QUANTITATIVE SUPERGENE MINERALOGIC STUDY OF A PORPHYRY COPPER SYSTEM IN THE SOUTHWESTERN UNITED STATES

By

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In loving memory of
Shaun Joseph Pinson, age 3,
with courage and strength
against all odds

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ABSTRACT

This study assesses the mineralogic characteristics and spatial distribution of supergene copper enrichment, and describes the relationship of these characteristics to heap leach recovery of low–grade copper ores at an unspecified copper porphyry system located in the southwestern U.S, designated Mine X in this paper. This supergene mineralogic study establishes the thickness, extent, and depth of the leached, oxide, and enrichment zones, and their relationship to the primary copper zone. Due to supergene alteration, copper porphyry deposits having low grade primary mineralization can become enriched to greater (economical) grades; thus, supergene enrichment characteristics warrant further research in order to better understand this ore deposit and the distribution of chalcocite–covellite mineralization within various portions of Mine X.

Preparation and analysis of 577 samples has been completed. Methods of study entail heavy liquid separation of sulfide and oxide phases, preparation of polished sections, and analysis by standard petrographic and SEM techniques. Pulp samples, collected at ore control drill holes at varying depths, are separated into light silicate minerals and heavy sulfide and oxide minerals by centrifuge in a heavy metatungstate liquid. The sulfides collected for each sample comprise grain mounts of epoxy casts, and are polished for high luster of metal sulfides. Each sample is analyzed by volume grain count methods to determine the supergene–to–hypogene copper sulfide ratio defined by the quotient $\underline{cc+cv+bn}/cp$, with observations noted as to the character of supergene mineralization and accompanying sulfides and oxides. The resulting ratio data is quantified to define numerically leached/oxide capping, supergene enrichment blanket, and protore mineralization. The "blanket" boundaries are established by the top of dominant sulfide (TDS) and protore (bottom of enrichment blanket) surfaces. Plotting of resulting data on to a fence diagram provides contours and cross–sections of the thickness, extent, and depth of the various mineralogic zones. Thickness and elevation of the supergene "blanket" are controlled by phyllic, argillic, and potassic alteration and

a northwest–trending fault system confined to the Mine X mineral district. Local effects in the "blanket" morphology are related to northeast–trending fault systems of Laramide age and certain lithologic units (carbonaceous and intrusives).

The Mine X Operations apply these ratios by determining whether to send ores to the mill, to their "fast" or "conventional" leach pad, or to the waste dump. This application of sulfide ratios provides mine operators with an efficient means of classifying mined materials using supergene mineral distribution and relative abundances.

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INTRODUCTION

Purpose of Research

Due to supergene alteration, porphyry copper systems with low grade primary mineralization ("protore;" usually less than 0.3-wt % Cu) can become enriched to greater, economically important grades. Figure 1 illustrates a "typical" economic porphyry copper deposit. Because understanding supergene enrichment characteristics is important in exploration applications and in economic assessment of a porphyry copper prospect, research to better understand weathered and enriched porphyry ore deposits is needed. This study assesses the mineralization characteristics and spatial distribution of supergene copper enrichment for a large (>500 MT), low-grade (protore grade=0.15% Cu) porphyry system. Supergene-related mineral zones are defined in terms of supergene-to-hypogene ratios and chalcocite-to-covellite ratios, and by drill hole core log data where ratio data is not available. Ratios are discussed in more detail in a following section. Supergene-related mineral zones refer to the oxide/leached capping, enrichment blanket, incipient enrichment, and protore mineralization. Because this ratio is a function of supergene enrichment parameters (ratio=function of Cu, Fe, and S concentrations, fugacity of O_2, and the activity of wallrock), it is independent of total copper grade. As such, this ratio is also useful in quantification of enrichment intensity which measures the extent of copper sulfide replacement of pyrite. Furthermore, the acquired data relates geologic parameters as influences on supergene oxidation, leaching, and enrichment and aids in heap leach recovery of copper from low grade copper ores. Thus, application of study results has substantial importance in the assessment of those volumes of a porphyry copper system containing significant chalcocite enrichment and associated favorable recovery characteristics. In practice, mine operations of the porphyry copper system under study use the supergene-to-hypogene ratios to determine whether to send the ore to the mill,

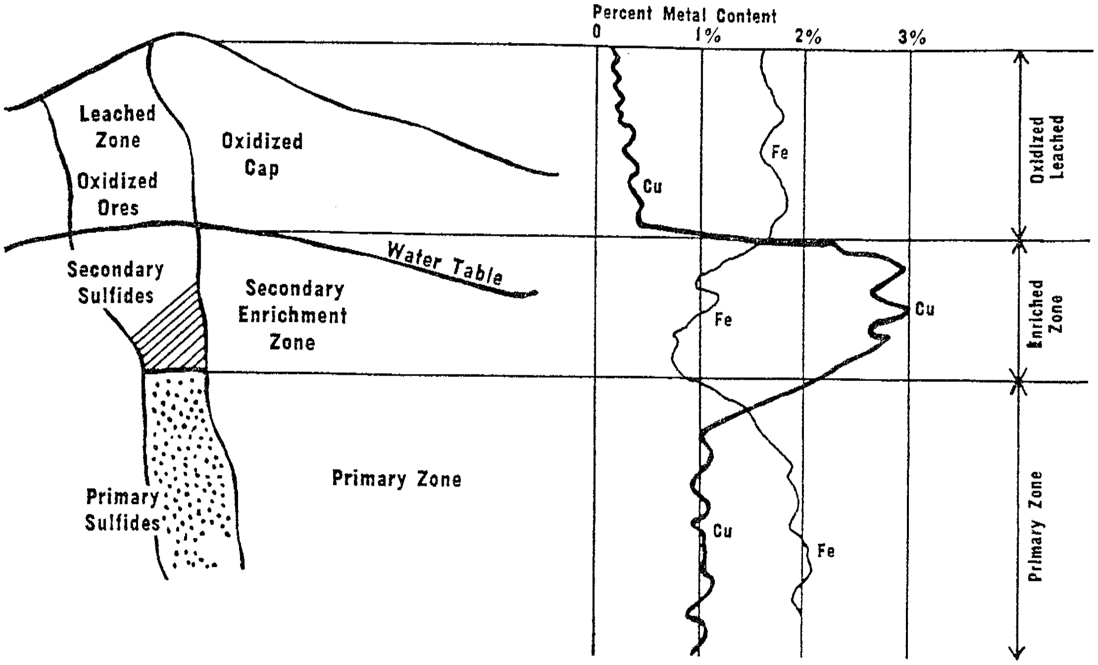


FIGURE 1. A schematic cross–section of typical secondary (supergene) enrichment of a porphyry copper system. Metal content based on values in porphyry copper deposits of Chile (modified after Sutulov, 1974).

"fast" (chalcocite–dominant, pyrite–impoverished ore) or "conventional" (chalcopyrite–dominant, pyritic ore) leach pads, or to the waste dump.

Supergene Enrichment Processes Applicable to Porphyry Copper Systems

Important in the development of economic porphyry copper deposits, supergene alteration can produce secondarily enriched copper mineralization. This enrichment develops at relatively shallow, often "minable" depths, with the necessary grade and tonnage of accessible copper ore (Titley, 1982). Generally, acidic, oxidizing waters above a water table take into solution soluble metals and ions which are precipitated when reducing conditions are met at and below the water table (phreatic zone). Supergene enrichment processes occur in porphyry copper systems that are characterized by:

1. porosity and permeability that allows the movement of meteoric waters

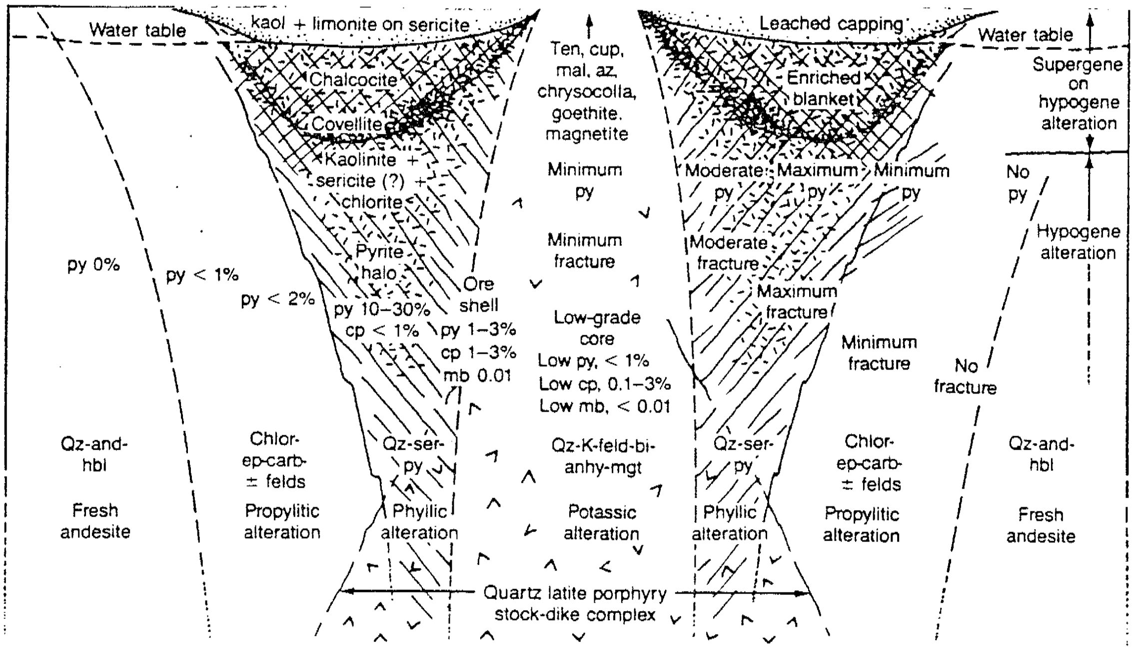


FIGURE 2. Generalized cross–section of the interaction of hypogene and supergene alteration at a porphyry copper deposit. Illustrated are an oxidized/leached capping, enrichment blanket, and hypogene (protore) zone and their relationship with the hypogene alteration zones. Also included are sulfide contents and distributions, and fracture densities (from Guilbert and Park, 1986)

through the system,

2. abundant pyrite to produce oxidizing acids,
3. acid–soluble ore metal bearing minerals, and
4. a precipitative (redox) environment at depth.

Also, to develop an appreciable concentration of copper, the rates of oxidation and erosion as well as a modulated groundwater system must be in balance (Guilbert and Park, 1986). This type of weathering of porphyry copper deposits results in an oxidized/leached capping zone, and supergene enrichment blanket. A protore (primary mineralization) zone underlies the enrichment blanket in which sulfides have not been altered due to weakened supergene fluids. Supergene fluids weaken by neutralization with wallrock and by loss of cupric ions through precipitation of copper phases as solutions move through preceding rock volumes. An incipient enrichment of covellite forms a boundary between the "blanket" and protore. The primary, subeconomic zone represents "fresh" mineralization that once could be found in the now altered zones of leached capping and blanket.

Supergene fluid strength is controlled by Eh and pH conditions. As seen in Figure 3, pH and Eh conditions form stability fields for copper sulfide and oxide minerals. The oxidation potential (Eh) lessens with depth when reducing (redox) conditions, such as a water table, are encountered. The net acidity (pH) of capillary waters, which remove soluble copper and sulfur from the oxidized zone to reducing environments, is controlled by four factors. These controlling factors are: (1) the total sulfide content of the rock, (2) the copper sulfide:iron sulfide ratio, (3) copper sulfide mineralogy, and (4) the reactivity of the host rocks (Anderson, 1982). The Eh−pH diagram in Figure 3 effectively represents a cross−section of a weathered porphyry copper system in terms of copper mineralogy under varying conditions. The geochemical conditions represented illustrate that at depths below chalcocite stability, covellite forms a stability field – a stable supergene phase – between overlying supergene chalcocite and subjacent primary mineralization (cp+py). Outside of lateral movement of copper solutions due to structure, weak supergene influence can result from either a combination or just one of the four factors. This causes neutralizing pH conditions in which incipient enrichment of covellite is not stable. For example, oxidizing conditions in the low pH (acidic) field would result from high pyrite content, but if copper sulfides are low or very reactive wallrocks are encountered, the pH value would shift to a more neutral solution, in which the covellite stability field is unstable. Another example is of moderate to high pH values resulting from low pyrite content and/or reactive wallrock in the oxidizing zone, in which copper mineralization is stable

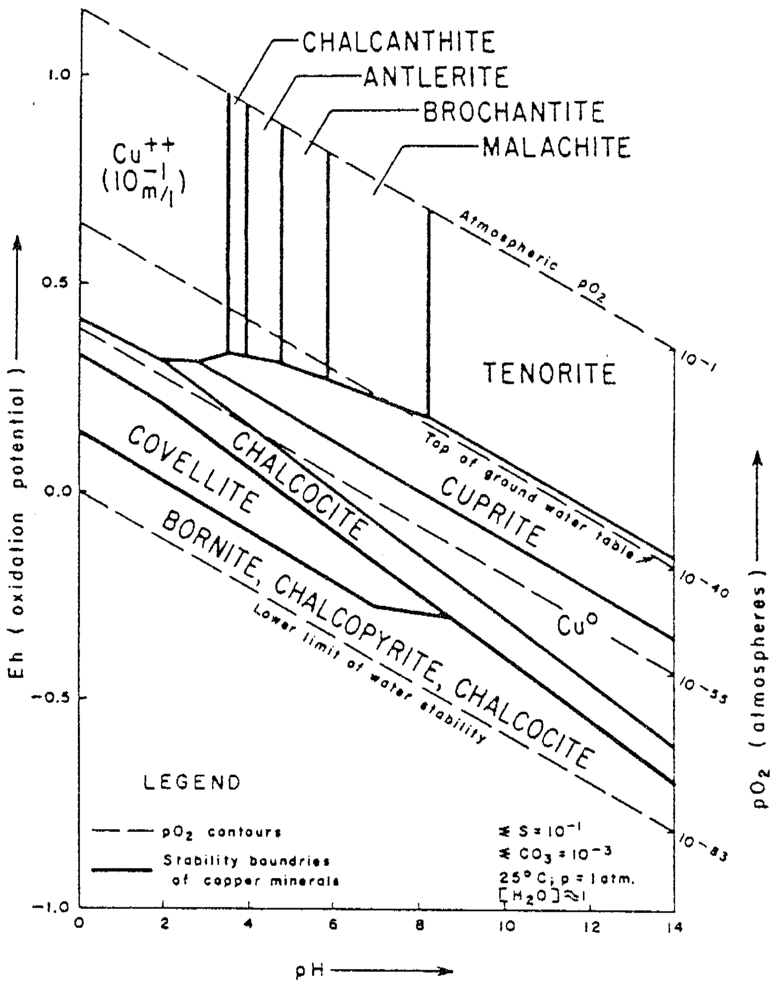


FIGURE 3. Eh−pH diagram showing the stability fields of copper minerals in the system Cu−S−H_2O (Anderson, 1982).

as oxides, native copper, and silicates. Very little soluble copper infiltrates to the redox surface to form chalcocite after which copper does not precipitate at greater depths outside of the chalcocite stability field.

Along with climatic factors, hypogene alteration and mineralization influences supergene processes through hypogene alteration mineralogy, host rock composition, fracture abundance, and primary copper and pyrite content. Figure 2 illustrates the results of hypogene and supergene processes in a sulfide mineralogy content, fracture density, and alteration patterns of an example porphyry copper system. These features influence the path and nature of secondary enrichment (Titley, 1982). Due to a quartz–sericite alteration assemblage, high pyrite content, and high density fracture system, the phyllic zone has the most extensive development of supergene oxidation, leaching, and enrichment of most porphyry copper systems. This zone is most susceptible to weathering, in which deep oxidation produces enriched copper sulfide ore "blankets." This is even more intense in areas of overlap with argillic alteration. Rarely does enrichment of any importance occur in zones of potassic alteration with high hypogene grades or in propylitically altered rocks (Titley, 1982).

The oxidation of sulfide deposits is controlled by climate because temperature influences the rate of chemical reactions and precipitation amounts influence the rate of leaching. Climate also controls the level of the water table which, in turn, controls the depth of oxidation. Therefore, semiarid to arid regions promote deep oxidation, leaching, and enrichment. In these climates, low water tables allow periodic recharge water to remove capillary solutions from the oxide zone (Anderson, 1982). Futhermore, post–mineralization events such as geomorphic changes, faulting and volcanic activity, can combine with climate to control or modify weathering and enrichment processes (Titley, 1982). The following discussion describes in more detail supergene alteration processes and resulting mineralogic zones.

Oxidation of a Porphyry Copper Deposit Supergene enrichment processes begin with the development of an oxidized–leached zone by the weathering of a porphyry copper system exposed at or near the surface. The oxidation of sulfides results in "limonite" formation as hematite (Fe_2O_3), goethite ($Fe(OH)_3$), and jarosite [$K(Fe^{+3},Al)_3(SO_4)_2(OH)_6$]. Weathering entails oxidation of sulfides above the water table (zone of aeration). Oxygen decreases rapidly at the groundwater table where pore space becomes saturated with water. Interconnected open fracture systems of various patterns permit free circulation of air and percolation of meteoric waters downward to the water table, minute fracture systems also exist between these open–spaced fractures. Within these rock fracture systems, hypogene sulfide deposition is greatest and subject to attack by the air–water oxidation processes. Oxidation is continous even during dry seasons due to thin films of water adhering to surfaces of unoxidized sulfides (Blanchard, 1968). In deposits with a high total sulfide content, soluble products of sulfide oxidation are washed away during periodic flushing by meteoric recharge water, leaving fresh surfaces exposed for futher weathering. In cases of deposits containing low total sulfide content, hydroxides, oxides, carbonates, sulfates, or silicates precipitate at the site of oxidation (Anderson, 1982). This is because sulfuric acid generated by oxidation decreases with a lowering of total sulfide content. Also, the amount of sulfuric acid decreases with an increase in the copper content of copper minerals.

Oxidation of sulfides begins with the interaction of air and water which generates sulfuric acid and ferric sulfate solutions from mostly pyrite (py). Sulfuric acid (H_2SO_4) and ferric sulfate ($Fe_2(SO_4)_3$) solutions form as expressed in the equation

$$4FeS_2\ (py) + 14O_2 + 4H_2O = 4FeSO_4 + 4H_2SO_4.$$

A large variable portion of the ferrous iron then oxidizes to ferric state as seen in the equation

$$4FeSO_4 + 2H_2SO_4 + O_2 = 2Fe_2(SO_4)_3 + 2H_2O.$$

When acidic solutions become very dilute, goethite (gt) and/or hematite (hm) precipitate through hydrolysis, as indicated by the equations

$$Fe_2(SO_4)_3 + 3H_2O = Fe_2O_3\ (hm) + 3H_2SO_4$$

and

$$Fe_2(SO_4)_3 + 4H_2O = Fe_2O_3 \cdot H_2O(gt) + 3H_2SO_4.$$

These equations also show that ferric ion can redissolve to varying degrees, if solutions become more concentrated again. Thus complete leaching of pyrite can occur by oxidation in an inert environment or iron will remain as indigenous limonite through oxidation and hydrolysis in dilute solutions. In both cases free acid is generated.

Besides hydrolysis, reactive gangue minerals also cause partial or complete neutralization of acidic solutions, as briefly discussed later in the section (Blanchard, 1968).

The amount of excess acid created by oxidation of pyrite is relatively larger compared to that yielded by chalcopyrite. Chalcopyrite contains less sulfur than pyrite, and consequently generates less free acid. The direct oxidation of chalcopyrite puts all of its copper and most of its iron into solution, with the remaining iron precipitating as indigenous limonite. This process generates no free acid as seen in the equation

$$12CuFeS_2\ (cp) + 51O_2 = 12CuSO_4 + 4Fe_2(SO_4)_3 + 2Fe_2O_3\ (hm).$$

If chalcopyrite undergoes oxidation and hydrolysis in dilute solutions, free acid is generated in which all the iron remains as indigenous limonite, seen in the equation

$$2CuFeS_2\ (cp) + 8.5O_2 + 2H_2O \rightarrow Fe_2O_3\ (hm) + 2CuSO_4 + 2H_2SO_4.$$

The oxidation of equal amounts of pyrite and chalcopyrite together causes complete leaching of both sulfides; expressed as

$$CuFeS_2\ (cp) + 8Fe_2(SO_4)_3 + 8H_2O \rightarrow CuSO_4 + 17FeSO_4 + 8H_2SO_4$$

(Blanchard, 1968).

Sulfides such as chalcocite and bornite are deficient in sulfur and will not dissolve completely from oxidation without an external source of acid as seen in the following equations

$$2Cu_2S\ (cc) + 5O_2 = 2CuSO_4 + 2CuO\ (cv)$$

$$CuO\ (cv) + H_2SO_4 = CuSO_4 + H_2O$$

$$4Cu_5FeS\ (bn) + 37O_2 = 16CuSO_4 + 4CuO\ (cv) + 2Fe_2O_3\ (hm)$$

and

$$CuO\ (cv) + H_2SO_4 = CuSO_4 + H_2O.$$

Under conditions of oxidation and hydrolysis two moles of chalcocite and one mole pyrite together leaches all copper but leaves all of the iron as indigenous limonite. Under the same conditions, one mole of bornite and two moles of pyrite can cause the complete leaching of all copper and pyrite–derived iron. Bornite–derived ferric oxide would precipitate as indigenous limonite. With a 1:2 chalcocite to pyrite or 1:5 bornite to pyrite oxidizing together, complete leaching of both sulfides occurs (Blanchard, 1968).

Under high pH and Eh conditions, as seen in Figure 3, oxidation of chalcocite can produce native copper and cuprite (cu), written as

$2Cu_2S\ (cc) + 8Fe_2(SO_4)_3 + 6H_2O + 1.5O_2 = 2Cu^o + Cu_2O\ (cu) + 8FeSO_4 + 6H_2SO_4.$

Further oxidation would cause the reaction

$$2Cu^o + Cu_2O\ (cu) + O_2 \rightarrow 3CuO\ (\text{tenorite}).$$

Tenorite may also form as in the equation

$$Cu^{+2} + H_2O \rightarrow CuO\ (\text{tenorite}) + 2H^+.$$

In contact with limestone, cupriferous solutions react to form hydrous carbonates of copper as an enriched oxidized zone, seen in the reactions

$2CuO + CO_2 + H_2O\ [2Cu^{+2} + CO_3{}^{-2} + 2(OH)^-] \rightarrow Cu_2(OH)_2CO_3$ (malachite)

and

$3CuO + 2CO_2 + H_2O\ [3Cu^{+2} + 2CO_3{}^{-2} + 2(OH)^-] \rightarrow Cu_3(OH)_2(CO_3)_2$ (azurite)

In the zone of oxidation, sulfides within 3 or 4 feet directly above the water table substain the most persistent and widespread attack by weathering. This is due to an adequate constant supply of moisture through capillary attraction from the water table. Also, the rock layer is porous enough for adequate movement of air by circulation or diffusion. This horizon above the water table contains the largest volume of unleached sulfide due to shorter exposures to weathering than the ground above. As this rock layer becomes more porous due to weathering, the water table drops correspondingly, and the oxidation zone deepens (Blanchard, 1968). However, many believe regional uplift is the main factor responsible for the lowering of the water table (Titley, 1982).

A flat water table can develop if the country rock is homogeneous with a uniform fracture pattern and if erosion has almost kept pace with the lowering of the water table.

However, if erosion occurs more rapidly than oxidation, much sulfide will remain unoxidized within the oxidation zone. An irregular pattern of oxidation will occur where rocks of different composition and/or non–uniform structural features prevail (Blanchard, 1968).

Precipitation of the Enrichment Blanket The enrichment blanket forms at and below the groundwater table. The water table acts as a zone of saturation and reduction zone for the descending cupric sulfate solutions. Because the specific gravity of these solutions is greater than that of groundwater, supergene fluids move downward as well as laterally through the zone of saturation. Sulfides here can be leached and/or oxidized. In areas such as the phyllic zone with its general veritical continuity of fracturing and weak neutralizing ability, solution can descend more than 300 to 400 feet below the water table.

Secondary enrichment of copper occurs as cupric sulfate solutions oxidize sulfide minerals by the following decreasing order of intensity: covellite, bornite, chalcopyrite, sphalerite, pyrrohotite, and galena. Supergene chalcocite replaces these sulfides in an interval from less than two feet to 200 feet or more below the reduction zone (Blanchard, 1968). Because pyrite is the most resistent to cupric sulfate solution, it is attacked last. Enrichment intensity can be measured by how much pyrite is replaced by supergene copper sulfides (Titley, 1982, and William X. Chavez, Jr., 1991, internal report). Examples of copper enrichment are seen in the following reactions

$$\mathrm{ZnS\ (sphalerite) + CuSO_4 = CuS\ (cv) + ZnSO_4}$$

$$\mathrm{CuFeS_2\ (cp) + CuSO_4 = 2CuS\ (cv) + FeSO_4}$$

and

$$\mathrm{2Cu_5FeS_3\ (bn) + CuSO_4 = 2Cu_2S\ (cc) + 2CuS\ (cv) + FeSO_4.}$$

Further attack of cupric sulfate upon covellite produces chalcocite as in the reactions

$$\mathrm{CuS\ (cv) + 7CuSO_4 + 4H_2O = 4Cu_2SO_4 + 4H_2SO_4}$$

and

$$4CuS\ (cv) + 4Cu_2SO_4 = 2Cu_2S\ (cc) + 4CuSO_4\,.$$

When attacked by supergene acidic solutions, pyrite will react as follows

$$4FeS_2\ (py) + 7CuSO_4 + 4H_2O = 7CuS\ (cv) + 4FeSO_4 + 4H_2SO_4$$

and

$$5FeS_2\ (py) + 14CuSO_4 + 12H_2O = 7Cu_2S\ (cc) + 5FeSO_4 + 12H_2SO_4.$$

Oxidation and precipitation can occur below and above the water table since no atmospheric oxygen is needed (Blanchard, 1968). These reactions are continous until the solution becomes weakened with the loss of cupric ions with depth. The weakened fluids form an incipient enrichment zone of covellite (CuS) with the last of its copper. Fresh, unattacked sulfides below form the protore zone.

With continous drops in the water table, leaching and oxidation of the enrichment blanket can increase the concentration of copper with each successive cycle. This is due to a more complete replacement of primary sulfides and concentration of a series of successive enrichment blanket sulfides (Anderson, 1982).

Supergene Alteration of Wallrock Gangue Wallrocks can also act as neutralizing gangues on supergene fluids. Inert gangue such as quartz, barite, or very kaolinized (argillic alteration) or sericitized rock (phyllic alteration) have scant neutralizing ability. Shales and feldspar–rich rocks such as granite and monzonite, have moderate neutralizing power. Carbonate rocks act as strong neutralizers in an acid environment (Blanchard, 1968). Equilibrium between wallrock and acidic fluids causes the alteration of feldspars, chlorite, biotite, and anhydrite to supergene kaolinite, gypsum, and alunite. Supergene processes remove alkalis and alkalii earths by the weathering reactions of hydrolysis, hydration, and oxidation. As supergene fluids slowly percolate down to the water table, they react with carbonates or feldspars and other silicate minerals to become neutral or slightly alkaline. This usually occurs through hydrolysis reactions which consume H^+ ions, increasing pH of the fluid phase.

These reactions generally occur as

$3KAlSi_3O_3$ (feldspar) $+ H_2SO_4 = KAl_3Si_3O_{10}(OH)_2$ (mica) $+ 6SiO_2 + 2K^+ + SO_4{}^{-2}$

or with the addition of water

$2KAlSi_3O_3$ (feldspar) $+ H_2SO_4 + H_2O = Al_2Si_2O_5(OH)_4$ (kaolinite) $+ 4SiO_2 + 2K^+ + SO_4{}^{-2}$

and

$2KAl_3Si_3O_{10}(OH)_2$ (mica) $+ H_2SO_4 + 3H_2O = 3Al_2Si_2O_5(OH)_4$ (kaolinite) $+ 2K^+ + SO_4{}^{-2}$.

In slightly more acidic fluids, montmorillonite (mn) will form as in the reaction

$3KAlSi_3O_3$ (feldspar) $+ 1.5H_2SO_4 = 1.5Al_2Si_4O_{10}(OH)_2$ (mn) $+ 3SiO_2 + 3K^+ + 1.5SO_4{}^{-2}$.

Groundwaters remove the K^+ (or Na^+ from albite). The silica produced may crystallize as quartz or chalcedony, or combine with alumina or copper as seen in the reactions

$$Cu^{+2} + SiO_2 + H_2O \rightarrow CuSiO_3 \cdot H_2O + 2H^+$$

and

$$Al_2O_3 + SiO_2 + H_2O \rightarrow Al_2Si_2O_5(OH)_4 .$$

Free oxygen is not required in silicate alteration reactions. Thus, supergene alteration can extend for considerable depths into the protore, below the oxide and chalcocite enrichment zones. This extension of supergene alteration below the base of copper enrichment forms a zone called the "quasi–protore" zone (Brimhall et al, 1985).

Due to decreasing strength with descent, acid–sulfate solutions moving through potassium silicate altered rocks create alteration zones. Zoning upwards, chlorite occurs, followed by a mixture of sericite and kaolinite with other minor clays. Within and above the enrichment blanket, a kaolinite zone is developed (Titley, 1982). Primary chlorite and biotite mark the extent of supergene acid attack. These minerals are stable under neutral to alkaline conditions at low temperatures and pressures. This stability field eventually occurs with the downward movement of acidic fluids and its reactive mineral acid consumption which increases the pH value (Anderson, 1982).

Location

On the conditions that the location of the copper porphyry system analyzed in this study remain undisclosed along with the name of the mining company and operations, permission and information needed for this research has been graciously given by company management. The regional and local geology of the "Mine X" area will be discussed due to the widespread occurrence of the same stratigraphy throughout the southwestern United States.

Scope of Study

This part of an on-going study to classify ore material for heap leach recovery at Mine X, began with preparation of polished sections from 577 samples, followed by volume grain count methods of copper sulfide phases. Mineralogic study determined the supergene-to-hypogene copper sulfide ratio from samples collected at varying depths, over intervals averaging 5 to 10 feet, from 138 ore control drill holes representing an area of approximately 3 square miles of the Mine X orebody. See Plate 1 for distribution of drill holes from which mineral ratios were determined. Note that determination of the supergene or hypogene origin of a mineral is based on detailed petrographic assessment of ore mineral paragenesis and areal distribution. Supergene mineralization includes chalcocite, digenite, covellite, idaite (Cu_3FeS_4), and scant bornite; hypogene mineralization is represented by chalcopyrite, minor bornite, and traces of digenite-chalcocite, as well as pyrite and molybdenite. Resulting data and ore control drill hole core logs were used to establish the thickness and extent of the leached, oxide, and enrichment zones. The relationship of mineral zones to the primary zone ("protore") is shown in Cross-Section A-A' and Cross-Section B-B' with cross-section lines plotted on Plate 1. Contoured sulfide ratios were plotted, with depth intercepts shown for "top of dominant sulfide" (TDS), defined as the top of supergene enrichment, and top of protore (or "bottom of blanket") surface (see Plates 2 and 3). The difference in elevation between TDS and top of protore gives thickness of the supergene "blanket" (see Plate 4). Contour maps were compared to the Mine X geology map showing wallrock lithology and alteration, with interpretations of this comparison given in the discussion section of this paper.

Ratios

Supergene–to–hypogene and chalcocite–to–covellite ratios quantitatively define the relative enrichment of copper of a sample with respect to the most intensly enriched rock volumes of the weathered porphyry copper system at Mine X. Supergene–to–hypogene ratios for the Mine X deposit is defined by chalcocite+covellite+bornite/chalcopyrite (cc+cv+bn/cp), also referred to as a chalcocite ratio. Chalcocite–to–covellite (cc/cv) ratios establish an incipient enrichment zone to define the top of protore surface. Chalcocite ratios are useful to quantify the enrichment blanket and related mineralogic zones, and to determine metallurgic treatment of low grade copper ores.

Important in exploration application and in economic assessment of a porphyry copper prospect, ratios define the relative abundances of hypogene and supergene copper sulfide phases within original host rock lithologies, alteration assemblages, and oxide and sulfide phases. This determines the distribution of copper sulfides within the various rock types, alteration minerals, and ore–related mineral phases. Viable economic grades need to be supported by mineralogic studies to determine copper recovery potential. Low ratios can indicate poorly developed supergene enrichment, especially important in areas of expected strong and thickest enrichment (William X. Chavez, Jr., 1991, internal report).

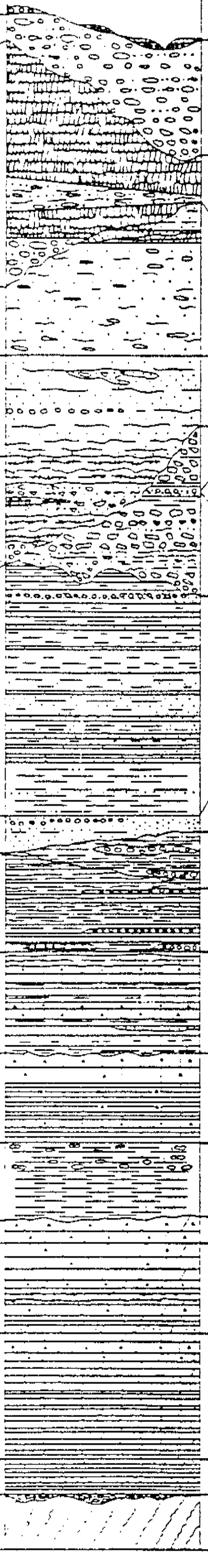
General Geology

Pre–porphyry system wallrocks, intrusive rocks, and structural features of the Mine X area are exposed within and adjacent to the mine. Covered areas comprise those with Tertiary volcanic rocks, Quaternary alluvium and colluvium in valleys, flat uplands, and slopes, and in basins between ranges. Sources for the general geology descriptions, including structure, are derived from anonymous sources. Figure 4 contains a stratigraphic column with regional geology of the Mine X district. See Geologic Map of Mine X in folder for detailed local geology.

