GEOLOGY AND GEOPHYSICS OF THE GRANBY 1968 LINE GRIDS, PHOENIX, BRITISH COLUMBIA.

GEOLOGICAL ENGINEERING THESIS
B.A.Sc.
APRIL 1969

GRAEME R. PERCY

302 - 36 East 14th Avenue,
Vancouver 10, B.C.
28 March 1969.

Professor W.M. Armstrong,
Dean of Applied Science,
The University of British Columbia,
Vancouver 8, B.C.

Dear Dean Armstrong,

Enclosed is a technical thesis, "Geology and Geophysics of the Granby 1968 Line Grids, Phoenix, British Columbia." The purpose of this thesis is to fulfill the requirements of Geology 499, for graduation as a Geological Engineer, as outlined in the University of British Columbia Applied Science Calendar, 1968-69.

Yours truly,

Graeme R. Percy

Student Geological Engineer,
University of British Columbia,
Vancouver 8, B.C.

Encl: 1

GRP/mep

GEOLOGY AND GEOPHYSICS OF THE GRANBY 1968 LINE GRIDS, PHOENIX, BRITISH COLUMBIA.

A thesis submitted in fulfillment of the requirements for the degree of Bachelor of Applied Science at the University of British Columbia.

GRAEME RAYMOND PERCY

28 March 1969

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PREFACE

The material in this thesis has been collected primarily by personal experience gained as geologist in charge of outside-exploration for Granby Mining Company (Phoenix Copper Division) during the 1968 field season.

Recognition is accredited to Mr. J. Jewitt, Mine Superintendent at Phoenix, and Mr. James Paxton, Mine Geologist at Phoenix, for their assistance in supplying production data and general statistics, as well as technical advice.
Dr. W.H. White, my thesis advisor, has a sound knowledge of the Phoenix area and was particularly helpful in the general writing of the thesis. In addition, his encouragement was greatly appreciated. Mrs. M.E. Percy is to be thanked for typing and proofreading the thesis.

Graeme R. Percy

28 March 1969

GEOLOGY AND GEOPHYSICS OF THE GRANBY 1968 LINE GRIDS, PHOENIX, BRITISH COLUMBIA.

I. Introduction

On 10 March 1969 the author of this report submitted a preliminary report based upon experience gained during the summer of 1968 in the Phoenix area of British Columbia. The preliminary report was submitted to the Geology Department of the University of British Columbia for approval in principle. The purpose of this report is to fulfill the B.A.Sc. requirements for a graduation thesis.

The summer outside-exploration program of the Granby Mining Company (Phoenix Copper Division) was designed as a continuation of the previous summer's work and included cutting line grids, running induced polarization and magnetometer surveys and surface geological mapping of line grids. Line-cutting was done on a contract basis by local persons. Huntec, Limited, contracted to carry out the induced polarization survey, while the magnetometer survey was run by an assistant to the geology staff.

The author of this report, as geologist in charge of outside-exploration, mapped the line grids on a scale of 1" = 200'. Mapping was initiated in early June 1968 and was completed in mid-August 1968. Subsequently, diamond-drill holes were put down in the more geologically favourable locations. At the date of this writing the results of this drilling program are not authorized for release.

Many of the geophysical interpretations presented here are credited to the work of W.A. Finney and N.R. Paterson, Huntec geophysicists. However, the author of this report accepts the responsibility for this presentation.

James Paxton, B.Sc., mine geologist at Phoenix, worked with the author on geological correlation during the 1968 field season.

II. History

The mining history of the Boundary district is a record of early developments in the areas of Rock Creek, Midway, Greenwood, and Grand Forks, British Columbia. In the West Kootenay district discovery of silver-copper ores at Nelson in 1886 was followed by staking of the Bruce claim near Midway. Discovery of gold-copper ores at Rossland was made in 1889-90.

Prospectors moved both eastwards along the Dewdney Trail and westwards from the Kootenays into the Boundary. Here, in 1891, the Sunset, Crown Silver, Big Copper and King Solomon claims were located west of the Mother Lode, and in June 1891, the Mother Lode itself was staked. On 15 July, 1891, Matthew Hotter and Henry White, two prospectors who had elected to examine the other side of Boundary Creek, staked the Old Ironsides and Knob Hill claims. By year's end most of the valuable orebodies of the camp had been staked, although it was not until 1894 that John Stevens located the adjoining Victoria claim. Stevens is also given credit for running an open cut on the Knob Hill claim which indicated the probability of a very large tonnage. Other more notable claims that were staked were the Rawhide, Monarch, Gold Drop, Snowshoe and War Eagle. The larger companies in the Boundary camp included New Dominion Copper Company, Consolidated Mining and Smelting Company of Canada and B.C. Copper Company.

In 1896 the Miner-Graves Syndicate optioned the Old Ironsides - Knob Hill orebody and the winter of 1897 saw the installation of the first steam plant on the Old Ironsides claim. The steam plant had been hauled over rugged wagon roads from the nearest railway station at Bossburg, Washington, some 75 miles away. When development results justified a larger program, Jay P. Graves and A.L. White of Spokane acquired the main interest of the Hotter - White - Stevens group. Through purchases of claims and smelter sites, several companies were formed in 1898 under the Miner-Graves Syndicate groups. Amalgamation was completed in 1899 with the birth of the Granby Consolidated Mining, Smelting and Power Company, Ltd. . Granby, whose best producers were the Knob Hill - Old Iron-

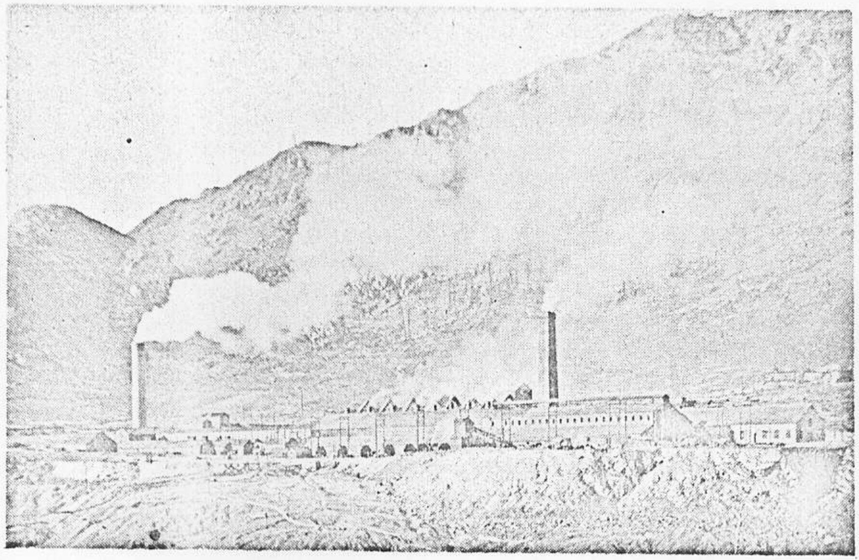

Figure 1. Grand Forks Smelter Under A Full Load.

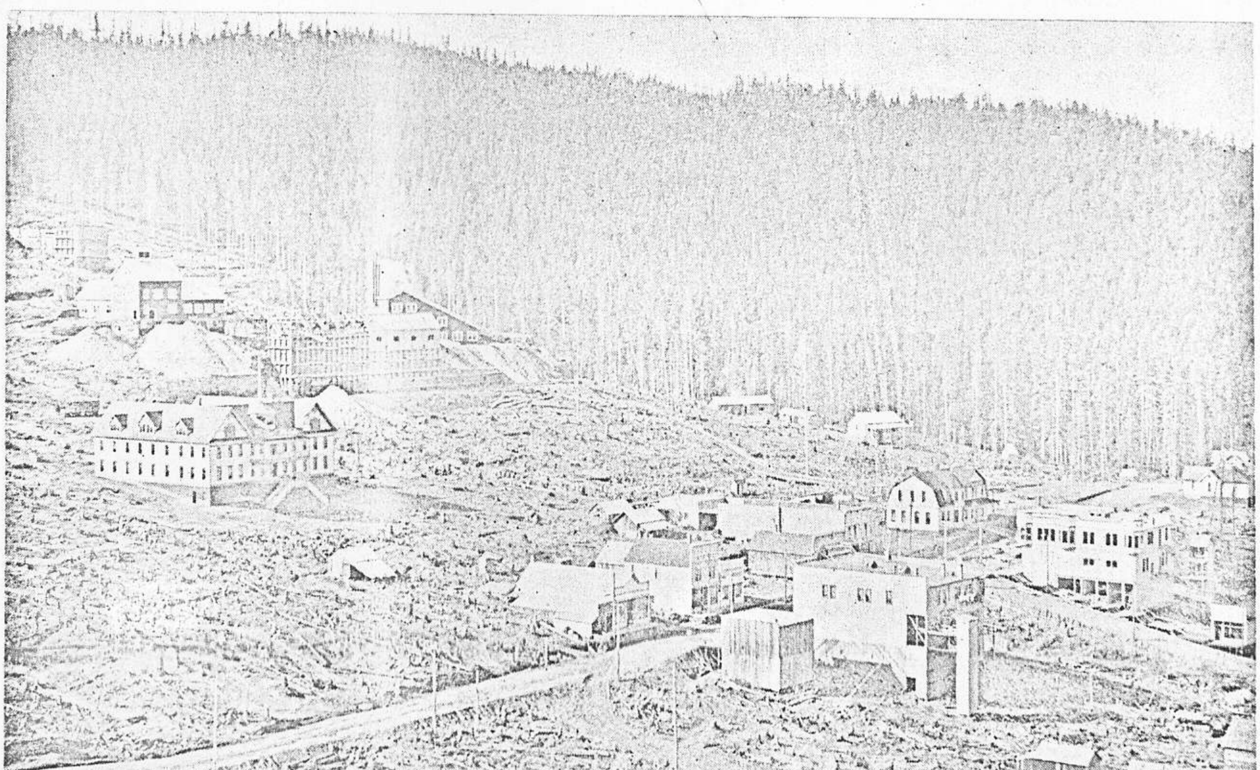

Figure 2. The Beginning --- Phoenix 1900.

sides - Victoria claims, controlled most of the valuable ground in Phoenix.

Although some attempts at smelting the Nelson ores had been made in 1887, the first successful copper smelters were blown in at Nelson and Trail in 1896; followed by Granby's smelter at Grand Forks in August 1900, which by itself treated 14 million tons of ore. In 1901 other successful copper smelters at Greenwood and Boundary Falls were blown in. The discovery that Phoenix ores were practically self-fluxing and were of considerable extent offset the fact that the ores were relatively low grade. The Boundary camp became the most important early producer of copper in the Northwest.

