British Columbia Geological Survey
Geological Fieldwork 1992

GEOLOGY, GEOCHEMISTRY, HYDROTHERMAL ALTERATION AND MINERALIZATION IN THE VIRGINIA ZONE, COPPER MOUNTAIN COPPER-GOLD CAMP, PRINCETON, BRITISH COLUMBIA

(92H/7)

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(MDRU Contribution 024)

KEYWORDS: Economic geology, Copper Mountain, Princeton, Quesnellia, porphyry, copper, gold, veins, magnetite, hematite, albite, potassic, propylitic.

INTRODUCTION

The Virginia zone is one of several copper-gold mineralized zones in the Copper Mountain camp, located 15 kilometres south of Princeton, British Columbia. Reserves consist of 4.5 million tonnes grading 0.39 per cent copper (Tim Carew, personal communication, 1992) and approximately 0.17 gram gold and 1.49 grams silver per tonne (calculated from median Cu/Au and Cu/Ag ratios in samples within the deposit). This zone has special interest because it contains higher gold grades than other previously or currently mined zones in the camp and because it is in the initial stage of production. As a result, there is currently an opportunity to document the geology of this zone more fully, and to use this information to understand the genetic controls on copper and gold deposition.

This report presents the results of surface geological mapping, drill-core logging of lithologies, vein types and alteration, and statistical analysis of a 30-element lithogeochemical database from the Virginia zone. These data and subsequent analytical research will be used to determine the ore controls within the Virginia zone. They should also provide broader insight into the genetic controls on other deposits in the Copper Mountain camp.

GENERAL GEOLOGY

Detailed descriptions of the regional setting and local geology of the Copper Mountain camp are presented by Takeda (1976), Preto (1972), and Fahrni *et al.* (1976). The discussion that follows summarizes these descriptions and new observations made during 1992. A generalized geological map of the Copper Mountain camp is presented in Figure 2-4-1.

Volcanic rocks of the Nicola Group are exposed in a northwesterly oriented belt 1100 metres wide by 4300 metres long that is bounded by several large intrusive bodies. Rock types within the Nicola Group include coarse agglomerates, tuff breccia, tuff, massive flows and minor sedimentary units. Compositions of the volcanic rocks in this belt range from basalt to rhyolite.

To the south the Nicola Group is intruded by the Copper Mountain stock, a large, concentrically zoned pluton that grades from a chilled margin of diorite into monzodiorite, monzonite and ultimately into syenite and pegmatitic perthosite in its core. The Smelter Lake and Voigt stocks, and the Lost Horse complex lie to the north of the belt of Nicola Group rocks. The Voigt and Smelter Lake stocks are not compositionally zoned, but have an overall composition that is similar to the marginal diorite phase of the Copper Mountain stock.

The Lost Horse complex is a composite body of dikes that range in composition from diorite to monzonite. Two principal phases of the complex have been recognized. The LH1 phase is a set of equigranular diorite dikes that comprise most of the volume of the complex. The LH2 phase represents a later intrusive episode characterized by diorite to monzonite dikes with subporphyritic to strongly porphyritic textures. Both phases of dikes dip steeply and strike roughly east.

All volcanic rocks and large intrusions within the Copper Mountain camp yield Late Triassic to Early Jurassic K-Ar radiometric dates (Preto, 1972). A group of post-mineral felsite dikes which cut the entire system along a general northerly orientation are, however, probably Cretaceous or Tertiary in age.

MINERALIZATION

Copper-gold mineralization occurs predominantly as chalcopyrite, with or without, bornite in veins, both within the Nicola volcanic rocks and at the contact of the Nicola Group with the bordering intrusions (Figure 2-4-1). The major ore zones, from west to east, are the Ingerbelle, Pit 1, Pit 2, Pit 3 and Virginia deposits. Sub-economic mineralization occurs farther to the east in the Voigt zone and the economic potential of several other areas (Oriole, Alabama and Mill zones) is currently being assessed. The intensity of copper mineralization within the Nicola volcanic belt diminishes to the east as the distance between the Copper Mountain stock and Lost Horse complex increases. The Copper Mountain stock is not mineralized beyond its outer few metres and apparently formed a barrier to the migration of hydrothermal fluids (Fahrni *et al.*, 1976).

The Virginia zone is located in the northeastern sector of the camp, near the contact of the Lost Horse complex and the Nicola Group (Figure 2-4-1). Ore in the Virginia zone is hosted primarily by the LH1 phase of the Lost Horse complex, with lesser volumes in the Nicola Group and the LH2 phase. The Virginia zone orebody is composed of a variety of different crosscutting and closely spaced chalcopyrite veins with orientations strongly influenced by east-trending structures. Copper, gold and silver grades in the Nicola