Lithology Pre–stock wallrocks consist of Precambrian granite, gneiss, schist, and greenstone which lie under Late Cambrian Bliss Formation of glauconitic and hematitic sandstone, and sandy limestone, the oldest sedimentary rocks in the mine area. The El Paso Limestone Formation, of Lower Ordovician age dolomite and sandy limestone, is followed in sequence by the Montoya Dolomite Formation. The Montoya Dolomite includes cherty dolomitic limestone and is Middle to Upper Ordovician in age. The Cambrian and Ordovician rock units have only a few "questionable" exposures within the mining district. The Mine X pit geology has no exposures, or drill hole encounters of, PreCambrian through Silurian age rocks.

In an unconformable contact, Silurian Fusselman Formation, consisting of cherty dolomite underlies the Percha Shale Formation described as Late Devonian black shales and gray shale containing limestone nodules. Carboniferous units follow in sequence in which Pennsylvanian Oswaldo and Syrena Formations comprise an important part of the local stratigraphic section because they contain copper–zinc skarn mineralization. The Lake Valley Limestone Formation, comprised of Lower Mississippian age white crinoidal limestone, gray limestone and shaly limestone, is unconformably overlain by the Lower Pennsylvanian Oswaldo Formation of massive, cherty limestone, with thin shale partings and interbeds. The Upper Pennsylvanian Syrena Formation consists of calcareous shales and interbedded impure (shaly) limestone.

The Permian Abo Formation of red shale, limestone, and limestone



SYSTEM OR SERIES	FORMATION	APPROXIMATE RANGE IN THICKNESS (FEET)	LITHOLOGY
Recent and Pleistocene	Younger alluvium Older alluvium		Unconsolidated alluvium and colluvium in valley floors, flat uplands, and on slopes. Includes sand, silt, and gravel.
Pliocene and Miocene(?)	Gravel deposits	0-800	Somewhat consolidated poorly sorted bolson deposits ranging from silt to boulder deposits. Similar and in part equivalent to Gila Conglomerate and Santa Fe Formation.
Miocene(?)	Basaltic andesite flows and underlying gravel and boulder deposits	0-850	Dark-gray finely crystalline porphyritic flows; weather reddish brown; contain phenocrysts of pyroxene, magnetite, and olivine in matrix of labradorite.
	Pitchstone, sandstone, and indurated rhyolite tuff underlain by Tuff	0-600	Crystal fragments of quartz, sanidine, biotite, and oligoclase, and rock fragments imbedded in compacted glass shards, in part devitrified and in part replaced by chalcedony. Black pitchstone contains rock fragments and is locally vesicular.
	Tuff	0-600	Pumiceous tuff, gravel, and sandstone locally replaced by clinoptilolite. Generally well stratified.
			Andesite breccia. (See below.)
		0-600	Conglomerate containing intercalated indurated tuffs and rhyodacite and andesite flows. (Rubio Peak Formation)
Lower Tertiary and Upper Cretaceous(?)	Andesite breccia	0-500	Andesite breccia and fine-grained crystal tuff, volcanic sandstone, and some nonvolcanic sandstone and mudstone.
Upper Cretaceous	Colorado Formation	0-1000	Upper 800 feet consists of tan, greenish-brown, and white sandstone interbedded with dark-green, brown, and black shale. Lower 225 feet is black limy shale except for 20 feet of quartzite about 80 feet above base. Thin beds of fossiliferous impure limestone conspicuous in lower part above the lower beds of black shale.
Upper(?) Cretaceous	Beartooth Quartzite	66-142	Fine-grained quartzite containing thin black-shale partings locally. Conglomerate beds near top.
Lower Permian	Abo Formation	0-265	Red shale, mudstone, and limy mudstone containing lenses of algal conglomerate locally.
Upper Pennsylvanian	Syrena Formation	170-390	Impure limestone and limestone interbedded with irregular lenses of red calcareous shale and with shale beds particularly in lower 140 feet.
Upper and Middle Pennsylvanian	Oswaldo Formation	330-420	Blue-gray limestone, fairly pure except in upper part, interbedded with thin shale beds; gray to red siliceous shale or grit about 20 feet thick occurs at base; known locally as "Parting shale."
Lower Mississippian	Lake Valley Limestone	300-400	Limestone, pure crinoidal and massive in upper part, argillaceous and thin bedded in central part. Much nodular chert throughout.
Upper Devonian	Percha Shale	230-315	Upper member, or Box Member, is gray calcareous shale containing abundant limestone nodules; lower member, or Ready Pay Member, is black fissile shale, calcareous at base.
Silurian	Fusselman Dolomite	100-300	Gray cherty finely crystalline vuggy massive dolomite.
Upper and Middle Ordovician	Montoya Dolomite	300-350	Light-gray to gray very finely crystalline massive dolomite containing interbedded dolomite and dark chert in central part and concentrations of opalescent quartz sandstone at base.
Lower Ordovician	El Paso Limestone	500-519	Thin- to thick-bedded light-gray limestone and dolomite. Chert nodules in upper part; abundant fucoidal markings in lower part.
Upper Cambrian	Bliss Formation	140-188	Predominantly dark-brown massive quartzite, locally hematitic and glauconitic. Grayish-brown shaly dolomite and basal coarse conglomerate locally.
Precambrian			Granite, granite gneiss, and greenstone.

FIGURE 4. Stratigraphic column of the regional geology of the Mine X district (modified after an anonomous source).

conglomerate is unconformably overlain by Upper Cretaceous Beartooth Quartzite Formation (with minor sandstone, limy sandstone, and shaly sandstone) and Colorado Formation of black shale and sandstone interbedded with shale. The key in Appendix A provides a more detailed description of Mississippian to Recent rocks within the mine area.

Intrusive rocks of the area range from Late Cretaceous to Miocene in age. The igneous events culminating in mineralization began with Late Cretaceous – Early Tertiary intrusions consisting of andesite and diorite porphyry dikes, a gabbro plug, and a quartz diorite porphyry. Younger intrusions comprise Early Tertiary granodiorite porphyry dikes and granodiorite porphyry stocks. These intrusions can be distinguished as relatively "fresh" (showing only incipient alteration) or hydrothermally altered rock, with wallrock alteration consisting of phyllic (quartz–sericite), and potassic (clay–biotite, feldspar porphyry, or quartz–orthoclase) alteration. These granodiorites grade into rock of quartz monzonite composition, and are considered to comprise part of the main mineralized stock. Early Tertiary dikes of quartz monzonite porphyry are cut by Miocene age intrusions which include basalt dikes, and locally porphyritic, flow banded rhyolite plugs and dikes.

Miocene volcanic rocks, comprising rhyolitic tuffs and basaltic andesite flows, are the dominant extrusive rock type in the mine area.

Structure The Mine X porphyry copper deposit and adjacent iron and zinc ores lie in an uplifted mountain range between two northwesterly trending faults. Regionally, sediments have a gentle southwest dip toward the axis of a broad syncline (anonomous source). This pattern is disturbed in the Mine X district by the larger intrusive bodies and faults. Bedding dips away from the main mine intrusion; and abundant faults exist in the area, most of which trend in two distinct northeast directions. Northwest–to–north trending faults, fissures, and fractures are also present, and apparently guided the emplacement of Tertiary quartz monzonite and granodiorite dikes mentioned above. The volumetrically most extensive intrusions, including granodiorite porphyry, are elongated in a north–northwest direction. Regional intersection of northeast and north–northwest trending zones of structural weakness appears to have localized the granodiorite stock and subsequent copper mineralization. Northeast–trending structures appear to characterize the basement rocks, while northwest–north fractures appear to be restricted to the Mine X district (anonomous source).

Several breccia zones exist near and within the mine area, and are found at the north end of the granodiorite porphyry stock, and west and northwest of the orebody.

Orebody Description and Morphology

Mine X disseminated and fracture–controlled mineralization is hosted by the granodiorite porphyry stock. This Laramide intrusion intrudes gently–dipping Paleozoic and Mesozoic sedimentary rocks. Pyrometasomatic ore–grade copper mineralization occurs in two deposit types in the Mine X area: (1) as replacement orebodies of magnetite–chalcopyrite–pyrite, with abundant quartz and calc–silicate minerals within a skarn developed in the Oswaldo and Syrena Formations adjacent to the granodiorite porphyry stock; and (2) as stockwork and disseminated sulfides within igneous rocks, sandstone, and shale. These garnet–diopside skarn, with interstitial magnetite and pyrite, to massive garnet–epidote–magnetite skarn ores are of hydrothermal origin and have little or no supergene enrichment. Drill holes collared in skarn ores are contoured around for supergene enrichment blanket thickness. Ratio data from skarn mineralization gives eratic changing values with depth and abundant magnetite and pyrite is observed. Weathering–induced chalcocite mineralization is the economically most important ore phase in Mine X. The following discussion concerns stockwork and disseminated, intrusion–hosted copper and copper–iron mineralization at Mine X.

Hypogene mineralization consists of pyrite, the dominant primary mineral, and chalcopyrite, with minor amounts of bornite, molybdenite, marcasite, and pyrrhotite. Chalcopyrite in the granodiorite porphyry occurs as disseminations and in small veinlets, generally accompanied by pyrite. Primary mineralization in noncalcareous shale and sandstone and in quartz diorite sills occurs in veins. Rarely and in very minor amounts, hypogene chalcocite occurs as microspic blebs within chalcopyrite and pyrite.

Supergene mineralization is dominated by volumetrically abundant chalcocite, with minor amounts of covellite. Oxide zone minerals, exposed in early mining operations, consisted of important native copper, chrysocolla, cuprite, malachite, and azurite. Although these phases were important ore minerals and are still found locally, they comprise only minor ore–grade mineralization in present mining. Chalcocite occurs in "sooty" and "steely" forms as veins, discrete grains, coatings on pyrite, and, in deeper material, as coatings and replacements along fractures in chalcopyrite and pyrite. Paragenetic relationships between primary sulfides and supergene–derived phases are discussed in the ratio data section

The orebody, with variable thickness of supergene–derived ("secondary") enriched ore, consists of three north–west trending zones of tens to 200 meters thick relatively high–grade ore (< 0.97% Cu) formed mostly in the phyllic alteration zones within and around the granodiorite porphyry stock and its potassic alteration (Gilmour, 1982). Noteably, the porphyry and its alteration zones also trend northwest. Appreciable amounts of chalcocite are present locally at greater depths, occurring at least 800 feet or lower below the original surface of the pit. The most northeasterly orebody occurs in sediments, quartz diorite, and the granodiorite stock, generally as supergene chalcocite; locally important skarn mineralization occurs near the north end of this supergene zone. See overlay of Geologic Map of Mine X with Plate 4 for morphology of the supergene blanket.

The areally most extensive mineralization occurs in the center of the study area, in granodiorite porphyry; this mineralization extends northwest into sediments and quartz diorite. This orebody consists of chalcocite ore with only relict and volumetrically minor skarn mineralization. A smaller, northwest–trending orebody occurs southwest of the granodiorite stock in sediments and quartz diorite, consisting entirely of supergene–derived mineralization. Between these well–developed zones of supergene mineralization, enrichment occurs as a continuous but locally thin (~ <60 meters) and low grade ($\leq$0.2% Cu) blanket.

<u>*Alteration*</u> Hypogene (hydrothermal) and supergene alteration are economically important within the Mine X orebody because both alteration types control the nature and distribution of copper mineralization. Hydrothermal alteration occurs in calcareous and noncalcareous sediments adjacent to the granodiorite porphyry stock, and in igneous rocks intruded by the granodiorite porphyry stock. Silicification and recrystallization of the calcareous Oswaldo and Syrena Formations produce hornfels and skarn. The most abundant hydrothermal alteration products in these calcareous rock types are magnetite, quartz, garnet, and pyrite. Shaly limestone and calcareous shales, altered to hornfels, develop abundant epidote, tremolite–actinolite, and chlorite, as well as magnetite–quartz–garnet–pyrite. Less abundant alteration minerals are hematite, orthoclase, biotite, and sericite, with minor amounts of siderite, apatite, hedenbergite, ilvaite, and trace kaolinite, minor montmorillonite, and gypsum. Hypogene alteration of felsic to intermediate igneous rocks, and noncalcareous sediments produced potassic silicates (orthoclase and biotite), sericite, quartz, clays (kaolinite and illite), chlorite and epidote. Phyllic alteration is associated with the highest grade of primary ore. Hornfels, adjacent to the potassic alteration in the stock, are cut by biotite–orthoclase veinlets. Skarn becomes more abundant in magnetite and pyrite–chalcopyrite at this same contact, and is probably synchronous with potassic alteration in the stock (Einaudi, 1982). Hornfels in contact with phyllic alteration in the strong pyrite halo on the west margin of the stock, up to 10% pyrite

occurs in veinlets with alteration envelopes of variable epidote, chlorite, montmorillonite, calcite, siderite, and specular hematite. Early skarn assemblages are overprinted by hydrous silicates and carbonates near contacts with sericitized porphyry; and contain 20–75% magnetite and 10–25% total sulfides (Einaudi, 1982). These zones of phyllic (quartz+sericite+pyrite) and potassic (biotite+K–feldspar) alteration, overprinted in some areas by argillic alteration, trend northwest as does the granodiorite porphyry stock. Propylitic (chlorite+epidote+calcite) alteration also occurs outside of the study area (Barnes, 1986).

Supergene alteration resulting from the oxidation of primary mineral phases, has engendered kaolinite, montmorillonite (smectite), alunite, sericite, quartz, and minor chlorite. Oxidation of sulfides due to supergene processes produces (1) indigenous ("derived from immediate area") iron–bearing phases (goethite, hematite, and jarosite), and (2) transportation of iron and other metals from sites of source sulfides (exotic oxide development), including transportation of metals to significant depths (hundreds of feet) below the current topographic surface. The leached capping, comprising rock from which metals such as copper and iron have been removed via oxidation and dissolution in meteroic waters, above the enrichment blanket ranges from zero to several hundred feet in thickness, generally thin in the north and thicker to the south. See Cross–Sections A–A' and B–B' for distribution of supergene alteration within study area. See results and discussion for alteration, lithology and strutural effects on supergene alteration.

Background

Most previous studies of the Mine X area, emphasize general geology and structure, and detailed characterization of hypogene mineralization. Supergene enrichment has received little attention. Such supergene enrichment at Mine X, however, was critical in the formation of economically important mineralization and includes sulfides as "sooty" and "steely" chalcocite/digenite, volumetrically minor amounts of covellite, and trace amounts of bornite, idaite, and covellite–like phases. Native copper, chrysocolla, cuprite, malachite, and azurite obtained from the "oxide zone" immediately below a zone of intense cation leaching were important ore minerals in early mining operations,and are locally present in minor qualities.

The volumetrically and economically most important supergene sulfide mineral is chalcocite, occurring as veins, discrete grains, coatings on pyrite, and, in deeper material, as coatings and replacements along fractures in chalcopyrite and pyrite. Because copper leaches more readily from highly fractured, silicified, and sericitized rocks than from less altered rocks containing clay or carbonate, igneous rocks and noncalcareous sediments contain the most significant enrichment at Mine X . Structural control of supergene enrichment is evident at the east and west contact zones of the copper porphyry stock; these areas are more fractured than other areas of the stock, forming two of the three northwest–trending supergene ore zones (see Geologic Map of Mine X).

Previous Studies

Past work on porphyry copper systems, in particular supergene alteration and mineralogy, include studies by Locke (1926), Blanchard (1968), Lowell and Guilbert (1970, 1974), Gustafson and Hunt (1975), and Bladh (1978, 1982). Locke (1926) and Blanchard (1968) discuss the interpretation of leached outcrop characteristics as guides to supergene–derived mineralization. In continuance of these studies, Blahd (1978, 1982) discusses the weathering processes by which goethite, jarosite, and alunite form from sulfide–bearing felsic rocks and their correlation with abundance and composition of sulfide minerals originally in these rocks. Lowell and Guilbert (1970) define lateral and vertical alteration–mineralization zoning common in porphyry copper deposits. Guilbert and Lowell (1974) extend this study to describe variations in porphyry copper zoning patterns and assemblages from the "typical" model, and discuss the functions of several variable conditions in the porphyry copper environment. Gustafson and Hunt (1975) propose a genetic model for the emplacement and deposition of porphyry copper deposits using a detailed study of the orebody and its environment at El Salvador, Chile.

Previous studies on New Mexico porphyry systems include studies by Graton (1910), Paige (1912 and 1916), Spencer and Paige (1935), Lasky (1936), Schmitt (1939), Lasky and Hoagland (1948), Kerr, et al. (1950), Leroy (1954), Ordonez, et al. (1955), Jones, et al. (1961), Rose and Baltosser (1966), Nielsen (1968 and 1970), Jones (1967), Jones and Hernon (1973), and Ahmad and Rose (1980). Most of these studies pertain to general geology and structure, and detailed studies of hypogene mineralization with some mention of supergene enrichment.

METHODS OF INVESTIGATION: SAMPLE PREPARATION AND ANALYSIS

Sample preparation and analysis of ~400 samples (sample numbers 1–1705), started in 1985, beginning as a project by Dr. William X. Chavez, Jr. to aid in heap leach recovery by Mine X operations. That information has been incorporated into this study along with an additional 177 samples (numbers 1701–1888) analyzed by the author.

Methods and Procedures

Preparation methods entail heavy liquid separation of sulfide and oxide phases from silicate minerals, and preparation of polished sections. Assay pulps, comprising crushed core samples representing composite intervals, were collected from ore control drill holes at varying depths. Such composite interval samples provide excellent volumetric representation of the oxide and enrichment zones of this ore deposit because counting statistics of heavy concentrations are based on large–volume samples. Aliquots of 25 gram crushed pulps were separated into a light fraction (mostly silicate minerals) and a heavy fraction by centrifuging in a heavy ($\rho=2.95-3.00$) sodium metatungstate liquid. The heavy fraction contains mostly sulfide and oxide

TABLE 1. Chemical formulas for copper sulfide minerals used in supergene–to–hypogene (cc+cv+bn/cp) and chalcocite–to–covellite ratios.

CU SULFIDE MINERALS		CHEMICAL FORMULAS
Chalcopyrite	Hypogene	$CuFeS_2$
Chalcocite	Supergene	Cu_2S
Covellite*	Supergene	CuS
Bornite	Hypogene**	Cu_5FeS_4
Digenite*	Supergene	$Cu_{1.7}S$
Idiate	Supergene	Cu_3FeS_4

*May occur as trace hypogene phases, usually encapsulated by pyrite.

**Bornite occurs as a hypogene phase (used for copper recovery study; generally in trace counts) and as a minor supergene phase.

minerals, with some heavy silicates such as biotite and horneblende.

After this separation, the heavy fraction is frozen in the centrifuge bottle usingliquid nitrogen; the lighter (top) fraction of the sample, consisting of silicate minerals, is poured off and filtered separately. Note that the amount of sample subject to separation depends on the amount of sulfides recovered; approximately 1.0 grams are needed for a statistically significant mineralogic analysis. The heavy and light fractions of each sample are then washed with distilled water during filtering to collect the sodium metatungstate for recycling. After the samples have dried, the heavy fraction is cast into grain mounts in cold–setting epoxy (see Figure 2). The silicate mineral concentrate is saved for future analysis as needed; the heavy fraction is then polished perpendicular to the grain settling cross–section for standard ore petrographic study

Analytical Techniques

Each sample was analyzed by standard petrographic techniques using area (volume) grain count methods to determine the supergene–to–hypogene copper sulfide ratio, defined by the quotient <u>cc+cv+bn</u>/cp (see Table 1 for chemical formulas). Note that chalcocite grain count values also include digenite and idiate minerals because of the paragenetic relationship and similarity with respect to leaching behavior between these supergene sulfides. The character and paragenesis of supergene mineralization and accompanying sulfides and oxides is noted for each sample. The sample surface, analyzed by volume grain count methods, is a cross–section of the settling column. This is representative of particle size and composition, which avoids biasing due to size segregation, degrees of particle liberation and size and density. Average surface grain size is tens of microns (u^2) (see Figures 5 through 9). Resulting ratio values reflect sulfide mineralogy content and not grade values; thus, variation of heavy fraction amount is only of importance in samples with very low sulfide contents (less than 0.5%–wt) which can bias ratio values through poor counting statistics. For petrographic technique, grain count was made under reflected light at 100 X, using 50 microns for one unit of linear count. For example, Figure 5 represents a surface area in which the chalcopyrite mineral counted as 3 grain units and the chalcocite as 13 units. Examples of characteristics noted during petrographic study and assessment of paragenesis of sulfides in the leached capping, oxide, enrichment, incipient enrichment, and protore zones can be seen in Figures 6, 7, 8, and 9.

For each sample, the total of each mineral were calculated, and used to determine the mineralogic ratios noted above. Some scanning electron microscope (SEM) work was required in order to identify mineral phases in a some samples. Grain count data and resulting ratios, with notes pertaining to sample character and paragenesis, are listed in Appendix B in numerical order of samples, except where sample numbers differ in sequence within a drill hole as indicated. Appendix A serves as a key to locate ore control drill holes in Appendix B.

FIGURE 5. Photomicrograph of a section of sample 1828, at 100 X under polarized light, shows chalcocite (cc) replacing chalcopyrite (cp) in the central grain (140 microns in length). Pyrite and magnetite, with biotite, are also present (see analytical techniques).

FIGURE 6. Sample 1855 is an example of supergene oxidation with abundant hematite (hm) and minor chysocolla (chy), at 200 X under crossed nicols. Hematite grain is 20 microns in width.

FIGURE 7. Sample 1863 displays supergene enrichment paragenesis of chalcopyrite --> bornite --> covellite (cp>bn>cv), with trace chalcocite (cc), under microscopic 400 X and polarized light. Grain is 57 microns across.

FIGURE 8. An example of incipient enrichment comprising covellite (cv), grain size 25 microns in width, proximal to chalcopyrite and pyrite (py) grains is seen in a section of sample 1801 at 400 X.

FIGURE 9. Sample 41, seen at 100 X and polarized light, is characterized by primary sulfide mineralization of unaltered chalcopyrite (cp) and pyrite (py); sample is of very low total sulfide content. Largest chalcopyrite grain 120 microns in width.

INTERPRETATION OF RATIO DATA

Each supergene–to–hypogene ratio defines the leached–oxide, sulfide enrichment, incipient enrichment, or primary zone of the porphyry copper system. These chalcocite ratios can also be applied to heap leach classification of ore–grade material, as discussed in a later section. Chalcocite ratios in this study range in value from 230 to low (<0.09). Material with ratios ≥ 0.4 corresponds to supergene mineralization which is amenable to "fast" leach treatment. Low ratios (≤ 0.3) indicate volumetrically important hypogene (primary) mineralization with "slow" leach characteristics. However, ratio values used to classify slow or fast heap leaching material vary with the metallurgy and economics of a mine. These values do not necessarily correspond to ratio parameters of the ore zones defined herein.

Intermediate ratio values indicate transitions between zones. Oxide phases of copper and iron or altered Fe–oxides and hydroxides indicate "oxide zone" and "leached zone" mineralogies with little or no sulfide occurrence, respectively.

Quantification of Copper Sulfide Mineralogy and Definition of Mineralogic Zones

Porphyry copper mineralization zones defined in terms of supergene–to–hypogene ratio values can be contoured for thickness, extent, and depth. See Figure 10 for summation of supergene–to–hypogene ratio parameters for supergene–related ore zones and chalcocite to covellite ratio distributions. Note that all ratio values are considered in conjunction with sampled intervals above and below, and in correlation with ratios in adjacent drill holes to establish copper mineralization zones at depths where no data is available. This insures that ratios do not result from sporadic local effects. Note also that observations of mineral phases are used to refine definition of zones.

Oxide and leached capping zones, caused by weathering–related alteration engendered through acidic oxidizing solutions, are established by lack of sulfides and concomitant presence of abundant iron oxides (hematite, goethite, and jarosite) in a sample interval.

The TDS interface with the leached/oxide capping zone has been determined in this study in order to establish the elevation of the upper surface of supergene enrichment. This is important because as the base of the leached zone is approached, the amount of copper increases both in the form of oxidized minerals and supergene sulfides, and even some remnants of primary sulfides. Thus, sulfide ratios for TDS can range in value from unity to low or high ratio values.

Supergene mineralization produces $\underline{cc+cv+bn+id}/cp$ ratio values of ≥ 0.4. The lower value (0.4) is defined in this study as "weak or incipient supergene enrichment," characteristic of the "bottom of enrichment blanket".

Protore is quantified by chalcocite ratios ≤ 0.3 and low total (cc+cv+id+bn)

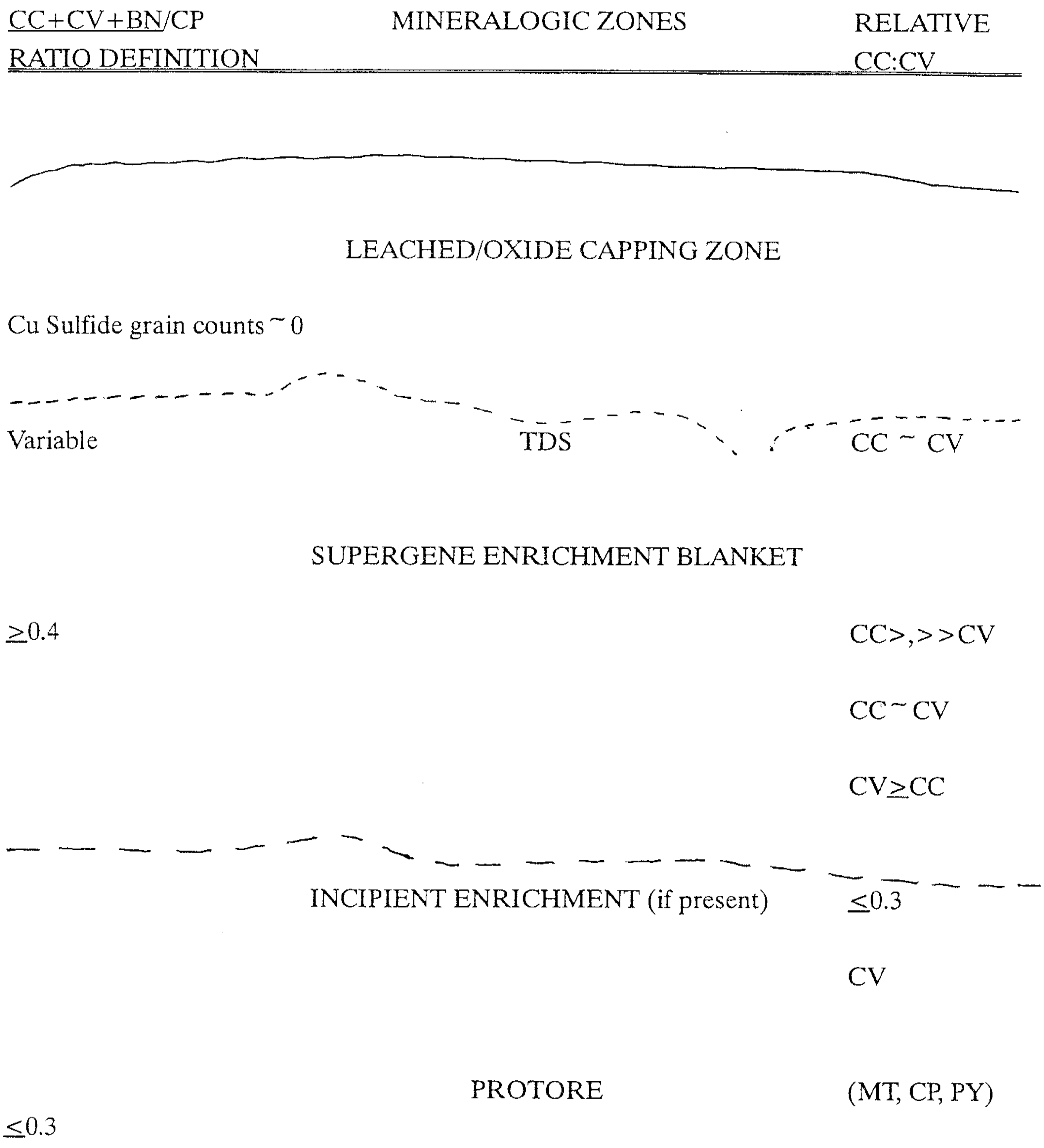


FIGURE 10. The supergene–related mineralogic zones, as defined in this study, illustrated in a schematic representation. These zones are defined through quantification of supergene–to–hypogene and chalcocite–to–covellite ratio values. Also shown are the relative abundances of chalcocite–to–covellite within different copper ore zones.

columns due to a general scarcity of supergene mineral occurrence. Unless otherwise defined as incipient enrichment (established through covellite occurrence as discussed below) the top of primary mineralization is defined by ratio values ≤ 0.3. Lack of incipient enrichment in some areas reflects weak supergene influence, probably because of low solution copper content, lateral movement of mineralizing fluids, or neutralizing environment of wallrock (see Figure 9). It is observed that for chalcocite ratios ≤ 0.3, supergene processes did not effectively replace protore minerals, chalcopyrite and pyrite.

Chalcocite–to–covellite ratios were used to establish an incipient enrichment zone below the strongly enriched chalcocite zone. In general, within the supergene enrichment blanket, chalcocite (Cu_2S) occurs at the top where supergene solutions have relatively high Cu^{+2}/HS^- ratios; covellite (CuS) occurs at greater depths and the "blanket" becomes less enriched where Cu^{+2}/HS^- is lower (Guilbert and Park, 1986). Figure 10 illustrates an incipient enrichment boundary based on relative abundances of chalcocite–to–covellite. A low chalcocite–to–covellite (cc/cv) ratio of ≤ 0.3, defines the incipient enrichment boundary for protore mineralization for sample intervals in which covellite occurs.

PREPARATION OF RATIO CORRELATION MAPS

Correlation and computer contouring of the data from chalcocite ratios, chalcocite–to–covellite ratio data, and drill hole core logs, generates contours for the thickness, extent, and depth of the Mine X mineralogic zones. Map preparation includes correlation of ratios on a complex fence diagram using drill holes for control data. Defined by the TDS and protore surfaces, depths to ore zone boundaries were plotted and correlated for leached/oxide capping, supergene enrichment, and primary mineralization. Due to removal of overburden and ore by mining, 64 drill holes intercept supergene enrichment at their collar elevations which prohibits the determination of TDS surfaces by ratio parameters. In these cases, the TDS elevations have been approximately established using logs of older, adjacent ore control drill holes made prior to mining of the supergene enrichment surface. Not all core logs of adjacent older drill holes were available, which required inference of TDS surfaces based on geologic and mineralogic trends. Elevations deduced by correlation with other drill holes (using either core log or ratio data) for top and bottom of supergene enrichment, results in approximations with variable error of 10 to 40 feet . See Cross–Sections A–A' and B–B,' and Appendix A for TDS and protore surfaces with resulting supergene blanket thickness, including location and numbered sample intervals, for each drill hole.

Figure 11 illustrates a cross–section of an ore control drill hole with volume grain counts and ratio values for intervals sampled. Copper mineralogic zones are established by these values and by correlation with adjacent drill holes. These correlations provide trends in boundaries which is useful in evaluting local effects and in determining mineral zones between and beyond control points. In Figure 11, the drill hole intercepts a local, sporadic occurrence of a 13 foot interval of low ratio values, unaffected or slightly influenced by supergene enrichment within the "blanket". These local areas of primary mineralization within the supergene enrichment blanket are not uncommon, due to local structural features or change in wallrock geochemistry. For this particular drill hole, possibly a xenolith or interfinger of limestone has promoted a "pocket" of skarn mineralization within this interval containing a high volume count of chalcopyrite.

Due to lack of data, or due to skarn development in limestone units, drill holes not used for contouring the TDS and/or top of protore surfaces are thus noted in Appendix A. Where indicated by ratio and core log data, areas of metasomatic ore are not included as extensions of the supergene enrichment blanket, as seen in the

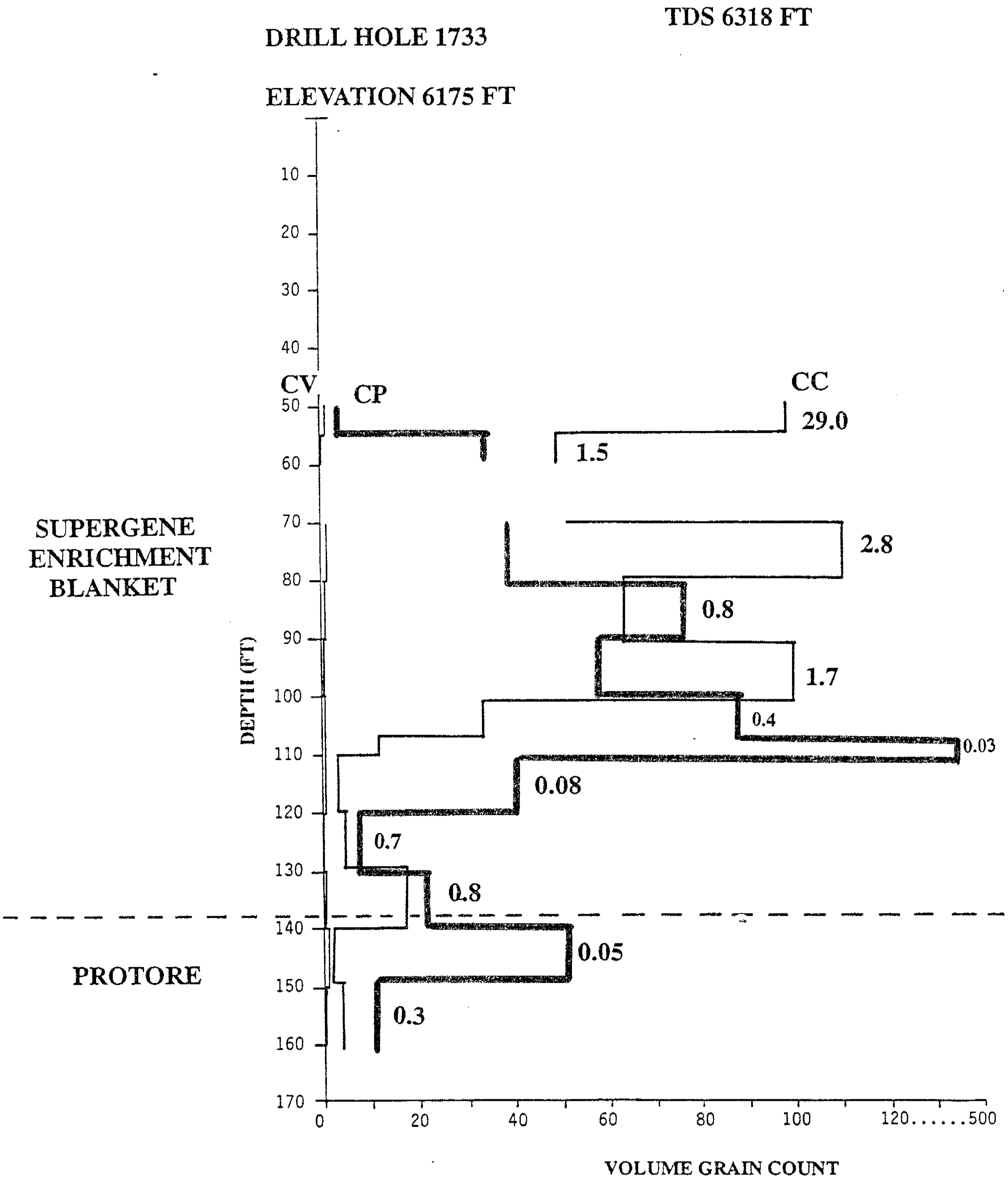


FIGURE 11. Example of cross−section of a drill hole illustrates volume copper sulfide grain count for chalcocite (cc), covellite (cv), and chalcopyrite (cp) per sampled interval. These grain counts result in cc+cv+bn/cp ratio data (example 0.8) used in establishing mineralization zones of the Mine X porphyry copper system. See discussion.

thickness contour map. This is done because skarn–type ores are charactereized by mineralization (carbonate–hosted) which does not promote leaching for supergene enrichment of copper.