In 1898 the Canadian Pacific Railway extended a line of its Kettle Valley railroad branch from Eholt to Phoenix. By 1900 the Canadian Pacific Railway had lines connecting Phoenix to the rest of the Boundary. The arrival of the Great Northern Railway in 1904 brought freight rates down from 10 dollars to 25 cents per ton.

Incorporated as a city in 1900, Phoenix was soon a spirited, thriving community with many first-class hotels, livery stables, stores, schools, a hospital and even a "sporting district" down on 4th of July Avenue. Hostelriee bore such picturesque names as the "Blue Goose".

Gambling was a 24 hour a day business, with 28 saloons and five dance halls which never closed. The rough and tough atmosphere of the mining town did not interfere with personal independence. Individuals always remained fiercely aware of their rights to freedom and free enterprise, as was exhibited in the celebrated boarding house brawl in which 400 miners once fought over a girl named Sue. By 1905, twenty-six mines were producing in the Boundary and at its peak, Phoenix boasted a population of 7000 persons.

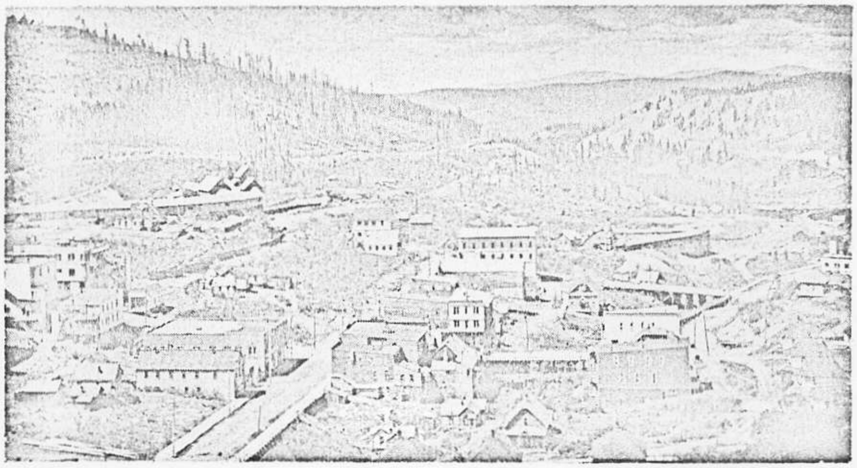

Figure 3. Looking West Over Lower Phoenix, 1908.

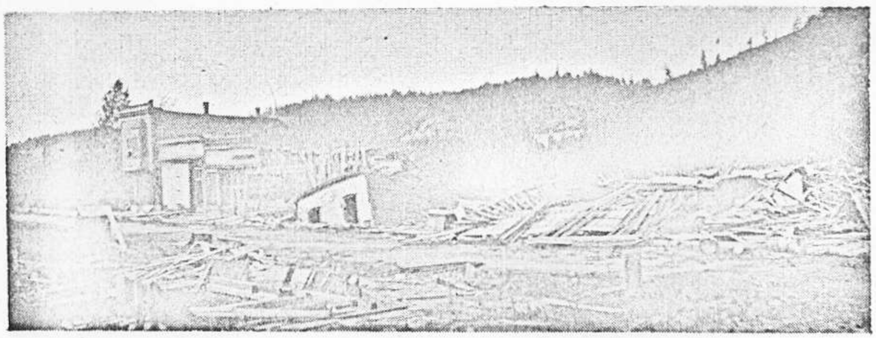

Figure 4. Phoenix Business District, 1944.

Granby shipments, which started with 271,762 tons in the first full year, had increased to 801,404 tons by the year 1906. With the prevailing high copper prices, that year alone dividends amounted to 1,602,000 dollars. The dream that they were "working the greatest copper deposit in the known world" was over by 1908. In 1919 Phoenix came to a premature death when the mines and the Grand Forks smelter closed down due to labour strikes in the Crowsnest which cut off all supply of coke to the smelters. Overnight, the once-bustling city became a ghost town. Phoenix city had existed less than a quarter century but its mines had produced 13,678,901 tons of ore grading from 1.1 percent to 1.5 percent copper with minor values in gold and silver.

Although the mine was re-opened and worked during the 1930's under the direction of Ted McArthur of Greenwood, it closed again on the advent of World War II with the scarcity of labour.

Attwood Copper Mines Limited, under the direction of Dr. D.F. Kidd, optioned some of the old properties from Ted McArthur in 1951 and initiated an extensive exploration program in and around Phoenix. Areas indicated as favourable by the geological mapping were tested with biogeochemical and geophysical techniques. Any resulting anomalous areas were analyzed and those suspected of being caused by orebodies were diamond-drilled. Attwood's field program was managed by geologist R.H. Seraphim who consulted Dr. C.D.A. Dahlstrom in the latter stages of the project. In addition, Dr. W.H. White was engaged as Consultant Geologist to gather and interpret geological data pertinent to the property.

A combination of factors resulted in Attwood dropping their option with T. McArthur. Some of the contributing factors were:

- unstable copper prices on the London Metal Exchange,

Figure 5. Victoria Shaft In Present Pit (July 1968).

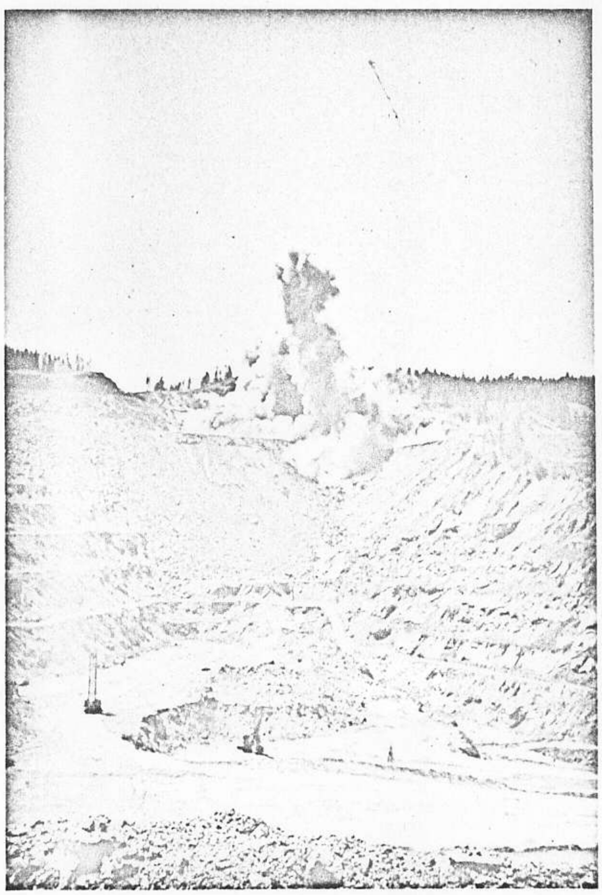

Figure 6. Secondary Bench-Blast In Present Pit (July 1968).

- conservative estimates as to the grade and quantity of ore available,
- lack of funds for the purchase of necessary mill equipment,
- general indecisiveness of the company directors.

Granby returned to Phoenix late in 1955, purchasing from T. McArthur clear titles to the mining rights for some 75,000 dollars. After several years of exploration, feasibility studies and pit-detail planning, production was initiated in the spring of 1959. The Allenby concentrator had been moved from Copper Mountain and was tuned up at 600 tons per day. The mill rate was boosted to 1000 tons per day shortly thereafter, and presently 2000 tons of ore are treated daily. The waste/ore stripping ratio in the pit is maintained at 4:1. Ore-grade cut-off is about 0.61 percent copper although all material over 0.40 percent copper is stockpiled pending clean-up operations. Mill-heads grade from 0.615 percent copper to 0.885 percent copper with a recovery of 82.57 percent. The tails average 0.133 percent copper. A concentration ratio of 41.62:1 results in copper concentrates averaging 25.56 percent copper. These concentrates are shipped to Japan for smelting. Gold (one dollar per ton of ore) and silver (60 cents per ton of ore) are also recovered in the copper concentrates. Granby presently employs a total of 163 persons at the mine.

In addition to guiding the present pit operations, which have produced some 4.3 million tons of 0.6 percent copper ore since 1959, the geology department at the mine is actively engaged in local exploration programs in an effort to discover

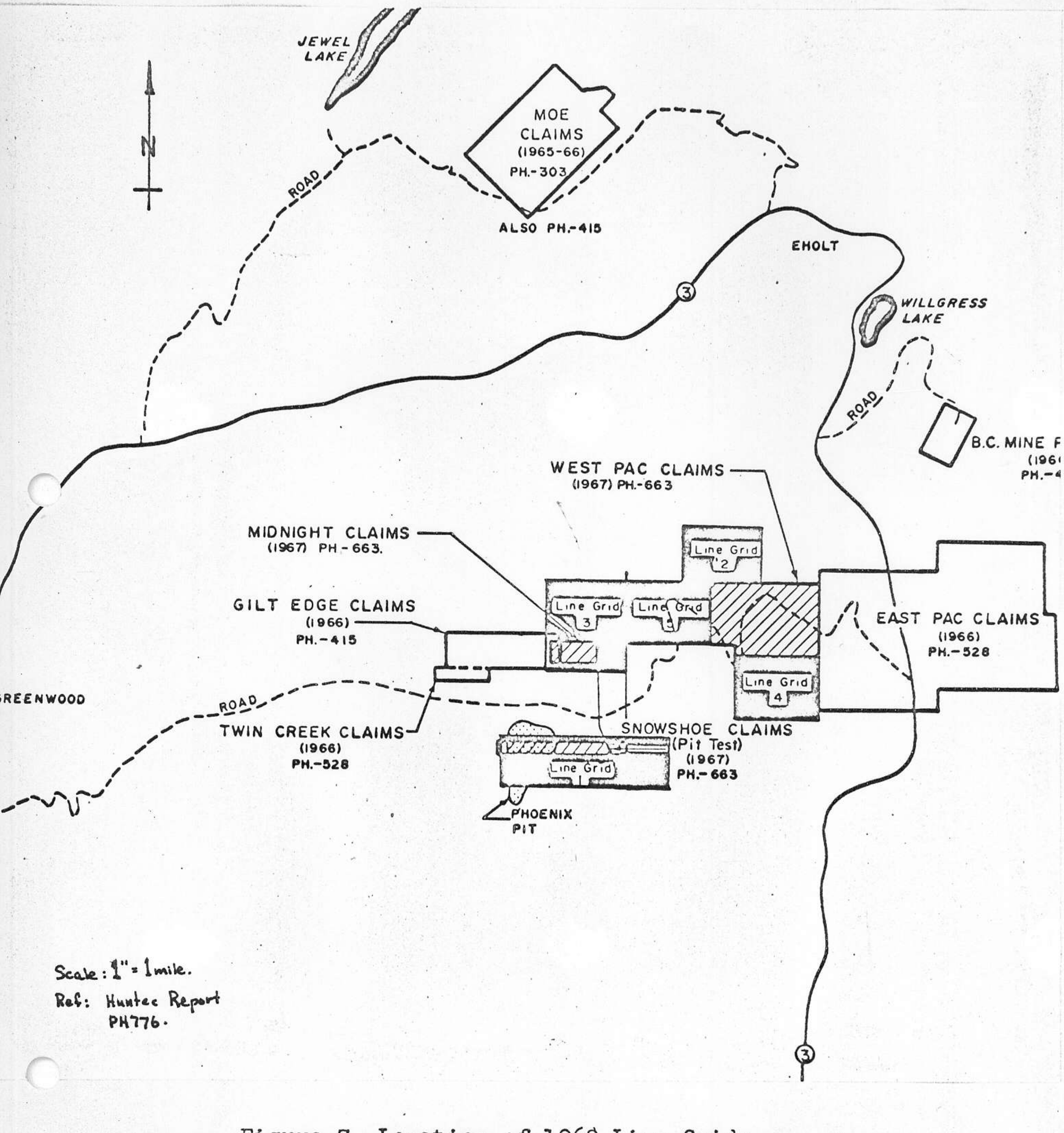

Figure 7. Location of 1968 Line Grids.

new orebodies that may be worked when the present operation is completed by about 1975.