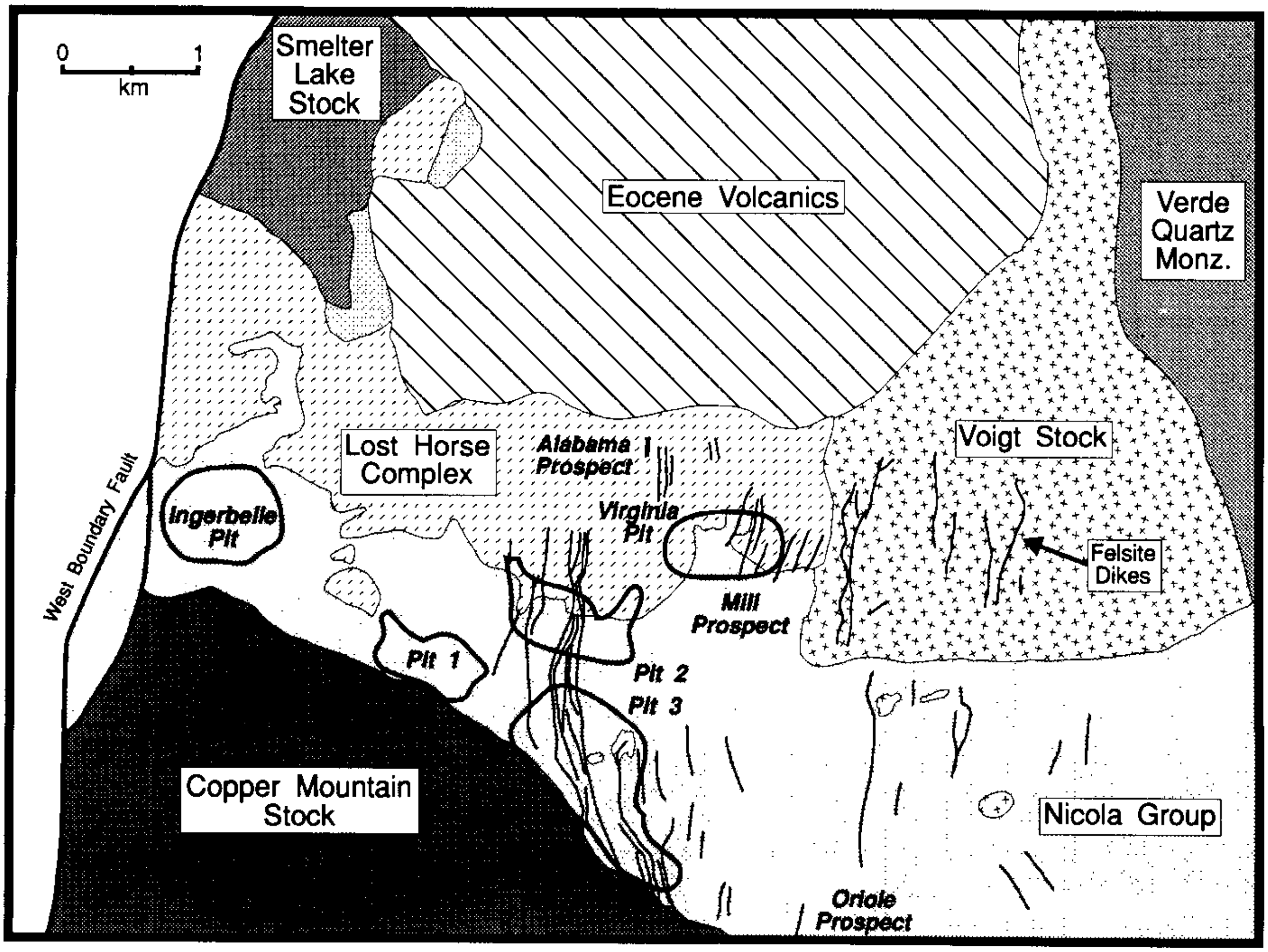

Figure 2-4-1. Simplified geology and the location of mineral deposits and prospects in the Copper Mountain Camp (modified after Preto, 1972).

Group and the LH1 phase are similar but are higher, on average, than grades in the LH2 phase (Stanley, 1992). The LH1 dikes are thought to be pre-mineral intrusions whereas the LH2 dikes have been interpreted by Huyck (1986, 1990, 1991) as syn-mineral intrusions which may be related to mineralization. However, field data also suggest that at least some of the LH2 dikes are post-mineral and intruded along the same structures that host vein mineralization (Stanley, 1992).

OPEN PIT GEOLOGY

During 1992, the three benches comprising the Virginia zone open pit were mapped at 1:200 scale (Figure 2-4-2). Data were collected from traverses of the pit walls and from drill-core logs at depths corresponding to the elevation of the pit floor. Three general rock types occur within the open pit. These consist of steeply dipping, easterly striking volcanic flows and tuffs of the Nicola Group which were intruded by a steeply dipping, easterly striking diorite dike swarm of the Lost Horse complex. These rocks were subsequently intruded by steeply dipping, northerly striking, post-mineral felsite dikes.

The Nicola volcanic rocks consist of light-coloured, very fine grained felsic (cherty) ash tuffs and massive, dark green to black mafic flows. These rocks now exist as screens up to 100 metres thick between thick sections of Lost Horse dikes that are composed of multiple cooling units which range from 2 to 15 metres thick. The dikes probably intruded parallel to and along contacts between and within the volcanic rocks and earlier dikes. The Lost Horse dikes can be subdivided into a number of petrologically distinct varieties that are distinguished by the presence and size distribution of plagioclase, augite and biotite phenocrysts. Whereas only four Lost Horse dike varieties are observed in the Virginia open pit, at least seven different varieties have been mapped in the Lost Horse complex. The diorite dikes are equigranular to subporphyritic with very fine to medium-grained textures, and contain numerous xenoliths of both Nicola mafic volcanic rocks and earlier Lost Horse dikes. Subporphyritic varieties exhibit both hiatal and seriate grain size distributions.

Within the Virginia open pit, a general chronology of dike emplacement can be determined using contact and crosscutting relationships, types of contained xenoliths, degree and type of hydrothermal alteration, and degree and type of veining. Earliest to intrude were the LH1 diorite dikes of the equigranular phase. These comprise roughly 65 per cent of the volume of the Lost Horse complex within the pit. They were followed by the intrusion of biotite-phyric, plagioclase-phyric and plagioclase-biotite-phyric subporphyritic diorite dikes of the LH2 phase. These later dikes comprise approximately 20, 10 and 5 per cent of the intrusive volume, respectively. The emplacement of these later dikes probably overlapped significantly in time.

From south to north across the open pit, there appears to be a general increase in grain size and thickness of each Lost Horse dike phase, and a decrease in the width and textural contrast of chilled margins in the equigranular diorite dikes. Furthermore, the LH1 dikes usually have more distinct chilled margins than the LH2 dikes.

The textural variations within the open pit indicate that the Virginia zone is located at the southern margin of the Lost Horse complex (Figure 2-4-1). Furthermore, the emplacement of early Lost Horse dikes into relatively cool country rocks north of the zone probably introduced sufficient heat to cause later Lost Horse dikes to exhibit limited chilled margin development due to emplacement into a relatively hotter environment. The textural variations also constrain the age difference between the earliest and latest Lost Horse dikes to be less than the time necessary for the decay of this thermal aureole. Finally, the occurrence of subporphyritic textures and biotite phenocrysts in later Lost Horse dikes may indicate that fractionation of the Lost Horse parental magma(s) resulted in an increase in volatile concentrations.