Maps were contoured for ore control drill hole collar, TDS, and protore surfaces, and thickness of supergene blanket, using contour data listed in Appendix A (see Plates 1, 2, 3, and 4). Plots of three–dimensional surface expressions were produced with the *Surfer* program for these same surfaces including an overlay of TDS and protore surfaces (see Figures 12 through 18). Cross–sections A–A' and B–B' were produced from surface contour maps, in conjunction with a fence diagram used as a worksheet for correlation of data. These cross–sections show variations in the copper sulfide zones with drill hole collar geology in representative north to south and east to west directions.

RESULTS

Through definition and correlation of cc+cv+bn/cp ratios calculated from volume grain count of copper sulfides in geostatistically sampled intervals , elevations of supergene–related mineral zones were ascertained. Contouring of these depths, listed in Appendix A, produced surface maps and three–dimensional surface expressions for TDS and bottom of enrichment blanket elevations, and supergene enrichment blanket thickness. The surface contour maps (Plates 2, 3, and 4) were overlayed with the Geologic Map of Mine X to establish the relationship of supergene enrichment thickness, extent, and top and bottom depths to wallrock lithology, alteration, and structure. For visualization of results, the reader should refer to overlays of specified contour surfaces (Plates 2, 3, and 4), including Plate 1 for location of drill holes and cross–sections, on the geologic map; three–dimensional expressions

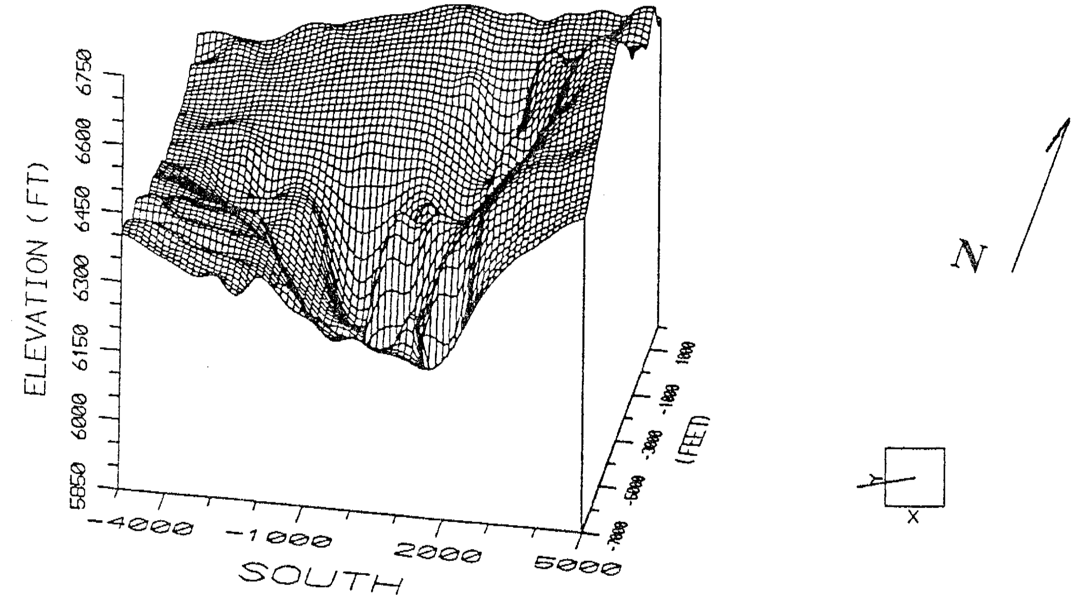


FIGURE 12. TDS surface expression of the Mine X porphyry copper deposit.

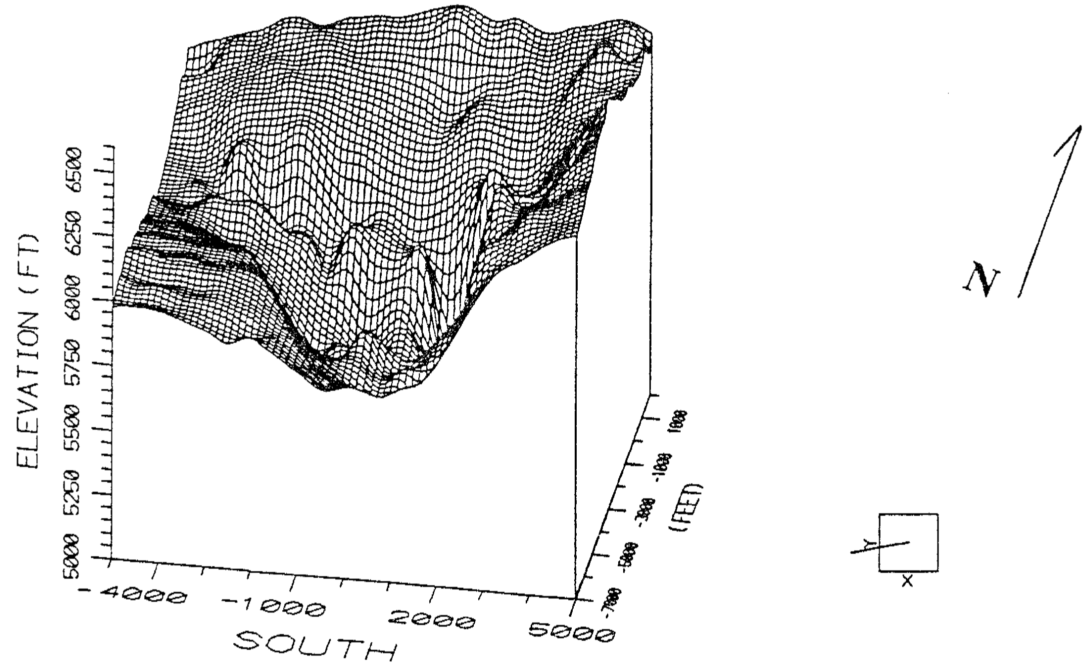


FIGURE 13. Protore surface expression of the Mine X porphyry copper deposit.

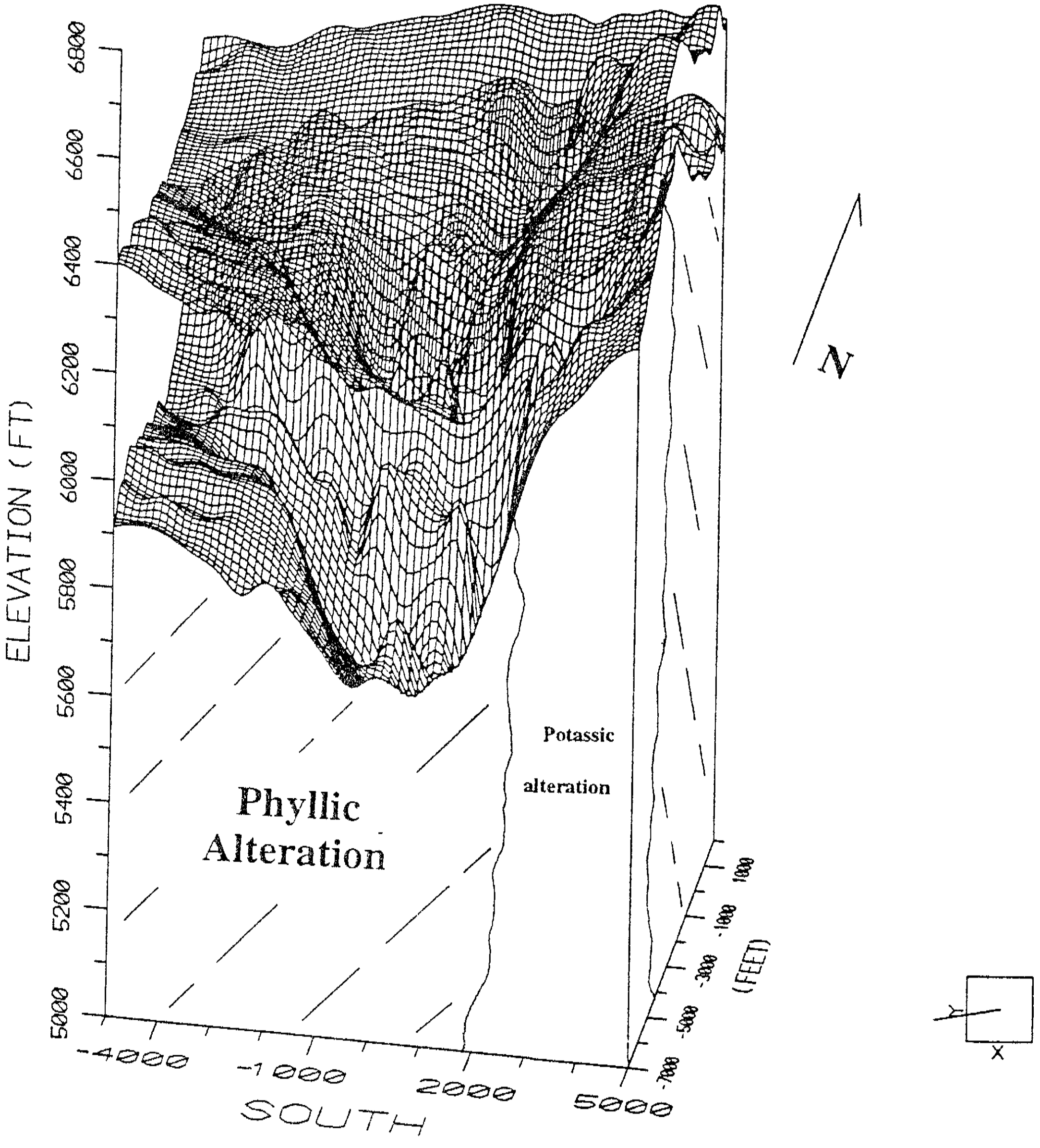


FIGURE 14. Overlay of TDS and protore surfaces of the Mine X porphyry copper deposit.

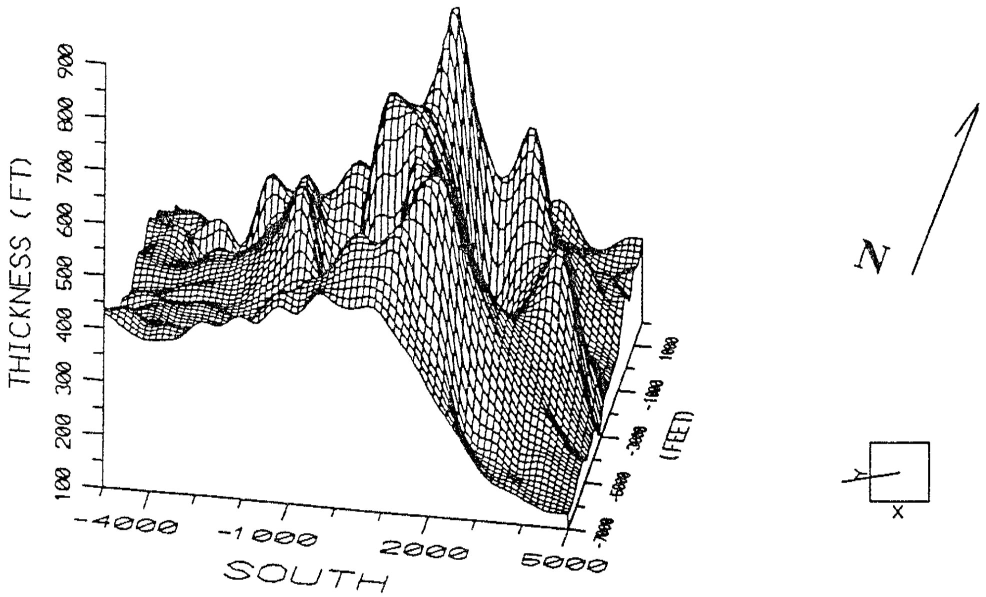


FIGURE 15. Oriented view of supergene enrichment blanket thickness expression of the Mine X porphyry copper deposit, looking north.

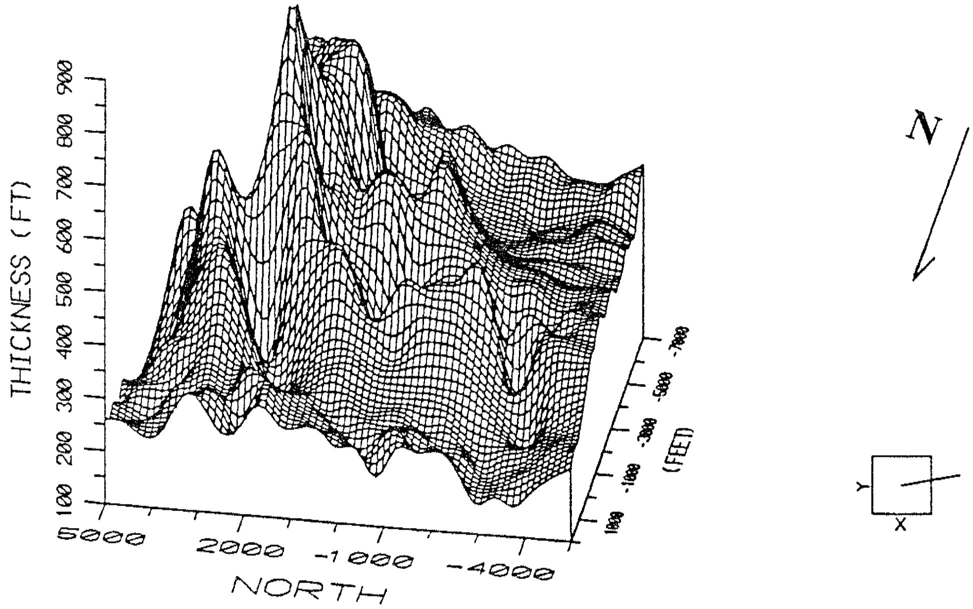


FIGURE 16. Oriented view of supergene enrichment blanket thickness expression of the Mine X porphyry copper deposit, looking south.

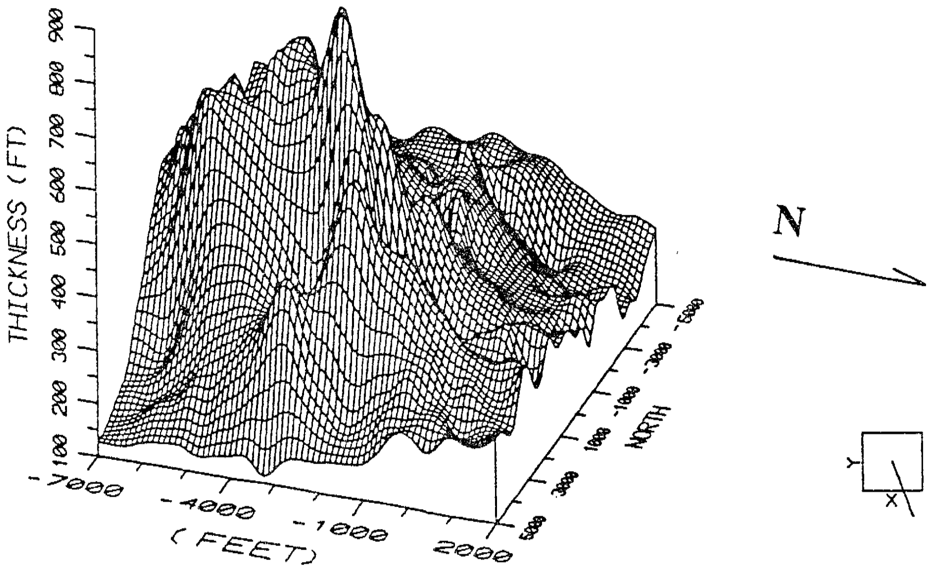


FIGURE 17. Oriented view of supergene enrichment blanket thickness expression of the Mine X porphyry copper deposit, looking east.

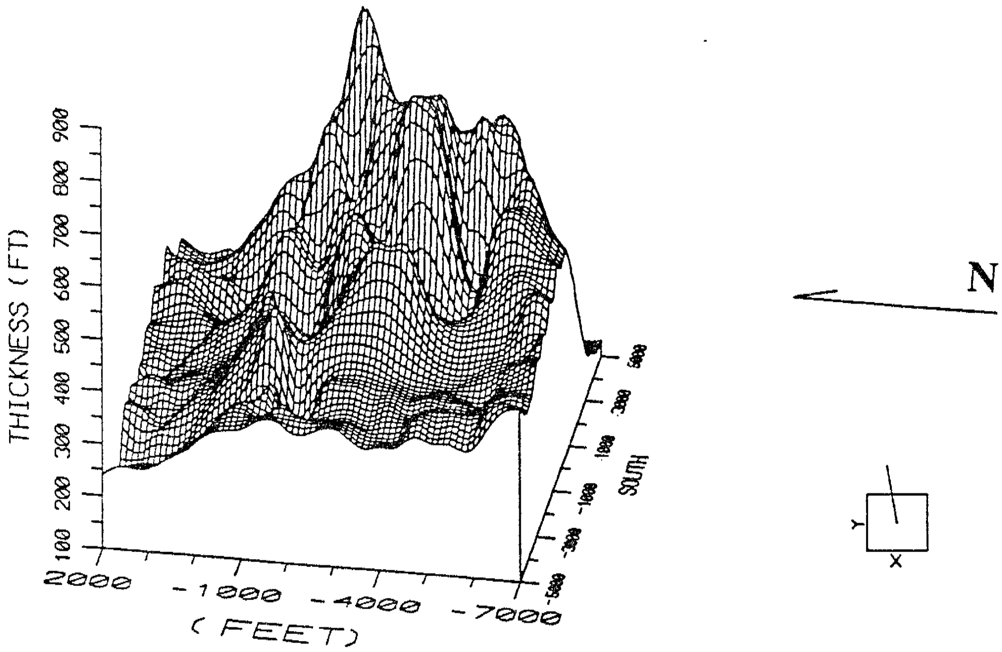


FIGURE 18. Oriented view of supergene enrichment blanket thickness expression of the Mine X porphyry copper deposi, looking west.

of surfaces (Figures 12 through 18); and Cross–Sections A–A' and B–B'.

TDS and Top of Protore Surface Elevation Variations with Geology of Mine X

The protore and TDS surfaces, whose separation interval defines the enrichment blanket thickness, decrease sharply in elevation from the sedimentary rocks on the eastern margin of the porphyry system, and decrease gradually from the northern and western margins. These elevations decrease, in an irregular fashion, towards the central and southern sections of the study area, which contain granodiorite (Tgq) characterized by phyllic alteration. In general, the higher TDS and top of protore surfaces elevations occur on the east, west, and northern perimeter of the study area, in sedimentary rock units. (see Figure 14). Top and bottom of the enrichment blanket elevations decrease in the biotite–clay altered granodiorite (Tgb) in the north and central area of the map before dropping sharply into Tgq.

Within the area containing the supergene blanket, irregular topographic highs occur for the protore surface at drill holes 1891 and 1703. These drill holes are in or near Tgq and northeast–striking faults with dips of 70–80° west, respectively (northwest–striking faults also occur in these areas). Other shallow top of protore surfaces occur at drill holes 1613 and 1609 in the Colorado Formation (Kc) along a major northeast–striking fault, with 53° south dip, and at drill hole 1546 in breccia in the northwest section of the map. Drill hole 1786 has high elevations for both TDS and top of protore surfaces in granodiorite with feldspar alteration (Tgf) in the south–central section of map. Other shallow elevations for TDS occur in Tgb, adjacent to the Tgf, in drill holes 1848 and 1850. Drill hole 1850 is located at a northeast–striking fault with 65° north dip. Also noted are three occurrences in the south section of the map, in drill holes 1888, 1838 and 1713, of relatively higher TDS surfaces near granodiorite porphyry dikes (Tgd) which cut through Tgq and the early quartz diorite porphyry sill (Kep).

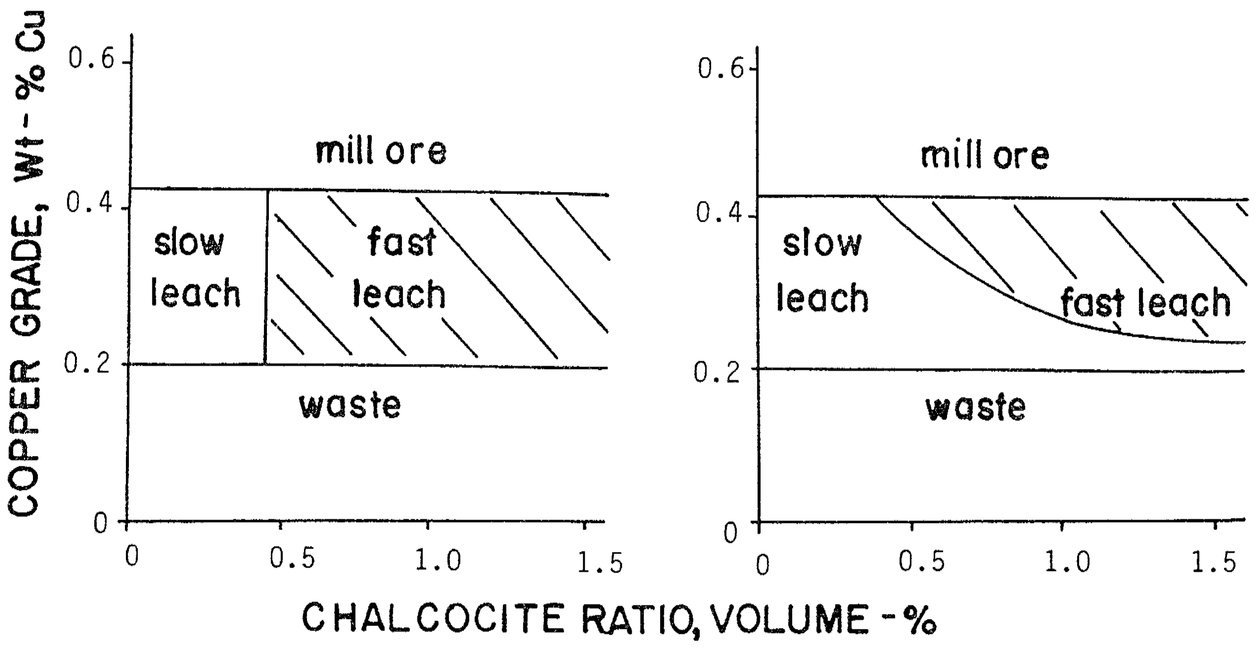
Overall, the lower elevations for TDS and protore surfaces occur in Tgq and in the late quartz diorite porphyry sill (Klp), Kep, and some minor Kc in the southern section of the study area. Of interest, lowest elevations, and thickest blanket, occur in an area of Tgq that is nearly encircled by Tgb. Faults in this area are of variable northwest strikes and variable south dips. Local deeping, relative to higher surrounding elevations, of the top and bottom "blanket" surfaces occur in Kc just east of northwest–trending faults dipping south, Kep, and Klp, located in the south section of map. The top of protore surface forms a northeast to east trending trough in Tgq, latite dikes (Tli), and quartz orthoclase (potassic) altered granodiorite (Tgk) of the northwest section of map. This depression is south of a Tli dike which defines a major northeast fault system. Protore surface depressions also occur in the northeast section of the map in Klp . Drill hole 1548 has a depressed protore surface in a minor northeast–striking fault system dipping south in the Syrena Formation (Cs) near a quartz latite dike (Tliq). Depressions in TDS surface occur in Kep at drill hole 1887 east of a northeast–trending fault dipping south and at drill hole 1800 in the Beartooth Quartzite Formation (Kb). The TDS surface also has low elevations at drill hole 1703 in a highly faulted area of Cs in which the protore surface is high.

Supergene Enrichment Blanket Thickness Variations With Geology of Mine X

The supergene blanket is generally thickest where TDS and protore surfaces are deepest, and thinner in the west, east and northern perimeter of the study area where these same surfaces are shallow. In the central and most southern sections of the study area which encompass Tgq, Klp, Kep, and Tgb, blanket enrichment thickness is thicker. See Figures 14, 15, 16, and 17 for oriented views of enrichment thickness. The thickest blanket (950 feet) occurs in the area of Tgq nearly encircled by Tgb.

Blanket thickening, relative to surrounding values, also occurs in a suspected northwest trend of ≥ 720 feet thickness. This trend is located in the lower south section of the map, in areas of Tgb near a Tliq dike trending northeast and near northeast–striking faults dipping north; and in Tgq near a northwest–trending Tgd dike. The enrichment blanket thickens locally in Klp, in contact with Kc, in which most of the drill holes are near northeast–striking faults dipping north in the northeast section of the map. A local thickening also exists where the top of protore surface is depressed along the major northeast–trending fault system of the northwest section of the map, defined by the Tli dike.

Localized blanket thinning occurs in the central section of the study area in areas of Tgq, close to fault systems trending northeast and northwest; and in Kb (may be underlain by Tgq) near a quartz monzonite dike (Tqm) which defines a northeast–striking fault. Thinning of the blanket occurs in a minor outcrop of Syrena Formation with a northeast–striking fault dipping south, in the northwest section of the map. Drill hole 1703, located in a northeast and northwest trending, highly faulted zone and close to Tgq, contains the thinnest enrichment. Drill hole 1699 also occurs in this area of blanket thinning but is in Tgq in a northeast–striking fault with 54° north dip. In the northeast section of study area, the Syrena Formation (Cs) also has thinning of the enrichment blanket, formed near skarn formation where carbonates are more prominant than shale and underlain by the Oswaldo Formation (Co). Skarn occurrences (primary mineralization) are not mapped for enrichment thickness or as part of the protore surface, as seen in Cross–Section B–B'. Metasomatic mineralization has been identified in the upper northeast section of the study area, from ratio characteristics and ore control drill hole core logs. Thinning of the enrichment blanket occurs in other areas of Cs outcrop, in the western margins of study area, extending into breccia and Kc. This outcrop of Kc occurs in one of the thinnest areas of the mapped blanket, and is in contact with a major northeast–striking fault (dipping south), breccia and a north–trending Tqm dike.



A B

FIGURE 20. Classification of heap leach materials by chalcocite ratios is illustrated in graphs A and B (see above discussion) (Chavez, 1987).

APPLICATION OF RATIO DATA BY MINE OPERATIONS

Study data have been applied to heap leach classification of ore–grade material at Mine X. Because study observations permit segregation of ores by mineralogy as well as by grade, ores may be distinguished by their salient physico–chemical characteristics, permitting copper leach efficiency and recovery to be determined by the geochemical composition of ore materials, rather than just by copper grade. This has resulted in faster copper recovery from ores with high chalcocite ratios.

Heap leaching is used to recover copper in moderate to high grade ores and low grade waste rock having copper mineralization that is amenable to acid leaching such as oxides, silicates, and certain sulfides. These sulfides exclude chalcopyrite and pyrite because these minerals are not attacked by acid ferric sulfate solutions. Because of the sensitivity of leaching to copper mineralogy, mineralogy is especially important in heap leaching schemes. Careful consideration of pH and oxidation potential is required to establish the conditions for solubilizing copper (Hiskey, 1986). The graphs in Figure 20 illustrate how supergene–to–hypogene ratios are used in relation to copper ore grades to determine whether to send ores to the mill, to the "fast" or "conventional" leach pad, or to the waste dump. Graph A is the original classification scheme, modified in graph B for better recovery of copper. The cutoff copper grades between mill ore/waste and leaching depend upon the economic factors of a mine and metallurgy of the copper sulfides. In Graph A, the chalcocite ratio boundary between fast and slow leach materials is dependent upon the same factors. In Graph B, the boundary between fast or slow leaching is determined by the formula grade=$\underline{0.2(\text{ratio})-0.086}$/ratio. This curved boundary enables a more economical recovery of copper at low grades with a slow leaching process. Even at high chalcocite ratio values, low copper grades are usually associated with a high pyrite content which would promote a more complete leaching of ore. This application of sulfide ratios provides mine operators with an efficient means of classifying mined materials using supergene mineral distribution and relative abundances.

DISCUSSION

The depth of enrichment of any weathering porphyry system depends upon the local hydrology, including such factors as the permeability of the various alteration zones, topographic relief, and rates of precipitation and infiltration. Other factors include the kinetics of secondary mineral precipitation, relative to the rate of ground water flow in the lower portion of the blanket zone. Changes in enrichment thickness locally may reflect lateral flux of copper during late stages of "supergene evolution" or represent a fundamental change of the physical and chemical properties of the rock type and/or wallrock alteration with depth in these areas (Alpers and Brimhall, 1988). Observed effects of specific wallrock characteristics on copper sulfide mineralogy zones are discussed in the following sections.

Observations described in results, deduced from contour characterization of the enrichment blanket coincident with geology, agree with the supergene morphology described in the literature on the Mine X porphyry copper system. The description from literature, which agrees with study results, is listed in the following and discussed in later sections. The secondary enriched orebody consists of three northwest trending zones of tens to 200 meters thick relatively high–grade ore (< 0.97% Cu) formed mostly in the phyllic alteration zones within and around the granodiorite porphyry stock and its potassic alteration (Gilmour, 1982). Appreciable amounts of chalcocite are present locally at greater depths. Besides these ore zones, the porphyry and its alteration zones also trend northwest as noted in the geologic map and contour maps. The following descriptions from the literature are also noted in the enrichment blanket thickness map. The most northeasterly orebody occurs in sediments, quartz diorite, and the granodiorite stock, generally as supergene chalcocite. Locally important skarn mineralization occur near the north end of this supergene zone.

The areally most extensive mineralization occurs in the center of the study area, in granodiorite porphyry; this mineralization extends northwest into sediments and quartz diorite. A smaller, northwest–trending orebody occurs southwest of the granodiorite stock in sediments and quartz diorite, consisting entirely of supergene–derived mineralization. Between these well–developed zones of supergene mineralization, enrichment occurs as a continuous but locally thin (~ <60 meters) and low grade ($\leq$0.2% Cu) blanket.

Alteration Effects on Supergene Enrichment

Phyllic alteration of the granodiorite stock (Tgq), Klp, Kep and Kc has the thickest enrichment, located near the contact with Tgb, especially west of the potassic altered granodiorite. The western contact between Tgq and Tgb appears to have promoted supergene enrichment processes to greater depths: away from this interface of potassic and phyllic alteration, enrichment thickness and grade decrease. Note that the thickest enrichment in the study area is adjacent to this contact, in the southern section of study area (Tgq nearly encircled by the Tgb). Phyllic altered Klp and Kc, east of the potassic zone, have equivalent enrichment thicknesses to those of phyllic altered areas west of the potassic alteration, but at higher elevations for top and bottom of the supergene enrichment blanket (see Figure 14). Drill holes located in Tgb, near its western contact with Tgq, also have relatively thick enrichment; probably due to overprinting of phyllic alteration on potassic alteration with argillization. In these zones of phyllic and mixed phyllic–potassic alteration, chalcopyrite is usually more abundant relative to pyrite in protore sulfides.

Chalcopyrite is most abundant in a zone approximately along the boundary between the potassic and phyllic alteration zones, and in a zone extending east–west through the central part of the granodiorite stock. It is noted that the areas of thickest enrichment are along the contact between alteration zones in areas of abundant hypogene mineralization (<0.4% wt cp). Pyrite comprising 4–8%–wt, is abundant in the phyllic zone. Chalcopyrite and pyrite are both volumetrically low in the north–central and south–central portions of the stock, with a "patch" of pyrite in the south central part of stock (Rose, 1970). This agrees with the Lowell and Guilbert (1970) porphyry copper model in which potassic alteration is known to have sub–ore grade copper associated with potassic alteration minerals.

The greater depths of secondary enrichment is attributed to advanced argillic and phyllic alteration assemblages having little or no capacity to neutralize supergene acids. The western contact has greater development of phyllic and argillic alteration than the east side, creating the trough within the "blanket." The quartz diorite sills

(Klp and Kep) are geochemically equivalent to the granodiorite stock and thus react the same under phyllic alteration. If Tgq is inferred to underlie Klp, Kep, and Kc at the southern section of the map, in contact with the potassic zone, then phyllic altered granodiorite and the quartz diorites contain overall the deepest and thickest section of the enrichment blanket. Potassic and propylitic alteration assemblages, however, have more reactive gangue minerals, such as feldspars, chlorite, and biotite, which inhibit iron transport by consumption of hydrogen ions through hydrolysis reactions. Thus, the geochemical, structural setting of the phyllic altered granodiorite and quartz diorites favor greater depth of supergene enrichment. This mechanism is likely responsible for the trough in the enrichment blanket.

Local areas of thinning of the blanket that do not appear structurally related, may be due to hydrologic effects, influenced reductions in permeability. Supergene alteration to, or production of kaolinite, alunite, and chalcocite toward the end stages of the leaching and enrichment process may reduce permeability to the extent that downward infilitration would be significantly reduced. This results in more lateral groundwater flux (Alpers and Brimhall, 1988). Another local effect of alteration on the "blanket" morphology is attributed to the feldspar–altered granodiorite (Tgf) which appears to promote shallow depths for both TDS and protore surfaces relative to surrounding values.