III. General Conditions

A. Location

The area mapped covers the Pac, Snowshoe and Bobcat claim groups (see Appendix A.) and is known as the 1968 line grids. These line grids (see Figure 7.) are numbered #1 to #5 inclusive and #1 SW Extention. Their location south and east of the Ironsides pit is approximately latitude 49° North and longitude 118° West in the Greenwood Mining Division. The nearest city is Greenwood, about seven miles by road to the west. Grand Forks is 24 miles to the east on the southern trans-provincial highway.

B. Access

Access to the mine is only by road. The Phoenix road is maintained by the provincial department of highways as an all-weather gravel road. One end junctions with Highway 3 (the southern trans-provincial highway) 18 miles west of Grand Forks, while the other end connects with Greenwood. Old railroad grades provide limited two-wheel-drive access to the line grids from Phoenix mine. Several old logging skid-roads afford similar access to the line grids from the Phoenix road. Four-wheel-drive access from the Phoenix road via skid-roads is present in several instances. On the whole though, walking from the Phoenix road is the usual form of access to the line grids.

C. Climate and Vegetation

Located generally at about 4500' elevation, the area of Phoenix in the southwestern interior of British Columbia is classified as semi-arid plateau. Unlike its neighbouring towns of Greenwood and Grand Forks, which swelter in extremely hot summers, Phoenix temperatures are moderate. The mean monthly range in January is from 10° to 20°F, while July experiences temperatures generally from 55° to 60°F. Mean daily temperatures likewise are moderate --- in January ranging from 0°F to 10°F minimum and July between 70° and 75°F maximum. As a rule, for three months the temperatures are above 50°F while for eight months they average below 32°F. Average frost-free days number approximately one hundred during the year.

Since Phoenix lies in the rain shadow of the Coast Mountains, precipitation generally averages about 20 to 25 inches, 30 percent to 50 percent of that being snow. Sunshine is abundant year round, although during July and August thunder showers are common.

Biotically, the Phoenix area is comprised mostly of dry forest with spruce, hemlock, some cedar, fir, aspen and birch being the dominant flora. Wild strawberries are locally abundant.

D. Facilities

Pacific Western Airlines operates three times a week between Castlegar, Penticton and Vancouver. Seasonal airport facilities are available at Grand Forks. Although no helioport exists, as such, there are ample landing sites for helicopters in the pit area.

▭	10	PHOENIX VOLCANIC GRP.
▭	9	KETTLE RIVER FM.
▭	8	CORYELL INTRUSIONS
▭	7	VALHALLA INTRUSIONS
▭	6	NELSON INTRUSIONS
▭	5	ULTRABASIC ROCKS
▭	3	ANARCHIST (KNOB HILL)

Ref: GSC Map 6-1957
KETTLE RIVER (East Half)

Scale: 1" = 4 miles

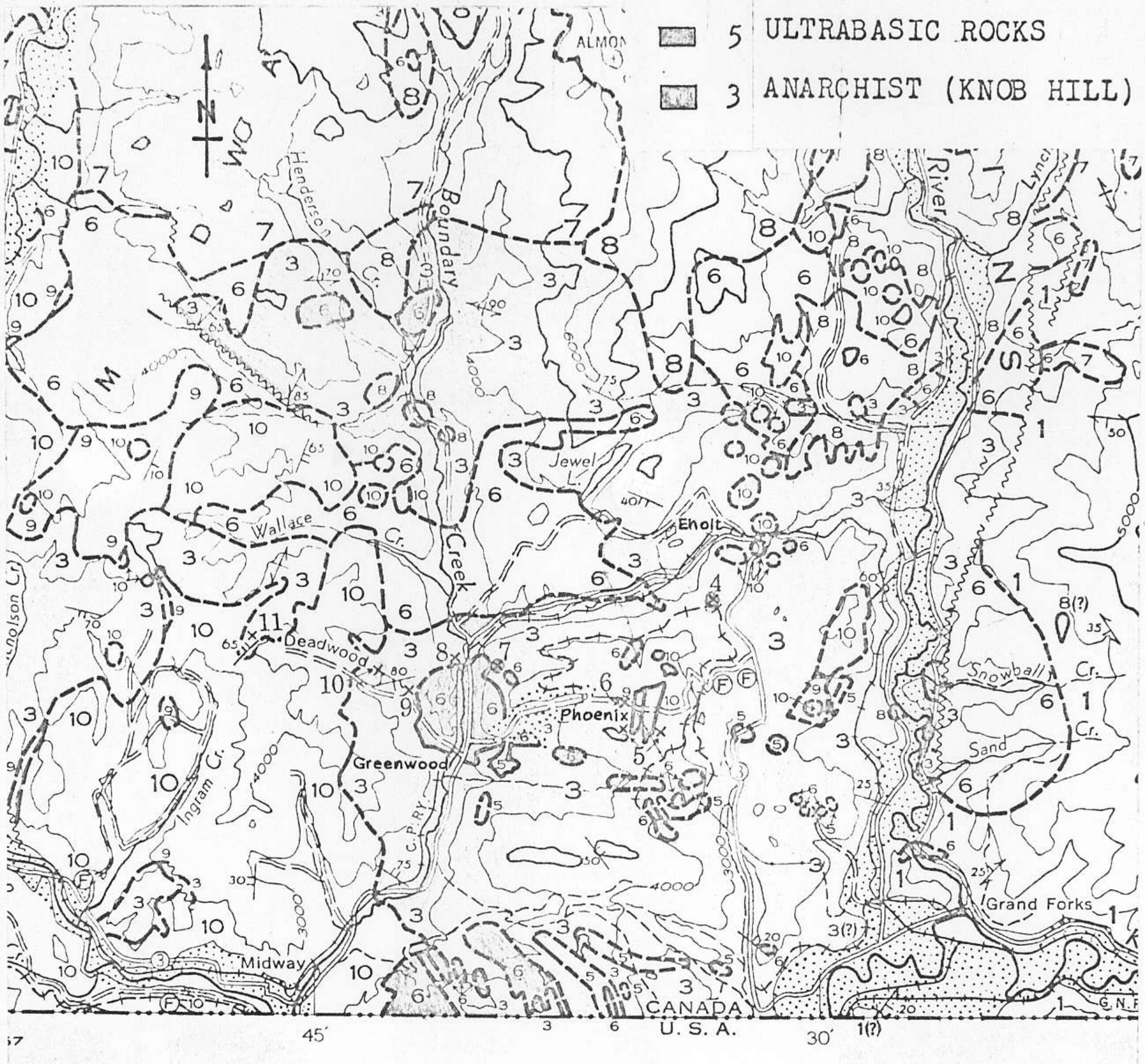

Figure 8. General Area-Geology.

(See Appendix B. Table Of Formations).

The facilities at Greenwood consist of most of the amenities available in any small city. Grand Forks has the same modern facilities with slightly more choice and, having the larger population, is the location of the hospital. Separate detachments of the Royal Canadian Mounted Police are stationed at Grand Forks and Greenwood.

IV. General Geology of the Phoenix Camp

A. Introduction to Local Geology

Essentially, Phoenix is an area of only moderately deformed rocks which overlay a Paleozoic (Knob Hill) andesite basement. These Knob Hill rocks are unconformably (?) overlain by a great variety of Triassic sediments. In the upper Mesozoic the area experienced several periods of intrusion. Tertiary times saw the unconformable deposition of the Kettle River sediments followed by the Midway volcanic rocks. Probably after a period of erosion there was limited deposition of breccias, possibly in the Oligocene. Coryell Intrusions were fairly widespread throughout the Boundary in Miocene (?) times. The Phoenix area underwent Pleistocene glaciation with subsequent deposition of reworked glacial drift and Recent alluvium.

B. Phoenix Mine Stratigraphy

The Phoenix area specifically has been geologically mapped to varying degrees by at least three Geological Survey of Canada geologists. In addition, R.H. Seraphim mapped the Phoenix camp for Attwood Copper Mines Ltd. . Also, several Granby Mining Company (Phoenix Copper Division) geologists have worked on the correlation and interpretation of the Phoenix

Mine stratigraphy. Each successive mapping removes more uncertainties in the geological history of the area and results in a more detailed knowledge of the rock units. Due to personal judgement no two tables of formation are the same.

The major change in the accepted sequence of deposition occurred when the stratigraphic positions of the Rawhide and Brooklyn Formations were reversed. The Brooklyn Formation consists of limestone and altered equivalents, while the Rawhide Formation is defined as shales and argillites. LeRoy (GSC Memoir 21, 1912) believed that the "cherty rocks" which underlie the Rawhide Formation were silicified limestone, thus placing the Rawhide above the Brooklyn. Subsequently, as reported by McNaughton (GSC Paper 45-20), it was found that these cherty rocks in question were either formed by silicification of argillites or were angular conglomerates. This finding is substantiated by the mapping of R.H. Seraphim and today the accepted sequence places the Rawhide Formation between the Knob Hill and Brooklyn formations. Other changes in the stratigraphic column have occurred with minor regrouping of subunits. The ages of some formations are subject to change as more detailed work is performed.

Since the Phoenix ores occur as pyro-metasomatic and contact metamorphic deposits only within the Brooklyn Formation, this unit is perhaps the best mapped. The following table of formations is based on the accepted data to date. (See Appendix B.).