Contact orientations of Lost Horse dikes indicate that they were emplaced along a subvertical to steep northerly dipping, east-southeast-striking fracture system (Figure 2-4-3A). The large volume of dikes relative to the enclosed volcanic rocks also indicates that significant extension accompanied intrusion. One fault set within the open pit has this same general attitude and exhibits both apparent dextral and sinistral displacements. A second, subvertical, northerly striking fault set controls the emplacement of the post-mineral felsite dikes and appears to have predominantly dextral offset.

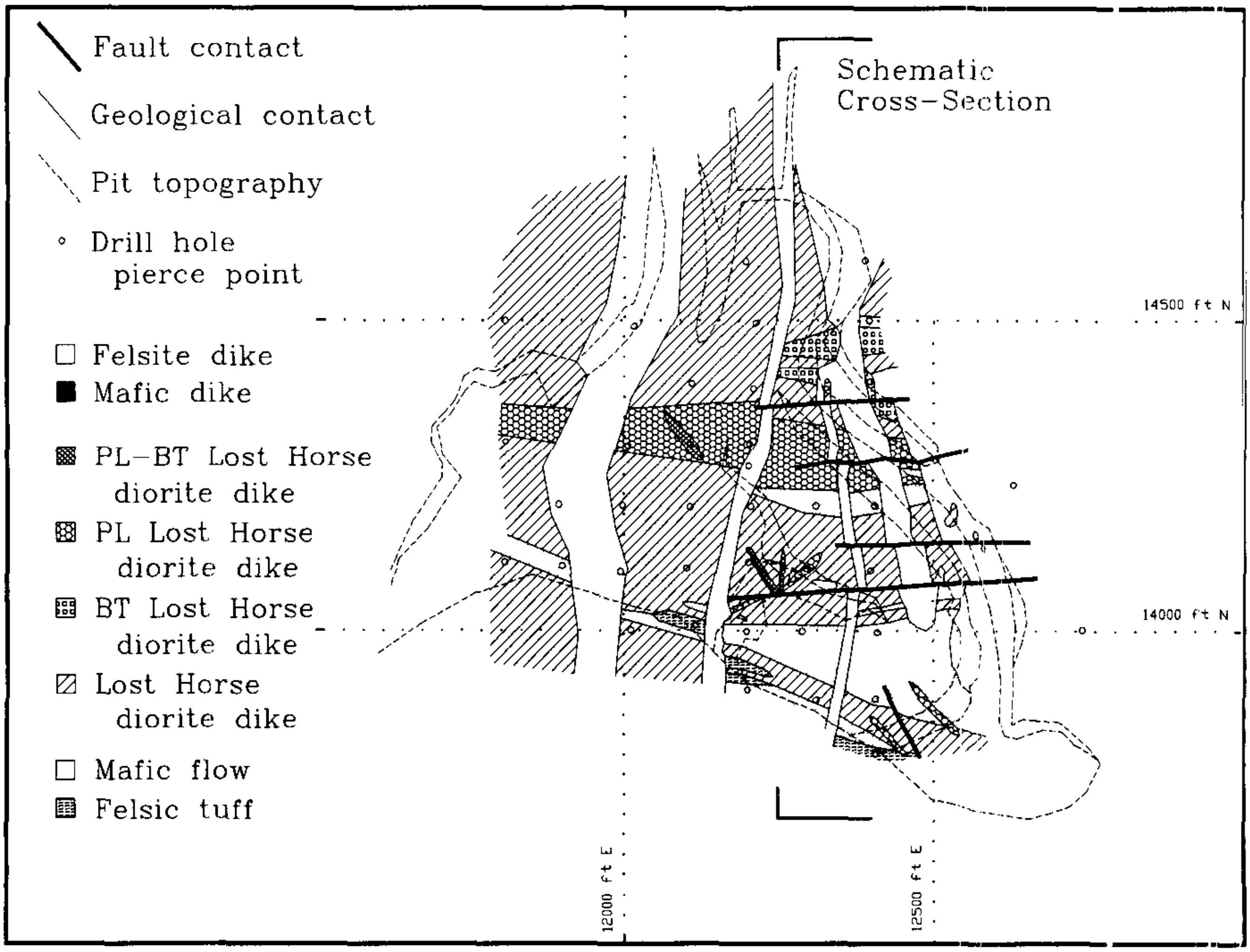

Figure 2-4-2. Virginia zone open pit geology mapped originally at 1:200-scale

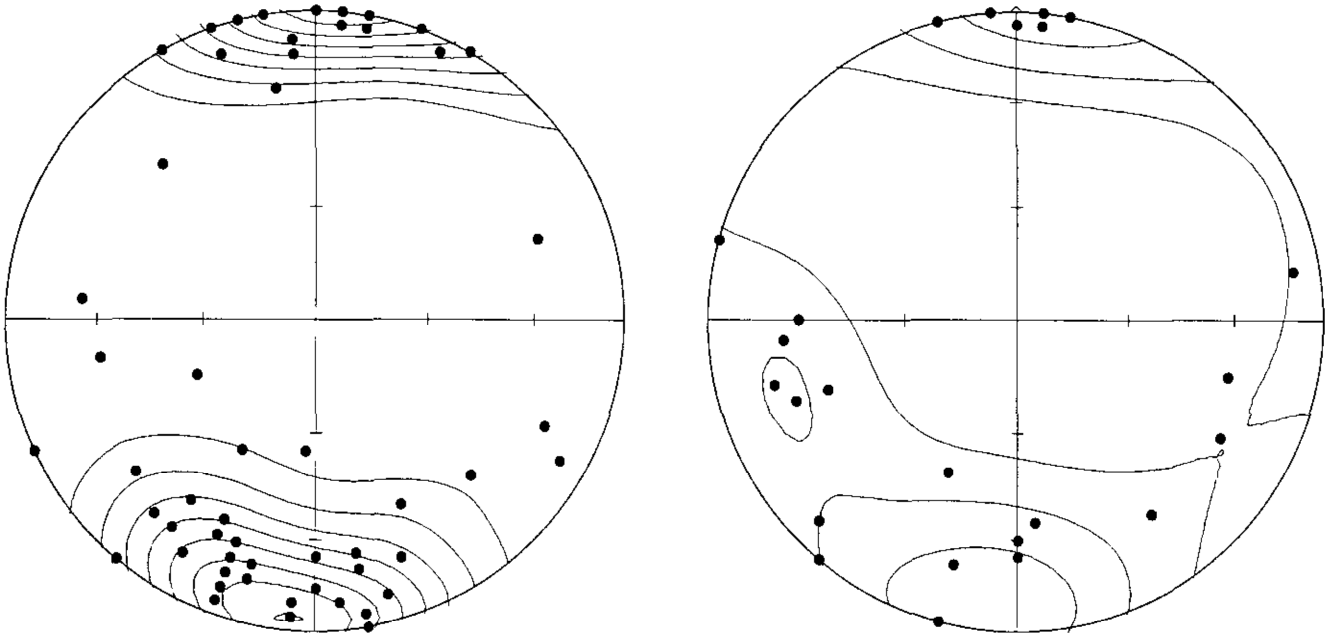

Figure 2-4-3. Poles to the orientations of intrusive contacts of (A) Lost Horse dikes and (B) mineralized veins measured in the Virginia zone open pit.

Within the open pit, the veins which carry the greater proportion of copper mineralization are magnetite+pyrite±chalcopyrite and chlorite+pyrite±chalcopyrite veins. These cut both Nicola Group rocks and most of the early Lost Horse dikes. Measured orientations of these veins in the pit walls indicate that they also strike west-northwest and dip steeply north (Figure 2-4-3B).

Post-mineral felsite dikes exhibit flow banding, columnar jointing, strongly chilled margins, variable amounts of quartz and feldspar phenocrysts and late, disseminated clots of chlorite alteration. Thick felsite dikes also appear to have produced a biotite hornfels envelope with disseminated pyrite cubes extending up to 10 metres from their margins. These dikes are clearly late (Fahrni *et al.*, 1976) and were intruded into cold country rocks.

VEINS AND HYDROTHERMAL ALTERATION

Hydrothermal alteration in the Virginia zone consists of demonstrably veinlet-controlled alteration and pervasive alteration that cannot yet be ascribed to a specific vein stage. Several types of veins were observed in drill core and the following descriptions distinguish these on the basis of their mineralogy and associated hydrothermal alteration of the adjacent wallrocks (Lang, 1992). The informal vein nomenclature derives from the most abundant and distinctive vein mineral(s). Sufficient crosscutting relationships have been observed among the veins to present a preliminary paragenetic sequence (Table 2-4-1). Several styles of pervasive alteration have also been observed (Table 2-4-2) but their spatial distribution and genetic controls are not yet well defined.

VEINLET-CONTROLLED ALTERATION

MAGNETITE STRINGERS

This stage of veining comprises narrow, irregular, discontinuous stringers that typically occur in clusters or zones. The veinlets are commonly less than 2 millimetres wide and consist solely of magnetite. They commonly have no recognizable alteration envelope, but in some cases a narrow zone of pink potassium feldspar is present.