Structural Effects on Supergene Enrichment

Structural features that appear to have some control on mineralization are either regional or local to the Mine X porphyry copper system. The northwest trend defined by a trough of relatively thick and deeper depths of supergene enrichment is a structural characteristic of the Mine X district. The geometry of the granodiorite and its hydrothermal alteration phases are also structurally controlled by this northwest–striking fault structure.

Deepest TDS and top of protore surfaces appear related to both the alteration effects and to this northwest–striking regional structure which allows, under favorable geochemical conditions, extensive thickness of enrichment to form. This abrupt change in depth for the TDS surface may have been caused by other, unknown factors besides the paleo–water table, such as post–enrichment tilting to the south.

This trend is also noted in the literature in which high chalcopyrite zones occur near both of the stock contacts in elongate northwest directions. Pyrite also forms northwest–trending zones overlapping with the chalcopyrite zones along the outside margin of the stock.

Local thickening of the blanket at drill hole 1744, located in Kc at the south end of the study area, appears related to faults of northwest strike with 60° south dips. These faults can act as conduits for supergene fluids, promoting low elevations for TDS and protore surfaces.

A northwest trend of > 700 feet thickness occurs along the northwest trend of a Tgd dike which may indicate further extension of this fault structure in the southern direction.

The northeast–trending faults within the Mine X Geology Map are related to Laramide age regional tectonics of the southwestern United States. Some local thinning in the enrichment blanket is likely due to "open–system lateral flux" regions and usually occur as "sources" along trends of fracturing and faulting (for example, see Brimhall et al. 1985 for work at La Escondida, Chile). In the northwest section of the study area, a prominent northeast–striking fault system, defined by Tli dikes, produces a noticeable, local deepening of top of protore surface and thickening of the enrichment blanket. Just south of these Tli dikes, the northeast–striking fault with breccia and various dikes create a complex area in which the supergene blanket is very thin and the protore surface shallow. At drill holes 1703 and 1714, minor fault systems with overall northeast trends, and north approximately 60° dips, appear related to areas of thinning in the enrichment blanket and shallow top of protore surface.

All three drill holes in breccia units intercept thinning of the enrichment blanket, probably due to high permeablity for vertical and lateral movement of supergene fluids or to low pyrite content. Cuprite occurs as a minor constituent in the breccia matrix.

Wallrock Lithology Effects on Supergene Enrichment

In addition to structural controls, local effects on supergene enrichment morphology are due to certain lithologies which control the depths of TDS and protore surfaces, and "blanket" thickness. Limestone units of Co and Cs form skarn mineralization, and in some areas, thin and poorly–developed enrichment occurs in the Cs unit. Carbonaceous shales within Cs show weak supergene enrichment. Phyllic altered Klp in the northeast section of the study area produces a low protore surface, indicating a thickening of the enrichment blanket.

The three occurrences of shallow TDS depths and thickening of enrichment blanket, relative to adjacent values, occur near Tgd dikes which define northeast and northwest–trending fault systems. The Tgd dikes emplacement occurred as intramineral and postmineral, and may be apophyses of the granodiorite stock. Both Tgd and the surrounding Tgq are cut by quartz–alunite and quartz–sericite–pyrite veinlets. Tgd is bleached, with hornblende and biotite phenocrysts altered to illite and and andesine phenocrysts to a mixture of clay and sericite. The shallow TDS surface near these dikes may have resulted from their intrusion into the stock (Tgq) already altered to the sericite stage. A subsequent alteration of Tgd by deuteric action or later influx of acidic, metal–bearing fluid would then cause propylitization and mild argillization. The less phyillic altered Tgd would develop a more relatively shallower oxidation zone. The local thickening of enrichment near these dikes may have developed through the same structural controls used for emplacement of the Tgd.

CONCLUSION

This supergene mineralogic study defines quantitatively the mineralogic sulfide zones of the Mine X porphyry copper system within an area sampled by ore control drill holes. Application of study results has substantial importance in the assessment of those volumes of the porphyry copper system containing significant chalcocite enrichment and associated favorable recovery characteristics for heap leach methods. Futhermore, this research is a detailed case study of an enriched porphyry copper system in terms of the Lowell and Guilbert (1970) model.

Although the enriched chalcocite zone at Mine X formed in response to a gradually descending water table and redox front, certain aspects of hydrothermal alteration, lithology, and structural features of the host rock appear to have had a major influence on the thickness, extent, and depths of supergene enrichment. The following summarizes the results of applying ratio data in the form of contour maps to the geology of Mine X.

Map Results From the northern half perimeter of the study area, the supergene blanket becomes deeper and thicker towards the central and southern areas of the Mine X porphyry copper deposit. From the west and north margins, the enrichment blanket deepens and thickens gradually towards the center of the study area. This is as opposed to the sharp descent in elevation and sharp increase in blanket thickness from the east margin. Due to structure and lithology effects, this general trend is interrupted by local changes in the TDS and top of protore surfaces, and in the supergene blanket thickness. A northwest–trending trough of thickest, and lowest elevations of, supergene enrichment results. This trough of enrichment is parallel to, and west of, the general trend of the potassic altered granodiorite (Tgk and Tgb), and occurs in the phyllic alteration of predominantly Tgq with Kep, Klp, and Kc. The mapped thickness for phyllic alteration of Klp, east of the potassic alteration, has equivalent thickness to some areas of enrichment west of Tgb. However, this occurs at shallower depths and abruptly thins out away from the granodiorite stock.

Supergene Enrichment High chalcopyrite content and strong phyllic alteration of granodiorite appear to favor increased thickness of the enrichment zone. Factors, in order of importance, for developing the Mine X enrichment blanket are: (1.) structurally developed permeability (pre–copper mineralization), on which the degree of hydrothermal alteration depends, (2.) host rock mineralogy, (3.) paleo–topography (piezometric surface), including climatic desiccation, and (4.) primary mineralization characteristics. All of these factors control rates of sulfide oxidation and groundwater table descent, which in turn, determine overall efficiency of supergene leaching and enrichment processes.

Supergene enrichment at Mine X began after deep erosion of the granodiorite stock and surrounding lithologies, exposing the top of the protore. Approximately 2,000–3,000 feet of overlying rocks were eroded and during this process the protore became enriched to nearly its present extent. Oligocene volcanic rocks then blanketed the area and the water table became shallow, submerging the leached and enrichment zones. With the erosion of the volcanic rocks, the exposed porphyry system underwest further weathering and subsequent enrichment until the Pliocene(?). At this time, the deposit became buried by the Gila Conglomerate (of unknown thickness). With erosion over time, the Mine X deposit was again exposed to weathering and supergene processes. Part of the leached zone is known to have eroded away.

Overall, the morphology of the supergene enrichment blanket appears to be controlled by a major northwest fault system resticted to the Mine X district and the change from potassic (biotite–clay) altered to phyllic (quartz–sericite, +pyrite) altered granodiorite stock with its ranging chalcopyrite and pyrite content. Minor depth changes for the TDS and protore surfaces, and blanket thickness, are attributed to local major and minor fault systems of both northeast and northwest (the dominant system) trends; and to lithologies which prohibit or promote to some extent reactions for supergene processes.

RECOMMENDED FUTURE STUDIES

Recommended future studies should include isotope work on selected silicate minerals (light fractions) of the samples used in this research, creating isotope contour values for the same drill holes. Isotope contours correlated to the mineralization zones determined in this study, may determine a relationship between these two factors and help to define argillic alteration areas as supergene or hydrothermal. This relationship would establish a better understanding of the geochemistry at Mine X porphyry copper deposit and similar orebodies in the southwestern United States. Also recommended is a quantitative study similar to this work, but using instead total copper sulfides to total pyrite content ratios for all samples per drill hole as listed in Appendix A and B. A structural study of the northwest–trending fault system should be given some thought as it is local to the Mine X minerals district and appears to be a control in localizing sulfide mineralization and orienting intrusive emplacements. A quantitative study of the remaining leached capping/oxide zone would be of interest in determining if there is an overall lateral flux system related to this northwest structural system (Brimhall, et al. 1985).

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APPENDIX A

DRILL HOLE DATA

LEGEND

Formation	Age and Formation Name	Thickness (feet)	Description
Qal	Quaternary aluvium	variable	Unconsolidated sand, gravel, and clay.
Tli	Tertiary latite dikes	variable	Mostly porphyritic.
Tliq	Tertiary quartz latite dikes	variable	Mostly porphyritic
Tqm	Tertiary quartz monzonite porphyry	variable	Dikes of salic quartz monzonite porphyry. Phenocrysts of plagioclase, coarse orthoclase, biotite, and quartz in a fine to aphanitic groundmass of quartz and orthoclase.
Twb	Tertiary breccia	variable	Breccia consisting of angular fragments of stock rock, some quartzite, and schist, cemented with quartz, orthoclase, and magnetite.
Tgd	Tertiary granodiorite porphyry dikes	variable	Phenocrysts of plagioclase, thick biotite, horneblende, and sparse quartz in a groundmass of fine to aphanitic quartz and orthoclase.
Tgr	Tertiary granodiorite porphyry stocks	variable	Composition and texture very similar to above, except for lighter color.
Tgq	Tgr with quartz–sericite alteration		
Tgb	Tgr with clay–biotite alteration		
Tgf	Tgr with feldspar porphyry alteration		
Tgk	Tgr with quartz orthoclase alteration		
Klp	Late Cretaceous, late quartz diorite porphyry	variable	Phenocrysts of plagioclase and horneblende in a groundmass of quartz and othoclase, as sills and local dikes.
Kep	Late Cretaceous, early quartz diorite porphyry	variable	Phenocrysts of plagioclase, thin biotite, horneblende and quartz in a groundmass of fine quartz and feldspar.
Kc	Late Cretaceous Colorado Formation	0–1000	Upper 800 ft consists of tan, greenish–brown, and white sandstone interbedded with dark–green, brown, and black shale. Lower 225 ft is black limy shale except for 20 ft of quartzite about 80 ft above base

Formation	Age and Formation Name	Thickness (feet)	Description
			Thin beds of fossiliferous impure limestone conspicuous in lower part above the lower beds of black shale.
Kb	Late(?) Cretaceous Beartooth Quartzite Formation	66–140	Fine–grained quartzite containing thin black–shale partings locally. Conglomerate beds near top.
Ca	Lower Permian Abo Formation	0–265	Red shale, mudstone, and limy mudstone containing lenses of algal conglomerate locally.
Cs	Upper Pennsylvanian Syrena Formation	170–390	Impure limestone and ls interbedded with irregular lenses of red calcareous shale and with shale beds particularly in lower 140 ft.
Co	Upper and Middle Pennsylvanian Oswaldo Formation	330–420	Blue–gray limestone, fairly pure except in upper part, interbedded with thin shale beds: gray to red siliceous shale or grit about 20 ft thick at base.
Clv	Lower Mississippian Lake Valley Limestone Formation	300–400	Limestone, pure crinoidal and massive in upper part, argillaceous and thin bedded in central part. Much nodular chert throughout.

*LEGEND DERIVED FROM THREE DIFFERENT DESCRIPTIONS OF REGIONAL GEOLOGY OF THE MINE X AREA.

@See Legend, page 45, for description of geology. Except where indicated, lithology is derived from Geological Map of Mine X made in 1984.

*Indicates different lithology than on geologic map. See notes listed for drill hole and samples in Appendix B.

**Indicates exposed supergene surface at the drill hole collar, due to removal of overburden and ore by mining. TDS was determined by correlation with adjacent drill holes or from logs of older and adjacent ore control drill holes made prior to mining of the supergene surface. Drill holes, *in italics*, used to determine the missing data follow below the indicated supergene surface with the approximate (~) TDS elevation. Supergene "blanket" thickness determined by these drill holes are *in italics* also. The older ore control drill holes are not plotted on any maps herein.

^ Indicates skarn within or throughout sampled interval. See notes in Appendix B.

DRILL HOLE	@SURFACE GEOLOGY	SAMPLE NUMBERS	DEPTH INTERVAL	COORDINATES NORTH EAST ELEV.(ft)	TDS SURFACE ELEV. (ft)	PROTORE SURFACE ELEV. (ft)	SUPERGENE "BLANKET" THICKNESS
1500	*Kep	1605–1615	437–518.5	−1405.7, −1902.8, 6389.1	6238	5798	440
1501	Cs	1616–1629	465–573.7	−1208.6, −3097.3, 6363.3	6272	5915	357
1529	Tgq	3–7	545–625	−1410.5, −2512.1, 6442.0	6238	5776	462
1530	Cs–Tgq	1–2	570–590	−1395.1, −2891.2, 6420.2	6209	5884	325
1546	Twb	1630–1644	310–550	−1595.1, −3091.2, 6363.7	6260	6054	206
1548	*Cs	1650–1664	325–615.3	−1601.4, −3297.4, 6362.2	6237	5842	395
1559	*Tli	1645–1649	500–630	−1176.5, −892.0, 6127.9	6128	5700	428
1573	Cs	4 intervals	235–285	−1175.1, −3732.6, 6346.6	6281	5920	361
1579	Kep	1721–1733	470–690	−1796.9, −1900.7, 6385.9	6243	5844	399
1580	Kep	1734–1743	190–347	−1401.1, −3698.5, 6314.1	6281	5911	370
1591	Cs	1586–1600	248–600.5	−1202.1, −3507.0, 6372.4	6281	5920	361
1592	Kep	1601–1604	375–420	−1801.8, −2293.9, 6380.9	6247	5926	321
1596	*Kc	1208–1211	152–192	−3197.3, 4401.2, 6758.5	6744	6361	383
1597	*Kc	1212–1221	107–173	−3005.6, 4198.7, 6702.2	6702**	6220	*490*
					6710~ correlated		
1602	Twb	8–10	370–420	−1796.9, −2898.9, 6369.8	6240	5960	280
1603	Kep	11–15	374–425	−1801.1, −2497.3, 6375.1	6242	5925	317
1605	Kep	1222–1226	130–160	−2158.4, −3257.5, 6255.7	6219	5943	276
1606	Kep	16–19	330–400	−1798.0, −2102.4, 6380.6	6238	5844	394
1607	Kep	4 intervals	180–240	−2228.7, −2086.9, 6261.5	6237	5812	425
1609	Kc (Kep)	1227–1235	250–350	−2002.3, −3103.1, 6358.6	6205	6004	201
1613	Kc (Kep)	993–997	190–310	−2000.5, −3301.3, 6354.3	6240	6044	196
1618	Kc	980–992	240–420	−1797.4, −3501.6, 6360.4	6238	5994	244

DRILL HOLE	@SURFACE GEOLOGY	SAMPLE NUMBERS	DEPTH INTERVAL	COORDINATES NORTH EAST ELEV.(ft)	TDS SURFACE ELEV. (ft)	PROTORE SURFACE ELEV. (ft)	SUPERGENE "BLANKET" THICKNESS
1628	Cs	2 intervals	240–300	5.1, −3715.6, 6399.2	6334	6159	175
1632	*Kep	1236–1244	260–440	−1996.2, −2108.9, 6375.9	6221	5861	360
1651	Kc	1744–1750	60–190	−1434.9, −4078.9, 6281.2	6281	5967	*326*
1578				−1589.8, −4108.3, 6293.5	6293~		
1664	Twb	2 intervals	170–210	−599.9, −3899.3, 6401.2	6337	5984	353
1682	Twb	1751–1757	160–235	−317.1, 281.5, 6340.3	6340~	5984	356
1683	Cs	1758–1770	250–460^	−1336.5, 2047.4, 6100.4	6100**	6085	*225*
1847				−1209.2, 2302.0, 6146.0	6310		
1690	Cs	1771–1785	50–210^	−396.3, 1906.8, 6249.6	6250**	6075	*225*
					6300~ correlated		
1698	Tgq (Cs)	1579–1585	310–420	−1595.8, −699.3, 5950.3	5950**	5859	*161*
					6020~ correlated		
1699	Tgq	970–979	130–290	−1821.3, −882.9, 5952.9	5953**	5861	*139*
					6000~ correlated		
1703	Cs	1665–1674	108–560	−1353.4, −742.7, 6052.8	6053**	5918	135?
					unknown		
1706	Cs (Tgb)	960–969	280–520	−1600.4, −990.1, 6004.0	6004**	5764	*256*
					6020~ correlated		
1713	Cs (Kb)	826–835	180–342	−3303.4, −786.3, 5800.7	5801**	5596	*454*
1042				−3300.0, −815.0, 6253.3	6050~		
1714	Kep	76–77	310–330	−4887.9, 1000.7, 6230.5	6076	5826	250
1716	Kep	78#	790–800	−5315.0, 1023.5, 6402.8	6082~	unknown	----
1717	*Kep	98–99	810–840	−5696.2, 1013.3, 6480.7	5871	5361	510
1718	Kep	100–101	500–540	−5227.4, 1311.2, 6412.8	6222	5562	660
1719	Kc	79,102–103,124	32–301	−4615.4, 192.1, 5900.4	5900**	5663	*436*
1014				−4750.0, 193.0, ?	6099~		
1721	Kep	104#	590–600	−5622.0, 568.7, 6394.6	6088	5545	543
1722	Kep	1678–1687	320–421	−5705.1, 403.0, 6396.0	6101	5542	559
1724	Klp	105–106,125	260–440	−4045.2, −1086.4, 5907.8	5908**	5396	*584*
1080				−3905.0, −1028.0, 6262.8	5980~		
1725	Kep	4 intervals	320–630	−5482.4, 796.7, 6398.5	5948	5554	394
1728	Kep (klp)	351–358	520–593.5	−6132.5, 1219.3, 6519.1	6285	5653	632
1729	*Klp	107–108	465–510	−5925.8, 661.0, 6474.1	6069	5519	550

DRILL HOLE	@SURFACE GEOLOGY	SAMPLE NUMBERS	DEPTH INTERVAL	COORDINATES NORTH EAST ELEV.(ft)	TDS SURFACE ELEV. (ft)	PROTORE SURFACE ELEV. (ft)	SUPERGENE "BLANKET" THICKNESS
1731L	Tgq	40#	540−550	−792.6, −731.8, 6260.2	6260**	5830	*460*
					6290~ correlated		
1733	Kb (klp)	1786−1797	50−160	−593.3, 2089.0, 6174.7	6175**	6033	*285*
1696				−420.9, 2302.1, 6333.8	6318~		
1738	Cs	109−111, 126−127	290−400^	−1364.2, 2266.3, 6101.3	6101**	6079	*231*
					6310~ correlated		
1743	Cs	1798−1804	110−230	−789.9, 1891.9, 6138.5	skarn	skarn	−−−−
1744	*Kc	359−361	56−480	−6101.6, 1801.0, 6560.7	5791	5225	566
1745	*Tgq−Tgk	41#	370−380	−601.4, −747.0, 6310.2	6310~	6005	305
1747	Co	42, 128	110−330^	488.4, 1316.1, 6329.0	6329**	6189	*236*
					6425~ correlated		
1749	Kep	20−23	330−380	−1792.4, −1708.1, 6252.1	6212	5844	368
1752	Kep	24#	330−340	−1817.5, −1337.3, 6129.0	unknown	5683	*446*
1078				−2001.0, −1235.0, 6117.0	6068~		
1755	*Klp	112−114	520−554	−6304.8, 1601.8, 6559.2	6094	5639	455
1759	Kep	2 intervals	200−220	−5336.1, 1628.5, 6475.6	6280	5626	654
1760	Kep	362−370	86−255.5	−5116.9, 1488.5, 6417.3	6222	5550	672
1771	Kep	371−379	50−170	−3856.9, −2436.3, 6405.9	6316	5936	380
1772	*Tqm	380#	63−70	−4101.7, −2425.3, 6357.1	6297	5932	365
1779	Co	43#	230−240^	1605.4, 897.6, 6499.4	6499**	−−−	−−−
2056				1801.0, 696.0, 6512.0	unknown	6440 skarn	
1781	Tgb	115−118, 129−132	30−161.5	−2871.7, 2263.3, 6131.7	unknown	6132	*318*
					6450~ correlated		
1782	Tgq	381−387	30−105	−3499.0, −209.2, 5747.3	5747**	5545	*475*
1071				−3501.0, −178.0, 6034.6	6020~		
1783	Tli (Kb)	119#	126−130.6	2.3, 1935.2, 6327.7	unknown	unknown	−−−
1649				−85.9, 2075.1, 6339.0	6218~		
1784	Tgb (Kb)	120−123, 133−136	117−334	−1642.5, 2641.8, 6147.3	6147**	6047	*453*
911				−1595.0, 3002.0, ?	6500~		

DRILL HOLE	@SURFACE GEOLOGY	SAMPLE NUMBERS	DEPTH INTERVAL	COORDINATES NORTH EAST ELEV.(ft)	TDS SURFACE ELEV. (ft)	PROTORE SURFACE ELEV. (ft)	SUPERGENE "BLANKET" THICKNESS
1786	Tgf	388–397	20–101	–4263.6, 203.1, 5800.3	unknown	5800	*580*
832				–4300.0, 200.0, 6465.0	6380~		
1788	Kc	1675–1677	144–309.5	–1670.0, 3183.0, 6312.3	6312**	5977	*647*
939				–1600.0, 3188.0, ?	6624~		
1792	Tgq (Tgb)	25–28,137–139	34.5–165	–2684.0, 656.3, 5752.7	5753**	5602	*502*
800				–2748.0, 738.0, 6204.0	6104~		
1794	Kb	80, 140	58.4–245	–3539.0, –783.1, 5775.5	5776**	5564	212
					6030~ correlated		
1795	Tgb	81#	126–134	–2338.3, 3065.9, 6251.5	6252**	6072	*453*
914				–2200.0, 3050.0, ?	6525~		
1796	Tgb	44#	163–171	–401.0, 1699.9, 6154.6	6155**	6075	*205*
					6250~ correlated		
1797	*Co	45–48,141–144	161–351	600.8, 1143.1, 6300.7	6301**	6100 skarn	*325*
					6425~		
1798	Cs (Tgb)	49–51	94–169	5.3, 1490.6, 6165.1	unknown	6165	–––
1799	*Kc	82#	20–25	–2984.9, 4148.1, 6566.3	6566**	6220	346
975				–2998.0, 4000.0, ?			
1800	Kb	83–84, 145	34–164	–3898.8, –606.6, 5756.9	5757**	5554	*241*
1710				–3903.3, –390.9, 5791.2	5795~		
1801	Cs	1805–1815	127–222	–1000.0, 2099.6, 6146.8	skarn	skarn	–––
1802	Tgq	85#	303–313	–2696.8, –203.2, 5806.6	5807**	5442	*598*
1053				–2899.0, –617.0, 6227.7	6040~		
1810	Tgb	86–87	440–508	–1595.1, 1419.5, 5955.1	5955**	5375	625
					6000~		
1811	Co (Tgk)	52–53,146–148	147–318	797.8, 1057.4, 6323.5	6324**	6116	309
1884				841.3, 1332.7, 6447.7	6425~		
1814	Tgq	1688–1697	159–246	–2689.9, –391.8, 5806.1	5806**	5456	*574*
1053				–2899.0, –617.0, 6227.7	6030~ correlated		
1816	Tgb	88–90	125–186	–1826.5, 1001.4, 5951.6	5952**	5422	*648*
					6070~ correlated		
1817	Kc	1267#	187–193	–4415.9, –1476.1, 6191.6	6048	5629	419
1818	Tgq	951–959	191–332	–2390.1, 1500.6, 5859.6	5860**	5262	658
					5920~ correlated		

DRILL HOLE	@SURFACE GEOLOGY	SAMPLE NUMBERS	DEPTH INTERVAL	COORDINATES NORTH EAST ELEV.(ft)	TDS SURFACE ELEV. (ft)	PROTORE SURFACE ELEV. (ft)	SUPERGENE "BLANKET" THICKNESS
1822	Kep	937–950	110–373	−2207.7, −459.6, 5862.9	5863**	5528	*472*
					6000~ correlated		
1823	Klp	1698–1703	0–150	−978.7, 2890.1, 6401.9	6402**	5992	*475*
1321				−8905.0, 2970.0, ?	6467~		
1824	Kc	895–899	198–216	−1989.8, −2304.7, 6303.1	6221	5822	399
1826	Tgb	91#	286–296	−2002.1, 1510.7, 5905.0	5905**	5340	*660*
					6000~ correlated		
1827	Tgq	92–93	70–100	−1722.9, 802.5, 5956.2	5956**	5861	*409*
					6270~		
1829	Tgq	917–926	90–152	−2651.3, 1671.3, 5900.6	5901**	5010	*950*
					5960~		
1830	Tgq	998–1007	180–302	−2506.6, 1212.6, 5835.9	5836**	5349	*526*
1096				−2500.0, 1100.0, 5895.2	5875~		
1833	Kep	29#	88–93	−2202.5, −3282.8, 6303.3	6215	5840	375
1835	Tgq	927–936	38–157	−2701.9, 982.6, 5748.3	5748**	5408	*647*
802				−2620.0, 970.0, 6194.0	6055~		
1836	Kc	908–916	117–233	−2000.6, 3200.9, 6255.4	6255**	5970	*580*
907				−2000.0, 3200.0, ?	6550		
1837	Kc	900–907	0–94	−839.0 2306.0, 6184.4	6184**	5994	*324*
					6318~ correlated		
1838	Tgq (Tgd)	885–894	20–76	−3701.4, 387.9, 5748.3	5748**	5555	*765*
812				−3700.0, 400.0, 6460.0	6320~		
1841	Cs	1816–1827	106–299	−1190.0, 1908.9, 6008.5	unknown	6080	– – –
1842	Klp (Kc)	878–884	14–273	−1933.7, 3498.8, 6360.2	6360	6050	*605*
933				−2000.0, 3499.0, ?	6655~		
1843	Tgq	398#	105–110	−3502.1, 205.7, 5748.7	5749**	5513	377
1213				−3500.0, 199.0, 5895.0	5890~		
1846	Cs	1254–1261	395–603	−1984.0, 2293.0, 5981.6	5982**	5328	*674*
903				−1990.6, 2103.4, 6005.0	6002~		
1847	*Cs (Tgb)	1828–1839	83–204	−1209.2, 2302.0, 6146.0	6146**	6085	225
584				−1204.0, 2290.0, 6318.0	6310~		
1848	Tgb	866–877	10–103	−4099.8, 1302.9, 6112.1	6112**	5662	*695*
841				−4100.0, 1400.0, 6455.0	6357~		

DRILL HOLE	@SURFACE GEOLOGY	SAMPLE NUMBERS	DEPTH INTERVAL	COORDINATES NORTH EAST ELEV.(ft)	TDS SURFACE ELEV. (ft)	PROTORE SURFACE ELEV. (ft)	SUPERGENE "BLANKET" THICKNESS
1850	Tgb	856−865	56−194	−4301.7, 1302.0, 6153.0	6153**	5638	*742*
842				−4300.0, 1200.0, 6434.0	6380~		
1852	Tgb	847−855	78−181	−4801.0, 1805.0, 6425.2	6343	5700	643
1854	Tgb	836−846	0−75	−3898.0, 1923.6, 6259.3	6259**	5759	*561*
1872				−4104.1, 2127.7, 6406.8	6282~		
1860	*Kc	1315−1324	41−113	−5145.5, 68.1, 6091.1	6021	5646	375
1876	Tgb	3 intervals	29−58	−4081.3, 1694.9, 6217.7	6218**	5743	*609*
1879				−4298.9, 1905.5, 6356.2	6352~		
1882	Tgb	1325−1332	28−94	−3887.8, 1492.4, 6117.8	6118**	5655	*695*
					6350~ correlated		
1885	Kep (Tgq)	1840−1858	26−248	−5085.1, 1211.1, 6382.1	6164	5497	667
1887	Kep	1859−1868	191−576	−5085.3, 588.3, 6176.4	5948	5563	385
1888	Kep (Tgd)	1547−1550	620−675	−5278.3, 781.1, 6305.6	6126	5516	610
1889	Ca (Tgq)	1551−1565	32−301	−4499.9, 399.5, 5904.6	5905	5530	*660*
					6190~ correlated		
1890	Tgq	1277−1285	0−64	−4518.8, 806.2, 6045.3	6045**	5565	*629*
1001				−4304.0, 800.0, 6219.2	6194~		
1891	Tgq	1286−1293	10−59	−4708.2, 991.6, 6162.5	6163**	5572	*613*
					6185~ correlated		
1892	*Kc	1262−1266	42−128	−1605.7, 4003.5, 6642.2	6532	6302	230
1897	*Kc	1268−1276	80−117	−2611.9, 4329.1, 6721.3	6671	6335	336
1908	Co	94#	623−628	−799.0, −1998.2, 6259.9	unknown	unknown	156?
1279				−793.7, −1898.1, 6393.1	6288~	6132~	
1910	*Kep	1314#	130−134	−5007.4, −1901.1, 6382.8	6297	5943	354
1912	Tgk	1304−1313	96−184	−1121.0, 502.4, 6104.8	6105**	5739	*522*
1238				−1063.8, 400.0, 6291.2	6261~		
1921	Tgb	399#	161−166	−5701.9, 1804.2, 6505.4	6369	5715	654
1930	Tgb	1566−1578	131−574	−5893.9, 1784.8, 6513.7	6368	5709	659
1937	Tgr	39#	571−561	−6098.0, 2596.0, 6627.0	6448	6215	233
1945	Tgb	1704−1705	185−195	−5490.0, 1942.0, 6502.0	6368	5648	720
1947	Kep	1299−1303	184−216	−5682.0, 207.0, 6313.0	6138	5548	590
1954	*Tgq	1294−1298	113−148	−2470.0, 1933.0, 5907.0	5907**	5010	*940*
					5950~ correlated		

DRILL HOLE	@SURFACE GEOLOGY	SAMPLE NUMBERS	DEPTH INTERVAL	COORDINATES NORTH EAST ELEV.(ft)	TDS SURFACE ELEV. (ft)	PROTORE SURFACE ELEV. (ft)	SUPERGENE "BLANKET" THICKNESS
1955	Kep	1711–1717	66–139	–3294.0, –2256.0, 6238.0	unknown	*415*	
1055				–3295.0, –1900.0, 6367.1	6180~		
1958	Tgb	95–96,315–320	100–155	–2997.0, 3026.0, 6402.0	unknown	6100	*296*
973				–3014.0, 3300.0, 6546.9	6396~		
1961	Tgb	819–825	65–113	–3276.0, 2602.0, 6346.0	6346**	6106	*290*
1856				–3496.3, 2800.5, 6460.5	6396~		
1962	Kep	97, 321–328	147–342	–2790.0 –1886.0, 6192.0	6192**	5702	*448*
1037				–2700.0, –1700.0, 6234.2	6150~		
1965	Tgb	808–818	122–296	–2432.0, 2297.0, 6034.0	6034**	6000	*350*
					6350~ correlated		
1969	Tgb	801–807	26–66	–2397.0, 2694.0, 6062.0	––––	6062	*388*
					6450~ correlated		
1972	Cs(Tgq)	30,149–150 329–343	146–250 150–269	–2006.0, –526.0, 5867.0	5867**	5676	*264*
1218				–1998.0, –788.0, 5948.4	5940~		
1980	Kc	32#	86–96	–1780.0, –3892.0, 6276.0	unknown	5967	*283*
1657				–1594.4, –3708.0, 6287.6	6250~		
1981	Twb	34,344	56–88	–153.0, –4235.0, 6294.0	6294**	6009	*311*
1608				1.2, –4300.1, 6349.8	6320~		
1983	Cs	35–36	998–1046	–1010.0, –3390.0, 6308.0	unknown	unknown	*216*
1631				–999.0, –3394.2, 6424.9	6316~	6100~	
1984	Tli	38, 345–350	67–150	–1748.0, –4096.0, 6276.0	6276**	5931	*362*
1578				–1589.8, –4108.3, 6293.5	6293~		
1996	*Kc	1245–1253	92–167	–3182.0, 4787.0, 6795.0	6730	6598	132
2006	Klp	1869–1874	85–155	–601.0, 2722.0, 6502.0	6477	5999	478
2008	*Kc	1875–1888	129–357	–2403.0, 4166.0, 6703.0	6663	6363	300
2026	*Kb	400#	250–255	–3332.0, –1106.0, 5713.0	5713**	5463	*579*
1035				–3299.0, –1115.0, 6266.8	6042~		

APPENDIX B

SAMPLE INTERVAL DATA

EXPLANATION

Cp, cpy	chalcopyrite
Cc	chalcocite
Bn	bornite
Dg	digenite
Id	idiate
Mb	molybdenite
Py	pyrite
Mt, mgt	magnetite
Hm	hematite
Lm	limonite
Sh	shale
Ls	limestone
#	sample number out of sequence
%	ratios calculated from weight percentage instead of line counts
*	notes a mixture of observations and core log notes.
<u>Log notes</u>	descriptions from core logs put in notes for each drill hole if available

			LINE COUNTS *with Bn*			PROPORTIONS	*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	(Cc+Dg+Cv) / Cp	(Cc+Dg) / Cv	NOTES*
1530	1	570–580	73.5	7	trace	<1:10	----	Low total sulfides, Trace bn.
	2	580–590	57	trace	0	<1:50	----	Low total sulfides. No significant dg, cc or cv observed. Py–cpy inter–growths in some grains.
1529	3	545–555	1.25	2	3	4:1	----	Low total sulfides. (Cc+Dg +Cv)/ Cp ratio very approx–mate due to low total ore sulfides, but probably >3:1. Significant molybdenite (7.5).
	4	555–570	13.25	13.25	4.50	1.4:1	3:1	Traces of magnetite, molybd. Abundant rutile/leucoxene.
	5	585–595	4.5	0.50	2.50	1: 1.3	----	Low total sulfides. Ratio approximate due to low total sulfides. Minor molybdenite.
	6	605–615	6.50	8.5	4.5	2:1	2:1	Only moderate total sulfides Significant mb (2.5). Most cpy rimmed by dg–cv. Minor cpy encapsulated in py. Tr idiate.
	7	615–625	42.50	15	8.50	1:2	2:1	Minor rutile/leucoxene.
1602	8	370–380	41	2	8	1:4	1:4	Abundant rutile/leucoxene. Minor magnetite.
	9	400–410	42.50	15	2	1:2.5	8:1	Abundant rutile/leucoxene. Minor magnetite.
	10	410–420	35.5	2.5	1.5	1: 8.4	1.7 :1	Traces of rutile/leucoxene.
1603	11	374–385	65.5	6.5	0	<1:10	----	Some cpy encapsulated

DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	LINE COUNTS			PROPORTIONS		NOTES*
			Cp	*with Bn* Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	*without Bn* $\frac{(Cc+Dg)}{Cv}$	
								within pyrite.
	12	385–395	78	1	1	<1:30	1:1	Traces of rutile/leucoxene.
	13	395–405	76	4	0.50	<1:10	8:1	Traces of idaite (Cu_3FeS_4).
	14	405–415	95.5	7	3.5	1:10	2:1	Traces of idaite.
	15	415–425	32.5	63	trace	2:1	high	Traces molybdenite, magnetite and rutile/leucoxe.
1606	16	330–340	3	57.5	12	>20:1	5:1	Abundant rutile/leucoxene.
	17	340–350	2.5	108	1	>30:1	----	Essentially all cpy is encapsulated within pyrite.
	18	350–360	3	64.5	27.5	>30:1	2:1	Much cpy encapsulated within pyrite.
	19	390–400	0	22	0	high	----	No cpy noted; covellite scarce; less ore sulfides vs. total pyrite.
1749	20	330–340	0.50	17	13.5	>30:1	1:1	Low total ore sulfides vs. total pyrite.
	21	351.1–360	1.50	22	6	>10:1	4:1	Traces of cpy; ratio probably greater (>20:1).
	22	360–370	trace	20	5	>20:1	4:1	Only traces of cpy, all encapsulated within pyrite.
	23	370–380	trace	24	5	>30:1	4:1	Only traces of cpy, all encapsulated within pyrite.
								Less cpy, more cc+dg+cv than in previous sample.
1752	24	330–340	2.50	18.5	0	>7:1	----	Dg replaced by cc. Moderate total sulfides.