C. Description of Line Grid Rock Types

(See Appendix C. --Detail Map of the 1968 Line Grid Geology.).

1. Knob Hill Formation

The Knob Hill Formation, shaped like a broadly elliptical trough-like bowl, may be part of a north-south syncline. It is intensely brecciated and otherwise a distorted formation consisting predominantly of chert (quartzite) and andesite. Although the actual thickness of the group is unknown, drill holes indicate a minimum depth of 1200 feet.

The fine-grained quartzite is generally pure white to light grey in colour and is usually brecciated to the point where it is often difficult to obtain a freshly broken surface larger than one's thumbnail in size. Whenever extensive brecciation occurs it is accompanied by intense limonitic staining along the joints. Manganese oxide stains are also present along joints, but to varying degrees. Occasionally an outcrop of quartzite (chert) may appear quite massive. In the vicinity of Deadman's Ridge and the Phoenix-Grand Forks road indications are that chert bodies may exceed individual thicknesses of several hundreds of feet.

Knob Hill andesites commonly resemble tuffs or intensely weathered diorite porphyries. These rocks are dark grey-green to grey-brown in colour. The phenocrysts, possibly formed by recrystallization after deposition, are predominantly pyroxene (augite), biotite and plagioclase feldspar. There are apparently at least three separate andesitic intrusions which together form a massive complex lacking sufficient structure to enable determination of a relative stratigraphic sequence. In places, andesite outcrops may be cleaner, fresher looking and more coarse-grained than usual. Many of the countless shears which cut the andesite in all directions and all dips, are filled with gouge material. Occasionally, both the gouge material and the parent andesite contain finely disseminated and/or very minor amounts of chalcopyrite.

In mapping, some augite porphyries may have mistakenly been included in the Knob Hill proper. Their absolute age has not been determined and even though there is nothing to indicate that these porphyries cut the Attwood Series, it is very possible that they are indeed Jurassic extrusions or part of the Midway Volcanics.

2. Rawhide Shale

This formation is a dark grey to black argillaceous shale lens with a maximum thickness of 200 feet. It lies below and is transitional to the Brooklyn Formation. The shale exhibits distinct bedding laminations which vary from light- to dark-grey. The dip of the beds varies from zero to 20 degrees west and northwest. A single exposure containing truncated symmetrical ripple marks indicates that the shale was deposited in quiet water and that the beds are oriented top side up. Only one fossil imprint (graptolyte or fern frond) has been found in the shale. It is believed that the Rawhide Shale pinches out in the southwest, and towards the east the lens is only seen as far as the Rawhide Mine. Rawhide Shale does not outcrop in the areas of the 1968 line grids.

3. Brooklyn Formation

LeRoy (1912) described a unit of "cherty rocks" or jasperoids (siliceous rocks formed by replacement of limestones). Since then these rocks have been reclassified as sharpstone conglomerates and the lithology of the lower Brooklyn Formation has been divided into three separate units. Subsequent to Seraphim (1956), field work has resulted in the addition of two units between the skarns and the top unit of the formation, a basalt. Intensive interest in the Brooklyn Formation is justified by the fact that this formation is host to all the major orebodies in the Boundary camp.

a. Sharpstone Conglomerate

This unit is a conglomerate in which the fragments are angular to sub-angular. This author and others maintain that the chert fragments in this conglomerate are original pebbles rather than siliceous replacements. Subsequent to deposition, metamorphic events have reworked some of the quartz and/or chert, but essentially no silica has been added to the bulk of the unit. The reasons for this statement follow:

i. (a) The distribution of coloured chert fragments is completely haphazard,

(b) the banded chert fragments are haphazardly oriented,

(c) the composition of neighbouring fragments is completely non-uniform,

(d) the "jasperoids" do not show the regional structure of a tectonic breccia.

ii. The rock is bedded and forms conformable contacts with shale, argillite, and impure limestones; except

iii. Several outcrops of interbedded fragmental rock and shale or argillite show scour and fill structure.

Figure 9. Bedding in Sharpstone Conglomerate.

Some of the angular fragments are limestone, suggesting not only that this was a quickly deposited sediment, but also that it must be within several thousands of feet of the source materials.

b. Argillite with Pebbles

An aphanitic sediment (claystone) which contains a profusion of well-rounded pebbles of various compositions. The pebbles, though rounded, do not appear to be flattened or preferentially aligned, except for some rudimentary bedding.

c. Aeolian Sandstone

This rock was termed "Peanut-Brittle Limestone" by Seraphim; and LeRoy postulated that it was a transitional stage in the silicification of the limestone. The rock has a fine-grained limestone matrix which contains well-rounded, frosted, well-graded chert grains of fairly uniform colour and specific composition. Weathered surfaces of this rock are very distinctive. No quartz veinlets are known to occur in this unit, and this author strongly believes that these chert granules, being stratigraphically distributed as they are, are a windblown deposit.

Figure 10. Weathered Surface Of Aeolian Sandstone.

d. Marble

In the Phoenix area a lens of creamy to light-grey limestone overlies the basal bed of sharpstone conglomerate. This limestone achieves a maximum thickness of about 2000 feet, and in places contains abundant shale and/or argillite laminations. Both the northern (under drift) and southern (in the old Idaho Mine) terminations of this limestone are very abrupt. The limestone, although somewhat pyro-metamorphosed exhibits residual bedding. In places the introduction of silica has formed siliceous bands which may host metallic mineralization.

e. Skarns

The skarns in the Phoenix area are pyrometasomatic effects which are expressed as a zone of lime silicates. This zone is composed generally of epidote and garnet together with quartz, chlorite, hematite, and secondary calcite. Actinolite is the only other skarn mineral of any abundance. Although the predominant skarn is of limestone origin, argillite-, chert-, and sharpstone-skarns are also known where these units are more limey than usual. Metallic mineralization may occur in any of the skarns. Local conditions determine whether this mineralization is disseminated, banded, or massive.

Figure 11. Garnet - Epidote Skarn.

Figure 12. Secondary Calcite With Disseminated Chalcopyrite.

Figure 13. Polished-Section Of Chlorite Skarn.

Figure 14. Partially Replaced Argillite-Skarn.

f. Pebbly Argillite (Blackstone Argillite)

This unit was given the field name "meta-argillite" by this author. It differs from the previously mentioned "argillite with pebbles" in that this is a very distinct unit. In this argillite the pebbles are all a black andesite or basalt. These pebbles have been flattened and elongated. In addition, micro flow structures are exhibited within the fine-grained, pale-green matrix. Secondary calcite occurs along fractures within this unit. (see Figure 15).

g. Sharpstone Conglomerate

The major stratigraphic unit above the main Phoenix limestone lens and skarns is another sharpstone conglomerate. This unit has a thickness of from 1000 feet to 1500 feet. Angular fragments of the Blackstone Argillite are common in at least the lower part of the unit which also contains two 100 foot thick pods of limestone breccia known as the Stemwinder limestone. The association of the sharpstone conglomerate suggests that this limestone is of sedimentary rather than tectonic breccia origin.

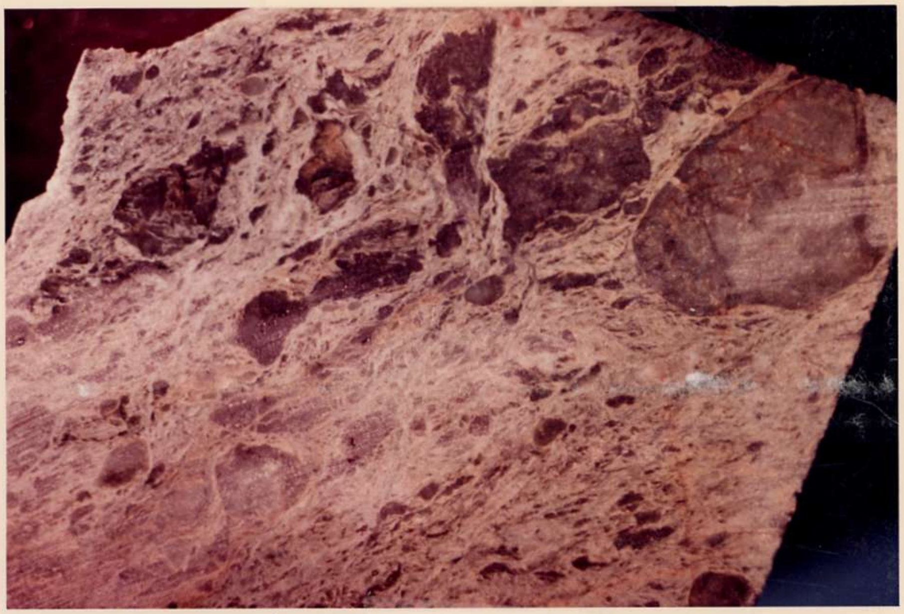

Figure 15. Blackstone Argillite.

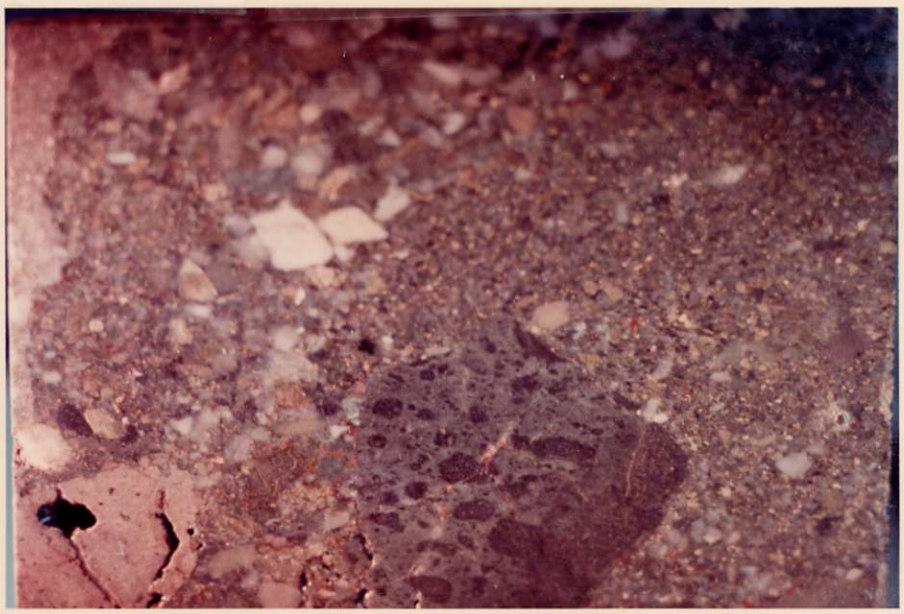

Figure 16. Sharpstone Conglomerate.

h. Basalt

Massive beds and lenses of a rock andesite to basaltic in composition lie within and unconformably above the Brooklyn Limestone. The more andesitic and siliceous phases of this rock are quite difficult to distinguish from the massive Knob Hill andesites and accordingly the rock may be incorrectly mapped in places.