MAGNETITE-SULPHIDE VEINS

These veins differ markedly from the magnetite stringers. Individual veins range from one centimetre to several metres wide with steep dips (Huyck, 1990). Huyck suggests that they occur in wide zones with significant vertical extent. Magnetite is the most abundant mineral in these veins and commonly has a coarse-grained, bladed habit adjacent to vein margins but less well defined and more equant habit in the centres of the veins. Hematite commonly occurs in the cores of magnetite blades but the relative timing of these minerals is not yet clear (personal communication, Huyck, 1992). Pyrite and chalcopyrite are commonly less abundant. Pyrite usually occurs as large, subhedral to euhedral grains. Chalcopyrite has irregular grain shapes and appears to post-date pyrite; its relationship to magnetite is less clear. Calcite is the most abundant gangue mineral, is commonly coarse grained and is generally interstitial to the metallic minerals. Other gangue minerals include variable but minor amounts of epidote, potassium feldspar, apatite, chlorite and sphene. In one sample a 30-micron grain of native gold was observed as an inclusion within a large pyrite grain. These veins typically have

TABLE 2-4-1
PETROGRAPHIC CHARACTERISTICS OF HYDROTHERMAL VEIN TYPES IN THE VIRGINIA ZONE CU-AU DEPOSIT

Vein Stage	Mineral Assemblage[1,2]	Envelopes	Morphology
Earlier Veins			
Magnetite Stringers	mag-(hem)	K-fld	irregular
Magnetite-Sulphide	mag-py-cpy-calc-(ep-K-fld-apt-chl-sphn-Au-hem)	K-fld-chl-alb?-(ep)	planar
K-Feldspar	K-fld-chl-calc-(mag-py-cpy-qtz-apt-sphn-hem)	K-fld-alb?	variable
K-Feldspar-Epidote	K-fld-ep-chl-(mag-py-cpy-hem)	K-fld-alb?	irregular
Chlorite	chl-py-cpy-(calc-mag-hem)	chl-calc-py-cpy	variable
Calcite-Sulphide-Chlorite	calc-py-cpy-chl-(ep)	K-fld	planar
Epidote	ep-py-cpy-calc-(chl)	K-fld-alb	planar
Quartz	qtz-calc-(cpy-py-chl-bt)		planar
Calcite-Hematite	calc-hem-(chl)		planar
Calcite	calc-(py)		planar
Breccia Matrix	calc-K-fld-py-cpy-hem-(chl-qtz-bt)	?	
Later Veins			

[1] sphn = sphene
[2] Parentheses indicate mineral species of minor to trace abundance.

TABLE 2-4-2
PETROGRAPHIC CHARACTERISTICS OF PERVASIVE STYLES OF ALTERATION IN THE VIRGINIA ZONE CU-AU DEPOSIT

Alteration Type	Mineral Assemblage	Distribution
Potassic/Deuteric	Kfld	Locally strong; LH intrusions only
Potassic	Kfld± alb± bio± py± cpy	Wide distribution; in all rock types
Albitic	alb± ep± chl± diop± scap	Minor overall; locally strong
Propylitic	calc-chl-ep-py-hem	Evenly distributed; in all rock types
SCC	ser-clay± calc	Spotty; locally strong
Hornfels	bio± py	Adjacent to felsite dikes only

alteration envelopes of pink potassium feldspar and chlorite after primary igneous biotite. In addition, they, together with the magnetite stringers, are cut by all other vein types with the possible exception of potassium feldspar veins. Magnetite-sulphide veins introduced a large proportion of the sulphides in the Virginia zone.

