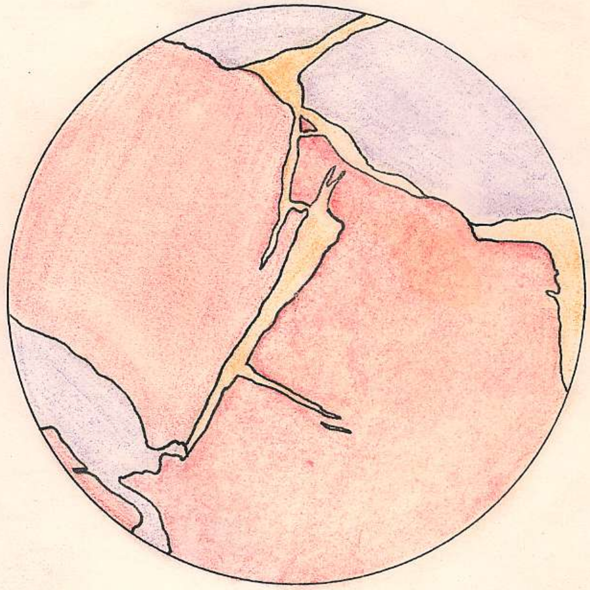
1/6 pound Pine oil per ton.

1/5 pound Amyl Xanthote per ton.

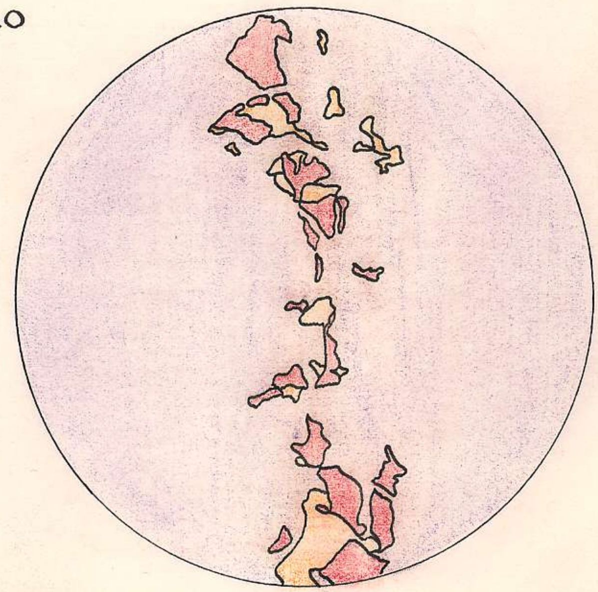
Heads 0.44 oz. Au. per ton.

Recovery 97.6%.

MAG. 75X
SECT. E.
W10.1 N54.9



MAG. 75X
SECT H
W12.5 N54.0



LEGEND:

Blue — quartz
Red — pyrite
Yellow — chalcopyrite.

SECTION D

I.

X 274 200 MESH SHOWN.

YELLOW - GOLD

RED - CHALCOPYRITE.

BLACK - QUARTZ.

WHITE - PYRITE.

SECTION D

2.

X274.

200 MESH SHOWN

YELLOW - GOLD

RED - CHALCOPYRITE.

BLACK - QUARTZ

WHITE - PYRITE

SECTION D

3.

X 274 200 MESH SHOWN

YELLOW - GOLD

RED - CHALCOPYRITE

BLACK - QUARTZ

WHITE - PYRITE