4. Jurassic (?)

Geologists who have mapped the Phoenix area generally believe that flow breccia deposits, massive greenstone occurrences and flows of augite-, biotite-augite-, and biotite- porphyry occured in Jurassic times in the Boundary District. Some augite porphyries on the 1968 line grid map may be mistakenly identified as belonging to Group 2 (Knob Hill) rather than group 2A -- Jurassic (?).

5. Cretaceous

A batholith of granodiorite believed related to the Nelson Intrusions of Laramide age underlies most of the Boundary Creek and Kettle River drainage areas.Mesozoic intrusives in the general area of Phoenix include the quartz-diorite stock which outcrops around the city of Greenwood, and just west of the Oro Denora and Emma Mines, south of Eholt. Two granodiorite dykes occur on the Snowshoe claim and one occurs underground in the Rawhide Mine. These last three dykes were mapped by Le Roy and may actually be related to the pulaskite and syenite dykes of the Coryell Intrusions, rather than the Nelson or Valhella Intrusions.

Figure 17. Typical Piece of Nelson Intrusive Rock.

6. Tertiary

The early Tertiary stratified rocks of the Greenwood Map area were studied in detail by J.W.H. Monger (GSC Paper 67-42).

a. Kettle River Formation

This group of rocks is predominantly dacitic tuffs, arkose or greywacke with local occurrences of shale or conglomerate. The matrix of these units contains variable amounts of calcite. Individual beds range in thickness from a few tenths of inches to over 50 feet. The arkosic sediments are well exposed in the Phoenix pit. The general dip of the arkose at Phoenix is 30°E which, if righted to the horizontal, would give a synclinal shape of northerly plunge to the areas of ore deposition.

b. Midway Volcanics

This unit includes about 5000 feet of latite, andesite and feldspar-porphyry basalts. These flows lie conformably or slightly disconformable over the Kettle River rocks.

Figure 18. Kettle River Arkose.

Associated with the flows are hypabyssal intrusions of syenite (pulaskite), and small augite porphyry dykes. In the Phoenix skarn, pulaskite dykes are highly altered to clay and/or related minerals making identification difficult. Pulaskite contacts are invariably sharp. The rock is flesh-brown coloured, contains partially dissolved feldspar phenocrysts and both pyrite and magnetite grains. Due to the magnetite content magnetic geophysical penetration of pulaskite sills is almost impossible.

(See Figure 19 and Figure 20)

Figure 19. Pulaskite.

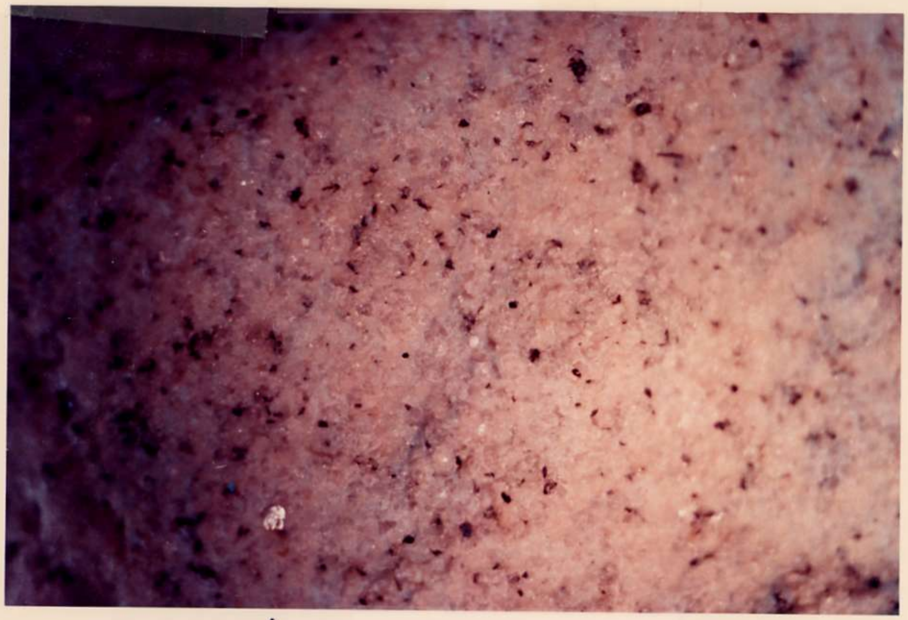

Figure 20. Syenite.

D. Local Structural Geology

1. Knob Hill Formation

Well-defined horizon markers and bedding are noticeably absent from the Knob Hill Formation. Locally, zones which exhibit their own characteristics may be beds. Such zones are several hundred feet thick and have a northwesterly trend.

2. Knob Hill-Brooklyn Contact

Though only one outcrop is known to span this contact (S.E. slope of Deadman Ridge) and here, in Seraphim's words, "The contact is 'frozen', with no faulting or distinguishable hiatus. The transition from massive andesite to chert pebble conglomerate (andesite matrix) occurs within a few inches." However, the contact is believed unconformable because:

(a). Angularity of the sharpstone conglomerate indicates rapid deposition of sediments which upon subsequent lithification and metamorphism would appear to have a gradational and conformable contact.

(b). The variation in composition of the lowest Brooklyn unit is simply a result of lateral gradation common to deltaic deposits, whereas Knob Hill members do not lens out.

(c). The orogeny which distorted and brecciated the Knob Hill rocks apparently had no effect on the Brooklyn Formation, as beds and bedding in these units may be traced over considerable distances.

(d). Alteration type and fractured nature of the contact at the Gold Drop and Sunset mines could conceivably be caused by weathering and erosion in early Brooklyn, in Mesozoic to Tertiary and in Recent times --- rather than by faulting.

3. Brooklyn Foarmation

The presence of limestone in the Brooklyn and symmetriaclly ripple-marked shale in the Rawhide Formation is very indicative of shallow-marine deposition. Non-diagnostic fossils from the limestone have suggested that the probable age is lower- or middle- Triassic.

The Brooklyn rocks, including the Granby orebody, dip from 45° to 70° easterly in surface exposures. However, 200 feet below surface the orebody and original banding in it have flattened to a 10° or 15° easterly dip. At a depth of about 1000 feet the orebody is approximately horizontal and is underlain by Knob Hill cherty-andesite. A major fault, the Footwall Fault, cuts off the Granby orebody across its northwest end. An Old Ironsides-Victoria cross-section follows.

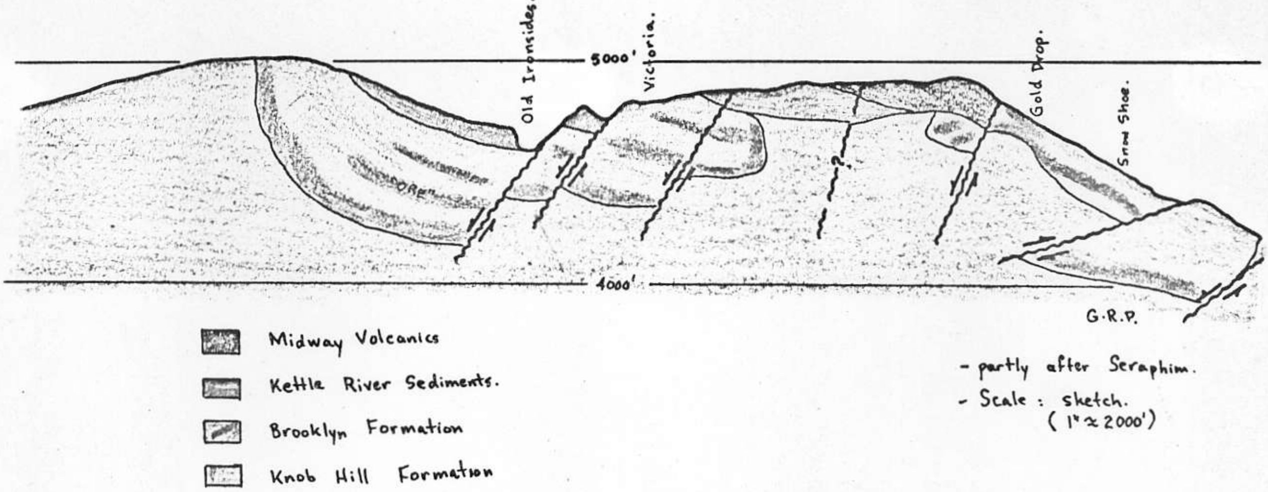

Figure 21. Old Ironsides-Victoria Cross-Section Looking North.

V. Mineralization Associated with Skarn

The Phoenix copper orebodies are essentially all pyrometasomatic replacements of altered limestones or impure limey rocks. Although different horizons in the skarn zone are mineralized the ore generally prefers the lower and outer portions. Orebodies range in size from the lenses about 100 feet by 40 feet by 20 feet to extensive masses such as the Knob Hill-Old

Ironsides deposit which is about 2500 feet long with a known width of some 900 feet. Although the ore locally varies from disseminated to massive or veined, the ore as a whole is remarkably uniform and is almost self-fluxing.

Three phases are suggested in the formation of the main Granby orebody. The first --- a syngenetic phase; the second --- a stage of alteration and thirdly, ore deposition, probably epigenetic.

Figure 22. Post-ore Slickenside in Magnetite.

(1) Syngenetic

The syngenetic minerals are: calcite, quartz, pyrite, magnetite. These minerals are seen in the footwall sharpstone conglomerates. Due to lack of other evidence it is believed that the pyrite and magnetite is authigenic.

(2) Alteration

The alteration products are: calcite, chlorite, garnet, euhedral quartz, hematite and fractured pyrithohedral pyrite.

The phases of alteration and mineralization are spatially related and were probably very close in time. Despite the fact that large areas were subjected to alteration (magnetic garnets have been found in the sharpstone conglomerate) only in an environment of very steep thermal gradient did ore deposition occur. Even within the ore zone there were probably "hot" spots --- indicated by completely crystallized garnet and small pyrite areas. At this time it is likely that some calcite was mobilized to form calcite veins; followed perhaps, by a small amount of euhedral quartz.

(3) <u>Epigenetic</u>

These minerals are: gold,silver, chalcopyrite, magnetite, specular hematite and calcite.

Silver-gold ratios would seem to indicate that the thermal gradient at this time was quite high. These elements were followed by chalcopyrite which contains about 2/3 of the gold and silver values. (1/3 is alloted to pyrite). Finally, probably only in the ore zone, the mass was enriched in carbonate porphyritic texture.