POTASSIUM FELDSPAR VEINS

These common, widely distributed veins are usually planar and continuous and may reach several centimetres in width. More rarely they appear to form the matrix of 'breccias'; however, these may represent zones of intense, multiple phases of veining rather than true breccias with rotated fragments. The veins are dominated by deep salmon-pink potassium feldspar and contain lesser chlorite and calcite. Minor phases include pyrite, chalcopyrite, magnetite, apatite and sphene. Quartz and biotite occur in trace amounts. Alteration envelopes are usually distinct zones dominated by potassium feldspar; associated light-coloured, very fine grained minerals that do not stain are interpreted to be albite. Calcite and epidote are locally stable.

POTASSIUM FELDSPAR+EPIDOTE VEINS

This style of alteration may be transitional between the potassium feldspar and epidote vein types. They are both common and widespread and usually occur as numerous, wispy stringers and veinlets with an overall vein-like expression. The major minerals are potassium feldspar and epidote, which occur either intimately intergrown or in textures suggesting that epidote post-dates potassium feldspar. Chlorite is common in the vein structure and adjacent wallrock. This vein type is nearly devoid of sulphides, and magnetite is either absent or occurs only in trace amounts. Contacts between this vein type and wallrock are often indistinct and no significant alteration envelopes are apparent. These veins formed before the epidote-dominated alteration but their relationship to other vein types is unknown.

CHLORITE VEINS

Chlorite veins are very common and widely distributed. They typically range from hairline fracture coatings to veins a few millimetres wide. They vary from discontinuous, sinuous stringers to planar veins and are characterized by abundant chlorite, with lesser but variable amounts of calcite, and minor epidote, magnetite and hematite. They commonly carry abundant pyrite and chalcopyrite and are distinguished from other chlorite-bearing vein types by prominent, narrow chlorite alteration envelopes. In the envelopes, abundant pyrite and chalcopyrite were introduced and magnetite was not destroyed. Chlorite veins exhibit mutually crosscutting relationships with calcite-sulphide-chlorite veins. Their abundance and high sulphide concentrations demonstrate that they were an important mineral-forming stage in the hydrothermal system.

CALCITE-SULPHIDE-CHLORITE VEINS

These veins are similar to the chlorite veins in distribution, mineralogy and position in the paragenetic sequence. They are distinguished from them by a greater proportion of calcite relative to chlorite, by the presence of an epidote selvedge within the vein structure, by the absence of a chlorite-bearing alteration envelope and the presence of a pink potassium feldspar envelope. These veins were also important in the introduction of copper and gold into the system.

EPIDOTE VEINS

Epidote veins are typically regular, continuous fracture fillings and range from a millimetre to more than a centimetre wide. They can be entirely composed of epidote, or epidote with any combination of calcite, chlorite, potassium feldpsar, pyrite and chalcopyrite. Alteration envelopes range from absent through a faint pinkish zone, to strong development of pink potassium feldspar. Potassium feldspar may yield outward to albite in some vein envelopes.

QUARTZ VEINS

Quartz veins are uncommon. They are planar, regular, continuous, and 1 to 3 millimetres wide. Quartz and calcite dominate the veins in subequal amounts and pyrite and chalcopyrite are trace to minor constituents. These veins do not have obvious alteration envelopes and although they formed late in the paragenetic sequence, their timing relative to late calcite veins is unknown.

CALCITE VEINS

These veins comprise three subtypes that together form the latest episode of veining. They are regular, continuous veins and vary from hairline fracture fillings to veins up to tens of centimetres wide. Only rarely do they have visible alteration envelopes. The first subtype contains only coarse-grained calcite that commonly grew as euhedral crystals into open space. The second subtype is composed primarily of calcite but contains significant pyrite and chalcopyrite, and minor chlorite. Although well mineralized, these veins are not volumetrically important and their timing relative to the barren calcite veins is unknown. The third subtype contains calcite, earthy hematite and, rarely, minor chlorite.

BRECCIAS

Breccias are a minor component of the Virginia zone and their distribution and timing are poorly understood. The matrix of breccias is coarse grained and consists of abundant calcite, potassium feldspar, pyrite, chalcopyrite and earthy hematite, and trace amounts of chlorite, quartz and biotite. Fragments consist of LH1 dike rocks and Nicola volcanic rocks altered to potassium feldspar, calcite and trace chlorite and biotite. Pyrite and chalcopyrite are evenly disseminated throughout fragments and matrix. Primary igneous magnetite has not been destroyed in altered fragments.

PERVASIVE ALTERATION

Potassic alteration is expressed by two distinct assemblages (Table 2-4-2). The earliest occurs as washes of light pink coloration that are erratically distributed within, but confined to, the Lost Horse intrusions. Original igneous magnetite is almost always obliterated. This assemblage is thought to represent an early deuteric alteration and is not associated with sulphide mineralization. The second type of pervasive potassic alteration occurs in patches related to microveinlets. The primary alteration mineral is also potassium feldspar accompanied by various combinations of albite, biotite, pyrite and chalcopyrite; magnetite is not typically destroyed. This second style of potassic alteration appears, at least in part, to overprint the deuteric alteration. A significant portion of the potassic alteration may be due to coalescing alteration envelopes of potassium feldspar veins. In other cases, it appears to be distributed in zones independent of vein type. In places, significant sulphide mineralization accompanies this potassic alteration.

Pervasive albitic alteration has been observed locally, but in much smaller volumes than potassic alteration. The primary alteration assemblage is white albite, usually with epidote and chlorite, and locally with diopside and, possibly, scapolite. Zones of albitization affect both the Lost Horse intrusions and Nicola volcanic rocks. Some albitic alteration zones may represent overlapping envelopes of epidote veins. Albitization does not appear to be related to sulphide introduction.

Propylitic alteration is widely and evenly distributed throughout the deposit. It consists of calcite, chlorite, pyrite, epidote and hematite and affects both intrusive and volcanic rocks. The timing of propylitic alteration is poorly constrained. It shows evidence of being both early and late in the sequence of alteration, possibly as a result of early expansion and later contraction of the hydrothermal system.