			LINE COUNTS			PROPORTIONS		NOTES*
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	
1792	25	34.5–39	1	105	36	>>40:1	3:1	very low total py; ore >>py. Minor but significant mb (2.5) Traces of idaite.
	26	67–75.5	37.5	2	7	1:4	1:3	Low total sulfides, low py. Cp generally "clean", some repl. by cv. Minir mb (1).
	27	80–85	0	0	11.5	high	low	Very low total ore sulfides; mod. total sulfides (py). No mb. Traces bn, cp locked in py
	28	93.5–99	0.25	1.5	trace	6:1	––––	Ratio actually >1. Low total sulfides;very lo ore sulfides, making ratio statistic poor.
#	137	115.5–119.5	22.5	50	182.5	11:1	1: 3.5	Abun. sulfides. Cc, dg, and cv replace cv.
#	138	125–133	28.50	13 dg+ dg–id	33.50	1.6 :1	1: 2.6	Low total sulfides; abundant lath–like mineral (trem–olite?) Essentially all cp replaced in part by cv; i replaces cp, occurs w/dg. Hypogene replacement.
#	139	151.5–165	23.50	2.5 cc 0.5 bn	0	1:7	––––	Lo total sulfides; mod. mgt replaced by hm.
1833	29	88–93	0	0	5	high	low	Very low total ore sulfides; only traces of cp; Mod to low total sulfides, as pyrite.
1972	30	146–150	147.5	1	trace	v. low	––––	Very low "enrichment" ore

			LINE COUNTS *with Bn*			PROPORTIONS		
							without Bn	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
								minerals & very hi cp; Very hi mo (10.5). Mod.–hi total sulf.
#	329	150–156	89%	9.6%	0.8%	1: 8.5	12:1	Major amount cp liberated. Minor amount cp attached to py. Cc, bn, cv rimming cp. Mo ++.
#	330	156–163	62.8%	37.2%	trace	1: 1.7	----	Cp liberated. Cc, cv, bn liberated. Mo++.
#	331	163–170	86.7%	12.6%	0.7%	1: 6.5	18:1	Majority cp liberated. Bn,cc, cv liberated. Mo++
#	332	170–175	80.5%	19.5%	0%	1:4	----	Similar 331. Mo++.
#	333	180–186	56.8%	27.2%	16%	1: 1.3	1.7 :1	Majority cp, cc, bn liberated. Mo++.
#	334	186–190	58.3%	40.2%	1.5%	1: 1.4	27:1	Similar to 333. Mo++.
#	335	190–195	94.9%	4.3%	0.8%	1: 18.6	5.4 :1	Cp, cc, bn, cv liberated.Mo+
#	336	202–208	97%	2.3%	0.7%	1:32	3.3 :1	Cp,bn,cc,cv liberated. Mo+
#								
#	149	208–214	19.50	0	0	v. low	----	Low to mod. total sulfides. Mod. moly (3 units).
#								
#	337	214–220	98.7%	0.7%	0.6%	1:76	1.2 :1	(Est.)90% cp liberated. 10% cp attachments or inclusions in pyrite.
#	338	231–236	98%	2%	trace	1:49	----	Similar to 337. Mo++.
#	339	236–241	91.9%	7.2%	0.9%	1:11	8:1	Similar to 337. Mo++.
#	340	241–246	97.4%	1.8%	0.8%	1:37	2.3 :1	Similar to 337. Mo++.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	(Cc+Dg+Cv) / Cp	(Cc+Dg) / Cv	NOTES*
#								
#	150	246–250	14	0	0	v. low	----	Moderately abun. sulfides; minor magnetite.
#								
#	341	250–255	98.8%	1.2%	0%	1:82	----	Similar to 337. Mo++.
#	342	255–263	95.7%	2.6%	1.7%	1:22	1.5 :1	Similar to 337. Mo++.
#	343	263–269	97.5%	2.5%	0%	1:39	----	Similar to 337. Mo ++.
1980	32	86–96	1	0.5	0	1:2	----	Mod. to lo total sulfides. Very lo total ore sulfides. Dg–cc in fractures within pyrite.
#1981	344	56–64	9%	83%	8%	10:1	10.4 :1	Cc, cp, cv liberated. Dg, Cv replacing cp.
	34	80–88	1.5	46.5	13	>40:1	4:1	Low total sulfides; minor bn. Cv replaces cp, dg–cc. Tr mb.
1983	35	998–1022	20	0	0	v. low	----	Low to mod. total sulfides; low total ore sulfides. No mb.
	36	1038–1046	13	0	0	v. low	----	Low to mod. total sulfides; low total ore sulfides. No mb.
#1984	345	67–76	1.8%	97.4%	0.8%	54:1	122:1 high	Majority Cc, cp, cv liberated. Cc rims and veins in–on py.
#	346	76–94	1.5%	97.7%	0.8%	66:1	122:1 high	Cc, cv, cp liberated. Trace amount cc rimming py.
#	347	94–102	2.6%	96.8%	0.6%	37:1	161:1 high	10% cc liberated. 90% rims and veins in pyrite.
	38	102–117	3	12.5	3.5	>5:1	4:1	Mod. total sulfides; low ore sulfides. Dg repl. (?) pyrite.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{\underline{(Cc+Dg+Cv)}}{Cp}$	$\frac{\underline{(Cc+Dg)}}{Cv}$	NOTES*
#	348	117–125	3.4%	95.6%	1%	28:1	95.6 :1	Majority cc, cp, cv liberated.
#	349	125–132						Insufficient sample for analy.
#	350	140–150	0%	98.8%	1.2%	high	82:1	70%Cu constituents liberated 30%cc, bn rims & veins in–on pyrite.
1937	39	561–571	29	0	0	v. low	––––	Lo total sulfides; very lo ore sulfides. Traces cv.
1731	40	540–550	22	2.5	0	<1:9	––––	Very low sulfide content; very hi mgt content. Very lo py content (mgt >>py), No cv, mb observed.
1745	41	370–380	88.5	0	1	<1:40	low	Low to mod. total sulfides. Cp "clean"; No dg–cc obs. Tr mb. Log notes: Tgr. Altered (stage II)granodiorite V. broken & jointed. Minor py & rarely cpy on fractures. Becomes fresher w/depth.
1747	42	110–120	45	11	0	1:4	––––	Moderate total sulfides; mod. to lo Fe–ox. (hm repl. mgt) Traces bn; no mb observed.
#	128	320–330	182	8 5.5 bn	0	<1:13	––––	Moderately abun. sulfides; mod. abun. Fe–oxides as mgt, hm (mgt altering to hm); some cp, py encap. in mgt. Bn+ dg+cc+cp assemblages

DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	LINE COUNTS			PROPORTIONS		NOTES*
			Cp	*with Bn* Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	*without Bn* $\frac{(Cc+Dg)}{Cv}$	
								noted.Ore:py relatively hi 1:4
1779	43	230–240	20	0?	trace	v. low	––––	Abundant unidentified mineral (sulfide? Ag phase?). (Appar. not a Cu phase) Pyrrhotite? 2 grains. Traces only of cv, id (id). ??
1796	44	163–171	16.25	0?	trace	v. low	––––	Very low sulfide content; py:cp – 1:2 (!). Tr cv repl. cp. No signif. dg–cc–cv.
1797	45	161–168	25.50	1	0	<1:20	––––	Very low total sulfides & Fe–oxides; abundant Ti(?)oxides. Traces only bn, dg; minor mgt.
	46	208–212	165	tr id?,bn	0	v. low	––––	No cv, dg–cc observed; traces only of bn (id?). total sulfides abundant. Relatively lo ratio py:cpy (2–3: 1).
	48	257–265	28	0	0	very low	––––	No dg–cc–cv obv. Trace mgt.
#	141	287–297	249	0	0	very low	––––	Abun. sulfides; relatively hi cp:py (about 1:2–3); very signif. moly (19 units).
#	142	305–308	84.50	0	trace	v. low	––––	Abun. sulfides; minor moly (1.50 units).
#	143	323–327	62	tr bn	0	v. low	––––	Moderately abun. sulfides; very signif. moly (10.5 units)
#	144	348–351	148	tr bn	0	v. low	––––	Moderately abun. sulfides; v. signif. moly (9 units).

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
1798	49	94−99	101.5	8.5	0	1:12	−−−−	Dg−cc rims cp when it occurs Minor cp locked in py. No cv, mb observed.
	50	159−164	52	3(bn)	0	<1:15	−−−−	Low total sulfides; low pyrite. Traces only dg−cc; no cv. Minor but significant mb (3).
	51	164−169	16.5	2dg 0.5 bn−id	0	<1:7	−−−−	Very low total sulfides, very low py. Cp "clean"; no cv.
1811	52	147−152	28	trace	trace	very low	−−−−	Very low total sulfides and ore sulfides; py:cp ≤ 2:1. Traces only dg−cc, cv. Minor mb.
	53	184−188	34	12	0	1: 2.8	−−−−	Very low total sulfides, very low py. No cv, mb obs. Mgt moderately abundant.
#	146	214−218	33.50	0.5 bn	0	<1:20	−−−−	Low total sulfides; very lo py. Moderately abun. oxides (mgt≥py). No mb observed.
#	147	236−241	20	1 bn−dg	0	<1:10	−−−−	Low total sulfides; low py. Abun. mgt (mgt >py).
#	148	314−318	65	trace	0	v. low	−−−−	Low total sulfides (but more than 146, 147); relatively high cp:py (1:2−3). Trace molyb.
******* missing 54−75 could be unnumbered drill hole samples below								
1573		235−240	11	3.5 cc	0	1:3	−−−−	Low total and low ore sulfides Ratio mgt:py about 1:3 (high magnetite).

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	(Cc+Dg+Cv) / Cp	(Cc+Dg) / Cv	NOTES*
		260−265	6	3 cc	0	1:2	----	Low total and ore sulfides. Mt:py about 1:2 (!).
		275−280	6.50	1	0	1:6	----	Very low total sulfides. Ratio has low confidence due to low total ore minerals (low grade) Mt:yp about 1:2 (!). Cpy assoc w/mgt, early py.
		280−285	8.5	3.5	trace	1: 2.5	----	Low ore & total sulfides. Tr idaite, cv. Minor mgt, hm. Ratio Approx. due to low total ore sulfides.
1664		170−180	30	10.5	2	1: 2.5	5:1	Low to moderate total pyrite. Moderate magnetite. Cc & dg replace cpy.
		200−210	16	5.5	1	1: 2.5	5:1	Low total sulfides, low total py. Abundant magnetite.
1628		240−250	6.5	1.5	trace	1:4	----	Very low total sulfides. Tr to minor mgt, some of which replaced by hm. Sulfides in this sample very fine grained.
		290−300	129	4	0	<1:30	----	1 grain only of dg−cc noted so ratio may be <<1:30. Moderate total sulfides. Relatively hi cp:py=1:3 to 1:5
1607		180−190	2	78	13.5	>35:1	6:1	Cp repl. by dg−cc. Signif. mb
		190−200	22	14.5	37.5	2.3 :1	1: 2.5	Minor cp locked in py;minor

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	**SAMPLE NUMBER**	**INTERVAL SAMPLED**	**Cp**	**Cc+Dg+Id**	**Cv**	**(Cc+Dg+Cv) / Cp**	**(Cc+Dg) / Cv**	**NOTES***
								molyb.
1725		210−220	31	6+9id	15	1:1	1:1	Minor mb; signig. id(?). Most cp "clean" (no cv); most cv "clean" (no cp).
		230−240	0.25	32.50	3	>40:1	10:1	Abun. py, low total ore sulfide
		320−330	5	0	0	low	−−−−	Cp:py ratio about 1:6.Biotite? Imp. native Au (3 grains). Abun. mgt, hm (may explain why Au is present in samples!)
		440−450	0	1 grain	0	high	−−−−	Low total sulfides, abun. Fe oxides (but less so than above sample). Imp. native Au (3 grains=0.25). Hm repl. mgt.
		490−500	1	52.5	0	>>30:1	−−−−	Moderately abun. Fe−oxides, less than above sample. Very low py; (cc+dg)/py about 1: 4.5 (!). Imp. native Au (about 0.5 units).
		620−630	0	28	0	high	−−−−	Low to moderate total sulfids, total py. Very low Fe−oxides. No cp, cv. No mb, Au obs. (Does this imply that the Au is genetically associated w/the Fe−oxide zone? Quite poss. (see Mann, 1984, Econ. Geol. V. 79, p. 38)).

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	NOTES*
1759		200–210	0.50	5	0	>5:1	----	Very low total sulfides; low total Fe–oxides (hm); Ratio approx. due to lo total sulfides
		217–220	1	8	0	>5:1	----	Very low total sulfides; abund. mgt; hm repl. mgt. Dg repl. cp
1876		29–37	5.5	43.5dg+ 42bn	1.5	>8:1 (w/dg) >15:1 (dg+bn)	>>20:1	Relatively hi ore:py ratio. Signif. (hypogene?) bn & little cv. Minor Fe–oxides.
		49–53	2.5	20	5.5	>10:1	4:1	Traces of bn (id?); Cp repl. by cv, dg–cc.
		53–58	9.25	23	2.5	2.8 :1	10:1	Mod. abund. Fe–oxides. No mb obs. Traces bn, cv.
*******above drill holes probably missing interval of 54–75								
1714	76	310–320	trace	10	0	hi ratio	----	Very low total sulfides; low total ore sulfides; mod. Fe–oxides. Trace molyb.
	77	320–330	1.50	10.50	0	7:1	----	Low total sulfides. Tr mb, Cu°
1716	78	790–800	2	88.5+ 10 bn	1	>30:1	high	Moderate total sulfides; high ore:py ratio (about 1:2–3). Minor mgt. Hypogene (?) bn.
1719	79	32–40	4.50	36.5	23.5	>10:1	1.5 :1	Moderate to hi total sulfides. Most cv assoc. c/dg–cc (little w/cp). Significant mb (4.50).
#	102	110–120	16	4 0.5 bn	trace	1: 3.6	----	Lo total sulfides; py:ore ratio relatively low. Minor molyb.
#	103	150–160	32	68(w/cv)	4	2.3 :1	15:1	Abundant sulfides; minor cp

			LINE COUNTS			PROPORTIONS		
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	*with Bn* Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	*without Bn* $\frac{(Cc+Dg)}{Cv}$	**NOTES***
				2 bn				encap. in py. Most cp rimmed by cc–dg;association cc–dg–cv. Signif. moly: 6.5 units
#								
#	124	290–301	42	2 cc trace bn	0	<1:14	----	Moderately abun. sulfides.
1794	80	58.4–62	0	29	trace	high	----	Mod. total sulfides; lo to mod. total ore sulfides. Minor mb (1.50).
#	140	235–245	10	trace	0	v. low	----	Very low total sulfides; ratio less than 1:10, but due to lack of sulfides say very low.
1795	81	126–134	0.50	13	3.50	>7:1	4:1	Lo total sulfides; lo total ore sulfides.Some cp encapsulated in pyrite (minor).
1799	82	20–25	1	39.50	0	>20:1	----	Very low total sulfides. Cc replaces digenite. Minor mb (2). No cv observed. Kc: shales & lime shales. Lots cc. Lm staining on fractures locally. Cc w/py on fractures locally. Shale relatively unaltered.
1800	83	34–39	0.50	10.50	0	>6:1	----	Lo to mod. total sulfides; very lo total ore sulfides. No cv, bn, mb, observed.
	84	70–79	3.50	52+	0	15:1	----	Lo total sulfides. Significant

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
#	145	155–164	42.5	1 bn 2.5 dg 19.5bn–id	trace	1:2	----	mb (4.5). No cv observed. Moderately abun. sulfides; Most cp isolated grains or assoc. w/bn–id.Minor mb (2).
1802	85	303–313	0	37+ 3 bn	0.50	high	74:1	Very lo total sulfides; bn repl. by cv, dg–cc. Trace mb (0.50).
1810	86	445–456	1	54	0	>25:1	----	Low total sulfides; very low py (ratio ore:py>>1). Abun. Fe–oxides. Trace mb.
	87	498–508	1	20.50	0	>10:1	----	Very low total sulfides; very lo pyrite. Large grain Cu*.
1816	88	125–130	12	27.50+ 0.50 bn	0	2.3 :1	----	Very lo total sulfides; lo ore sulfides. Ratio ore:py about 1:3–4. Significant mb (2.5).
	89	147–152	1	96.5	0	>40:1	----	Lo total sulfides; very low py. Ore:py >>1. Trace mb.
	90	178–186	0	46	0	>40:1	----	Very lo total sulfides; very abund. Fe–oxides as hm. Very lo py; Cc:py about 3:1. No cv, mb, cp observed.
1826	91	286–296	0	16w/tr bn	0	v. high	----	Very lo total sulfides. No cv, mb, cp obs. Traces of (hypoge) bn repl. by dg.
1827	92	70–73	2	6.50+ 16 bn	11.50	(w/o bn) 9:1 (w/bn) 17:1	1:2	Very lo total sulfides; very low pyrite. Abundant argillized feldspar (relics). Ore:py about

			LINE COUNTS with Bn			PROPORTIONS	without Bn	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	NOTES*
	93	95–100	95	tr bn	trace	v. low	----	1:1. Trace molybdenum. Mod. to hi total sulfides; abun. py. Abundant argillized feldspar (relics).
1908	94	623–628	11	0 tr bn	0	low	----	Mod. to lo total sulfides;very lo total ore sulfides as cp. Trace molybdenum.
1958	95	100–104	0	24	trace	v. high	----	Mod. total sulfides; hi py. Low total ore sulfides.
#	315	109–119	0	99%	1%	high	100:1	(H.M.Est.)90%py. 5%gangue 3% cc liberated. 2% cc veins, rims & attachments to py.
	96	119–124	0.50	5	2	>3:1	----	Mod to lo total sulfides; very low total ore sulfides
#	316	124–130	1.2%	97.8%	1%	82:1	97.8 :1	Similar to #315.
#	317	130–135	0.4%	99.1%	0.5%	99:1	199:1 high	40% cc liberated. 60% cc rims & veins in–on py. Cp inclusion in pyrite.
#	318	135–141	0.6%	99.4%	0%	99:1	----	Similar to #317.
#	319	141–150	0.7%	95.3%	4%	99:1	24:1	80% cc liberated. 20% cc, bn rims veins on pyrite.
#	320	150–155	2.1%	61.9%	36%	47:1	1.7 :1	90% cc liberated. Cp precipitating to cv.
1962	97	147–151	0.50	58.50	trace	>25:1	----	Mod. total sulfides; cp occurs only as minute grains encapsulated within py.Mnor mb(1)

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
#	321	156–160	1.7%	98.3%	0%	58:1	----	40% cc liberated. 60% rims & veins in–on py. Cp inclusions in pyrite. Moly.
#	322	160–166	3.6%	96.4%	0%	27:1	----	(H.M.Est.) 90% py. 5% gangue. 4% cc liberated. 1% cc attachments, veins, rims.
#	323	166–171	1%	97.4%	1.6%	99:1	61:1	Similar to #322. Moly.
#	324	304–307	0.4%	89%	10.6%	99:1	8.4 :1	Similar to #322. Cc, cv liberated. Mo +.
#	325	307–312	0.6%	85%	14.4%	99:1	6:1	(H.M.Est.) 85% py. 10% gangue. 4% cc, Cv liberated 1% attachments, veins, rims. Moly.
#	326	328–333	1.5%	95.9%	2.6%	66:1	37:1	Similar to 325. Cp inclusions in pyrite.
#	327	333–337	4%	96%	0%	24:1	----	(H.M.Est.)90% py. 5% gangue.4%cc, bn,cp liberated 1% cc, bn, cp, attachments, rims, inclusions on py. Moly.
#	328	337–342	2.4%	87.6%	10%	40:1	8.8 :1	Similar to 327 w/cv.
1717	98	810–820	trace	23.5 dg 4.50 bn	2.50	>>30:1	>8:1	Low total sulfides; low pyrite content. <u>Log notes</u>: Silicified &/or baked shales & quartzite w/minor py on fractures. Rare some cc & mb. Later w/some quartite & late qtz diorite

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	NOTES*
								stringers.Cc content lessons.
	99	830–840	2.50	23 dg 12.5 bn	0	>10:1	----	Low total ore sulfides; mod. pyrite content. Same log note
171	100	500–510	0	6.50	0	high	----	Very lo sulfide content; very lo total ore sulfide content. Minor molybd. (0.50) unit.
	101	530–540	0.50	25.5	0	>15:1	----	Lo total sulfides; very lo total ore sulfides. Cc>>Dg,
1721	104	590–600	trace	4.5 1.25 bn	0	high	----	Lo total sulfides; very lo ore sulfides; by assoc. w/dg–cc.
1724	105	260–270	0	6.50	0	high	----	Low total sulfides; very low total ore sulfides
	106	360–370	0	1.50	0	high ??	----	Moderately abund. sulfides; low total ore sulfides.
#	125	430–440	0	5	0	>5:1	----	Low to mod. total sulfides. All Cu as chalcocite.
1729	107	465–470	0.50	11	0	>8:1	----	Abun. py; minor ore sulfides. All cp encap. within py. Traces of pyrrhotite+cp within py(!). <u>Log notes</u>: Klp. Stage III. alt. Py disseminated&on fractures Cc as coatings on py. Cc content lessens below 621 ft. Bright py common.
	108	500–510	trace	3.50	0	high? <<12:1	----	Moderately abund. py; very lo ore sulfides. Same log notes.

DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	LINE COUNTS with Bn Cp	LINE COUNTS with Bn Cc+Dg+Id	LINE COUNTS with Bn Cv	PROPORTIONS (Cc+Dg+Cv) / Cp	PROPORTIONS without Bn (Cc+Dg) / Cv	NOTES*
1738	109	290–300	13.25	tr–0.25 tr bn	0	1:7	----	All sampled intervals in skarn. Lo total sulfides; mod. hm & mgt; minor cp encap within py
	110	320–330	5.50	6	0	1:1	----	Lo to mod total sulfides; mod. Fe–oxides; lo ore sulf. content.
	111	360–370	40	1	0	>1:20	----	Moderately abun. sulfides; abundant Ti–oxides(?).
#	126	380.4–390	53.50	0	0	v. low	----	Moderately abun. sulfides; Fe–ox. as mgt, hm (minor)
#	127	390–400	21	0	0.25	<1:20	----	Moderately abun. sulfides; mod. Fe–oxides as mgt, hm.
1755	112	520–530	0	3.5	0	high(?)	----	Mod total sulfides(as py); very low ore sulfides. <u>Log notes</u>: Klp; V. broken & silicified. Py common of fractures w/cc coatings. Cc content diminish rapidly w/depth. Py increases with depth.
	113	540–543	trace	8	0	high	----	Lo total sulfides; Only traces of cp, encap. in py. Low ore sulfide, as cc. See log notes.
	114	550–554	trace	1.50	0	high (?)	----	Lo to mod py;lo ore sulfides. See log notes above #112.
1781	115	30–40	54.5	trace trace bn	trace	v. low	----	Abun. sulfides; minor cp occurring as encapsulations in

			LINE COUNTS			PROPORTIONS		
				with Bn			without Bn	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
								py; most cp is liberated. Signif. mb (5.5 units).
	116	60–70	163.50	0.50 bn	0	<<1:50 low	----	Abun. sulfides; abun. heavy oxides: mgt, Ti–oxides. Ratio cp:py relatively high (1:2). No signif. cc, dg, cv. Traces mb(1).
	117	80–90	98	trace	trace	<<1:50 low	----	Moderately abun. sulfides; ratio cp:py approx. 1:2. Signif. mb (6 units).
	118	99–99.5	189.50	3 0.5 bn	0	<1:54	----	Moderately abun. sulfides; very minor cp encapsulated in py. Ratio cp:py 1:2. Signif. mb (5.50 units).
#	129	126–136	77.50	0	0	v. low	----	Moderately abun. sulfides; minor molyb.
#	130	141.5–146.5	39.50	0	0	v. low	----	Low to mod. sulfide content; minor molyb. (0.5 units).
#	131	146.5–154.5	60	0	0	v. low	----	Low total sulfides; Minor molyb. (1.50 units).
#	132	154.5–161.5	170	tr bn	0	v. low	----	Abun. sulfides; relatively high cp:py (1:3–4). Bn assoc. w/cp (hypogene?). Very significant moly (10.5 units).
1783	119	126–130.6	15	86.5	2.5	6:1	>30:1	Mod. abun. sulfides. Cc>dg.
1784	120	117–123.5	12.5	1.50	0	1:8	----	Lo total sulfides; lo ore sulfid.
	121	132–136	15	2.50	0	1:6	----	Low to mod. total sulfides.

			LINE COUNTS *with Bn*			PROPORTIONS		
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	*without Bn* $\frac{(Cc+Dg)}{Cv}$	**NOTES***
	122	160–169	10	0	0	low	––––	Cc–dg replaces some cp. 6 Cu^{o} Mod. abun. total sulfid Is "Cu^{o}"brass? (No native Cu noted in adjacent samples!).
	123	174–181	15	0	trace	low	––––	Mod. to abun. sulfides. No molyb. observed. No signif. Cu sulfides.
	133	235–243.5	219	5 cc tr dg	trace	<1:35	––––	Abun. sulfides, abun. py. Traces of pyrrhotite?
	134	265–274	263.5	11 cc tr bn	trace?	<1:25	––––	Very abun. sulfides; very abundant pyrite.
	135	305–313.5	67.5	trace	trace	v. low	––––	Moderately abun. sulfides.
	136	324–334	150	0	0	v. low	––––	Abundant sulfides. Trace mb.
*******124; 125; 126–127; 128; 129–132; 137–139; 140; 141–144; 145; 146–148; 149–150; out of sequence								
*******315; 316–320; 321–328; 329–343; 344; 345–347; 348–350 out of sequence								
1728	351	520–525	trace	14.50	0	v. high	––––	Mod. total sulfides; low ore sulfides. Trace Cu*; trace mb.
	352	530–540	trace	6.25	trace	v. high	––––	Mod. total sulfides; low ore sulfides. Trace po+cp. Some cc/dg with qtz, pyrite.
	353	540–550	0.25	22	0	>20:1	––––	Mod. total sulfides; low ore sulfides.
	354	550–560	trace	11.50	0	>10:1	––––	Mod. total sulfides; low ore sulfides.
	355	560–570	trace	13.50	0	>10: 1	––––	Abun. sulfides, abun. pyrite

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	NOTES*
								Trace pyrrhotite.
	356	570–580	trace	8.50	0	>10:1	----	Abun. sulfies; abun. py. Trace po. Trace liberated cp (not encapsulated).
	357	580–590	trace	10	0	>10:1	----	Abun. sulfides; abun. py. Tr. mb. Trace liberated cp.
	358	590–593.5	0.50	10	0	>10:1	----	Abun. sulfides; abun. py. Low total ore sulfides.
1744	359	56–60	1	9.5cc/dg 0.5 id	5.5	>15:1	2:1	Mod.–lo total sulfides; trace cp+po encap. in py. Essentially all cp encap. in py (little liberated). <u>Log notes:</u> Chrystaline tuff, boulders & soil: overburden.
	360	460–470	trace	0	0	---	----	No signif. sulfides; no py; traces cp. Total heavies v. low; almost all as Fe–oxides. Oxide zone sample! <u>Log notes:</u> Tli dike argillized & locally Fe–stained.
	361	470–482	trace	0	0	---	----	No signif. sulfides; no py; trace cp. (oxide zone). Same log notes as #360.
1760	362	86–90	0	0	0	---	----	Py only obs. (traces). No Cu sulfides obs. Traces of malachite (?) & minor chrysocolla

DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	LINE COUNTS			PROPORTIONS		NOTES*
			Cp	*with Bn* Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	*without Bn* $\frac{(Cc+Dg)}{Cv}$	
								(only Cu–minerals obs.).
	363	140–150	0	0	0	---	----	No Cu minerals obs.; Abun. Fe–oxides, implies is from v. oxidized zone, w/goethite, hm
	364	196–200	0	4.5	0	high	----	Py:cc+dg about 2:1; v. low total sulfides, lo total py. Cc replaces py (implies either low initial cp ore content &/or efficient leaching/pptn.
	365	200–210	0	58	0	v. high	----	Mod.total sulfides;abun. Fe–oxides; some dg/cc assoc. py.
	366	210–220	0	40	0	high	----	Mod. total sulfides; Cc>>dg Mod. ore sulfides. Minor dg/cc assoc. with pyrite.
	367	220–230	0	30	0	high	----	Abun. sulfides, abun. py. Cc>>dg. Minor dg/cc w/py.
	368	230–240	0	25.50	0	v. high	----	Mod. to abun. sulfides; abun. pyrite. Cc>>Dg.
	369	240–250	0	24	0	v. high	----	Abun. sulfides; abun. py and Fe–oxides.
	370	250–255.5	0	12	0	v. high	----	Low total sulfides; minor dg/cc replacing pyrite.
1771	371	50–60	0	0	0	----	----	No Cu–mineralization obs.; (No signif. mineralization). Abun. Fe–oxides. Only traces of bn–cp (1 grain, v. minute).

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
	372	60–70	0	0	0	----	----	Very low sulfide content, as pyrite; abun. Fe–oxides.
	373	90–100	0	1.50	trace	high	----	Mod. total sulfides; very low ore sulfides.
	374	100–110	0	3.25	0	high	----	Mod. to abun. sulfides; minor dg/cc replacing pyrite.
	375	110–120	0	0.50	0	high	----	Mod. total sulfides; traces dg/cc with pyrite.
	376	120–130	0	trace	0	---	----	Moderately abun. sulfides traces pyrrhotite within py. No signif. Cu mineralization.
	377	140–150	0	trace	0	---	----	Low total sulfides; trace dg/cc replacing pyrite. No signif. Cu mineralization.
	again		0	2	0	high	----	Moderately abun. sulfides; abun.sulfides.Dg–cc replaces py; v. low ore sulfides.
	378	150–160	trace	2.50	trace	hi(>10:1)	----	Moderately abun. sulfides; abun. py; Traces cp encap. in py; minor dg–cc replacing py.
	379	160–170	0.50	8.5 0.5 id	1	>10:1	>8:1	Moderately abun. sulfides; minor id w/cv, dg. Some dg–cc replace py; minor cp encap. by pyrite.
1772	380	63–70	0.50	2 bn	trace	>2:1	----	No dg–cc obs.; low total sulfides; abun. Fe–oxides.

DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	LINE COUNTS			PROPORTIONS		NOTES*
			Cp	*with Bn* Cc+Dg+Id	Cv	$\frac{\text{Cc+Dg+Cv}}{\text{Cp}}$	*without Bn* $\frac{\text{Cc+Dg}}{\text{Cv}}$	
								Py:Fe−oxides about 1:1. <u>Log notes</u>: Tqm dike. V. weathered & Fe−stained(in form of lm) Stage II alteration. 104 ft base of weathering.
1782	381	30−40	0	6	0	v. high	----	Moderately abun. sulfides; Abun. py, low ore sulfides. Some dg−cc replacing pyrite.
	382	40−50	0	15.50	0	v. high	----	Low to mod. total sulfides; minor dg−cc replaces pyrite.
	383	50−60	1+	33.50	0	>20:1	----	Moderately abun. sulfides, abun. py; most cp as v. minute inclusions in py, traces "liberated" cp. Minor Cu^{o}. 0.25 units Cu^{o}
	384	60−71	trace	26	0	>20:1	----	Moderately abun. sulfides; abun. py. All cp occurs as minute encapsulations in py. Paragenesis:py−dg−cc!
	385	71−82.5	trace	15	0	>15:1	----	Low total sulfides; traces of cp encap. in py; tr. liberated cp.
	386	82.5−95.5	trace	28.50	0	>25:1	----	Moderately abun. sulfides; minor cc/dg veining py; minor cc c/qtz. Minor mb (1.5 units).
	387	95.5−105	trace	97.50	0	>>40:1	----	Abun. sulfides; some dg/cc attached to py, qtz. Dg

DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	LINE COUNTS			PROPORTIONS		NOTES*
				with Bn			*without Bn*	
			Cp	Cc+Dg+Id	Cv	(Cc+Dg+Cv) / Cp	(Cc+Dg) / Cv	
								replaces pyrite (!).
1786	388	20–25	74	1 cc tr bn	trace	<1:40	----	Moderately abun. sulfides; minor cp w/py; tr cp encap. within py; minor cp w/qtz as attached grains (not locked). 0.5 unit moly (minor).
	389	25–28	29.5	2 cc/dg 0.5 bn	trace	1:12	----	Abun. sulfides; minor encap. of cp by py. Paragenesis: bn–>dg–>cc.
	390	28–34.7	42	1	1.50	1:28	1: 1.5	Moderately abun. sulfides; signif. encapsulation of cp by py; many cp grains assoc. with py. Tr. bn+cp encap. by pyrite
	391	34.7–43.5	28	0.5 bn	0.50	<1:28	1:1	Moderately abun. sulfides; signif. encapsulation of cp by py; cp+py assoc. common.
	392	43.5–52.5	25	2.5 tr bn	0.25	1:10	----	Low total sulfides; signif. cp attached to py and/or qtz.
	393	52.5–59.5	27.50	0	1	<1:25	----	Low total sulfides; cv replacing cp. Minor cp attached to py; tr cp encap. in py.
	394	59.5–65.0	24.50	0	trace	<1:25	----	Low total sulfides; minor cp attached to qtz and/or pyrite.
	395	70.5–74.8	45	1.25	1.25	1:18	1:1	Moderately abun. sulfides; tr cp and po encap. in py. Minor cp attached to py, qtz.