Megascopically, magnetite occurs in distinct masses, or lens-like bodies, both in and along main orebody borders. In the Monarch deposit, magnetite is particularly abundant. Microscopically, most of the chalcopyrite is rimmed, largely by magnetite, although also by hematite. Magnetite seems to be the dominant mineral replacing chalcopyrite.

It is not known for sure if replacing silver-gold rich chalcopyrite would mobilize the gold and silver. It is probable that up to some critical concentration and temperature the gold and silver would stay with the magnetite.

Production data indicates that magnetite from the Phoenix pit assays average grade in gold and silver, while magnetite from the Golden Crown Mine gives exceptionally high gold and silver values. This problem of gold-silver relationships to the ore requires further research.

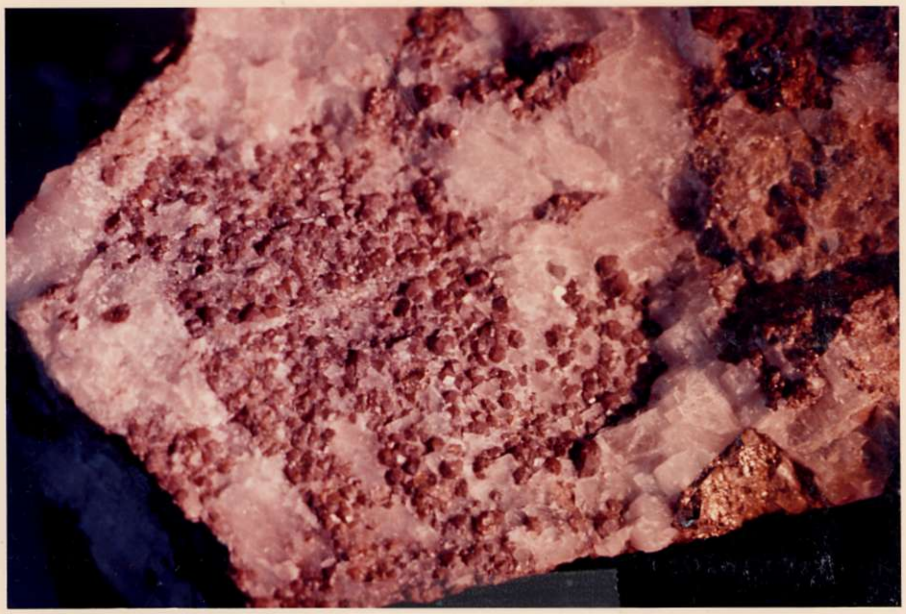

Figure 23. Garnets In Crystalline Calcite.

Figure 24. Garnet-Epidote Skarn.

Figure 25. Fractured-Pyrite Alteration.

Figure 26. Typical Ore From The Old Ironsides Pit.

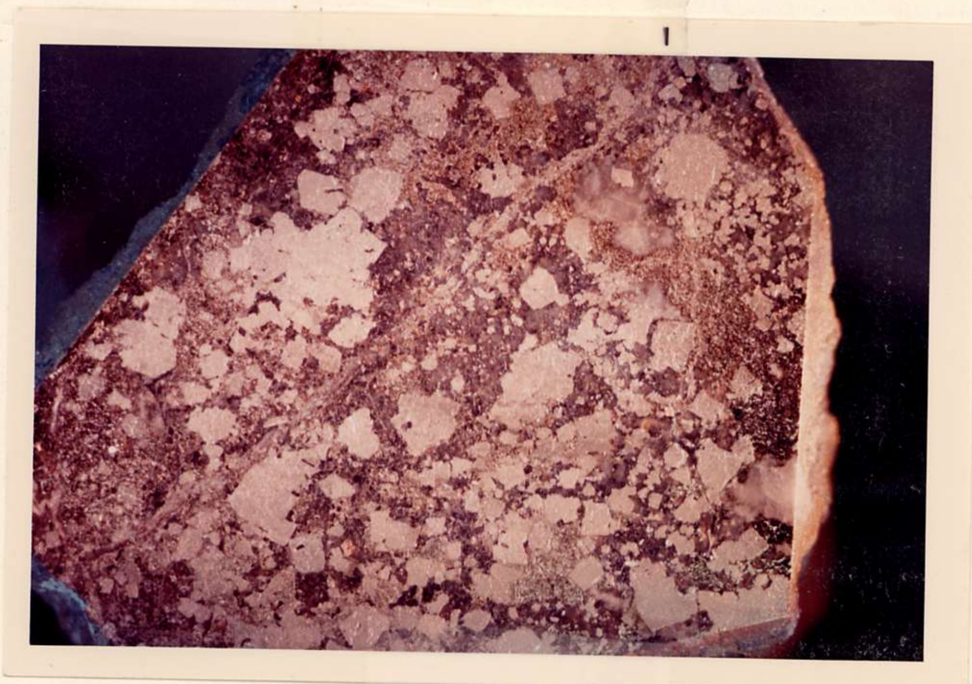

Figure 27. Massive-Sulphides Type Of Ore.

Figure 28. Vein-Type Ore.

Figure 29. Calcite And Massive Chalcopyrite In Epidote Skarn.

Figure 30. Calcite And Crystalline Pyrite In Epidote Skarn.

Figure 31. Calcite And Chalcopyrite From A Vug.

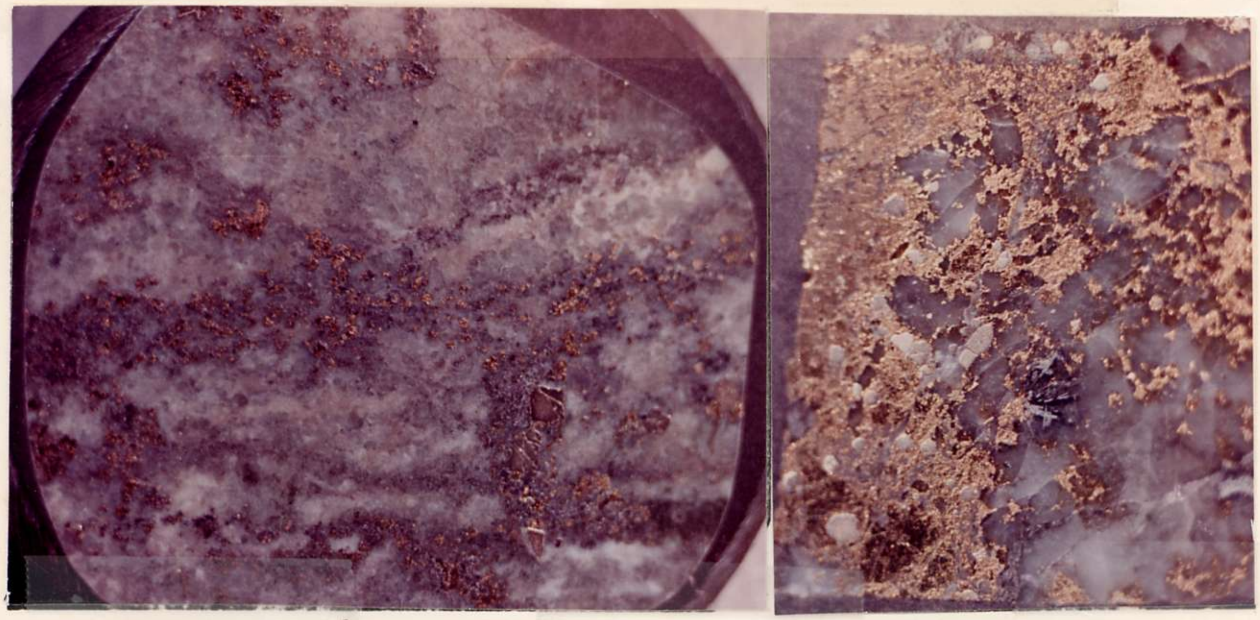

Figure 32. Close-ups Of Disseminated Ore.

Figure 33. Chalcopyrite-Pyrite-Hematite-Calcite Relationships.

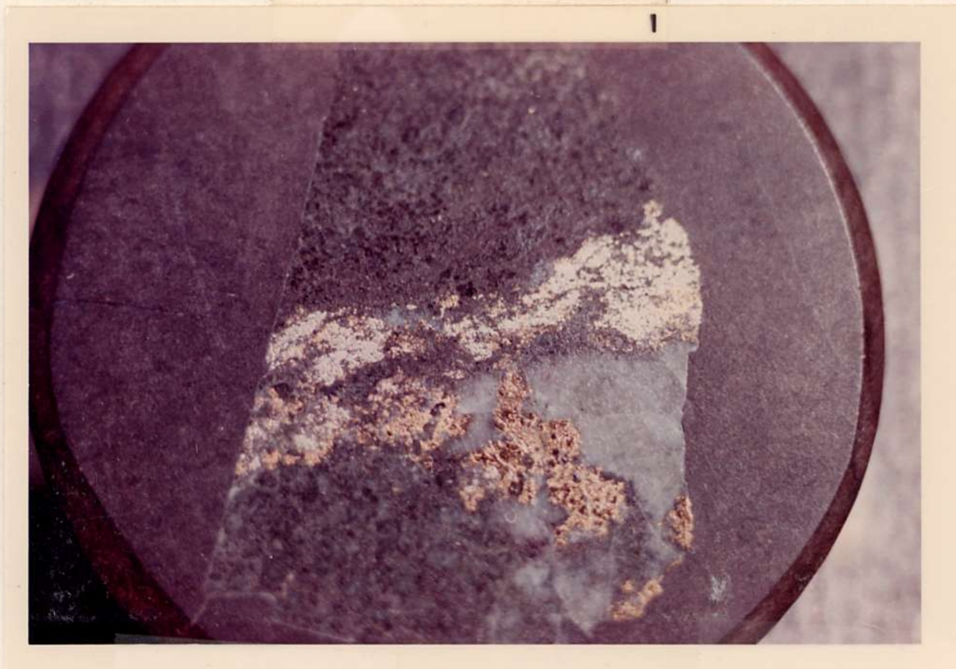

Figure 34. Pyrite And Chalcopyrite In Chlorite Skarn.

VI. Evaluation Of The 1968 Line Grid Geophysical Data

A. Introduction

The purpose of the induced polarization (IP) survey of the 1968 line grids was to prospect for sulphide mineralization in both massive and disseminated forms. The IP response over known mineralization in the ore zone of the Phoenix pit is quite positive.

The IP survey was done on grid lines 400 feet apart except on Line Grid 1 and Line Grid 1-SW Extension where the lines are only 200 feet apart. IP readings were taken along line with a 200 foot separation between readings. Detail work was done over several anomalies using a variety of electrode separations and smaller station intervals.