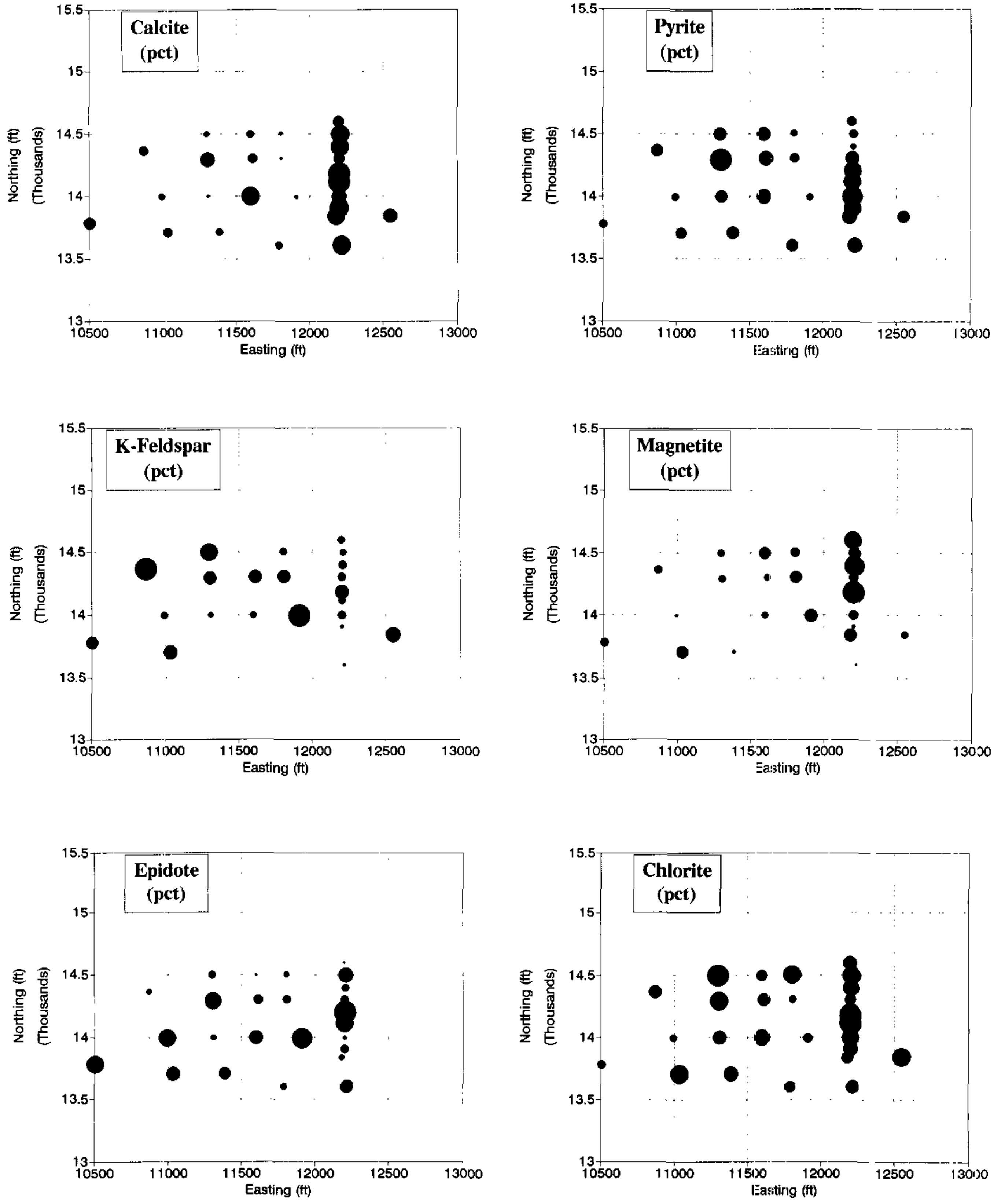

Figure 2-4-4. Bubble plots of hydrothermal alteration minerals in the Virginia zone of the Copper Mountain Cu-Au deposit. The size of the bubbles varies proportionally with the abundance of each mineral species. On these diagrams, the smallest and largest bubbles represent the minimum and maximum mineral concentration observed in the drill holes at the 3300-foot elevation. These are 0.68 and 21.25 % calcite, 0.36 and 4.50 % pyrite, 0.00 and 50.00 % potassium feldspar, 0.00 and 10.00 % magnetite, 0.00 and 8.90 % epidote, and 2.50 and 17,78 % chlorite.