			LINE COUNTS			PROPORTIONS		
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	*with Bn* Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	*without Bn* $\frac{(Cc+Dg)}{Cv}$	**NOTES***
	396	74.8–84.3	44.50	0.50 tr bn	0	<1:40	––––	Mod. total sulfides; signif. cp attached to py; tr dg/cc assoc. w/py (replacing pyrite).
	397	93–101	94.50	7 0.5 bn	0	1: 12.6	––––	Moderately abun. sulfides; also moderately abun. oxides as hm & mgt (hm repl. mgt). About half of dg/cc occurs as repl. of py (or cp+py). One grain of cp+bn appeared to show exsolution of cp from bn
1843	398	105–110	0.50	62.50	0	>50:1	––––	Moderately abun. sulfides; important assoc. dg/cc replacing py. Tr. cp encap. by py. Minor dg/cc with qtz.
1921	399	161–166	0	18	0	v. high	––––	Mod. to low total sulfides; Dg/cc assoc. w/py. Relatively abun. hm replacing py.
2026	400	250–255	65	2.5 15.5 bn	0	1: 3.6	––––	Abun. sulfides; Minor yet signif. cp encap. in py; dg & bn replacing py. Hm repl. dg/cc! Signif. moly (3.5 units). <u>Log notes</u>: Cs. Highly altered shale yellow green in color.
&1969	801	26–31	136	1.5 tr bn	8.5	1: 13.6	1: 5.5	Abun. sulfides; minor Fe–oxides as mgt & hm. Paragenesis shows moly early vs.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
								cpy. Minor moly.
	802	36–42	284.50	6 0.5 id tr bn	1	<1:33	6:1	Abun. sulfides; moderately abun. Fe–oxides as mgt. Minor id (replacing dg–cc!?).
	803	42–46	79.5	3 1 bn	0.5	<1: 17.5	3:1	Abun. sulfides; minor Fe–oxide as mgt.
	804	46–51	68.50	58	6	1: 1.1	9.7 :1	Moderately abun. sulfides & Fe–oxides (mgt). Less than 10% of cp attached to pyrite.
	805	51–56	136.50	5.50 tr bn	1	<1:21	5.5 :1	Moderately abun. sulfides; bn assoc. w/cp; cp replaced by cv, dg, cc; first replacement is by bn, then dg–cc, cv. Traces of bn, dg–cc within pyrite.
	806	56–61	105.50	39 1 bn 1 id	11	1:2	3.3 :1	Moderately abun. sulfides; minor Fe–ox. as mgt. Note: paragenesis: cp–>bn–>dg –>cc (!) & id w/cv (+dg??). Hypogene & supergene bn?!
	807	61–66	147.50	8	0	<1: 18.4	––––	Mod. total sulfides; minor mt.
1965	808	122–127	76	0.50	0	<<1:50	––––	Moderately abun. sulfides; mod. amounts of mgt; less than 5% cp encap. in py. Signif. moly (4 units).
	809	132–137	88	0	0	v. low	––––	Abun. sulfides; mod. mgt. very signif. moly (10.5 units).

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	NOTES*
	810	137–142	87.50	0	0	v. low	----	Moderately abun. sulfides, moly present.
	811	142–147	89.50	0	0	v. low	----	Moderately abun. sulfides; Minor moly (1.5 units).
	812	147–153	90	0	0	v. low	----	Low to mod. total sulfides; minor mgt. No moly obs.
	813	207–212	25	1 bn	0	<1:25	----	Low total sulfides; very signif. molybdenite (11 units).
	814	217–223	37	1 bn	trace	<1:37	----	Low total sulfides; very signif. molybdenite (10.5 units).
	815	232–237	87	0	trace	<<1:87	----	Low total sulfides; minor mgt. Signif. moly. (3.5 units).
	816	241–245	106.50	2.5	0	<1:41	----	Low to mod. total sulfides; Signif. moly. (4.5 units).
	817	255–261	9.50	0	0	v. low	----	Very low total sulfides; very signif. moly. (7 units).
	818	292–296	22.50	0	0	v. low	----	Low total sulfides; Minor mb (2.5 units).
1961	819	65–75	6	39.50	37.50	12.8 :1	1.05 :1	Low to mod. total sulfides; Paragenesis: cp–>dg–>cc –>cv(!). Some dg–cc–cv attached to py (py untouched by replacement!). No mb obs.
	820	75–80	0.50	12.50	10.50	>23:1	1.2 :1	Low to mod. total sulfides.
	821	85–90	1	30	6	>30:1	5:1	Abun. sulfides. Paragenesis as in the previous two samples.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
	823	95−101	0.50	10	4	18.5 :1	2.5 :1	Moderately sulfides; cv as latest replacement(of dg−cc).
	824	101−107	8	27.50	6	4.2 :1	4.5 :1	Moderately abun. sulfides.
	825	107−113	2.50	38	4.50	17:1	8.4 :1	Abun. sulfides; Paragenesis: cp−>dg+cc−>cv in rimming texture.
1713	826	180−190	37.50	22.50 2.5 bn tr id	trace	1: 1.5	−−−−	Abun. sulfides; moderately abun. mgt. Cpy enclosing id.
	827	210−220	29	5 2.5 bn	0	1: 3.9	−−−−	Moderately abun. sulfides; much of the bn assoc. w/cp.
	828	230−234	146	27 7.5 bn	0	1: 4.2	−−−−	Abun. sulfides; moderately abun. mgt. Assoc. bn−cp common. No moly noted.
	829	250−260	73.50	1 bn	0	>1:50	−−−−	Moderately abun. sulfides; bn assoc. w/cp. Moderate mgt.
	830	260−270	98.50	1	0	>>1:50	−−−−	Moderately abun. sulfides; mod. mgt. Bn assoc. w/cp.
	831	270−280	47.50	0.50 tr bn	0	<<1:50	−−−−	Low to mod. total sulfides; bn associated with cp.
	832	300−310	10	0.5 bn	trace	<<1:20	−−−−	Low to mod. total sulfides.
	833	310−320	9	0	1	1:9	low	Mod. total sulfides; cv replace cpy.
	834	320−330	37.50	tr bn	trace	<<1:40	−−−−	Mod. total sulfides; minor mb (2.5 units) paragenetically earlier than cpy.

			LINE COUNTS			PROPORTIONS		
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	*with Bn* Cc+Dg+Id	Cv	$\frac{Cc+Dg+Cv}{Cp}$	*without Bn* $\frac{Cc+Dg}{Cv}$	**NOTES***
	835	330–342	12.50	0.50 tr bn	trace	<1:20	----	Low total sulfides; traces moly (0.5 unit).
1854	836	0–20	1.50	20.50 0.25 bn	5.50	17:1	4:1	Low total sulfides; (tr) cp encap. in py; cc replaces dg.
	837	20–25	2.50	19	1	8:1	----	Low to mod. sulfides; (tr) cp & py encap. in qtz. Cv repl.cp.
	838	28–33	trace	10.50	1.50	≥12:1	>7:1	Moderately abun. sulfides; (tr) cp encap. in py. Low total ore sulfides.
	839	33–41	trace	33.50	1	>35:1	>>30:1	Low total sulfides; traces of cp encap. in pyrite.
	840	41–45	trace	49	1.25	>50:1	>>40:1	Moderately abun. sulfides; Cc much greater abun. than dg.
	841	45–50	0	4.50	0	high	----	Low to mod. total sulfides; lo total ore sulfides.
	842	50–55	1.25	25.50	0.50	≥22:1	----	Mod. total sulfides; cc much greater abundance than dg.
	843	55–60	0.50	48	trace	>>50:1	----	Abun. sulfides. Trace cp encap. in pyrite.
	844	60–65	0	5.25	0.25	high	----	Moderately abun. sulfides. Biotite present.
	845	65–71	trace	26	0	>>26:1	----	Mod. total sulfides; cc repl. py; dg replaces pyrite.
	846	71–75	trace	25	0	>>25:1	----	Low total sulfides; cp as encap in pyrite.
1852	847	78–84	0	0	0	----	----	No sulfides or Cu minerals

DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	LINE COUNTS Cp	LINE COUNTS *with Bn* Cc+Dg+Id	LINE COUNTS Cv	PROPORTIONS (Cc+Dg+Cv) / Cp	PROPORTIONS *without Bn* (Cc+Dg) / Cv	NOTES*
								obs. Martitic hm replacing mt Abun. Fe–oxides as hm, goethite.
	848	84–93	0.25	4	0	≥15:1	----	Abun.Fe–ox. as goethite, hm. Py total=0.50 unit.
	849	93–96	0	0	0	----	----	Trace total sulf. as py (1.25). Tr. cuprite? Abun. fe–oxides as goethite, hm.
	850	96–99	trace	1 bn–dg	0	>5:1 ?	----	Only traces of Cu sulfides; Traces of sulfides (py:ore= 3.5 :1). Abun. Fe–oxides as mgt (martite) & hm.
	851	108–115	0	0	0	----	----	3.5 units Cu^{o}. Total Cu as oxide greater than total py. Abun. Fe–oxides as goethite, hm, martitization of mgt.2.75 units total sulfides, as pyrite.
	852	115–119	trace	1	0	high?	----	Only traces sulf.; Abun. Fe–oxides as goethite, hm, mgt.
	853	128–136	2	208 tr bn	0	≥104:1	----	Abun. sulfides; cc replaces py. Traces of sl repl. by cc (?!).
	854	??140–143	trace	45	0	>45:1	----	Low total sulfides; mod to abun. hm. Cc–dg repl. py.
	855	175–181	3	66	0	22:1	----	Mod to abun. sulfides; Cc–dg repl. py; hm repl. cc!
1850	856	56–60	0	61	0	v. high	----	No cp obs. Mod. to abun.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	NOTES*
								total sulfides; cc−dg repl. py.
	857	60−66	2	106.50	trace	53:1	v. high	Low total sulfides; mod. abun Fe−oxides. Trace cp encap. in py. Minor molybdenite.
	858	66−72	2	78.50	0	39:1	----	Mod.total sulfides; abun. Fe−oxides; minor mb; Cc−dg replaces (rims, veins) py.
	859	72−76	1	49	0	49:1	----	Moderately abun. sulfides; Abun. Fe−oxides, hm, mgt. Cc−dg replace pyrite.
	860	76−86	0.25	≥30	0	30:1	----	Lo total sulfides; cp replaced by cc−dg.
	861	152−161	2.50	36 1.25 id	0	14.9 :1	----	Low total sulfides; cc−dg repl. py; Pyrrhotite (?) & cubanite (?!) as minute grains. Mgt replaced by hm.
	862	161−169	0.25	32.50 tr id	trace	≥32:1	v. high	Low total sulfides; cv replaces cc−dg. Tr. id (cubanite? po?)
	863	169−175	0.25	32.25	0	≥32:1	----	Mod. total sulfides; mod. totalFe−ox.; cc−dg repl.py
	864	181−189	trace	50.50	0	>50:1	----	Lo total sulfides; cc−dg repl. py; minor moly (2.5 units).
	865	189−194	trace	57.50 tr bn	0	>57:1	----	Mod. total sulfides; tr bn+cp as single grain; cc−dg repl. py.
1848	866	10−20	3	57.50 1.5 bn	trace	19.6 :1	v. high	Mod total sulfides; biotite moderately abun.; Tr. cp+po.

DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	LINE COUNTS			PROPORTIONS		NOTES*
				with Bn			*without Bn*	
			Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	
	867	20–29	1.50	16.50	2	12.3 :1	8.5 :1	Cc+dg distinguishable. Low total sulfides; py & cp replaced by cc–dg–cv.
	868	34–39	0	10.50	0	high	----	Low total sulfides; biotite mod. abun.; cc–dg replace py.
	869	39–45	trace	6 tr bn	0	≥6:1	----	Mod. total sulfides; biotite. Cc–dg replaces py. Note low total ore sulfides.
	870	45–50	trace	7.50	0	v. high	----	Traces cp. Low total sulfides; Tr. cp encap. by py. Minor cc–dg replacing pyrite.
	871	50–53	0	21	0	high	----	Mod. total sulfides; cc–dg replace py. No cp observed.
	872	59–66	0	47	0	v. high	----	No cp obs. Mod. total sulfides Low total Fe–oxides as hm. Cc–dg replace pyrite.
	873	71–78	1	32	0.50	≥32:1	v. high	Low total sulfides; cp+po(?) +cubanite? aggregate!? Cc–dg replace pyrite.
	874	78–85	0	31.50	0	v. high	----	Mod. total sulfides; cc–dg replace py. No cp observed.
	875	85–89	trace	39	0	≥39:1	----	Mod. total sulfides; tr cp encap. in qtz, py. Cc–dg replaced(?) by hm!
	876	89–94	0	21.50	0	v. high	----	No cp observed; low total sulfides; cc–dg replace pyrite

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	NOTES*
								minor biotite.
	877	94–103	1	13 1 bn	0	14:1	----	Lo total sulfides; cc–dg repl. py; minor moly.
1842	878	14–20	3	7 0.5 bn?	27	11:1	1: 3.9	Mod. total sulfides; cv repl. dg–cc & cc replaces(?) dg. Blaubleibender covellite.?
	879	20–24	11.50	0.50	7	1: 1.5	1:14	Mod. total sulfides; mt altered to hm. Cv replaces hm.
	880	185–188	26	1.50 tr bn	3.50	1: 5.2	1: 2.3	Mod. total sulfides; abun. hm; some hm repl. py.
	881	231–236	31.50	2 bn	0.25	1:14	low	Low total sulfides; traces of po+cp encap. by pyrite.
	882	252–261	30	22 tr bn	0	1: 1.4	----	Abun. total sulfides. Paragenesis is bn–>cp–>dg! Cc repl. cp. Tr. po encap. by pyrite.
	883	261–267	7	24.50 14 bn	1	5.6 :1	24.5 :1	Mod total sulfides. Bn shows interesting textures:cp (exso–lution) & replacement by cv and cc–dg.
	884	267–273	34.50	27 19.5 bn	0	1.3 :1	----	Mod. total sulfides. Bn repl. by dg, dg+cc and cc!
1838	885	20–26	0	13.50	0	high	----	No cp obs. Abun. sulfides; abun. py. Minor mgt; cc–dg repl. py.
	886	26–30	1.50	3 tr bn	0	2:1	----	Abun. sulfides; low total ore sulfides. Bn–>cg+cc, w/cpy.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	(Cc+Dg+Cv) / Cp	(Cc+Dg) / Cv	NOTES*
	887	30–36	1.50	24	0	16:1	----	Mod. to abun. sulfides. Minor mgt; cc–dg repl. py.
	888	36–42	trace	28.50 tr bn	0	28.5 :1	----	Modtotal sulfides;cc–dg repl. py. Bn & cp as inclusions within pyrite.
	889	42–51	trace	24	0	>>24:1	----	Abun sulfides; tr. cp encap. by pyrite; minor mgt, sphene. Cc–dg replaces pyrite.
	890	51–56	trace	69	0.50	>>69.5 :1	high	Abun. sulfides; tr cp encap py.
	891	56–61	0	78.50	0	v. high	----	Abun.sulfides; cc–dg repl. py. Shard of brass present (Cu^{o}?)
	892	61–66	trace	64.50	0	>>64.5 :1	----	Mod. total sulfides. Tr. cpy encapsulated by pyrite.
	893	66–70	0	33	0	high	----	No cp obs. Mod to abun sulfides. Tr bn(?) encap. in py.
	894	70–76	1	97.50	0	97.5 :1	----	Abun. sulfides; minor mgt.
1824	895	198–204	1	74 tr bn,id	16.50 (bcv?)	90.5 :1	4.5 :1	Abun. sulfides. Bn, po, bn–dg all encap. by py! Dg–>cc–>cv! traces of idaite.
	896	204–207	5	15	7.50	4.5 :1	2:1	Abun. sulfides. Tr. cp encap. by py. Only 1 grain of cp.
	897	207–210	0.50	17.50 0.5 id	6	>48:1	2.7 :1	Mod. total sulfides. Cp encap. by py. Minor idaite.
	898	210–213	trace	15 tr bn	0.25	15.3 :1	high	Mod total sulfides. Tr. bn encap. by py.
	899	213–216	trace	10	5	>15:1	2:1	low total sulfides. Cc–dg repl.

			LINE COUNTS			PROPORTIONS		
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	*with Bn* Cc+Dg+Id	Cv	(Cc+Dg+Cv) / Cp	*without Bn* (Cc+Dg) / Cv	NOTES*
1837	900	0–20	3	tr bn 24	0.50	8:1	≥48:1	py. Tr. bn encap. by pyrite. Lo total sulfides; cc–dg repl. py. Cc (& dg?) repl. cp. Cc with hm.
	901	25–29	trace	141.50 tr bn	1	>>100:1	>>100:1	Mod total sulfides; cc–dg repl. py. Py–>cc+hm!
	902	29–34	1	61	0	≥61:1	––––	Mod total sulfides; cc–dg replace pyrite.
	903	38–45	0	30.50	0	v. high	––––	Lo total sulfides. cc–dg repl. py. Appears cc much greater than dg.
	904	45–53	0.50	71 2 bn	0	>>73:1	––––	Low total sulfides. Highly anisotropic cc w/hm! Bn+cp –>cc!
	905	58–65	8	11.50 9 bn	1	2.6 :1	>11.5 :1	Low total sulfides. Cc>>dg.
	906	76–83	4	36.50 4 bn	0	10:1	––––	Low total sulfides. Assoc. bn–cp–cc. Bn anisotropic! Cc>>dg!
	907	88–94	21.50	177 13 bn	0	8.8 :1	––––	Mod.totalsulfides.Bn+cp––cc! Cc–dg replaces pyrite.
1836	908	117–124	27	5	8.50	1:2	1: 1.7	Mod. total sulfides. Minor cp encap. by pyrite.
	909	129–134	12	3.50 tr bn	11	1.2 :1	1: 3.1	Mod. total sulfides; cv repl.cp Some cp assco. w/py. Dg=cc.
	910	143–150	0	23.50	0	high	––––	Mod. to abun. total sulfides

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
								cc–dg repl. py.; cc>>dg.
	911	150–155	0	4	0	high	––––	Low to mod. total sulfides; abun. py; cc–dg repl. py.
	912	164–169	trace	7	0	≥7:1	––––	Low total sulfides. Cc–dg repl. py. Cc>>dg.
	913	189–193	0	14.50	0	high	––––	Low total sulfides; abun. py. Cc>>dg. Cc–dg repl. py.
	914	197–202	trace	4.50	0	4.5 :1	––––	V. low total sulfides; abun. py. Cc–dg replace py.
	915	214–220	0.50	18 1 bn	0	≥38:1	––––	Low total sulfides; Abun. py. Cc–dg repl. py. Cc>dg. Cp––bn––cc!
	916	226–233	0.50	13	0	≥26:1	––––	Lo total sulfides. Cc–dg repl pyrite.
1829	917	90–96	0	7	0	high	––––	V. low total sulfides. cc–dg repl. pyrite.
	918	96–106	0.25	13.50	0	>>27:1	––––	Lo total sulfides; cc–dg repl. pyrite.
	919	106–112	0	53	0	v. high	––––	V. low total sulfides; signif. mb (4.5 units). Cc>>dg.
	920	112–117	0	7.50	0	high	––––	Scarce sulfides! V. low ore sulfides; cc–dg repl. pyrite.
	921	117–121	1	49.50	trace	≥49.5 :1	v. high	V. low total sulfides. Cc–dg repl. py. Cc>>dg. Signif. mb
	922	127–131	0	24	trace	high	v. high	V. low total sulfides, low py. cc dg.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
	923	131–136	0	83.50	0	v. high	v. high	Low total sulfides, low py. cc–dg replace py.
	924	136–141	1.50	67	0	≥44:1	----	Lo total sulfides; cc–dg repl. pyrite; cc dg.
	925	141–146	0	46	0	v. high	----	Lo total sulfides; cc–dg repl. py; cc dg.
	926	146–152	0	21	1.50	v. high	14:1	Lo total sulfides; cc–dg repl. py; some hm replacement of cc. Martitization of mgt.
1835	927	38–48	4	16	0	4:1	----	V. low total sulfides; abun. hm goethite. Cp repl. by cc–dg.
	928	93–107	1	29	trace	29:1	----	Lo total sulfides; cc–dg repl. pyrite.
	929	107–112	1	20	trace?	20:1	----	V. low total sulfides; abun. hm–geothite; v. minor py.
	930	112–120	0	42.50	0	v. high	----	V. low total sulfides; cc–dg repl. py. Moderately abun. hm Pyrite very minor.
	931	120–125	trace	3.50	0	>7:1	----	V. low total sulfides; mod. total hm. V. low pyrite.
	932	125–130	0.50	80.50	0.50	>>100:1	v. high	Mod. total sulfides; v. low py content; moderate hm.
	933	130–135	0	45	0	v. high	----	Low total sulfides; v. common replacement of py by cc–dg. Mod. abun. hm.
	934	135–140	0.50	37	1	≥76:1	37:1	Mod. total sulfides; cc–dg

			LINE COUNTS *with Bn*			PROPORTIONS	*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	(Cc+Dg+Cv) / Cp	(Cc+Dg) / Cv	NOTES*
								repl. py. Both cc & dg present; py>>ore sulfides.
	935	140–145	1	16	0	16:1	----	V. low total sulfides. Cc–dg repl. py; some hm replaces cc! Traces molybdenite.
	936	145–157	1	94.50	0	94.5 :1	----	Moderately abun. sulfides, & abun. replacement of py by cc–dg.
1822	937	110–117	0.50	20.50	0	≥41:1	----	V. abun. sulfides; py ore minerals. Some cc–dg repl. py.
	938	117–120	2.50	54.50	0	22:1	----	V. abun. sulfides; abun. py.
	939	140–149	0.50	63	0	≥126:1	----	Abun. sulfides, abun. py. Trace molybdenite.
	940	149–159	0.50	11 tr bn	0	≥22:1	----	Low total sulfides, low pyrite. Minor moly (3 units).
	941	159–164	1	39.50	0	39.5 :1	----	Abun. sulfides, abun. py. Minor cc–dg replacing py.
	942	186–188	trace	39 tr bn	0	>39:1	----	Mod. total sulfides, abun. py; traces moly.
	943	209–213	1	42	0	42:1	----	Mod. total sulfides, abun. py. Abun. moly (6 units).
	944	290–297	trace	61 tr bn	0	>61:1	----	Low total sulfides, abun. py. Minor cc–dg repl. pyrite.
	945	297–300	trace	34 tr bn	trace	>34:1	v. high	Mod. total sulfides; signif. mb moly (3 units).
	946	310–320	trace	26.50	0	>26.5 :1	----	Mod. total sulfides. Minor

DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	LINE COUNTS			PROPORTIONS		NOTES*
			Cp	*with Bn* Cc+Dg+Id	Cv	(Cc+Dg+Cv) Cp	*without Bn* (Cc+Dg) Cv	
				tr bn				cc–dg relacing pyrite.
	947	320–331	0.50	14.50 0.5 bn	0	≥30:1	----	Mod totalsulfides;cc–dg repl. py, bn. Trace moly.
	948	341–352	33	0	0	v. low	----	Low total sulfides; assoc. py+cp.
	949	352–361	39	0	0	v. low	----	Mod. total sulfides; trace mgt Assoc. py+cp.
	950	361–373	34.50	trace	0	≤1: 34.5	----	Low total sulfides.
				tr bn				
1818	951	191–201	0	46	1.50	v. high	30:1	v. low total sulfides; v. low py. Minor moly (1.50 units).
	952	201–206	0	51	0	v. high	----	V. low total sulfides, v. low py.
	953	213–221	trace	8	1.50	9.5 :1	5:1	V. low total sulfides, v. low py. Moderate hm.
	954	231–235	1	18.50	0	18.5 :1	----	Low total sulfides, low pyrite.
	955	235–(9)240	1	11	0	11:1	----	Low total sulfides, low pyrite. Abundant hematite.
	956	286–291	1	55	0	55:1	----	Low total sulfides, low pyrite. Abun. hm.
	957	300–309	1	16	0	16:1	----	Low total sulfides.
	958	316–325	16.50	25	0	1.5 :1	----	Moderately abun. sulfides; abun. hm.
	959	325–332	0	32.50	0	v. high	----	Low total sulfides; abun. hm.
1706	960	280–290	18	0	trace	v. low	----	Abun. py & mgt. Some cp+py association.
	961	290–300	19.50	0	0.25	v. low	low	Abun. py. and mgt.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	(Cc+Dg+Cv) / Cp	(Cc+Dg) / Cv	**NOTES***
	962	300–309	23	tr bn	1.50	1: 15.5	low	Abundant py and mgt.
	963	360–369	32.50	0	0	v. low	––––	Abun. sulfides & mgt altering to hm, traces po & cp encap. by pyrite.
	964	369–380	54.50	1	0	$\leq$1: 54.5	––––	Abun. sulfides, abun. mgt altering to hm, minor cp encap. by py, biotite present.
	965	380–390	87	2	0	1: 43.5	––––	Abun. sulfides, abun. mgt altering to hm, id assoc. w/cp, cp assoc. w/py and mgt.
	966	440–450	29	tr id	0	$\leq$1:58	––––	Abun. sulfides, traces id repl. cp, minor cp encap in py &mt.
	967	490–500	34.50	0	trace	$\leq$1:73	––––	Abun. sulfides, cp encap in py, minor bn replace cp, minor cv replace cp.
	968	500–510	59	tr bn	0	$\leq$1:118	––––	Abun. sulfides, minor bn replace cp, cp encap in pyrite.
	969	510–520	133	9	0	1:15	––––	Abun. sulfides, traces hm.
1699	970	130–140	42.50	2	0	1:21	––––	Abun. sulfides, traces hm.
	971	150–160	84	4	1	1:17	4:1	Abun. sulfides, cc and dg repl. cp.
	972	180–190	15	0	0	v. low	––––	Low to mod. sulfides, abun py
	973	160–170	33	2	0	1:16	––––	Low to mod. sulfides, abun. py, cp replace py.
	974	202–209	26	6	0	1: 4.5	––––	Low to mod. sulfides, abun. py, cc & dg replace py.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
	975	230–240	20	0	0.50	≤1:40	low	Mod. sulfides, traces mb, abun. py.
	976	240–250	14	1.50	0	1:10	----	Mod. sulfides, dg repl. cc; abun. py.
	977	260–270	11.50	2.50	0	1: 4.5	----	Mod. sulfides, py assoc. w/cp, abun. py.
	978	270–280	5	0	2.50	1:2	----	Mod. sulfides, low total ore sulfides, abun. mgt, cv replace cp, traces cp encap in py.
	979	280–290	14	0	0.50	≤1:28	----	Mod. sulfides, low total ore sulfides, traces cp encap. in py very minor mgt.
1618	980	240–250	4.50	tr bn	0	v. low	----	Low total sulfides, v. low ore sulfides.
	981	250–260	2.50	0	1.50	1: 1.7	----	Mod sulfides, abun. mgt, very low ore sulfides.
	982	260–270	3.50	0	0.50	1:7	----	Low total sulfides, mod. mgt, very low ore sulfides.
	983	280–290	3.50	2	1	1: 1.2	2:1	Low total sulfides, v. low ore sulfides.
	984	297–310	14	1.50	1	1: 5.6	1.5 :1	Mod. sulfides, mod mgt, mgt assoc. w/cp & py, trace cv replace py, tr cp encap. py.
	985	320–330	16.50	5.50	0.50	1: 2.75	11:1	Mod. sulfides, mod. mgt, tr mgt replace hm, cc, dg, and cv replace cp.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	NOTES*
	986	330–340	5	3	3	1:1	1:1	Mod sulfides, mod mgt, traces bn, cc dg cv replace cp assoc. of qtz, mgt, and cv.
	987	340–350	23	13	1.50	1: 1.6	7:1	Low ore sulfides, abun. py.
	988	360–366	12.50	2.50	3.50	1:2	1: 1.4	Low ore sulfides, abun. py.
	989	366–372	7.50	1.25	trace	1:5	v. high	Low ore sulfides, abun. py.
	990	380–390	14.50	3.50	trace	1:4	v. high	Very fine grains of sulfides.
	991	400–410	20	3	trace	1:7	v. high	Moderate sulfides.
	992	410–420	28	3	0	1:9	----	Moderate sulfides.
1613	993	190–200	14.50	5.50	1	1:2	5:1	Abun. py, cv replace dg.
	994	250–260	26	5	9	1:2	1:2	Abun. py, cv replace cp. cp encap. in py.
	995	280–290	12	1	12	1:1	1:12	Abun. py, cv repl. cp, cp enclosed in py.
	996	290–304	7.50	0.50	8.50	1:1	1:17	Cv repl. dg, abun. py. Cv repl. cp, cp assoc. w/ py.
	997	304–310	6.50	2	7.50	1.5 :1	1:4	Mod. py, cv replace cp.
1830	998	180–184	0	5	0	high	----	Low pyrite.
	999	184–190	0.50	28	0	56:1	----	Low pyrite.
	1000	210–216	0	16	0	high	----	Cc replace pyrite, low pyrite.
	1001	216–221	0	32	0.50	high	64:1	Cv replace id, cc replace py, low pyrite.
	1002	221–226	0	32.50	0	high	----	Low py, traces id replace cc
	1003	226–231	0	30.50	0	high	----	Low py, cc replace pyrite.
	1004	231–236	0	25.50	0	high	----	mod. py, cc replace pyrite.
	1005	246–250	0.50	33	0	66:1	----	Mod. py, cc repl py, cp encap.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	NOTES*
								in py, hm encap. in cc.
	1006	280–292	0	34	trace	high	v. high	cc replace py, traces cv.
	1007	292–302	4.50	90	0	20:1	----	Mod. py, cc repl. py, traces hm
1596	1208	152–162	0	10	1	high	10:1	Abun. py, cc assoc. w/hm. Log notes: Klp until 165 ft Cc present
	1209	162–167	3.50	45	0.50	13:1	90:1	Abun, py, cv assoc. w/cc, tr hm <u>Log notes</u>: Kc until 244 ft. Qtz stringers.
	1210	185–186	0	47	0	high	----	Abun. py, cc replace py. See log notes in #1209.
	1211	186–192	1	19.50	0	39:1	----	Abun. py, cp encapsulated py. See log notes in #1209.
1597	1212	101–107	1.50	39.50	0.50	30:1	79:1	Abun. py, traces cc assoc. w/ bn and py, cv attack cc. <u>Log notes</u>: Kc. Gray quartzite & tan shale. Sericite on fractures. Cpy on py veinlets. Kc until 104 ft.
	1213	107–112	0	31.50	0	high	----	Abun. py, cc assoc. with pyrite <u>Log notes</u>: 104–117 coarse to fine quartzite w/shale stringers.
	1214	112–117	2	39.50	0	20:1	----	Abundant pyrite. See log notes in #1213.
	1215	117–123	1.50	32	0	21:1	----	Abun. py, py encap. in cpy. <u>Log notes</u>: coarse quartzite 117–153 ft.
	1216	123–130	0	5	0	high	----	Mod. py, cc assoc. w/ py.