Surface geology is fairly well known on all grids and previous diamond-drilling has yielded general sub-surface information. A ground magnetometer survey of all the 1968 line grids has been done on a 100 foot grid.

B. IP Survey Techniques

1. Field Measurements

The characteristics of the IP system that was used are as follows:

(a) Period: 1.5 seconds "current on"
C.5 seconds "current off",

(b) Integrating time ≅ 400 milliseconds,

(c) Maximum power available ≅ 2.5 kilowatts,

(d) Maximum current available ≅ 3.0 amperes.

The measurements taken in the field and the subsequent calculations that were performed are defined as follows:

(a) The current flows through the current electrodes (C_1 and C_2),

(b) The primary voltage (V_p) is measured between the potential electrodes during "current on" time,

(c) The secondary voltage (V_s) is measured between the potential electrodes during "current off" time,

(d) The apparent charge (Ma) = $\frac{V_s}{V_p}$ x 400 milliseconds.

(e) The apparent resistance equals:

$$\frac{V_p}{I} \times G.F.$$

where: I ≅ current applied.
G.F. = geometry factor that applies to the electrode array being used.

2. Electrode Configurations

The pole/dipole configuration was the most commonly used set-up. Here, the current electrode C_1 and the potential electrodes P_1 and P_2 are moved along in unison. (See Figure 35.)

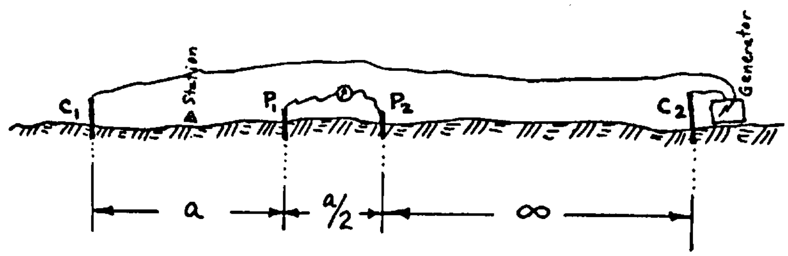

Figure 35. Pole/Dipole Configuration.

Since "a" is a rough approximation of the depth penetration achieved, detailing was done by profiling the anomalies. This is accomplished by varying the value of "a". The profile data provides additional information which allows easier calculation of depth, dip and location of the causative bodies.

For operational convenience the "three array" method was required for some detailing.

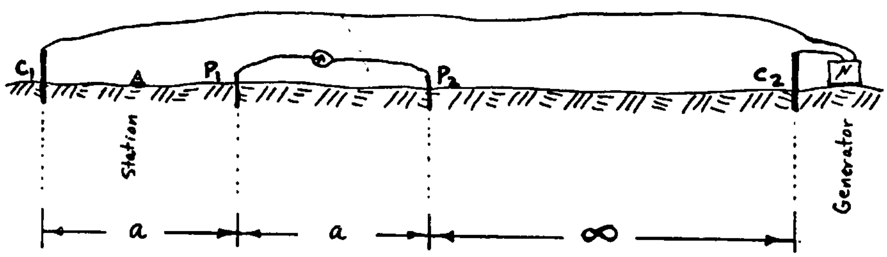

Figure 36. Three Array Configuration.

The response achieved with this array provides almost identical data. Due to the assymetry of the pole/dipole array Ma contours, in a broad sense, provide only the outlines of the main regions of the strong or weak IP response. Because detail work gives much better resolution it is used to determine the position and geometry of causative bodies.

C. Line Grid Geophysical Surveys

1. Line Grid 1

Chargeability response throughout the grid is very high. Background values of approximately four to five milliseconds were obtained in the extreme western and southeast part of the grid. Most of the grid gives a response greater than 15 milliseconds with a maximum value of 37 milliseconds in an area of numerous outcrops which carry minor disseminations of pyrite and chalcopyrite. This sulphide mineralization is the probable source of IP response. Geophysical results would indicate that sulphide mineralization is much more continuous than surface geology would show. The depth to causative bodies varies from 100 feet in one case, through 250 to 300 feet in a second case, to 300 to 400 feet in a third instance.

Magnetic relief throughout the grid is not very great and as such, magnetite is not suspected as being an IP source on this grid --- except in one case where a strong magnetic anomaly coincides with high IP response.

2. Line Grid 1 (SW Extension)

The strong apparent-chargeability observations on Line Grid 1 continue southward into this area. Here, causative bodies are indicated as being deeper than on Line Grid 1. Several abrupt depth changes are suggested by the IP data. Magnetometer results do not suggest any significant amounts of magnetite mineralization which could cause the IP anomalies on this grid.

3. Line Grid 2

On this grid one broad anomalous feature has been detected as a north - south trend. Detail of this broad anomaly indicates at least two causative bodies in the north and probably only one in the southern part of the anomaly. Background apparent chargeability is in the order of 2.5 to 4.0 milliseconds with the main anomaly peaking at 25.1 milliseconds.

In general, causative-body dips range from slightly westerly to apparently vertical. The center of the southernmost anomaly seems to be approximately 180 feet below the surface and mineralization is suggested as continuing to depth. The structure seemingly plunges north so that the northern anomalies are centered about 300 feet below the surface and indications are that sulphide mineralization increases with depth.

A number of chalcopyrite- and pyrite - mineralized showings can be directly correlated to the indicated causative bodies. However, a number of other such mineralized showings give entirely no apparent-chargeability response. In the cases of "no-response" readings this author suggests that the corresponding mineralization has little or no downward continuation. Although apparent-resistivity results fail to outline major rock types these resulte do indicate a possible northeasterly fault cutting across this grid.

Strong magnetic features are not associated with any of the suggested causative bodies. Where strong magnetic anomalies do occur on this grid they appear to be sufficiently localized so as not to interfere with IP results. Sulphides, then, are suggested by this author as being the most likely source of the IP anomalies on Line Grid 2.

4. Line Grid 3

Very strong apparent-chargeability readings were observed in the western part of Line Grid 3. There is no direct geological evidence to account for the eastern body of this anomalous zone which has a very well defined strike of 155°. Generally, the apparent-resistivity values associated with this chargeable zone throw little light on this question. The apparent-chargeability values of this anomaly are four to five times the background value of 3.5 to 4.0 milliseconds.

More geophysical detail-work should be done on Line Grid 3 as the complex chargeability pattern is almost impossible to interpret. There are, apparently, a number of causative bodies here and the ones that have been detailed have a definite easterly dip. Generally, mineralization starts near the surface and appears to have considerable depth extent. At least one anomaly corresponds fairly well with known disseminated pyrite mineralization indicated on the geology map.

Several magnetic anomalies have been outlined on Line Grid 3 but no particular strike direction or rock types appear to correspond to these magnetic anomalies. This together with the overall magnetic anomaly dimensions suggests disseminated sulphides as the source of the anomalous IP responses.

5. Line Grid 4

The main anomaly strikes approximately 165°. From detail work two causative bodies are indicated. Apparent-chargeability suggests that the western anomaly is much more strongly mineralized. This anomaly originates at or just below bedrock surface and continues downwards at least 400 feet. Surface mineralization at station 21W on line 32S may be an outcropping of the source material.

Apparent-resistivity lows occur sporadically and are probably caused by increased depth of overburden and/or swampy ground. In several cases strong apparent-chargeability readings correspond with apparent-resistivity lows, and maybe in these instances the apparent-resistivity lows are associated with increases in sulphide mineralization.

6. Line Grid 5

A broad, relatively weak IP anomaly on Line Grid 5 covers an area about 1500 feet by 1500 feet. The overall apparent-chargeability of the anomaly suggests a shallow easterly dipping causative body. The shallowest part of this causative body is below 150 feet and is probably still deeper, around 300 feet. This large anomaly is in an area of decreased magnetic intensity which rules out magnetite as the source material for this IP anomaly.

VII. Conclusions

The geological map indicates a number of areas that seem to be favourable hosts of sulphide mineralization. Despite the fact that surface samples which were assayed all gave uneconomical copper values, bodies of ore may exist at depth. Indeed, the IP survey indicates a number of areas that would seem to be favourably mineralized at depth.

The target areas outlined by compilation and correlation of IP survey results, magnetometer data, and surface geological mapping are worthy of further exploration. In fact, it is good exploration procedure to follow-up the outlining of target areas, as such, by diamond-drilling at least the apparently more favourable causative bodies. When this further work is being carried out several important facts should be remembered. Firstly, all previous geological work in the Phoenix camp has shown that mineralization of economic interest within the camp is confined entirely to the Brooklyn Formation. Secondly, since the Phoenix ores are pyrometasomatic in origin, the ores are haloed by skarns. Of course, exceptions to every rule exist and there is always the possibility that economic mineralization in the Phoenix camp will be found to occur under conditions other than those previously mentioned.

Appendix A. Claims Map Of Phoenix Area.

Scale: 1 cm = 1000 ft.

Ref: Greenwood, B.C. Claims Map.

Summit City
Phoenix
RIDGE
MONTEZUMA
Hartford
Junction
BAKER RIDGE
Fisherman Cr.
Neff Cr.
N

Appendix B. Phoenix Table Of Formations.

PHOENIX TABLE OF FORMATIONS.

CENOZOIC	QUAT.	RECENT		Stream Alluvium
		PLEISTOCENE		Reworked Glacial Tills
				Glacial Retreat
UNCONFORMITY				
	TERTIARY	(?)	CORYELL INTRUSIONS	Pulaskite, Syenite, Quartz Monzonite.
				Dykes & Sills
		OLIGOCENE (?)	BRECCIAS	Chert, Greenstone, Syenite, Diorite, Gabbro
	UNCONFORMITY (?)			
		EOCENE	MIDWAY VOLCANIC GROUP	Latite, Andesite, Feldspar Porphyry,
				minor Tuff
			KETTLE RIVER FORMATION	Dacitic Tuffs, Arkose, locally Shale
				or Conglomerate
UNCONFORMITY				
MESOZOIC	CRETACEOUS		VALHALLA INTRUS.	Porphyritic Granite, Syenite, Quartz Monzonite
			NELSON INTRUS.	Granodiorite, Quartz Diorite
				Serpentinite — Pyroxenite Complex
	JURASSIC (?)			Flow Breccia, massive Greenstone, Augite Porphyries
	TRIASSIC	ATTWOOD SERIES	BROOKLYN FORMATION	massive Basalt
				Sharpstone Conglomerate
				Blackstone Argillite
				Skarns: Limestones, Argillites, Cherts, Sharpstones
				Marble
				Aeolian Sandstone
				Argillite with Pebbles
				Sharpstone Conglomerate
			RAWHIDE FM.	Shales
UNCONFORMITY (?)				
PALEOZOIC	PERMIAN &/or earlier		KNOB HILL FORMATION	Chert
				Greenstone
				Black Phyllite
				Schist
				Amphibolite
				Limestone
				rgillite
				Andesite

G.R. Perry 1968-69

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RELATIONSHIP BETWEEN GOLD AND THE COMMON SULPHIDE ORES.

by:- GRAEME R PERCY.