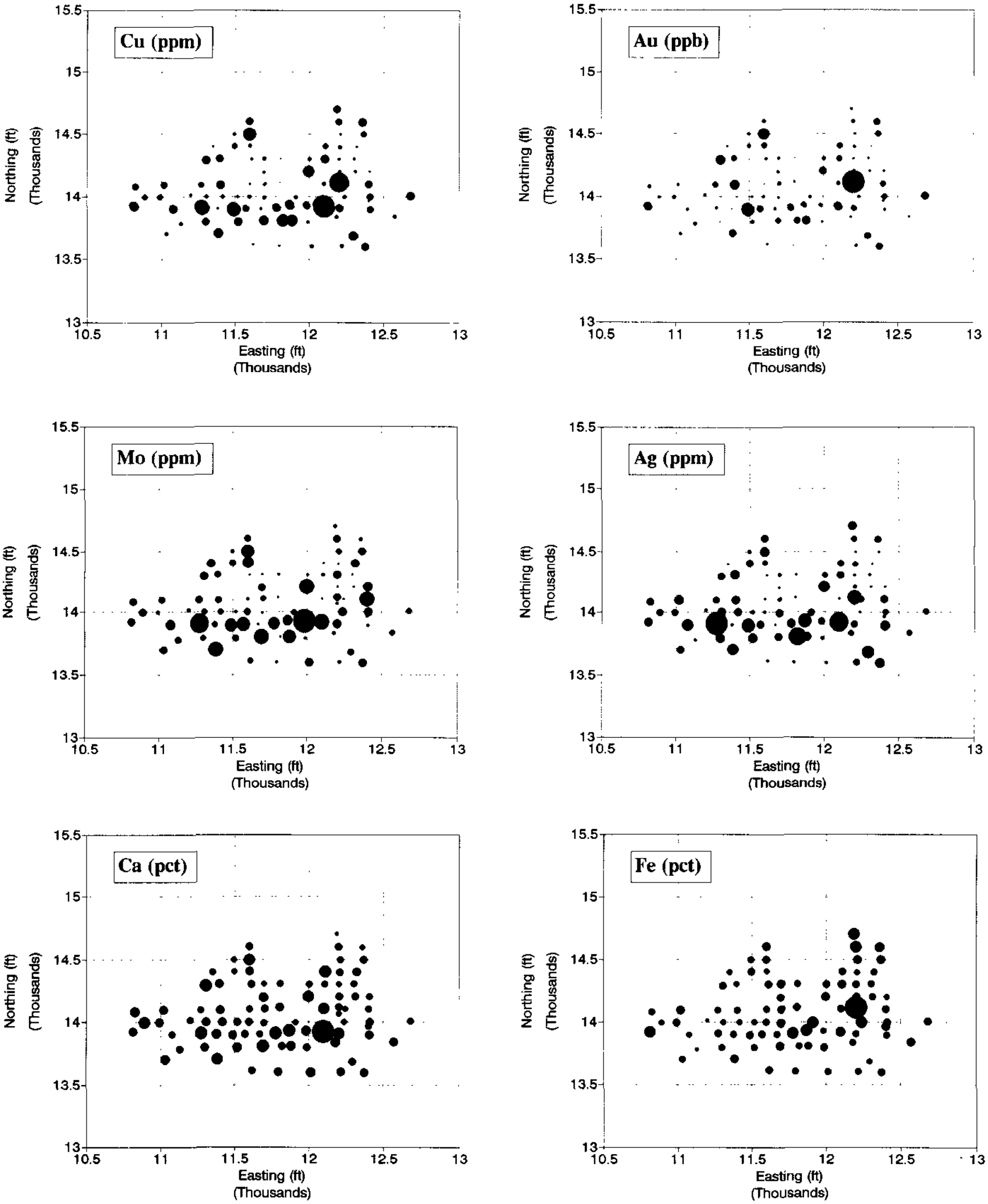

Figure 2-4-5. Bubble plots of Cu, Au, Mo, Ag, Ca and Fe geochemical concentrations in the Virginia zone of the Copper Mountain Cu-Au camp. The size of the bubbles varies proportionally with concentration of each element. On these diagrams, the smallest and largest bubbles represent the mininum and maximum concentration observed in the drill holes at the 3300-foot elevation. These are 150 and 18753 ppm Cu, 2 and 1165 ppb Au, 1 and 95 ppm Mo, 0.1 and 6.6 ppm Ag, 1.15 and 21.28 % Ca, and 2.06 and 41.13 % Fe.

Minor alteration types include a very late stage hydrothermal overprint consisting of sericite, calcite and a brown clay mineral. It is locally strong but very unevenly distributed. A biotite hornfels with disseminated pyrite is developed adjacent to thicker felsite dikes.

HYDROTHERMAL ALTERATION AND GEOCHEMICAL ZONING

Detailed drill-core logging and statistical analysis of a multi-element geochemical database provided data to produce hydrothermal alteration and geochemical zoning maps of the 3300-foot elevation.

Evaluation of mineral zoning patterns was based on visual estimations of the percentage of alteration minerals logged in intervals of core from 27 diamond-drill holes distributed across the deposit. Results are summarized in Figure 2-4-4. Fifty-foot intervals were logged in core along the 12250E cross-section, which is perpendicular to the main ore zone. Twenty-foot sections were examined in all other holes. All intervals were centred on piercing points through the 3300-foot elevation; some intervals were offset slightly from this level to avoid post-mineral felsite dikes. Emphasis was given to estimating the bulk percentage of alteration minerals in several assay intervals in each hole; the means of these intervals are plotted on bubble plots (Figure 2-4-4). Results indicate that no significant alteration zoning is evident in the Virginia zone. This may be due, in part, to the sparse sampling of drill holes through the deposit and to the dominance of fracture-controlled alteration and mineralization.

The geochemical database consists of 5436 samples from approximately 3-metre drill-core intervals from 110 drill holes. The samples were analyzed for a suite of 29 elements (Cu, Pb, Zn, Mo, Ag, Ni, Co, Mn, Fe, As, U, Th, Sr, Cd, Sb, Bi, V, Ca, P, La, Cr, Mg, Ba, Ti, B, Al, Na, K, and W) by aqua regia digestion with an inductively coupled plasma spectrophotometry finish; gold was determined by aqua regia digestion and atomic absorption finish. These data were composited across a 50-foot interval at the 3300-foot elevation. A number of statistical procedures (histograms, probability plots, bubble plots, scatterplots) were applied to each lithology to determine if any zoning or geological control on mineralization was present.

Results indicate that only limited geochemical zoning is apparent. A single easterly oriented (ore) zone with generally anomalous copper concentrations at the 3300-foot elevation also exhibits generally anomalous gold, silver and molybdenum concentrations (Figure 2-4-5). Iron and calcium concentrations, thought to represent the abundance of magnetite and calcite as gangue minerals in productive veins, do not correlate with this zone (Figure 2-4-5). Similarly, no other elements define haloes about this high-grade zone.

The high-grade part of the ore zone occurs within Nicola volcanics (Figure 2-4-6). Additional evidence in support of similar lithological grade control can be seen in the copper and gold grade distributions of the volcanic flows, fragmentals and tuffs, and early equigranular and late subporphyritic Lost Horse diorite dikes (Figure 2-4-7). Higher copper and

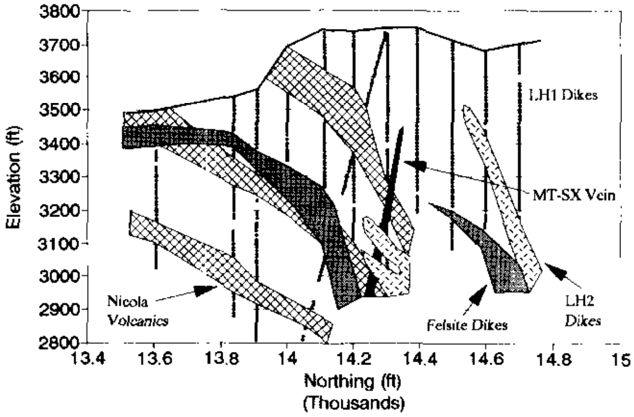

Figure 2-4-6. Generalized geological cross-section of the Virgina zone, at 12 250E, with drill-hole sample locations. Geologic correlations inferred from lithologic codes in the lithogeochemical data base.