			LINE COUNTS *with Bn*			PROPORTIONS	*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	(Cc+Dg+Cv) / Cp	(Cc+Dg) / Cv	NOTES*
	1217	130–137	0	7.50	0	high	----	Low total sulfides; abun. py, cc replaces py (abun.).
	1218	137–143	0	13	0	high	----	Low total sulfides; cc repl. py. Fault at 148' w/4" of gouge & breccia.
	1219	155.3–162	trace	3	5	8:1	1: 1.6	Cv replaces cp; cc replaces py. <u>Log notes:</u> Ca silicified 153–268.
	1220	162–167	5.50	29	4.50	6:1	7:1	Moderately abun. sulfides. Cv repl. cp; cc repl. cp.
	1221	167–173	1	18cc–dg 1 id	0.50	19.5 :1	v. high	Moderately abun. sulfides. Id assoc. w/cc, cv. Cc replaces py.
1605	1222	130–135	4	0	2.50	0.6 :1	low	Mod. total sulfides. Traces cp encap. by pyrite.
	1223	135–140	0	8.50	0.50	v. high	17:1	Minor total sulfides. Ratio cc:dg approx. 1.
	1224	145–150	21.50	7.50	20.25	1.3 :1	0.4 :1	Mod total sulfides. Cv replace cp; Cv replaces cc.
	1225	150–155	15.25	1	14.50	1:1	low	Low total sulfides; Cv repl. cp.
	1226	155–160	3	45	13	18:1	3.3 :1	Cv replaces cc, cp.
1609	1227	250–260	0	9.50	36.50	v. high	0.2 :1	Abun. py; blaubleibender cv.
	1228	260–270	11	34.50	0.50	3.1 :1	v. high	Abun. py; minor cv replacing cp. Low ore sulfides.
	1229	280–290	22.50	trace	39.50	1.75 :1	v. low	Abun. py; low total ore sulfid.
	1230	290–300	15.50	trace	25	1.5 :1	v. low	Cv replaces cpy.
	1231	300–314	3.50	8	10	5:1	1:1	Abun. py; low total ore sulfid.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	(Cc+Dg+Cv) / Cp	(Cc+Dg) / Cv	NOTES*
	1232	314–320	18	27.50	48.50	4:1	0.5 :1	Cv replaces cp, cc–dg.
	1233	320–332	18	15	24	2:1	0.6 :1	Abun. py; cv replaces cp, cc.
	1234	330–340	13.50	6	22.50	2.1 :1	0.3 :1	Moderate pyrite.
	1235	340–350	8	3	9	1.5 :1	0.3 :1	Cv replaces cpy.
1632	1236	260–270	0	9	5.50	v. high	2:1	Low total py; cv replaces cc. Log notes: Kep until 304'. Faulted & broken ground, considerable clay. Py w/cc coatings common. Qtz free at top but qtz phenocr. w/depth. V. altered & silicified.
	1237	270–280	1.50	3	4	4:1	1:1	Moderate total pyrite.
	1238	280–290	2.50	9	17.50	13:1	0.5 :1	Mod. total py; cv repl. cp, cc.
	1239	290–300	36.50	15.50	64	2.1 :1	0.25 :1	Mod. total py; cv repl. cp, cc.
	1240	300–304	38.50	1	21.50	0.4 :1	v. low	Cv replaces cp, cc; cc repl. cpy.
	1241	304–310	10.50	3.50	8.50	1.2 :1	0.4 :1	Mod. total sulfides; tr cp encap. by pyrite. Log notes: Klp 304–320'. Fine grained sill & white silicified shales. Py on fractures w/cc coatings.
	1242	310–320	1.50	6	0.50	4:1	high	Mod. total sulfides; cc repl. py
	1243	410–420	0.25	26	0.25	v. high	----	Mod. total sulfides. Cc repl. py; traces of cp encap. by py. Log notes: Kc. Dense white to light gray silicified shales. Some white py on fractures.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	NOTES*
	1244	434–440	0	15 2.5 id	1	v. high	high	Locally siltstone & fine grained quartzites. Minor cp assoc. w/py locally all v. broken w/numerous slips. Mod. total sulfides; Note: the "cc" has a distinct anisotropy; is this a cv variant? See log notes for drill hole.
1996	1245	92–97	0	43.50	0	v. high	----	Mod. total sulfides; py abun.; cc not obs. to replace py (!). <u>Log notes</u>: Kc. Sandy shale. Fracture Fe–stained w/hm & goethite. Ss content decreases below 75'. Base of weathering at 85'. Cc & on fractures below 85'. Cc decreases below 125'. Faults 106–140'. Shaly below 140'.
	1246	97–102	0	2	trace	v. high	----	Mod. total sulfides; some cc replaces pyrite. See log notes.
	1247	102–107	trace	4.50	0	high	----	Low total sulfides & very low total ore minerals. Trace cp encap. by pyrite. See log notes.
	1248	107–112	0	11	0	v. high	----	Mod. total sulfides; cc–dg replaces pyrite. See log notes.
	1249	112–120	0	14	trace	high	----	Moderate total sulfides.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
	1250	120–124	0.25	18	trace	v. high	----	Mod. total sulfides; cc–dg replaces cp. See log notes #1245.
	1251	134–139	1	22	0	22:1	----	Mod. total sulfides; minor cc–dg repl. py; most cc–dg replaces cp. See log notes #1245
	1252	159–162	2.50	2.50	0.50	1.2 :1	5:1	Mod. total sulfides; cp encap. by py; traces dg–bn encap. by pyrite. See log notes #1245.
	1253	162–167	12.50	5.50	7.50	1.1 :1	1: 1.4	Coarse–grained sample, low total sulfides; abun. cc–cv repl. cp. See log notes #1245.
1846	1254	395–400	48	25.50cc 53.5 bn	0	1.8 :1	----	Mod total sulfides; assoc. of bn–cp;dg–cc assoc.bn;signif. moly (13 units mb).
	1255	449–459	0.50	35 cc 1.5 bn	0	36:1	----	Low total sulfides; cc replaces bn; cc–dg replaces pyrite.
	1256	459–470	5.50	43 cc 18 bn	0	12:1	----	Low total sulfides; signif. mb (2.50 units).
	1257	539–547	0	23 cc 0.25 bn	0	v. high	----	Low total sulfides; cc replaces pyrite.
	1258	547–557	0.50	52.50	0	v. high	----	Low total sulfides; cc repl. py. traces molybdenite.
	1259	557–561	0	52	0	v. high	----	low total sulfides; traces moly.
	1260	561–571	12	74.50	0	6.2 :1	----	Mod. total sulfides; signif. mb

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	(Cc+Dg+Cv) / Cp	(Cc+Dg) / Cv	NOTES*
								(5.50 units). 1 grain Cu^o
	1261	583–603	0.25	14.50 tr bn	0	15:1	––––	Low total sulfides; some cc replaces pyrite.
1892	1262	42–46	0	0	0	––––	––––	No Cu minerals obs. Abun. oxide phases; v. low sulfides py only. Log notes: Kc until 126’
	1263	46–50	0	0	0	––––	––––	No Cu minerals obs. Abun. oxides; very low sulfides; (py)
	1264	112–117	0	7	0	high	––––	Low total sulfides; low total oxides(approx 1:1 vs. sulfides)
	1265	117–12	trace	2	0	high	––––	Low to mod. sulfides; trace cpy encap. in py.
	1266	122–128	0	3.50	0	high	––––	Low total sulfides; traces cc replacing py. Log notes: Kep, well fractrued, Fe–ox staining Partially oxidized py on fractures.
1817	1267	187–193	3.50	12	0	3.4 :1	––––	Abun. sulfides, w/py abun. Non–stoich. cv?
1897	1268	80–84.3	0.50	40	0	40:1	––––	Mod. total sulfides; cc replace cp, py. Log notes: Kc. leached cap at 67 ft followed by cc w/py.
	1269	84.3–88.4	0	27	trace	v. high	––––	Mod. total sulfides; py replace by cc (abun.). See log notes.
	1270	88.4–92.8	0	21.50	0.50	v. high	––––	Mod. total sulfides; cc repl. py

DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	LINE COUNTS			PROPORTIONS		NOTES*
			Cp	*with Bn* Cc+Dg+Id	Cv	(Cc+Dg+Cv) / Cp	*without Bn* (Cc+Dg) / Cv	
								See log notes.
	1271	92–97	0.25	5.50	2.50	32:1	2:1	Mod. total sulfides; cc repl py See log notes.
	1272	97–101	0	8	5	v. high	1.6 :1	low total sulfides; cc repl. py (much less than above). See log notes.
	1273	101–105	1	21 cc tr id	18	39:1	1.2 :1	Mod. total sulfides; cv repl. cc, cp. See log notes.
	1274	105–109	0	1.50	1.50	v. high	1:1	Low total sulfides. See log notes.
	1275	109–113	0.25	1.50	4.50	24:1	1:3	Mod. total sulfides; cv replace cc, cp. See log notes.
	1276	113–117	0	1	4.50	v. high	1: 4.5	Mod. total sulfides; cc repls. cpy. See log notes.
1890	1277	0–13.8	0.50	58	0	50:1	– – – –	Moderately abun. sulfides; minor moly (2 units).
	1278	13.8–18	0	30.50	0	v. high	– – – –	Mod total sulfides; cc replaces pyrite.
	1279	18–24	0	52	0	v. high	– – – –	Moderate total sulfides.
	1280	24–30	0	5	0	v. high	– – – –	Low total sulfides.
	1281	35–42	0	46	0	v. high	– – – –	Moderate total sulfides.
	1282	42–46	1	16.50	0	16.5 :1	– – – –	Low to moderate sulfides.
	1283	46–52	0.50	73 trs bn	0	50:1	– – – –	Mod. total sulfides; traces bn encapsulated pyrite.
	1284	52–57	7.50	138 trs id	trace	19:1	v. high	Abun. sulfides; traces cv replacing cc, cpy.

			LINE COUNTS			PROPORTIONS		
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	*with Bn* Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	*without Bn* $\frac{(Cc+Dg)}{Cv}$	NOTES*
	1285	57–64	0.50	65 trs id.	1	50:1	v. high	Abundant sulfides.
1891	1286	10–15	0	9	0	high	----	Low total sulfides; cc repl. py.
	1287	15–20	trace	14	0.25	v. high	56:1	Moderately abundant sulfides
	1288	20–25	0	58.50	5	high	11.6 :1	Mod. total sulfides; cc replacs pyrite (minor).
	1289	25–30	0	57	0	high	----	Moderate total sulfides.
	1290	30–35	0	92	0	high	----	Abundant sulfides; cc repl py.
	1291	39–45	0	102.50	0	high	----	Abun. sulfides; cc repl. py.
	1292	45–52	0	9.50	0	high	----	Mod. total sulfides; cc replacs pyrite (moderately abundant)
	1293	52–59	0	25.50	0	high	----	Mod. total sulfides; cc replaces pyrite.
1954	1294	113–118	0	8.50	0	high	----	Low total sulfides; cc repl.py. Log notes: Tgr. 5–165' highly altered granodiorite. Qtz sericite alteration. Numerous qtz phenocrysts & stringers with some mb on fractures.
	1295	128–133	0	11.50	0	high	----	Low total sulfides; cc repl.py. See log notes.
	1296	133–138	trace	68	0	high	----	Mod. total sulfides; cc replace py; signif. moly (4.5 units). See log notes.
	1297	138–143	0	132.50	0	high	----	Mod. total sulfides; abun. cc repl. py. Signif. moly (6.5 un.).

			LINE COUNTS			PROPORTIONS		
			with Bn				*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	NOTES*
	1298	143–148	0	7	0	high	––––	See log notes. Low total sulfides; v. signif. mb (9 units). See log notes.
1947	1299	184–190	0	3	0	high	––––	V. low total sulfides. Trace mb
	1300	195–200	0	11	0	high	––––	Abun. sulfides; abun. oxides (hm, goethite).
	1301	200–204	0	18	0	high	––––	Abun. py; minor Fe–oxides.
	1302	208–212	trace	14	0	high	––––	Mod. total sulfides; cc replace pyrite (minor).
	1303	212–216	trace	11	0	high	––––	Mod. total sulfides; cp encap. by pyrite.
1912	1304	96–100	0	10	0	high	––––	Low total sulfides; signif. mb (2 units).
	1305	100–103	0	46	6	high	7.5 :1	Low total sulfides; moderate total oxides.
	1306	108–113	0	63	0	high	––––	Low total sulfides; cc abun. replacement of pyrite.
	1307	116–122	0	33	6	high	5.5 :1	Low total sulfides; Fe–oxides abundant.
	1308	127–132	0	6	1	high	6:1	Low total sulfides.
	1309	135–140	0	50	6	high	8:1	Mod. total sulfides; low total pyrite.
	1310	140–144	trace	52	2.50	high	21:1	Low total sulfides; cc replaces pyrite (abundant).
	1311	144–150	trace	107.50 tr bn–id?	7.50	high	14:1	Mod. total sulfides; low pyrite Cc replaces pyrite.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
	1312	167–173	0	13	3	high	4:1	Mod. total sulfides; abun. py; low Fe–oxides. Mb signif.
	1313	179–184	0	21	0	high	– – –	Mod.total sulfides;Fe–oxides replace pyrite.
1910	1314	130–134	0	9.50	1	high	9.5 :1	Mod. total sulfides; cc repl. py
1860	1315	41–45	0	0	0	– – – –	– – –	7 units of green Cu–ox. No sulfides Cu–oxides only ("fast leach).Abun. Fe & Cu–ox.; green Cu–ox. possibly malachite Log notes: Kc. Baked sandy sh. Considerable hm stain on fractures to 50 ft. At 50 ft Kc ends.
	1316	57–61	trace	0	0	– – – –	– – – –	1.50 units green Cu–oxides. Traces cp; Cu–oxides pres. Traces only py, cp. Green Cu–oxides present. Log notes: Tgr. Intensly caly altered Tgr. Lots of hm stain. Some clay on fractures. Hm stain decrease below 63 ft. Fault at 90',93',99',108', & 116'. V. minor cc on fractures below 93'
	1317	74–79	17	2	0	1: 8.5	– – – – – –	Low total sulfides.
	1318	79–82	71.50	5.50 tr bn	0	1:13	– – – –	Mod. total sulfides. See Log notes above.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	**SAMPLE NUMBER**	**INTERVAL SAMPLED**	**Cp**	**Cc+Dg+Id**	**Cv**	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
	1319	82–87	35	0	trace	low	----	Mod. total sulfides. See log notes
	1320	87–90	43	0	0	low	----	Mod. total sulf.; assoc. py–cp. See log notes above.
	1321	90–94	16	0	0	low	----	Mod. total sulfs; assoc. py–cp. See log notes.
	1322	94–99	2.50	1	0	1: 2.5	----	Low total sulfides. See log note
	1323	99–106	54.50	0	trace	low	----	Mod. total sulfides; cp replace mafics (?). See log notes.
	1324	106–113	40	0.50 cc tr bn	0.25	low	2:1	Low total sulfides. See log notes.
1882	1325	28–40	0	10.50	0	high	----	Mod. total sulfides; cp replace pyrite.
	1326	46–51	0	76	0	high	----	Moderate total sulfides.
	1327	51–56	0	24	0	high	----	Moderate total sulfides.
	1328	60–67	0	76	0	high	----	Abun. sulfides; abun. biotite.
	1329	67–74	trace	23.50	0	high	----	Low total sulfides; Trace cp repl. by cc; biotite.
	1330	74–80	0	36	0	high	----	Lo total sulfides;biotite abun
	1331	80–89	trace	65.50	0	high	----	Abun. sulfides as py. Abun. biotite.
	1332	89–94	0	29	0	high	----	Mod. total sulfides; biotite abundant.
1888	1547	620–628	1	116.25	trace	116:1	----	Moderate total sulfides.
	1548	637–650	12	79	0	6.6 :1	----	Moderate total sulfides.
	1549	650–662	8	14.25	0	1.8 :1	----	Moderate total sulfides.

			LINE COUNTS			PROPORTIONS		
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	*with Bn* Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	*without Bn* $\frac{(Cc+Dg)}{Cv}$	**NOTES***
	1550	662–675	2.25	5	0	2.2 :1	––––	Low total sulfides.
1889	1551	32–36	2	4	5	4.5 :1	0.8 :1	Moderate total sulfides.
	1552	36–41	11.50	5	0	0.4 :1	––––	Moderate total sulfides.
	1553	41–46	5.25	0	0	low	––––	Low total sulfides.
	1554	51–56	0.25	0.50	0	2:1	––––	Very low total sulfides.
	1555	56–61	49	9.75	0	0.2 :1	––––	Moderate total sulfides.
	1556	61–66	11.75	8.50	0	0.7 :1	––––	Moderate total sulfides.
	1557	66–71						No data.
	1558	81–86	1.50	2.25	0	1.5 :1	––––	Low total sulfides.
	1559	102–107						No data.
	1560	107–111						No data.
	1561	111–116						No data.
	1562	120–128	19.75	53.50	0	3:1	––––	Moderate total sulfides.
	1563	128–132	0.75	2.50	0	3:1	––––	Low total sulfides.
	1564	291–296	10.75	33.50	6.25	4:1	5:1	Moderate total sulfides.
	1565	296–301	8.25	64.50	1	8:1	64:1	Moderate total sulfides.
1930	1566	131–137	0	0	trace	––––	––––	No cc or cp w/trace cv obs. Very low total sulfides; very signif.Cu–oxide (13.25 units).
	1567	142–147	1.25	0	0	low	––––	Very low total sulfides; very signif. Cu oxides (17 units).
	1568	341–345						No data.
	1569	432–436						No data.
	1570	436–442	0	3	0	high	––––	Low total sulfides.
	1571	448–453	0	1	0	high	––––	Low total sulfides.
	1572	453–459	5.50	105	0.50	19:1	210:1	Moderate total sulfides.

			LINE COUNTS	*with Bn*		PROPORTIONS	*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	(Cc+Dg+Cv) / Cp	(Cc+Dg) / Cv	NOTES*
	1573	459–464	0.25	13.75	0	55:1	––––	Moderate total sulfides.
	1574	464–468	1.50	27.25	0	18:1	––––	Moderate total sulfides.
	1575	483–488	0.50	54	2.50	113:1	22:1	Moderate total sulfides.
	1576	507–513	2	19.25	0	10:1	––––	Moderate total sulfides.
	1577	513–518	1.25	11.50	0	9.2 :1	––––	Moderate total sulfides.
	1578	570–574	1	9.25	trace	9.25 :1	––––	Moderate total sulfides.
1698	1579	310–320	331.25	9.50	0	0.03 :1	––––	Abundant pyrite.
	1580	330–340	227	16.50	0.25	0.07 :1	66:1	Abundant pyrite.
	1581	360–370	15	0	0	v. low	––––	Moderate total sulfides.
	1582	370–380	264	0	0.25	0.0009 :1	low	Moderate total sulfides.
	1583	390–400	94.75	5.75	0.25	0.06 :1	23:1	Moderate total sulfides.
	1584	400–407	9.25	0.25	0	0.03 :1	––––	Moderate total sulfides.
	1585	410–420	33	4	0	0.12 :1	––––	Moderate total sulfides.
1591	1586	248–255	1	0.50	0	0.5 :1	––––	Low total sulfides.
	1587	255–260	3	0	0.75	0.25 :1	––––	Low total sulfides.
	1588	260–265	0.75	0	0.25	0.33 :1	––––	Very low total sulfides.
	1589	265–270	1	0	0.25	0.25 :1	––––	Low total sulfides.
	1590	270–275	1.25	0	0.25	0.2 :1	––––	Low total sulfides.
	1591	275–280	4.50	2.25	0.50	0.61 :1	4.5 :1	Low total sulfides.
	1592	280–285	2.50	1	0.25	2:1	4:1	Low total sulfides.
	1593	360–370	1.75	0.50	0	0.3 :1	––––	Low total sulfides.
	1594	430–440	8.50	0.25	0	0.03 :1	––––	Moderate total sulfides.
	1595	440–450	5	2.50	0.25	0.6 :1	10:1	Moderate total sulfides.
	1596	450–460	3	0	0.25	0.08 :1	––––	Low total sulfides.
	1597	541–550	10.75	0	0	v. low	––––	Moderate total sulfides.
	1598	550–560	16.75	0	0	v. low	––––	Moderate total sulfides.

			LINE COUNTS			PROPORTIONS		
				with Bn			without Bn	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	NOTES*
	1599	580–590	4.50	0.25	0	0.06 :1	––––	Low total sulfides.
	1600	590–600.5	2	2	0	1:1	––––	Low total sulfides.
1592	1601	375–390	11.50	1.25	6.50	0.8 :1	0.2 :1	Moderate total sulfides.
	1602	390–400	28.50	2.50	1.25	0.1 :1	2:1	Moderate total sulfides.
	1603	400–410	17.25	1.25	2.75	0.2 :1	0.5 :1	Moderate total sulfides.
	1604	410–420	1	4	1.50	6:1	3:1	Low total sulfides.
1500	1605	437–442.2	0	0	0.25	––––	low	Very low total sulfides. <u>Log note</u>: Purple latite, barren 422–443 ft.
	1606	442.2–447.2	4.75	1.25	11.75	3:1	0.1 :1	Moderate total sulfides. <u>Log note</u>: Kep w/ py, local cc. 443–461 ft.
	1607	452–457	7.75	3.75	13	2:1	0.3 :1	Mod. total sulfides. See log note above.
	1608	457–459.6	20.25	2.25	60.25	3:1	0.05 :1	Mod. total sulfides. See log note above.
	1609	459.6–466.6	20	0	1	0.05 :1	––––	Mod. total sulfides. See log note above. <u>Log note</u>: 461–488 ft Fault zone, numerous slips w/ gouge. Some py, localized cc.
	1610	466.6–471.6	6	0.25	7.75	1:1	0.03 :1	Moderate total sulfides. See log note #1609.
	1611	471.6–477	5.50	2.25	5.75	1.5 :1	0.4 :1	Mod. total sulfides. See log note #1609.
	1612	477–481.8	11.25	7.25	7.75	1:1	1:1	Mod. total sulfides. See log

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
								note #1609.
	1613	481.8–484.8	10.75	1.75	42.50	4:1	0.04 :1	Mod. total sulfides. See log note #1609.
	1614	506.5–512.3	1.25	37.25	5.50	34:1	7:1	Moderate total sulfides. Log note: Fault zone w/Kep. Much gouge w/ ground py 500–562'.
	1615	512.3–518.5	0	3.50	0.25	high	14:1	Low total sulfides. Same log note.
1501	1616	465–469.8	5.25	1	0.25	0.2 :1	4:1	Low total sulfides.
	1617	469.8–473.5	9.50	0.25	trace	0.03 :1	– – – –	Low total sulfides.
	1618	490–493.2	12	0.25	0	0.02 :1	– – – –	Moderate total sulfides.
	1619	498.6–502.7	5	0	0	v. low	– – – –	Low total sulfides.
	1620	515.9–521.9	31.25	0.50	trace	0.02 :1	– – – –	Moderate total sulfides.
	1621	521.9–527.4	17.50	1	trace	0.06 :1	– – – –	Moderate total sulfides.
	1622	535–540	5.50	9.75	0	2:1	– – – –	Moderate total sulfides.
	1623	540–544.2	2.75	0	0.25	0.09 :1	– – – –	Low total sulfides.
	1624	544.2–548.4	18.25	3.50	0	0.2 :1	– – – –	Moderate total sulfides.
	1625	548.4–553	2.75	0	0.25	0.09 :1	– – – –	Low total sulfides.
	1626	553–556.1	11	0.25	0	0.02 :1	– – – –	Moderate total sulfides.
	1627	556.1–560.7	7.75	0.25	0	0.03 :1	– – – –	Low total sulfides.
	1628	560.7–565.8	7.25	0.25	0	0.03 :1	– – – –	Low total sulfides.
	1629	568.7–573.7	7.75	33	0	4:1	– – – –	Moderate total sulfides.
1546	1630	310–319	5.75	0.50	0.25	0.1 :1	2:1	Low total sulfides.
	1631	319–330	19.75	3.50	0	0.2 :1	– – – –	Moderate total sulfides.
	1632	330–340	15.75	0.25	0.25	0.03 :1	1:1	Moderate total sulfides.
	1633	350–355.6	14	0	0.50	v. low	low	Moderate total sulfides.

			LINE COUNTS			PROPORTIONS		
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	*with Bn* Cc+Dg+Id	Cv	$\frac{\text{(Cc+Dg+Cv)}}{\text{Cp}}$	*without Bn* $\frac{\text{(Cc+Dg)}}{\text{Cv}}$	NOTES*
	1634	355.6–360	10.25	0.50	0	v. low	----	Moderate total sulfides.
	1635	360–371.7	7	3	0	0.5 :1	----	Moderate total sulfides.
	1636	380–389	13	0.50	0	low	----	Moderate total sulfides.
	1637	389–400	42.50	2.25	0	v. low	----	Moderate total sulfides.
	1638	450–460	30.75	3	0	low	----	Moderate total sulfides.
	1639	460–470	83.25	0.75	0	v. low	----	Moderate total sulfides.
	1640	480–488	22.50	1.25	0	low	----	Moderate total sulfides.
	1641	488–513.1	37.50	2.25	0	low	----	Moderate total sulfides.
	1642	513.1–533.3	55.25	3	0.25	v. low	12:1	Moderate total sulfides.
	1643	533.3–540	70.50	6	0	v. low	----	Moderate total sulfides.
	1644	540–550	58.25	4.50	0	v. low	----	Moderate total sulfides.
1559	1645	500–510						No ratio data. <u>Log note</u>: Cs 500–504 ft. Fault, gouge & breccia of broken shales that are chloritiz., mgt content up to 15%, py 10%, cc & cpy. Little garnet. Shales w/ a small amount of sill breccia.
	1646	545–555						No ratio data. <u>Log note</u>: At 504' fault continues but breccia of altered Tgr. Some epidote & chlorite. About 5% py, some cc.
	1647	600–610						No ratio data. <u>Log note</u>: at 604' stage 3&4 Tgr, py w/minor cc & mb on fractures.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
								All in fault zone
	1648	610−620						No ratio data Same log note.
	1649	620−630						No ratio data. Same log note.
1548	1650	325−335						No ratio data. <u>Log note</u>: Klp.5% py. all v. broken
	1651	387−397.7	0.75	15.50	0	21:1	−−−−	Moderate total sulfides. <u>Log note</u>: Tqm. Mgt at 397−60% of core. Py 20%.
	1652	397.7−410	11.25	5	0	1:2	−−−−	Mod. total sulfides. Same log note as above.
	1653	430−440	2.25	12	0	5:1	−−−−	Moderate total sulfides. <u>Log note</u>: Cs. shale v. broken & altered. Some mgt , hm on seams. Py 3%. All v. altered. Chlorite common. Cp 1%. Lm staining.
	1654	440−451.7	18.50	29.75	3.50	2:1	9:1	Mod. total sulfides. Same log note as above.
	1655	451.7−460	49	9.75	0	1:5	−−−−	Mod. total sulfides. Same log note as above.
	1656	470−480	11.75	8.50	0	1: 1.3	−−−−	Mod. total sulfides. Same log note as above.
	1657	480−483.7						No ratio data. Same log note as above.
	1658	483.7−493.7						No ratio data. Same log note as above.

DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	LINE COUNTS			PROPORTIONS		NOTES*
			Cp	*with Bn* Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	*without Bn* $\frac{(Cc+Dg)}{Cv}$	
	1659	493.7–505.1						No ratio data. Same log note as above.
	1660	507.7–518						No ratio data. Log note: Co. At 516' green breccia of ls. Green matrix, probably Tqm at 522 ft.
	1661	540–550						No ratio data. Log note: Co. Mgt zone. Mgt 100% of core locally. Py 2%. Shale in zone also contain much mgt. Shale as described in 422–516'. Breccia zone recemented by silica at 591'.
	1662	591.6–602						No ratio data. Log note: Co. sh & ls v. broken & altered. Zone leached locally w/lm stain & chlorite. Py up to 15%. Py locally w/minor cp, garnet common below 645'. Cc common in bands. Cherty zones common.
	1663	600–610						No ratio data. Same log note as above.
	1664	610–615.3						No ratio data. Same log note as above.
1703	1665	410–420	311.7	1.25	1.25	v. low	1:1	Abundant total sulfides.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
	1666	420–430	427	7	0	v. low	----	Abundant total sulfides.
	1667	430–440	205.7	2.75	0	v. low	----	Abundant total sulfides.
	1668	460–470	264.7	13.25	0	v. low	----	Abundant total sulfides.
	1669	510–520	387.50	1.75	trace	v. low	----	Abundant total sulfides.
	1670	520–530	384.50	1.25	0	v. low	----	Abundant total sulfides.
	1671	530–540	279.7	1.25	0	v. low	----	Abundant total sulfides.
	1672	550–560	266.25	53.50	0	v. low	----	Abundant total sulfides.
	1673	108–117	5.75	24.75	32.25	10:1	1: 1.3	Moderate total sulfides.
	1674	117–127	66.7	17	67	1.3 :1	1:4	Moderate total sulfides.
1788	1675	144–156	12.25	67.25	0.25	6:1	269:1	Moderate total sulfides.
	1676	290–300.5	0	27.50	0	high	----	Moderate total sulfides.
	1677	300.5–309.5	31	10.50	8.25	1: 1.7	1.3 :1	Moderate total sulfides.
1722	1678	320–330	40.50	18	0.25	1:2	72:1	Moderate total sulfides.
	1679	330–340	0	189	0	v. high	----	Moderate total sulfides.
	1680	345–350	0	147.50	0	v. high	----	Moderate total sulfides.
	1681	350–360	0	223.75	0	v. high	----	Moderate total sulfides.
	1682	360–370	0	36.25	0	v. high	----	Moderate total sulfides.
	1683	370–380	0	105.25	0	v. high	----	Moderate total sulfides.
	1684	380–388	0	117.50	0	v. high	----	Moderate total sulfides.
	1685	388–390	0	191.50	0	v. high	----	Moderate total sulfides; signif. Cu (24.25 units).nativ?
	1686	390–400	0	7.25	0	high	----	Moderate total sulfides.
	1687	410–421	0	89.25	0	high	----	Moderate total sulfides.
1814	1688	159–162	0	442.25	0	high	----	Abundant total sulfides.
	1689	190–195	0	23.75	0	high	----	Moderate total sulfides.
	1690	195–200	0	48.50	0	high	----	Moderate total sulfides.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
	1691	205–210	1.50	185.75	3.25	126:1	57:1	Moderate total sulfides.
	1692	210–215	0	68.75	0	high	––––	Moderate total sulfides.
	1693	215–220	0	216.75	trace	high	––––	Moderate total sulfides; signif. moly (8.25 units).
	1694	220–225	0	222.75	0	high	––––	Mod. total sulfides; significant moly (1.75 units).
	1695	225–230	2.25	226.50	0	101:1	––––	Mod. total sulfides; significant moly (1.75 units).
	1696	230–235	1.25	66.25	0	53:1	––––	Moderate total sulfides; signif. moly (1.75 units).
	1697	235–246	0	282.50	0	v. high	––––	Abundant total sulfides.
1823	1698	0–6	7.50	37	0	5:1	––––	Moderate total sulfides.
	1699	11–24	10.25	169	150.50	31:1	1:1	Abundant total sulfides.
	1700	24–29	7.75	141.50	10.50	17:1	13:1	Moderate total sulfides.
	1701	46–53	0	107	6.50	v. high	16:1	Moderate total sulfides.
	1702	131–135	55.75	34.50	21.50	1:1	1.6 :1	Moderate total sulfides.
	1703	143–150	26	148.75	56.75	8:1	3:1	Abun. total sulfides; signif. moly (48.25 units).
1945	1704	185–190	61.75	82	0	1.3 :1	––––	Moderate total sulfides.
	1705	190–195	197.25	98.50	87	1:1	1.1 :1	Abundant total sulfides.
1955	1711	66–70	0	21	77.75	high	1: 3.7	Py 43%. Cv repl cc.
	1712	82–87	1	26.88	20.25	47:1	1.3 :1	Py 37%. Hm/mgt. Bn 0.13 un.
	1713	103–108	0	5.25	18.25	high	1: 3.5	Py 45%. Some oxides.
	1714	108–113	0	11.25	8.25	high	1.4 :1	Py 47%. Some cc rims py. Less oxides (mgt).
	1715	113–118	185	17.50	113.75	1: 1.4	1: 6.5	Py 45%. Cc & cv rims cp. Cv

			LINE COUNTS			PROPORTIONS		
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	*with Bn* Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	*without Bn* $\frac{(Cc+Dg)}{Cv}$	**NOTES***
								repl cc. some oxides.
	1716	128–133	95	35	25.25	1: 1.6	1.4 :1	Py 25%. Hi %oxides. Cc repl. cp and py.
	1717	133–139	110	33	22	1:2	1.5 :1	Py 50%. Less oxides.
1579	1721	470–480	9	25	5.5	3.4 :1	4.5 :1	Pyrite abundant (80%). Cp replaces py.
	1722	480–490	1	5	2.5	5:1	2:1	Pyrite 6%. Low total sulfides.
	1723	490–500	0	1.5	1	high	1.5 :1	Pyrite<5%. Low total sulfides
	1724	500–510	0	0	1.25	high	low	Pyrite 3%. Very low total sulf.
	1725	510–520	0	0	0.25	high	low	Pyrite 3%. Very low sulfides.
	1726	520–530	5.5	12.75	3	3:1	4.3 :1	Pyrite 5%. Sulfides increasing
	1727	530–536	2.5	2.5	0.25	1:1	10:1	Pyrite 4%. Low total sulfides.
	1728	536–542	0.75	0	0.75	1:1	low	Pyrite 5%. Low total sulfides.
	1729	550–560	20.25	0	0.50	1: 40.5	low	Pyrite 3%.
	1730	560–570	4.5	0	1	1: 4.5	low	Pyrite 5%.
	1731	570–580	1.5	0	0.25	1:6	low	Pyrite 3%.
	1732	580–590	0.75	0	0	low	––––	Pyrite 2%.
	1733	680–690	1.25	0	0.75	1: 1.7	low	Pyrite 3%.
1580	1734	190–195	0	2.25	0.25	high	9:1	Pyrite 3%. Hm, mt, TiO noted
	1735	195–200	1	8.5	0.25	8.75 :1	34:1	Pyrite 4%. Hm, mt noted.
	1736	200–205	0	11.50	0.75	high	15:1	Pyrite 23%.
	1737	205–210	2.25	8.50	0.50	4:1	17:1	Pyrite 20%.
	1738	272–275	2	10.5	0	5.3 :1	–––	Pyrite 17%.
	1739	310–315	3	1.5	0	1:2	–––	Pyrite 15%.
	1740	325–328	8	3	0	1: 2.7	–––	Pyrite 1%. Bn 1 unit.
	1741	330–335	7	3.25	4.63	1.1:1	1:1.4	Pyrite 1%.