18 FEBRUARY 1969

RELATIONSHIP BETWEEN GOLD AND THE COMMON SULPHIDE ORES

ABSTRACT. *

An intensive review of the literature indicates that gold occurs most frequently in direct contact with the following ore minerals in the order named: pyrite, arsenopyrite, galena, sphalerite, chalcopyrite, bismuth minerals, pyrrhotite, tetrahedrite-tennantite. The most common gangue minerals containing gold are: quartz, carbonates, chlorite, graphite (including other carbonaceous material), and tourmaline. Many other minerals are occasional hosts for gold. Available data suggest that few minerals are effective precipitants of gold under natural conditions although the possibility of precipitation of gold by the host mineral is not denied. Variability in the relation of gold to host minerals is common and it is concluded that each occurrence must be studied separately in deciding which mineral or minerals are valuable guides to gold values.

* Ref. 2.

Intensive investigation of the minor element content of sulphide ores in partcular has been going on for over a hundred years. Initially, the main object of such work was to find new elements and new sources of the rarer elements. For example, the discoveries of indium in sphalerite in 1863 and gallium in sphalerite in 1874. More recently, the emphasis has been on obtaining information about the ore genesis from minor element content and gaining knowledge as to which minerals contain the precious metals. This knowledge enables the proper design of concentrate flow sheets to recover any economic quantities of precious metals which exist in the ore.

I have chosen to investigate the relationships between gold and the common ore minerals, especially the sulphides.

The association of gold with the sulphides is both common and important. High power examinations reveal that certain sulphides are more often associated with high gold values. In the treatment of such ores the specific association of the gold may prove to be of great economic importance. One, however, should not jump to the conclusion that because of the apparent gold - sulphide relationships the sulphides exert some definite chemical control. The variation in the relation of the individual sulphides to the gold content must be emphasized. Personally, I would be inclined to conclude that host minerals do not always act as effective precipitants. Gold hosts are in fact hosts because of a fortunate association in time and place, plus the limited precipitating effects possible under the specific conditions of formation in each deposit.

Minor elements and precious metals may occur in ores in two ways:

1. as trace elements, which include isomorphous substitution and adsorption.
2. as trace minerals, which include the distinct phases of overgrowths, intergrowths and various types of inclusions.

Ore microscopy has shown that occurrence by distinct phases is the rule rather than the exception. This would agree with Dr. H.V. Warren's statement that " The relation of gold to sulphides is mechanical or electrochemical, rather than just chemical.

In extreme cases gold occurs as particles of sub-microscopic size, distributed throughout the contemporaneous sulphide or in solid solution with the sulphide. Grain size is dependent upon the initial temperature and the cooling rate, or auto - annealing of the ore.

Generally, however, the bulk of the gold in any ore occurs as particles within the microscopically visible range, and for any given ore the particle sizes will conform to a frequency, or average size, is characteristic of that ore, but will vary from ore to ore.

Argentite:

Although argentite is often an important mineral in epithermal gold - silver deposits, a distinct association between argentite and native gold does not appear to be common. Perhaps it should be noted that gold apparently does not occur primarily in epithermal deposits. However, the moderate number of epithermal gold deposits furnish some of the richest ore.

Arsenopyrite:

The direct association of gold with arsenopyrite has long been recognized but this relationship is not nearly as widespread as some may believe. In a few deposits, arsenopyrite, although present, apparently has little connection with the distribution of gold. Visible gold is often found during microscopic examination of arsenopyrite and assays in general would tend to indicate a preference of gold for arsenopyrite. Anomalous gold values are also often related to quartz -,chlorite or pyrrhotite-content. Laboratory data suggest that arsenopyrite may be fairly effective although definitely not always a consistent precipitant of gold. Perhaps the importance of arsenopyrite as a host of gold then, is simply a matter of association rather than actual precipitation by the host.

Gold - bismuth bearing minerals:

Native bismuth, bismuthinite, galenobismutite and cosalite occur in a few gold ores. Descriptions in the literature invariably emphasize the importance of these minerals when present. This would seem to justify concluding that these minerals act as precipitants of gold and gold tellurides. Possibly, if bismuth mineral occurrences were more widespread they would be of very great importance in the localization of gold.

Chalcocite:

Although native gold is known to occur often with chalcocite, and it has been shown experimentally that both gold and silver are especially effectively precipitated by chalcocite, in nature chalcocite seems to be of slight importance in precipitating gold. The solutions which form supergene chalcocite would not ordinarily carry gold. Also, although there does not seem to be any special reason, in epithermal deposits gold and chalcocite are apparently just not deposited together.

Chalcopyrite:

In a few ores chalcopyrite is an indication of good gold values and, in general, direct contact between gold and chalcopyrite is not unusual. However, in some instances gold and chalcopyrite occur together with other minerals and the gold - chalcopyrite relationship fails to even remotely suggest that the gold was precipitated by the chalcopyrite. It should be noted that, because of color similarities, great care must be taken if the gold in chalcopyrite is not to escape optical detection.

Galena:

There are numerous references to galena containing gold in gold deposits. Since the galena is most often not abundant, this association is perhaps explained by the relative positions of galena and gold in the paragenetic series. Galena is generally a late mineral and since gold is usually considered to be the last mineral in the series the two occur together, not only because of the precipitating power which galena may have, but also because of the purely mechanical association of the minerals at about the same time and place. This relation is apparently extensive enough that in many areas lead sulphide is regarded as a good indicator of high gold values.

Steel galena generally contains gold streamers due to granulation and recrystallization of gold during rock flowage.

Magnetite:

Gold is not commonly associated with magnetite although the mineral does occur in some gold mines. The most notable examples are:

1. gold replacing magnetite in the Homestake Mine
2. abundant free gold in magnetite in the Windpass Mine, B.C.
3. low gold values in magnetite which extensively replaces a carbonate rock - Ajax Mine, Willow Creek, New Mexico.

Molybdenite:

Although small amounts of molybdenite are common in hypothermal deposits and molybdenite is known to be capable of precipitating gold from gold-chloride solutions, only one example of gold intergrown with molybdenite has been reported.

Pyrite:

Pyrite and gold are so closely associated in many deposits that their close relationship is almost taken for granted. The almost universal distribution of pyrite in ores probably accounts for the common association rather than any special precipitating powers of pyrite. However surprising it may be, there are many exceptions to the gold - pyrite association. Perhaps the most striking example of an exception is the case of the Patricia Gold Mine, Ontario. In this mine the gold seems to be associated with all of the sulphides except the pyrite.

Extensive studies of the occurrences of gold in pyrite result in the conclusion that all gold in low grade pyrite ores is on the crystallographic faces of the pyrite, while in high grade specimens the pyrite is commonly fractured with gold filling in the fractures. Also, in high grade samples, gold occurs as isolated inclusions in the pyrite.

To sum up for pyrite then, whereas much gold does occur with pyrite, the association is neither universal nor consistent.

Pyrrhotite:

Gold associations with pyrrhotite are also erratic. In some hypothermal veins pyrrhotite has apparently localized the gold while in other deposits the pyrrhotite is essentially barren. There is little difference in the powers of pyrite and pyrrhotit to precipitate gold from gold - chloride solutions.

Specularite:

The occcurrence of specularite with gold does not seem significant except as an indication of fairly high temperature at an earl stage in formation of the deposit.

Sphalerite:

In general, the occurrence of gold in sphalerite is not as common and the genetic relation is not as evident as in the case of galena with gold. Some erratic trends occur with sphalerite, notably, that as a rule the darker zinc sulphides carry the most gold but exceptions to this rule are well known. It is interesting to note that blackjack is much more active than rosin jack in the precipitation of gold from gold -chloride solutions, and by comparison with other common sulphides any sphalerite is only a weak precipitant of gold.

Stibnite:

Although it has been reported that gold is closely associated with stibnite in the B.C. Bridge River area, no details of the occurrence were given. Apparently, polished section studies of the past three decades have shown stibnite to be relatively unimportant.

Tennantite:

Although tennantite is an effective precipitant of gold it is not a common enough mineral to assume much importance except in rare cases.

Tetrahedrite:

Since only nine of the deposits reviewed by Schwartz reported gold in association with tetrahedrite and/or tennantite and in another report only thirteen out of 585 samples indicated that gold was intergrown with, or disseminated in the tetrahedrite, it has been concluded that tetrahedrite is not particularly a favourable host for gold.

GANGUE MINERALS

Carbonates:

Ankerite is probably more important than calcite in gold - carbonate relationships, although in districts where calcite is abundant it may be a good host of native gold. Out of 585 deposits, reportedly 164 have gold and carbonates together. However, only 29 actually record gold as being found on, intergrown with, or disseminated in carbonates. Here calcite was the most abundant associate..

Chlorite:

Apparently gold is precipitated by chlorite. This precipitation is quite complex with the results that chlorite is by no means always the selective host for gold.

Epidote:

Out of 585 gold showings reported only twelve veins were believed to have both epidote and gold, while five positively had both minerals. In these five veins it was simply noted that both epidote and gold occured in the same vein.

Feldspar:

Gold is known to occur in altered country rock with feldspars but, insofar as visible gold is concerned, such occurrences do not seem important.

Garnet:

Out of 585 gold deposits reported, 13 contained garnets but in only one case was the gold actually in the garnet. In that case the gold was disseminated.

Quartz:

Gold - quartz veins are quite common, but it should be noted that there are at least two methods of occurrence. First, gold and quartz may form contemporaneously and, as such, the gold occurs as inclusions within the quartz. Much more common is the second method of occurrence, that is, the case of gold being deposited along fractures within the quartz.

In summary of gold occurrences in general, the following natural gold associations have been recognized at the Horne Mine, Noranda, Quebec:

1. in pyrite crystals
2. on the face of pyrite crystals
3. in magnetite
4. in pyrrhotite
5. in chalcopyrite
6. in intensely chloritized rhyolite and metadiabase
7. in small chloritic areas in massive sulphides
8. in quartz areas within rich chlorite - gold deposits
9. in quartz veins in syenite porphyry
10. in chloritized syenite porphyry
11. in quartz veins and matadiabase
12. in later diabase.

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Relationship Between Gold and the Common Sulphide Ores

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