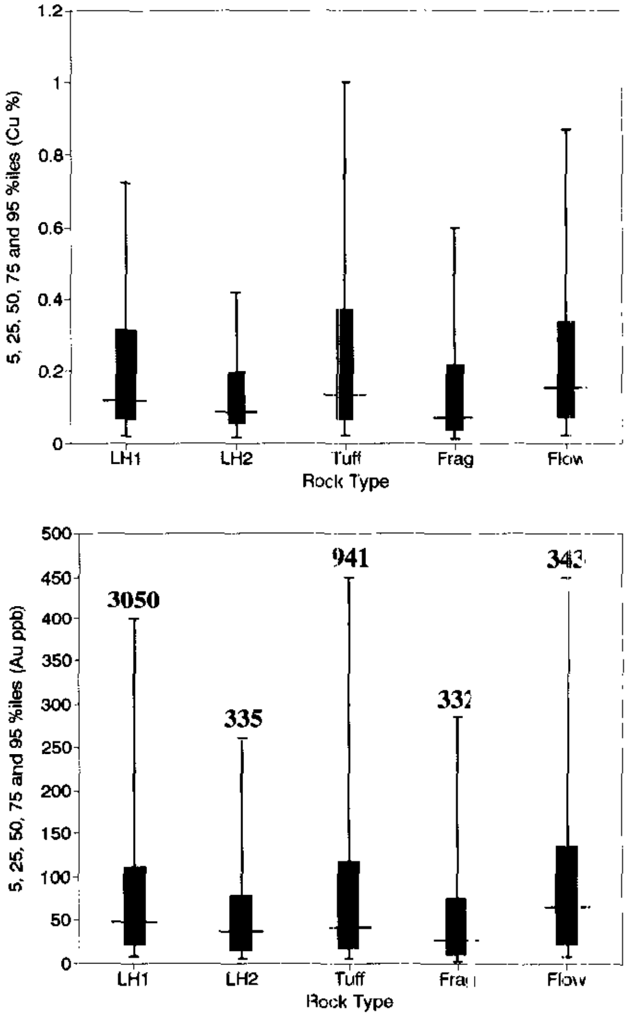

Figure 2-4-7. Plots of concentration percentiles for Cu (%) and Au (ppb) for equigranular (LH1) and subporphyritic (LH2) Lost Horse diorite dikes, Nicola volcanic felsic tuffs (TUFF), mafic flows (FLOW) and mafic lapilli tuffs, breccias and agglomerates (FRAG). The number of samples from each unit are indicated.

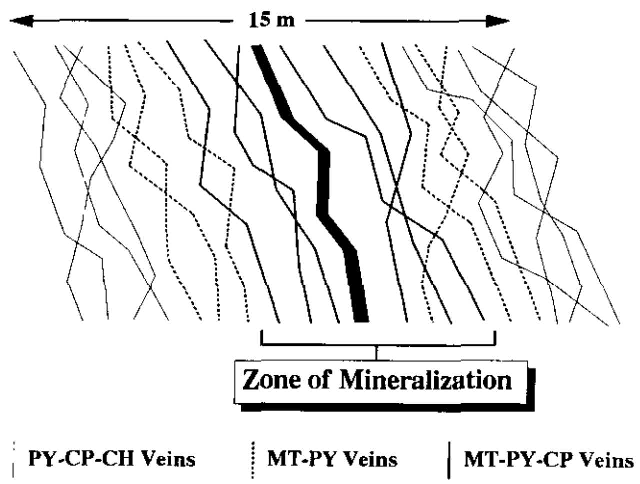

Figure 2-4-8. Schematic cross-section of a major mineralized structure within the Virginia zone.

gold concentrations in the massive flows and tuffs may be due to their tendency to fracture more readily than the less massive fragmental volcanics. Similarly, the pre-mineral, equigranular Lost Horse diorite dikes have higher copper and gold grades than the younger subporphyritic Lost Horse diorite dikes.

Despite the lack of deposit-scale zoning in the Virginia zone, geologic mapping in the open pit does indicate that there is a crude zoning of vein types across mineralized structures. Specifically, major magnetite-sulphide veins (>30 cm wide) which contain significant chalcopyrite are generally bounded by similar magnetite sulphide veins without chalcopyrite. These relatively barren veins are themselves bounded by calcite-sulphide-chlorite veins (as schematically illustrated in Figure 2-4-8). Furthermore, the thick magnetite-sulphide veins exhibit abundant conjugate magnetite-sulphide veins within zones up to two times the vein width from the major vein margins. These 'parasitic' veins are thinner, but contain a mineralogy which is identical to the major magnetite-sulphide veins.

CONCLUSIONS

Geological mapping, drill-core logging and geochemical analysis of samples indicates that the Virginia zone is a bulk tonnage copper-gold deposit hosted by Nicola volcanics which have been intruded by diorite dikes of the Lost Horse complex. Copper and gold mineralization is hosted by a series of closely spaced, easterly striking, steeply dipping veins and occurs with significant amounts of magnetite gangue. Geochemical and mineralogical zoning within the deposit is limited, but zoning of vein types about mineralized structures has been observed. Mineralization does appear to be controlled to some extent by host lithology and early Lost Horse dikes and massive volcanics appear to be the most favourable host rocks.

ACKNOWLEDGMENTS

The authors thank Princeton Mining Corporation for access to the Virginia zone and associated drill core, and for its assistance in support of the fieldwork undertaken in the course of this research. The assistance of Dr. Holly Huyck in locating property information and for helpful discussions of camp geology is also gratefully acknowledged.

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