			LINE COUNTS			PROPORTIONS		
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	*with Bn* Cc+Dg+Id	Cv	(Cc+Dg+Cv) / Cp	*without Bn* (Cc+Dg) / Cv	NOTES*
	1742	335–338.9	6	5.75	0	1:1	– – –	Pyrite 3%.
	1743	338.9–347	8	4.25	0	1:2	– – –	Pyrite 3%.
1651	1744	60–65	2.75	2.50	0.13	1: 1.05	19:1	Pyrite 20%.
	1745	135–140	0.25	2.25	0.13	9.5 :1	17:1	Pyrite 3%.
	1746	140–150	3.50	0.75	0.13	1:4	6:1	
	1747	150–160	6.5	0.38	4	1: 1.5	1: 10.5	
	1748	160–170	6	4.75	5	1.6 :1	1: 1.05	Pyrite 15%.
	1749	170–180	8.5	5.25	0.25	1: 1.5	21:1	Pyrite 11%.
	1750	180–190	2.25	2.25	0.25	1.1 :1	9:1	
1682	1751	160–165	3.25	0	0.25	1:13	low	Pyrite 8%.
	1752	165–170	18	37.75	0.25	2.1 :1	150:1 high	Pyrite 3%. Bn 0.25 units.
	1753	170–175	0	11.25	1	high	11.25 :1	Pyrite 7%
	1754	210–215	2.50	1.88	1.25	1.3 :1	1.5 :1	Pyrite<1%. Native Cu noted.
	1755	220–225	6.50	36.63	2.25	6:1	16:1	
	1756	225–230	15	32.75	0	2.2 :1	– – –	Coating
	1757	230–235	6.75	42	0.13	6.2 :1	323:1 high	Coating.
1683	1758	250–260	14	3.25	0.25	1:4	11:1	All sampled intervals in skarn.
								Coating. Bn 0.50 units.
	1759	280–290	7	1.75	0.38	1: 3.3	4.6 :1	Pyrite 6%. Cc, cp, cv repl. py.
	1760	299.5–310	4	1.25	0.38	1: 2.5	3.3 :1	Py 5%. Cc, cp, cv repl. py.
	1761	310–320	7	3.25	0.75	1:2	4:1	Py 45. Cc, cp ,cv repl. py.
	1762	320–330	20	6.5	0	1:3	– – –	Pyrite 4%.
	1763	340–352	14.75	1.5	0.25	1: 8.4	6:1	Pyrite 5%.
	1764	352–360	5	5.13	0.25	1:1	20:1	Pyrite 4%
	1765	360–370	34	9.5	0.25	1: 3.5	36:1	Pyrite 5%. Bn 0.50 units.
	1766	370–380	67	10.25	0	1: 6.5	– – –	Pyrite 3%

			LINE COUNTS			PROPORTIONS		
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	*with Bn* Cc+Dg+Id	Cv	(Cc+Dg+Cv) / Cp	*without Bn* (Cc+Dg) / Cv	**NOTES***
	1767	390–400	48	1.5	0	1:32	– – –	Pyrite 2%.
	1768	400–410	108	21.5	0.13	1:5	46:1	Py 10%. Bn 15.50 units.
	1769	410–420	31.50	18.50	0	1: 1.7	– – –	Py 4%. Bn 4.75 units.
	1770	450–460	61.50	4	0.75	1:13	1.3 :1	Py 3%. Bn 3 units.
1690	1771	50–55	109	14	0	1:8	– – –	All sampled intervals in skarn. Py 4%. Bn 6.50 units.
	1772	55–60	129	6.25	0.25	1:20	25:1	Py 12%.
	1773	71–80	52	2.75	0	1:19	– – –	Bn 0.25 units.
	1774	80–90	190	49.75	0	1:4	– – –	Py 8%. Bn 5.13 units.
	1775	100–110	90	19	0.63	1: 4.6	30:1	Py 10%.
	1776	110–120	29	17.50	0.50	1: 1.6	33:1	Cc repl. py, cp. Bn 1 unit.
	1777	120–123	15.5	2.25	0.25	1:6	9:1	
	1778	123–130	68	58.75	0.25	1: 1.2	216:1 high	Bn 4.75 units.
	1779	130–140	7	4.50	0.25	1: 1.5	17:1	Bn 0.25 units
	1780	140–150	21.25	1.25	0.13	1:15	8:1	Bn 0.25 units, coating on cc.
	1781	150–160	3.25	1.25	0.13	1: 2.4	9:1	
	1782	160–170	10.50	3.75	0.38	1: 2.5	9:1	Bn 0.25 units.
	1783	180–190	14.25	2	0	1:7	– – –	
	1784	190–200	5.50	1.50	0	1: 3.7	– – –	
	1785	200–210	19	4.25	0	1: 4.5	– – –	Bn 1 unit.
1733	1786	50–54.5	3.5	99.13	1.38	29:1	72:1 high	Py 20%. Rutile abun.Hm. Cc replacing py. Trace bn
	1787	54.5–60	33	49	0.25	1.5 :1	184:1 high	Py 20%. Mgt. Bn repl. cp. Cc replacing py, cp. Bn 3 units.
	1788	70–80	39.75	111.5	1.13	2.8 :1	97:1 high	Same as 1787. Bn 1.5 units.
	1789	80–90	75.5	60.5	0.38	1: 1.2	125:1 high	Py 25%. Hi % hm. Mt– >hm.

DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	LINE COUNTS Cp	LINE COUNTS *with Bn* Cc+Dg+Id	LINE COUNTS Cv	PROPORTIONS (Cc+Dg+Cv) / Cp	PROPORTIONS *without Bn* (Cc+Dg) / Cv
	1790	90–100	58.25	100.5	0.13	1.7 :1	567:1 high
	1791	100–108.7	87.5	33.75	0.25	1: 2.6	111:1 high
	1792	108.7–110	461.5	12.63	0.25	1:36	42:1
	1793	110–120	40	3	0.25	1:12	11:1
	1794	120–130	7.50	5.38	0	1: 1.4	– – –
	1795	130–140	22.25	17.63	0.13	1: 1.3	116:1 high
	1796	140–150	51.25	2.25	0.50	1:19	low
	1797	150–160	10.75	2.5	0.38	1: 3.7	6.6 :1
1743	1798	110–120	61.75	4.25	0.25	1:14	5:1
	1799	120–130	113.5	3.38	0.38	1:30	4.3 :1
	1800	130–140	43.75	7.25	0.13	1:6	33:1
	1801	160–170	8.5	49.88	17	8:1	3:1

NOTES*

Bn,cc replacing py, cp. Rutile.
Bn 12.75 units.
Py 22%. Same as 1789.
Bn 26.75 units.
Same as 1789. Bn 6 units.
Py ?%. Mgt 15%. Minor hm
rutile, lue? Cc mineral and as
replacement along w/bn of py
and cp. Bn 2.25 units.
Py 5%. Hm. Cc on py. Bn 0.25.
Py>1%. Hm, mgt. Low sulfid
and oxides. Bn 1.63 units.
Py 25%.Cc repl. py/cp.Hm,mt.
Bn 2.50 units.
Py 10%. HI mgt. Bn repl. cp.
No cc. Bn 1.75 unit
Py 7%.
All sampled intervals in skarn.
Py 8%. Hi% hm&mgt. Hm
repl. mgt. Cc repl. cp. Cc/bn
repl. cp. Bn 3 units.
Py 7%. Mgt and hm hi%.
Bn 1.75 units.
Py 5%. Hi% mgt. Hm. Bn
repl. cp. Bn/cc on mgt? Bn 3 u.
Py 12%. Supergene? py–>cc

			LINE COUNTS			PROPORTIONS		
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	*with Bn* Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	*without Bn* $\frac{(Cc+Dg)}{Cv}$	NOTES*
								Hm/mgt. Bn 1 unit.
	1802	200–210	283.5	10.75	0.13	1:26	75:1 high	Py 7%. Cp–>cc/bn. Hm. Bn1
	1803	210–220	121	14.26	0	1: 8.5	---	Cp–>bn.Cp–>cc. cc+bn.
								Bn 2.88 units.
	1804	220–230	68.25	15.13	0.13	1: 4.5	43:1	Py 10%. Cp–>bn/cc. Cc min.
								Bn 9.50 units.
1801	1805	127–135	126.5	20.75	0.50	1:6	27:1	All sampled intervals in skarn.
								Py 10%. Cc on hm/mgt. Cc/bn.
								Bn repl. cp. Bn 7.25 units.
	1806	135–143	32.50	16.13	0.75	1:2	20:1	Bn 1.38 units.
	1807	153–161	72.75	26.75	0.25	1: 2.7	92:1 high	Py 9%. Cc coating hm. Bn/cc
								on cp. Cc&bn together.
								Hm/mg present. Bn 3.75 units.
	1808	161–171	21.25	4.38	0.13	1: 4.7	26:1	Py 5%. hm, mgt. Bn 1 unit
	1809	171–176	14.5	5	0	1:3	---	Py 15%. Mg–>hm.
	1810	176–185	17.50	4.25	0	1:4	---	Py 15%. Hm, mgt.
	1811	185–192	32.75	1.75	0	1:19	---	Py 17%. Bn w/cc rims cp.
								Hm/mgt present. Bn 1 unit.
	1812	192–197	21.5	7.38	0.50	1: 2.7	11:1	Py 10%. Cc w/bn. hm/mg.
								Bn 2.13 units.
	1813	197–200	39.75	18.26	0	1: 2.2	---	Cc on hm?Hm pres. Cc on cp.
								Bn 2.38 units
	1814	200–212	23.75	17.38	0	1: 1.4	---	Py 27%. cc on hm. Hm/mt hi.
								Bn 2.13 units.
	1815	212–222	41.50	23.13	0.25	1: 1.8	86:1 high	Cc on hm. Cc on py/cp.
								Bn 1.63 units.

			LINE COUNTS *with Bn*			PROPORTIONS	*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	**NOTES***
1841	1816	106–112	79.5	5.26	0.50	1:14	5:1	Py 5%. Hi% oxides. Bn 2.88 u.
	1817	115–120	17.75	1.025	0	1:17	– – –	Py 1%. Cc w/bn on cp & py. Bn 0.25 units.
	1818	120–125	88.5	7.50	0	1:12	– – –	Py 2%. Hi% oxides. Bn 6.5 u.
	1819	130–134	126	0	0	low	– – –	Py 3%. Oxides. Bn 1 unit
	1820	134–139	31.50	10.75	0	1:3	– – –	Py 1%. Cc on cp & py. Bn/cc on cp & py. Hi% hm. Bn 1 un.
	1821	145–150	36.25	3	0	1:12	– – –	Py 1%. cc bn together Hi% hm Bn 1.50 units.
	1822	167–172	162.5	0	trace	low	– – –	Py 3%. hm/mt
	1823	233–239	278	1.75	0	1:159	– – –	Py 4%. Hm repl. mt. Bn on cp. Bn 1 unit.
	1824	243–250	137	2.13	0	1:64	– – –	Py 3%. Cc w/bn on cp Some hm. Bn 0.25 units.
	1825	261–266	114.5	0	0	low	– – –	Py 3%. Hm w/mt present.
	1826	266–272	219.5	2.5	0	1:88	– – –	Py 1%. Cc on cp. Minor hm.
	1827	292–299	369	0.75	0	1:492	– – –	Py<1%. Mgt. Clay contamin.
1847	1828	83–87	285.5	9.63	0	1:29	– – –	Py 18%. Bn w/cc on cp. oxides. Bn 0.38 units. Log notes: Cs. Baked & chloritized shale w/py disseminated & on fractures. Minor cc w/py. Tgr intrusion at 80’, 90–92’. Fault at 90, 93, 101’. Tgr intrusion at 99–102’. Py increases below 107’. Cs 71–115

DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	LINE COUNTS			PROPORTIONS		NOTES*
				with Bn			*without Bn*	
			Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	
	1829	87–90	319	3.25	0	1:98	– – –	Py 22%. Bn w/cc on cp. Minor oxides. Bn 2.25 units. Same log notes as above.
	1830	90–93	191	2.75	0	1:69	– – –	Py 10%. Bn on cp. some hm Bn 2 units. Same log notes above
	1831	115–121	145	42.13	0.88	1: 3.4	47:1	Py 40%. Cc on cp & py. Cv repl cc. Little or no ox. Bn 0.38 un. <u>Log note</u>: Tgr 115–202'. Clay alteration of Tgr.
	1832	129–134	153.5	21.26	0	1: 7.2	– – –	Py 18%. Cc w/bn on cp. Oxides Bn 5.13 units. <u>Log note</u>: Tgr. Quite fresh med. grained Tgr. Py disseminated & on fractures. Cp occurs. Lots of chlorite on fractures.
	1833	134–139	77	1.50	0.38	1:41	4:1	Py 10%. Cc min. & on cp. Same log note as above.
	1834	139–143	338	8.75	0	1:38	– – –	Py 40%. Cc w/bn on cp. Hm. Bn 0.75 units. Same log notes above.
	1835	143–147	405	8.25	0.50	1:46	11:1	Py 30%. Cc on cp & as minerals. Oxides. Bn 2.50 units. Same log notes as above.
	1836	147–154	257	4.13	0	1:62	– – –	Py 20%. Cc on cp. Hm.Bn 0.13. Same log note as above.

			LINE COUNTS			PROPORTIONS		
				with Bn			*without Bn*	
DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	Cp	Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	$\frac{(Cc+Dg)}{Cv}$	NOTES*
	1837	159–166	371	1	0	1:371	– – –	Py 2%. Same log note as above.
	1838	181–185	325	5.5	0	1:59	– – –	Py 1%. Mgt. Same log note above
	1839	200–204	187	1	0	1:187	– – –	Py 1%. Mgt. Same log note as above. <u>Log note</u>: Cs at 202 ft.
1885	1840	26–34	3	0	0	low	– – –	Very little py. Hm 99.9% Oxidation Zone
	1841	34–39	0.50	0	0	low	– – –	Same as 1840
	1842	39–44	0	0	0	– – – – – –	– – –	Py ~ 1 or 2%. Same as 1840
	1843	44–49	0	0	0	– – – – – –	– – –	Py 2–3%. Same as 1840.
	1844	68–75	0	0	0	– – – – – –	– – –	Py ~ 1%. Some chrysocolla. Same as 1840
	1845	75–80	1	0	0	low	– – –	Very minor py. Same as 1840
	1846	80–85	0	0	0	– – – – – –	– – –	Py<1%Hm 98%.Native Cu. Chrysocolla 1%. Ox. Zone.
	1847	85–90	1.5	0	0	low	– – –	Py<1%. Native Cu. Chrysocolla. Ox. Zone.
	1848	90–95	6	0	0	low	– – –	Same as 1847, but no Cu*.
	1849	99–104	0.75	0	0	low	– – –	Minor py. Same as 1847 but not as hematitic. Chrysocolla.
	1850	104–107	1.5	0.50	0	1:3	– – –	Same
	1851	125–130	5.75	8	0	1.4 :1	– – –	Lesser hm. Cc on cp.
	1852	130–133	0	0	0	– – – – – –	– – –	Py<15. Mgt present 99%hm. Chrysocolla present. Ox Zone
	1853	133–138	0	0	0	– – – – – –	– – –	Same as 1852.

DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	LINE COUNTS with Bn Cp	LINE COUNTS with Bn Cc+Dg+Id	LINE COUNTS with Bn Cv	PROPORTIONS $\frac{(Cc+Dg+Cv)}{Cp}$	PROPORTIONS without Bn $\frac{(Cc+Dg)}{Cv}$	NOTES*
1887	1854	146–150	0	0	0	–––––	–––	Same as 1852 but with much more Chryso. and native Cu.
	1855	150–154	0	0	0	–––––	–––	Same as 1852. 2 grains of py.
	1856	154–157	1.75	0	0	low	–––	Same as 1852.
	1857	157–162	0	0	0	–––––	–––	Same as 1852.
	1858	243–248	trace	65	0	high	–––	Oxidation Zone. Cc rims cp.
	1859	191–194	1.5	0	0	low	–––	Ox. Zone.
	1860	224–232	4	0.75	0	1:5	–––	Ox. Zone. 1% Cu*. Cc on Cu* Cc on hm.
	1861	424–435	4.50	49.25	3.63	12:1	10:1	Py 13%. Cv on cc w/bn. Bn 12.75 units.
	1862	445–458	6.50	223.75	6	35:1	34:1	Py 25%. oxides. Bn 20.75 units
	1863	458–467	6.75	209	5.25	32:1	34:1	Py 55%. Bn 32 units.
	1864	467–477	91.5	213.75	30.25	2.7 :1	4.4 :1	Py 5%. Cv on cc w/bn on cp. Some cp completely replaced. Oxides Bn 80.50 units.
	1865	531–541	100.25	23.51	2.75	1:4	5:1	Py 35%. Some oxides. Cc w/bn on cp. Cc minerals. Bn 9.63 un.
	1866	541–551	215	14.63	0.25	1:14	17:1	Py 20%. Oxides. Bn 10.38 un.
	1867	551–561	414	29.88	0.25	1:14	58:1	Py 50%. Oxides. Bn w/cc on cp & py. Bn 15.38 units.
	1868	567–576	54.5	31.25	0.25	1: 1.7	67:1	Py 4%. Cc w/bn on hm & cp Cc repl. bn. Bn 14.5 units
2006	1869	85–90	12.75	9.5	17.4	2:1	1: 1.8	Py 10%. Heavies & lights not separated. Cc & cv on py,cp, & hm.

DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	LINE COUNTS Cp	LINE COUNTS *with Bn* Cc+Dg+Id	LINE COUNTS Cv	PROPORTIONS (Cc+Dg+Cv) / Cp	PROPORTIONS *without Bn* (Cc+Dg) / Cv	NOTES*
	1870	95–100	1	16.38	38	54:1	1: 2.3	Py ?%. Cc w/cv on py. Cv repl. cc. Cv minerals. Hm present.
	1871	110–115	1.5	60.13	17.75	79:1	3.4 :1	Py 35%. Cv on py & hm. Cv repl. cc. Cc repl. cp.
	1872	115–120	4.25	20	5.63	6:1	3.5 :1	Py 48%. Cc on py. Hm.Cv–> cc.
	1873	145–150	0	84.25	0	high	– – –	Py 40%. Mgt. Cc rims py. Bn 0.25 units.
	1874	150–155	0	31	0	high	– – –	Py 50%.
2008	1875	129–134	0.25	72.63	197.25	1070:1 high	1:2.7	Py 47%. Cc on py. Cc repl. cv. <u>Log note:</u> Kc 70–543 ft. Silicified sh & fine grained qtzite, bleached hm stains on fractures. Py on fractures. V. thin cc coating on py. 143' small fault. Cc w/py to 191' & occassionally below. Cpy w/py on fractures at 382 ft.
	1876	134–138	3.25	110.5	11.88	38:1	9:1	Py 50%. cc on cp. Cv on cc. Same log note as above.
	1877	155–158	7.50	146	16.25	22:1	9:1	Py 37%.Cc w/bn on cp.Bn 1.25 Same log note as above.
	1878	163–168	0.50	356.75	9.25	732:1 high	38:1	Py 55%. Cv on cc. Cc on py. Same log note as above.
	1879	175–180	1.5	153.50	0.25	102:1	614:1 high	Py 40%. Mgt. Cc rims py. Same log note as above.

DRILL HOLE	SAMPLE NUMBER	INTERVAL SAMPLED	LINE COUNTS			PROPORTIONS		NOTES*
			Cp	*with Bn* Cc+Dg+Id	Cv	$\frac{(Cc+Dg+Cv)}{Cp}$	*without Bn* $\frac{(Cc+Dg)}{Cv}$	
	1880	185−191	0.25	78.25	28.75	428:1 high	2.7:1	Py 45%. Cc on py. Same log note as above.
	1881	191−195	1.25	98	157.75	205:1 high	1:1.6	Py 47%. Cc on py. some cc on cv. Same log note as above.
	1882	230−235	0.25	31.75	11.75	174:1 high	2.7:1	Py 40%. Cp−>cv−>cc? Same log note as above.
	1883	280−285	22.5	19	9.25	1.3 :1	2:1	Py 35%. Oxides. Cc w/cv on cp Cc on py. Same log note above.
	1884	300−305	3.25	12.75	7.50	6:1	1.7 :1	Py 52%. Mgt. pres? Cv on cc. Cv on cp. Same log note above.
	1885	311−316	3.5	9.5	4.75	4:1	2:1	Py 60%. Cc on py. Cc w/cv on cp. Same log note as above.
	1886	319−323	8.25	6.5	7	1.6 :1	1:1	Py 45%. Cc w/cv on cp. Cc on py. Same log note as above.
	1887	347−352	64.5	0.50	0.50	1:64	1:1	Py 47%. Same log note as above
	1888	352−357	128.75	0.50	0.50	1:129	1:1	Py 45%. Cc & cv together. Same log note as above.

This thesis is accepted on behalf of the faculty of the Institute by the following committee:

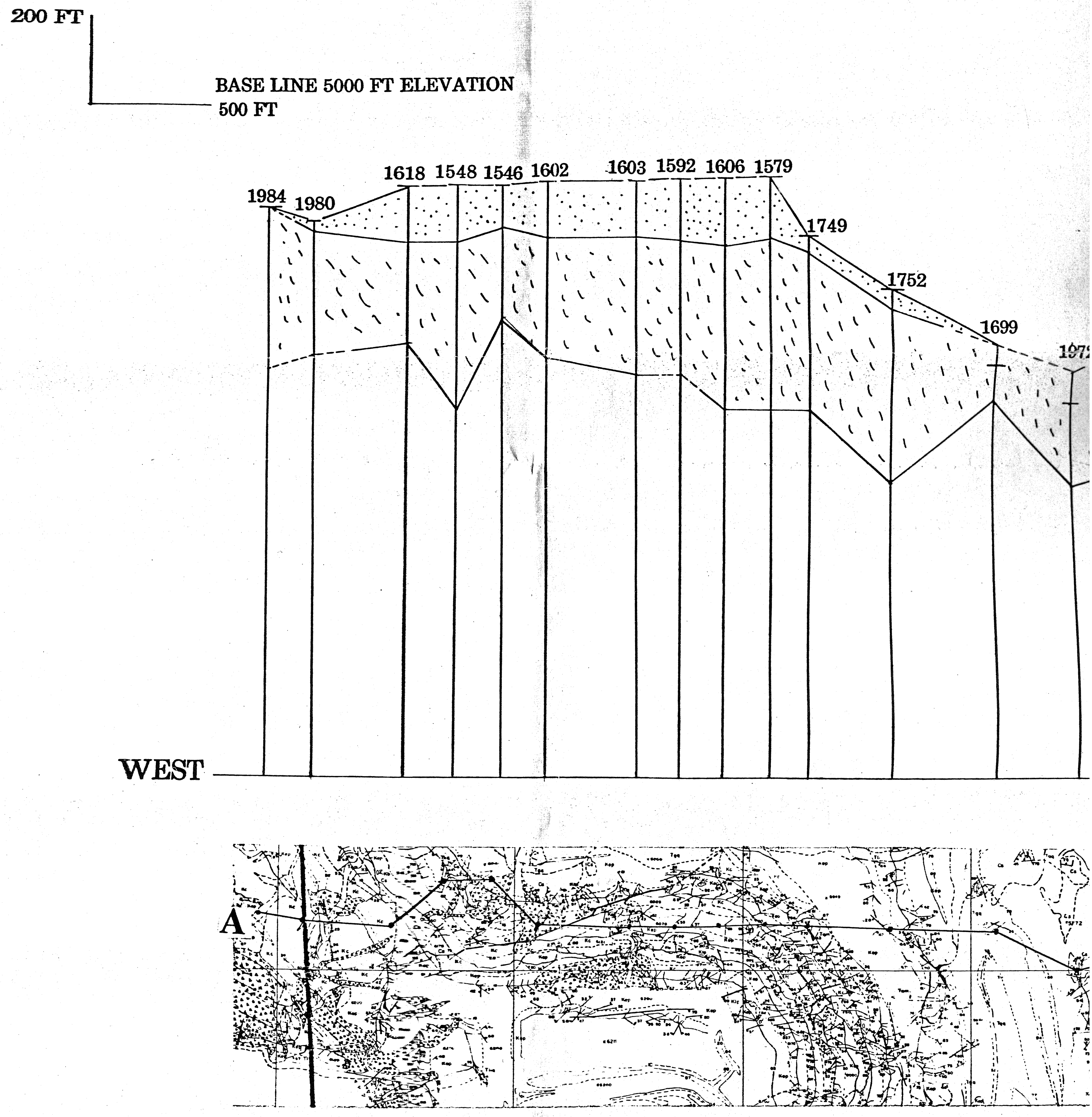
William L. Chávez, Jr.
Adviser

Andrew Campbell

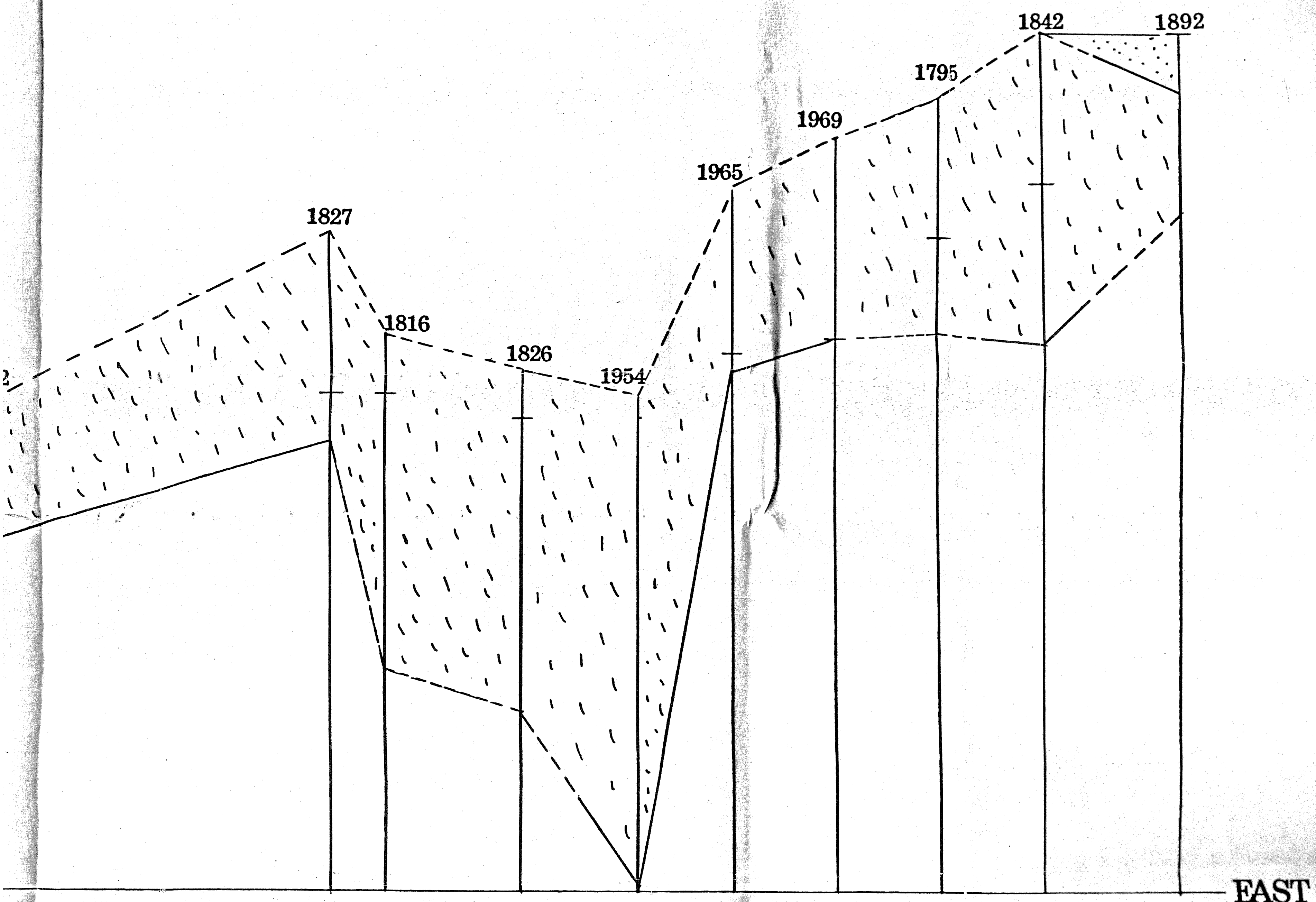
2 November, 1992
Date

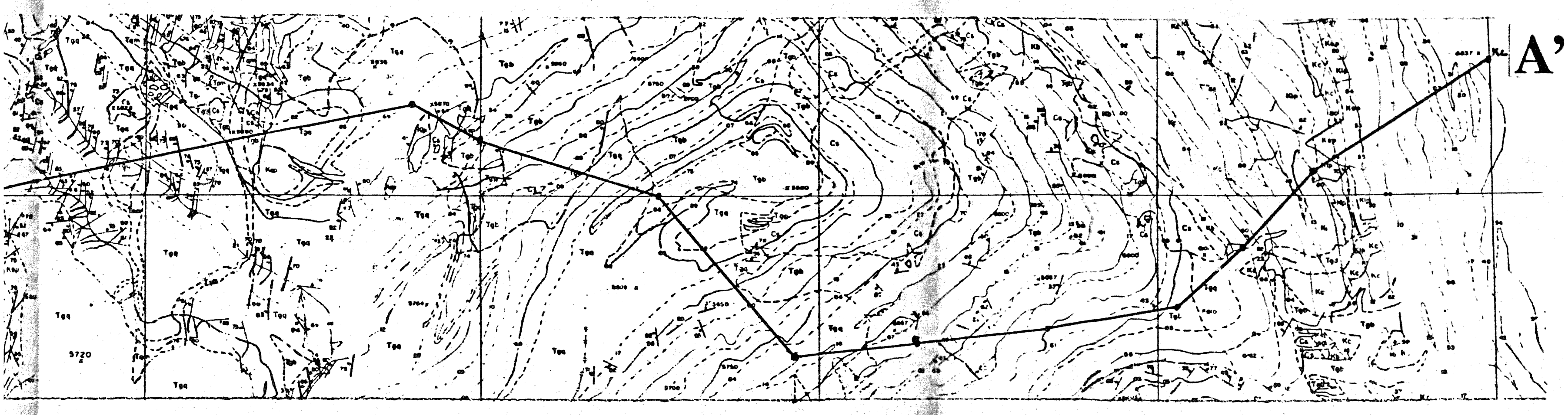
CROSS-S

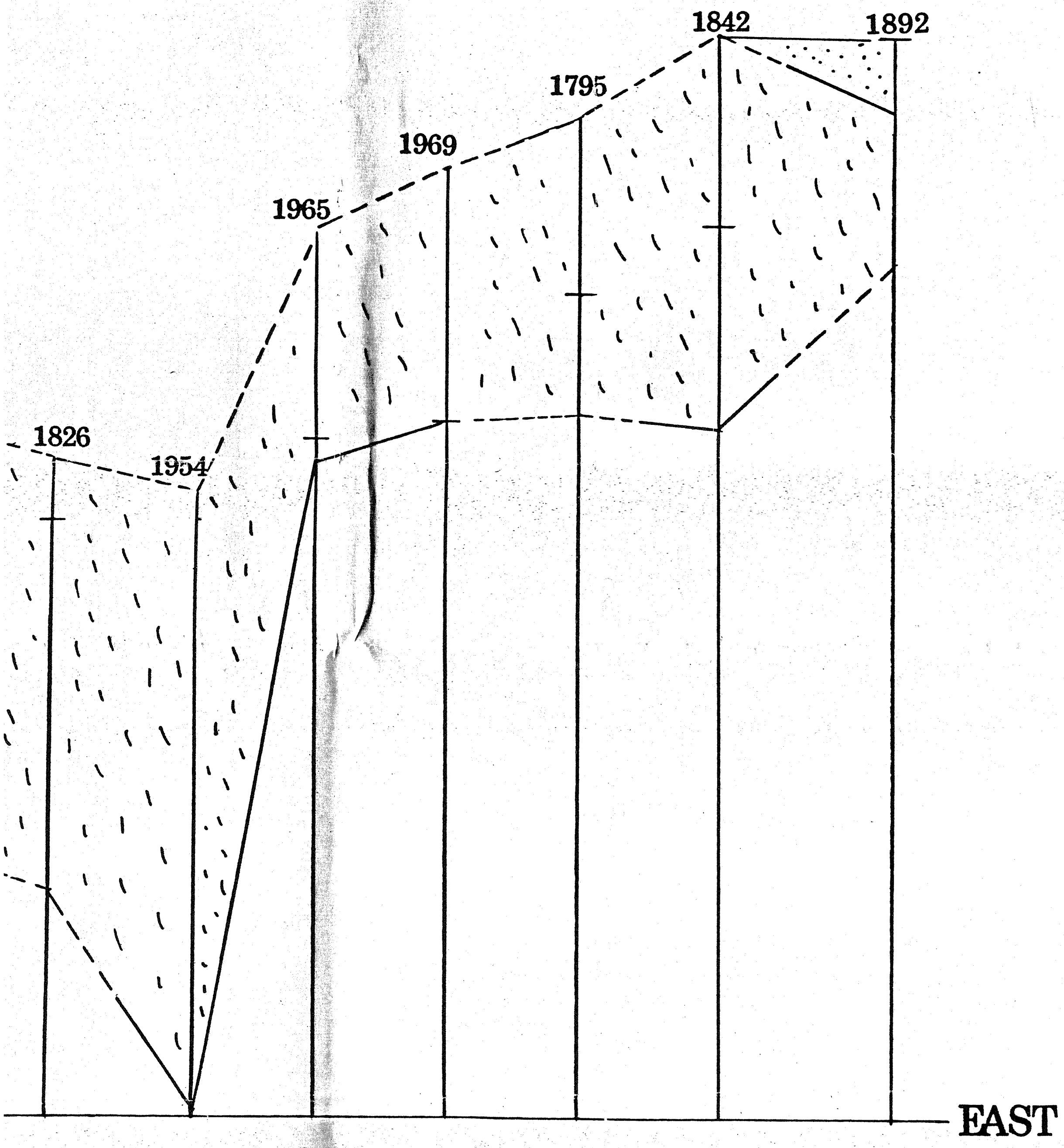
1682	DRILL HOLE NUMBER
┬	DRILL HOLE COLLAR
░	OXIDE/ LEACHED CAPPING ZONE
▨	SUPERGENE ENRICHMENT BLANKET
☐	PROTORE (PRIMARY MINERALIZATION)
—	MINERALIZATION ZONE BOUNDARY
- - -	APPROXIMATE MINERALIZATION ZONE BOUNDARY

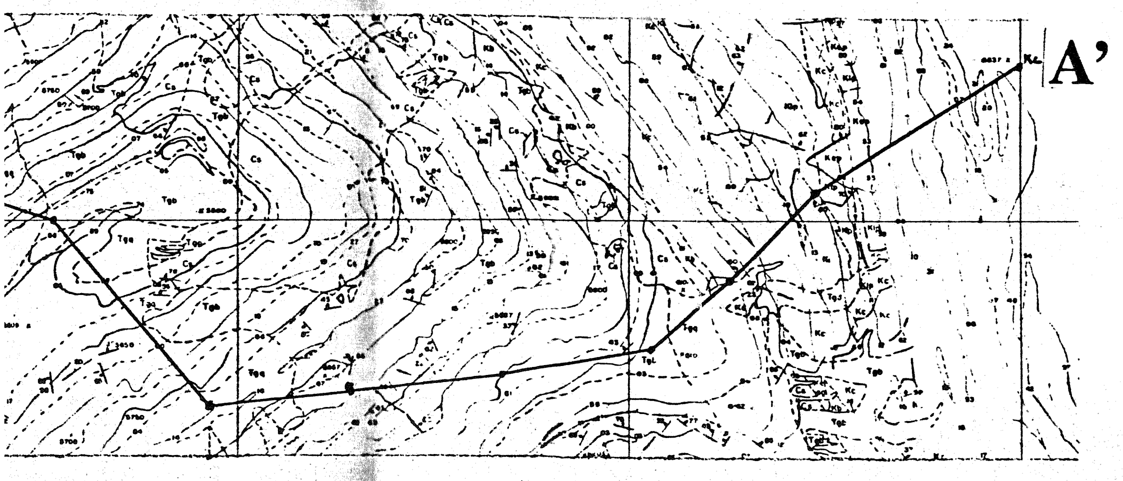


ECTION A-A'






1826
1954
1965
1969
1795
1842
1892
EAST


A'